DETERMINANTS OF PHYSICAL PERFROMANCE IN KNEE OSTEOARTHRTIS

DETERMINANTS OF PHYSICAL PERFROMANCE IN PEOPLE WITH KNEE OSTEOARTHRITIS

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Abstract

Osteoarthritis (OA) is a progressive degenerative joint disease affecting over 4 million Canadians. The knee is most commonly affected joint, making knee OA a leading cause of chronic disability. Leg power is more closely related to physical performance than leg strength in healthy older adults, but power has yet to be studied in people with knee OA. Self-efficacy beliefs, or the confidence one has in their own abilities, is a variable closely related to physical performance in people with knee OA.

The objective of this study was to identify the extent to which knee extensor strength, knee extensor power and self-efficacy explained variance in physical performance measures in adults with knee OA.

Thirty-three participants diagnosed with clinical knee OA were included (5 men; mean age 61.1 ± 6.2 y). Dependent variables included a timed stair ascent, a timed stair descent, and the six minute walk test (SMWT). Independent variables included self-efficacy beliefs for pain, mean peak knee extensor power and mean knee extensor strength.

Pearson correlations and linear regression models were completed using SPSS 15.

Average values on the numeric pain rating scale (NPRS), self-efficacy beliefs for pain and mean peak knee extensor power explained 34.7 % and 42.7% of the variance observed on the timed stair ascent and the timed stair descent, respectively. The determinants of the SMWT were different, with 29.4 % of the variance being explained by average NPRS and body mass index.

Similar to previous work conducted on healthy older adults, it appears that in adults with knee OA, knee extensor power is a closer determinant of physical performance when compared to knee extensor strength, on challenging everyday tasks, like ascending or descending a flight of stairs. For longer endurance type activities like the SMWT, the physical requirements may be different. Clinicians should consider these results when advising patients on the exercise interventions needed to maintain or improve physical performance.

Dedication

To my husband,
Michael
who supports me in all my chosen adventures

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Chapter 1: Introduction

1.1 Osteoarthritis

In Canada, over 4 million people suffer from arthritis (ICES, 2004). As the population ages, this number is expected to escalate to 6 million Canadians by the year 2026 (Health Canada, 2003). Arthritis does not only affect the elderly. It is estimated that by the year 2031 more than 2 million of the people suffering from arthritis will be between the ages of 45 and 64 (ICES, 2004). This statistic is alarming as these years are potentially the most productive in an adult's life. The loss in wages and healthcare expenses associated with arthritis is already costing the Canadian economy over 17.8 billion dollars each year (ICES, 2004). Perhaps even more concerning than the economic burden is the disability, pain and possible depression associated with arthritis.

The most common type of arthritis is osteoarthritis (OA) (ICES, 2004). Osteoarthritis is thought to develop from excessive and/or abnormal loading of joint surfaces, which affects both the articular cartilage and underlying bony tissue (Felson & Zhang, 1988). Pathologically, OA is characterized by a progressive narrowing of the joint space, loss of cartilage volume and osteophyte formation. Clinically, OA is responsible for pain, joint stiffness and mobility limitations, all of which contribute to the physical disability associated with the disease (Guccione, Felson & Anderson, 1994). It is well known that the mean age of the Canadian population is on the rise, and as a result, the economic and personal burden associated with OA is likely to increase. Since there is currently no known cure for OA, it is imperative to better understand the physiological and psychological factors facilitating OA disease among people diagnosed with this chronic condition.

To assess disability, physical performance measures can be used. Such measures may include the ability to walk a specific distance or the time it takes to climb a flight of stairs. A person's health status will ultimately affect their ability to perform on such tasks, leading to varying degrees of disability. As an example, in people with knee OA, the choice to undergo a total joint replacement is related to their performance on a stair climbing task (Zeni, Axe & Snyder-Mackler, 2010). Along with a specific diagnosis, other factors may affect physical performance. For older adults, such factors include muscle strength, muscle power and various personal factors (Bassey et al., 1992; Bean et al., 2003; Rejeski et al., 2001). Muscle strength, particularly of the quadriceps muscle, has been studied extensively in the knee OA literature. Nevertheless, much debate still exists around the importance of knee muscle strength and physical performance in knee OA (Segal et al., 2010; Slemenda et al., 1997).

Muscle power, however, correlates very strongly with physical performance on stair climbing tasks and timed sit-stand tasks in healthy older adults (Bassey et al., 1992; Skelton et al., 1994). Muscle power is defined as the rate of work produced by a muscle or the product of force and speed (Sayers, 2007). Muscle power differs from muscle strength in that the speed of movement a muscle can generate is just as important as the amount of force the muscle can produce. Muscle power requires strength and speed, both of which arguably affect one's ability to carry out physical tasks.

Self-efficacy, or the confidence one has in their own abilities, is a personal factor related to physical performance in people with knee OA (Rejeski et al., 2001). Many studies have shown stronger correlations between self-efficacy and physical performance than physical measures such as muscle strength (Maly, Costigan & Olney, 2005; Rejeski, 2001 et al.; Rejeski et al., 1996). By identifying which factors are the most strongly related to physical performance in people with knee OA, healthcare professionals and researchers can become more successful at devising and promoting various prevention and intervention strategies.

1.2 Study Purpose

The purpose of this study was to evaluate the relative contributions of knee extensor power, knee extensor strength and self-efficacy beliefs to performance on the six minute walk test (SMWT), a timed stair ascent and a timed stair descent task among community dwelling older adults diagnosed with knee OA. By exploring muscle capacity values, along with a psychological measure, this analysis will show how each factor may relate to one's performance on common functional tasks. The addition of muscle power in this study is novel to the current body of research. Others have shown that muscle power is more predictive of one's performance on a stair climb task than a measure of their muscle strength; however this study was completed on 17 healthy, older adults (Larsen et al., 2009). Even with promising results pertaining to muscle power values predicting physical performance, psychological measures like self-efficacy beliefs contribute even more to the understanding of self-reported ratings of perceived ability and actual speed of movement in people with knee OA (Rejeski et al., 2001; Rejeski et al., 1996). Therefore, it is hypothesized that knee extensor power will explain more variance seen with the SMWT, stair ascent and stair descent than knee extensor strength, but self-efficacy beliefs for physical tasks will explain the greatest amount of the variance observed in the performance of these tasks.

Chapter 2: Literature Review

2.1 Knee Osteoarthritis

For osteoarthritis, (OA) the knee is the most commonly affected joint in the body. In fact, knee OA is the leading cause of chronic disability in older adults (Guccione, Felson & Anderson, 1994). A World Health Organization report on global burden predicted knee OA to be the fourth most common cause of disability in women and the eighth most common cause in men (Murray & Lopez, 1997). Primary prevention strategies aimed at slowing the progression of knee OA need to become a priority within the healthcare system of many countries around the world.

Knee OA is a progressive musculoskeletal disease that affects the articular cartilage lining the surfaces of the tibia, femur and/or patella. The degenerative process occurring within the articular cartilage also affects the underlying bone, soft tissues and synovial fluid of that joint. These changes manifest as structural alterations seen as osteophytes, bony sclerosis, joint space narrowing and thickening of the joint capsule; all of which are pathological signs of the disease (Iagnocco et al., 2011). Knee OA is sometimes referred to as the 'wear and tear' condition that clinically leads to declines in strength, joint stiffness, an increase in pain and mobility limitations (Creamer, 2004). Along with the knee, OA affects the joints of the hand, spine and other large weight bearing joints of the body such as the hips (Biljima & Knahr, 2007).

The prevalence of knee OA is estimated at 12.5% of Canadian's over the age of 45 (Zhang, Doherty & Peat, 2010). It is the most common musculoskeletal condition currently affecting North Americans with incidence rates increasing with age (Blagojevic et al., 2010). There are also sex differences associated with the prevalence of knee OA (Blagojevic et al., 2010; Felson, 1998). Before the age of 50, men have a higher prevalence and incidence of knee OA compared with women, but after age 50, women have higher prevalence and incidence rates of the disease (Felson, 1998). Researchers believe the difference between the sexes is due to, at least in part, to various biomechanical factors such as alignment, rates of decline in muscle strength and post-menopausal estrogen deficiencies (Felson, 1998). Unfortunately sex and age are non-modifiable risk factors for knee OA.

Researchers interested in the clinical manifestations of knee OA are more concerned with finding modifiable factors that could potentially slow the progression of disease to improve and/or maintain a certain level of physical functioning. Much of the research to-date is cross-sectional in design and focused on examining factors such as obesity, lower limb alignment, levels of physical activity, self-efficacy for functional tasks and several other physical and psychosocial factors (Bijlsma & Knahr, 2007; Maly, Costigan & Olney, 2005; Messier et al., 2005; Sharma et al., 2003). To conduct useful longitudinal studies examining the possible determinants of functional changes in people with knee OA, it is imperative to identify the most common factors that lead to physical disability. Much debate still exists around this topic as individual differences surrounding the human experience of having a chronic disease go beyond the pathological diagnosis. For this reason, we require studies that include both physical and psychosocial determinants of performance when examining the clinical progression of knee OA (Sharma et al., 2003).

2.2 Diagnosing Knee Osteoarthritis

The most recent criteria for the diagnosis of knee OA were developed in 1986 by the American College of Rheumatology (ACR). The ACR diagnostic guidelines are grouped into three categories: clinical plus radiographic findings, clinical plus laboratory findings, and clinical findings alone (Altman et al., 1986). Radiographs are the most common diagnostic method used in clinical practice, outside of a physical examination (Salaffi et al., 2003). For a clinical and radiographic diagnosis of knee OA using the ACR criteria, a person must present with knee pain, show the presence of osteophytes on radiograph and have at least one of the following three criteria: age >50 years, stiffness < 30 minutes or crepitus (Altman et al., 1986). Sensitivity and specificity values for this type of diagnosis have been reported at 83% and 93%, respectively (Altman et al., 1986).

Using clinical findings alone, a diagnosis of knee OA using the ACR guidelines include having knee pain and at least three of the following six criteria: age >50 years, stiffness < 30 minutes, crepitus, bony tenderness, bony enlargement, and no palpable warmth (Altman et al., 1986). Sensitivity and specificity values with the use of clinical information alone are reported at 94% and 88% respectfully (Altman et al., 1986). Knee OA symptoms likely fluctuate from day to day based upon a person's activities. The specificity values for clinical criteria alone decrease in comparison to the specificity values for clinical plus radiograph criteria, increasing the possibility of finding a false positive. Combining methods to make a diagnosis may seem like the obvious solution, yet due to time constraints during medical visits and limited healthcare funds, obtaining all the necessary evidence to make a diagnosis using all the ACR criteria may not always be realistic.

The ACR guidelines for a diagnosis using clinical plus laboratory findings include having knee pain and at least five of the following nine criteria: age > 50 years, stiffness < 30 minutes, crepitus, bony tenderness, bony enlargement, no palpable warmth, erythrocyte sedimentation rate < 40 mm/hr, rheumatoid factor < 1.40, synovial fluid signs of OA (Altman et al., 1986). Due to the increase rigor and expertise needed to complete the necessary laboratory blood tests, this category of diagnostic criteria is the least often used (Tigges, Sutherland & Manaster, 2000).

The most common way knee OA is diagnosed is a physical examination accompanied by plain film radiographs (Swagerty & Hellinger, 2001). The radiograph hallmarks of knee OA include non-uniform joint space narrowing, osteophyte formation, cyst formation and subchondral sclerosis (Swagerty & Hellinger, 2001). In the early stages of knee OA, radiographs may not show all the findings typical of the disease. More severe symptoms tend to occur in the radiographically more advanced stages; however, considerable discrepancy exists between symptoms and the radiographic stage of OA (Barker et al., 2004; Swagerty & Hellinger, 2001). Therefore, if a clinician is more interested on the impact of symptoms in a person diagnosed with knee OA, radiographic information needs to be accompanied by clinical disease features as well.

2.3 Definition of Knee Osteoarthritis Radiographic Progression

Similar to diagnosing knee OA, there are different ways in which the progression of knee OA can be defined. Progression can mean a worsening of pathological features seen overtime with changes being documented with the use of radiographs or magnetic resonance imaging (MRI). Alternatively, progression can be a combination of changes seen on clinical measures leading to mobility limitations and disability.

For radiographic progression, the criteria used in diagnosing radiographic knee OA are also used to define progression. Joint space narrowing can be quantified allowing measurements to be compared from visit-to-visit tracking disease progression (An et al., 2011). The presence of osteophytes is used in diagnosing the disease, so the number, size and location of osteophytes can also be used to define radiographic progression (Boegard et al., 1998). Different scales such as the Ahlback grading scale, the Brandt grading scale and the most commonly known Kellgren and Lawrence scale (KL) have been developed to define disease severity and document progression through the use of radiographs (Kijowski et al., 2006). The KL score allows people with knee OA to be classified into severity categories based upon the presence of osteophytes, amount of joint space narrowing, and subchondral sclerosis (Felson, 1998). The KL grading system is a 5 point Likert rating scale ranging from 0 to 4, with a rating of 4 representing the greatest disease severity.

As an example of radiographic progression, moving from a KL score of 1, (doubtful narrowing of joint space and possible osteophyte lipping), to a KL score of 2, (definite osteophytes, definite narrowing of joint space), is one way knee OA progression can be defined using radiographs (Kellgren & Lawrence, 1957). Unfortunately the radiographic features documented using the KL scale does not necessarily match the progression of functional loss seen within the person (Jordan, Luta & Renner, 1997;

McAlindon, Cooper & Kirwan, 1993). For instance, one study found that among individuals aged 25-74 years reporting knee pain on most days of the past month, only 15% had radiographic knee OA (Hannon, Felson & Pincus, 2000). The same study also found that only 47% of individuals with radiographic evidence of knee OA reported having knee pain (Hannon et al., 2000). The severity of disease seen on radiograph does not always correlate with the mobility limitations seen within the person (Fukui et al., 2010) highlighting that radiographic changes alone are not enough when defining disease progression.

Recently, MRIs have been proposed as a method that could add information related to defining knee OA progression. MRI can capture soft tissue volumes and changes that radiographs cannot. Cartilage volume and/or lesions, meniscal damage and meniscal extrusion are quantifiable variables assessed using MRI that could aid in defining knee OA pathological progression (Alizai et al., 2011; Crema et al., 2011). Worsening MRI features are independently associated with the radiographic feature of joint space narrowing (Crema et al., 2011). Similar to the KL scoring system for radiographic severity, MRI scoring systems have also been developed to help define disease severity and document progression (Lynch et al., 2010). The Whole Organ Magnetic Resonance Imaging Score (WORMS) and the Boston Leeds Osteoarthritis Knee Score (BLOKS) are two popular methods used to quantify knee OA severity (Felson et al., 2010). The WORMS evaluates 14 independent articular features while the BLOCKS assesses for bone marrow lesions (Lynch et al., 2010). Both methods show high agreement with one another, but the WORMS has been cited as easier to score (Felson et al., 2010). Although research has shown good associations between MRI identified disease features and radiographic disease features, the ability of MRI to clearly distinguish knee OA pathology from non-knee-OA pathology remains poor (Sharma et al., 2009). MRI related disease features correlate more strongly with clinical disease features as compared to radiographs, but there are few studies that have looked at these relationships to-date, so strong conclusions cannot be made (Sayre et al., 2009).

2.3.1 Radiographic Progression Risk Factors

Varus alignment and obesity correlate with the radiographic progression of knee OA (Chapple et al., 2011; Cooper et al., 2000; Kuroyanagi et al., 2012; Schouten, Van den Ouweland & Valkenburg, 1992; Sharma et al., 1998). Age and sex may also correlate with the radiographic progression of knee OA, but the evidence supporting age and sex as risk factors is inconsistent (Chapple et al., 2011; Isbagio, 2004; Nishimura et al., 2011; Spector, Hart & Doyle, 1994). Some studies have found women have a greater risk of radiographic disease progression as they age compared to men (Bruyere et al., 2004; Nishimura et al., 2011), while others have found no relationship between sex and radiographic disease progression (Schouten et al., 1992). The increased risk in women has been attributed to an association between hormone levels and cartilage breakdown (Bruyere et al., 2004; Felson, 1998).

Having a varus or bowlegged alignment increases the rate of radiographic disease progression (Kuroyanagi et al., 2012; Sharma et al., 1998). It has been hypothesized that having a varus alignment increases the load over the medial compartment of the knee joint, promoting a degenerative process affecting the underlying articular cartilage and bony tissues (Kuroyanagi et al., 2012; Sharma et al., 1998). Worsening KL scores as well as decreased joint space width are associated with varus knee alignment after controlling for age, sex and severity of pain (Sharma et al., 1998).

Obesity is a factor contributing to the radiographic progression of knee OA (Cooper et al., 2000; Isbagio, 2004; Nishimura et al., 2011; Reijman et al., 2007). A reduction in body mass reduces knee joint loading in overweight and obese people with knee OA (Messier et al., 2005). Cooper and colleagues conducted a prospective study on 99 men and 255 women (>55 y) with knee OA to examine factors that could lead to radiographic disease progression utilizing the KL scale (Cooper et al., 2000). The factors studied included age, sex, body mass, changes in pain, previous injury to the knee joint, physical activity levels over the participant's life time, and the presence of hand disease. Among all the factors evaluated, obesity was the only predictor of radiographic progression (Cooper et al., 2000).

Pain is a poor predictor of disease severity and radiographic progression (Barker et al., 2004; Guccione, 1997). Fukui and colleagues found no association between osteophyte changes and self-reported pain levels in a group of adults with knee OA (n=68, 106 knees) (Fukui et al., 2010). Similarly, Cooper and colleagues also found no association between pain and radiographic disease progression (Cooper et al., 2000). Perhaps different relationships would have been found between pain variables and progression if progression was defined by clinical changes noted on self-report questionnaires or performance on physical measures as opposed to radiographs alone.

2.4 Definition of Knee Osteoarthritis Clinical Progression

The clinical presentation of someone with knee OA varies from person to person. Pain severity and self-reported mobility limitations related to knee OA do not correlate well with radiographic disease severity (Koca et al., 2011). At this time, there is no consensus in the literature on how to define clinical knee OA progression (Belo, Berger & Reijman, 2007). Researchers have started to conduct studies in which radiographic disease progression is defined separately from clinical progression. This distinction allows for differences between possible contributing factors to be explored. Self-report questionnaires, pain levels, range of motion changes, tenderness on palpation of the joint line and seeking a total joint replacement are various ways in which studies are starting to define clinical progression (Colbert et al., 2012; Fukui et al., 2010; Yusuf et al., 2011).

Self-reported pain and changes in physical performance could be used to define clinical progression, but at the present time there is no gold-standard self-report tool or clinical performance test used to quantify the disability associated with knee OA (Yusuf et al., 2011). Taking personal factors into account, such as sex, age and body mass provides a broader picture on how the disease may impact clinical progression, however alone these variables are not enough (Fukui et al., 2010). Developing a standardized model to explain a person's pathway through clinical progression is needed, but is an enormous challenge when all the possible contributing factors are considered.

The International Classification of Functioning, Disability and Health (ICF), is a tool developed by the World Health Organization and provides a framework for measuring health and disability at both the individual and population levels. The ICF organizes a broad range of elements that could affect one's health into unique categories, with the goal of defining health and disability universally using the same framework. Framework categories include the domains of body functions and body structures, personal and environmental factors as well as activities and participation (Appendix A). What makes the ICF unique is the organization of its categories. Environmental factors are separated from personal factors allowing one to describe the consequence of disease from a variety of potential causes. This viewpoint better allows clinicians and researchers to explain why differences often exist between radiographic disease severity and the clinical presentation seen within the person. The ICF is a universally accepted framework that could help unify the way in which researchers report the changes seen in people with knee OA, and help to create an accepted definition of clinical progression.

Body functions are defined as the physiological systems of the body (De Kleijn-De Vrankrijker, 2003). Examples of body functions include functions of the digestive system, movement related to the function of the neuromuscular system and sensory functions such as pain. The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) is a self-report tool that captures the impact of knee OA as it relates to various body functions. Body structures refer to the anatomy of organs, limbs and their various components, with changes being captured by way of diagnostic imaging, like radiographs.

Personal factors such as sex, age, personality traits, education level and socioeconomic status can be captured via interviews and surveys. As an example, self-efficacy beliefs is a personal factor measured by various questionnaires, such as the

Arthritis Self-Efficacy Scale (ASES), to determine one's confidence in their abilities as it relates to their arthritis (Lorig et al., 1989). Environmental factors make up the physical, social and attitudinal surroundings in which a person lives. Environmental factors are assessed with the use of interviews, surveys or through direct observation depending upon what the researcher is wishing to capture.

The ICF defines activity as the execution of a task or action by an individual. Participation is defined more broadly, stated as one's involvement in a life situation (De Kleijn-De Vrankrijker, 2003). Physical performance measures like the six minute walk test (SMWT) can be used to assess the activity domain. The various physical limitations brought about due to knee OA affect one's ability to perform on such tasks. This information can then be extrapolated to potentially predict a person's ability to participate in activities of daily life (Burr et al., 2011). Measurement tools such as the Keele Participation Scale or qualitative interviews that capture the amount one participates or one's level of satisfaction with their ability to participate could be used to document changes in participation (Wilkie et al., 2011). A decline in activity or participation could therefore help to define clinical progression. When these measurements are taken over time to document changes in physical performance, a decrease in performance could be a reasonable sign of clinical progression. Identifying which factors are the most closely related to physical performance decline, opposed to which factors lead to radiographic progression, is needed in the quest to define clinical progression in people with knee OA.

2.4.1 Clinical Progression Risk Factors

Relative to the number of people with knee OA, few people undergo knee replacement surgery, suggesting that clinical progression happens at various rates and to varying degrees depending on the person. There are likely a variety of modifiable variables related to progression that can account for the differences seen between people. Self-reported function, pain, joint range of motion, joint line tenderness, and low self-efficacy beliefs are all possible contributors to the clinical progression towards disability seen in people with knee OA, regardless of radiographic severity (Fukui et al., 2010; Rejeski et al., 2001; Yusuf et al., 2011). Increasing age is linked to radiographic progression, but few studies have found a link between age and limitations in mobility in people diagnosed with knee OA (Colbert et al., 2012). It appears the risk factors for clinical progression are different from the risk factors associated with radiographic progression.

Looking solely at clinical progression, Yusuf and colleagues set out to investigate factors associated with a good prognosis in people diagnosed with knee OA (Yusuf et al., 2011). A total of 117 participants with knee and/or hip OA were assessed at baseline for age, sex, body mass index (BMI), WOMAC pain and function scores, pain levels and range of motion. Participants completed follow-up visits one year and five years after baseline. Clinical progression was defined as: 1) having a joint replacement or 2) having an increase in self-reported pain or functional changes between baseline and the 6-year follow-up. Pain and functional changes needed to be above a pre-defined minimal clinically important difference (MCID) to be considered clinical progression. These values were determined and tested to be appropriate values by another research group (Ehrich, Davies & Watson, 2000).

At the 6 year follow-up mark, 53% of participants demonstrated clinical progression based upon a MCID cut-off score of 9.7 points for WOMAC pain and 9.3 points for WOMAC function (Yusuf et al., 2011). Age, sex and BMI were not associated with clinical progression in this study. Pain and loss of range of motion however, were associated with clinical progression (Yusuf et al., 2011). In this sample, 90% of those who showed the greatest change in pain scores within the first year had a poorer prognosis. Similar results were reported by Fukui and colleagues (n=68) in which baseline characteristics that included age, sex and BMI were not able to explain the differences seen between a progressed and non-progressed group of knee OA participants, but pain and changes in range of motion were able to predict a difference (Fukui et al., 2010). For non-progressed joints, self-reported functional scores related to pain declined over the 36 month follow-up period signalling a restoration of function, whereas scores for the progressed joints remained the same (Fukui et al., 2010). The results from these studies differ from radiographic studies, where age, sex and BMI were found to be associated with radiographic disease progression (Cooper et al., 2000; Schouten et al., 1992). These studies also highlight that people in the early stages of knee OA often present with more severe pain complaints and resulting disability. However, the course of this pain and disability will vary; some people will improve over time, while others will progress.

A physical factor found to be associated with clinical progression is a loss of total range of motion at the knee joint (knee extension and knee flexion) (Fukui et al., 2010; Yusuf et al., 2011). A reduction in range of motion was found to be an independent determinant of clinical progression (Fukui et al., 2010; Yusuf et al., 2011). Fukui et al. also found that severity of medial joint line tenderness was statistically related to participants in the progressed knee group (Fukui et al., 2010). These studies suggest that the factors contributing to clinical progression are different from the factors associated with radiographic progression.

A separate area to consider in relation to the clinical progression of knee OA is behavioural and psychosocial factors. A personal factor found to be associated with the clinical progression of knee OA is self-efficacy beliefs (Rejeski et al., 2001). In a 30-month prospective study following 480 men and women over the age of 65 years with complaints of knee pain on most days of the week, it was found that those with the lowest self-efficacy beliefs had the greatest amount of functional decline (Rejeski et al., 2001). The results became even more pronounced when baseline muscle strength values were included; highlighting that muscle function may in fact be a risk factor in the clinical progression of knee OA. Unfortunately, evidence supporting muscle strength and slower rates of clinical progression is mixed (Belo et al., 2007; Chapple et al., 2011).

2.5 Muscle Strength and Clinical Progression in Knee Osteoarthritis

Quadriceps weakness is among the modifiable variables that could potentially be protective against knee joint damage and the progression of existing knee OA. Muscle strength is defined as the ability of a muscle to produce force (Sayers, 2007). Muscle strength is often reported in Newton metres (Nm). However, strength varies with body size, so strength values should be normalized to account for this (most logically by body mass, reported as Nm/kg) (Bennell et al., 2008). Segal and colleagues found that women in the lowest tertile for quadriceps strength had an elevated risk for whole knee joint space narrowing over a 30 month period. This relationship was not observed in men, and the definition of progression only considered radiographic changes.

Muscle strength has been studied extensively in knee OA but there is debate around the effects that muscle strength has on disease progression. Research has yet to show convincing evidence that decreased quadriceps strength precedes the development of knee OA, or that a loss of quadriceps strength is a consequence of the disease. We do know that the quadriceps in people with symptomatic knee OA is weaker compared to healthy older adults when examined using a cross-sectional study design (Slemenda et al., 1997). Yet from the studies completed to date, there is limited evidence to suggest that muscle weakness leads to the progression of the disease (Belo et al., 2007; Chapple et al., 2011).

Studies assessing the relationship between quadriceps strength and knee OA are more heavily focused on incidence rates and less so on progression. Quadriceps weakness has been reported by multiple research groups to be associated with incident knee OA (Segal et al., 2009; Slemenda et al., 1997). The Multicenter Osteoarthritis Study evaluated 2,519 knees with OA and 3,392 knees without symptomatic knee OA over a 30 month period. Leg muscle strength did not predict incident radiographic knee OA, but leg muscle strength did predict incident symptomatic knee OA (Segal et al., 2009). These results differ from the results of Slemenda and colleagues who reported that quadriceps weakness was present in people with radiographic knee OA in the absence of knee pain (Slemenda et al., 1997). Slemenda suggested this finding could be due to an underlying muscle dysfunction which he proposed could be a risk factor for developing knee OA (Slemenda et al., 1997).

Despite conflicting results, quadriceps strength does appear to be associated to some degree with incident knee OA. Looking at odds ratios, Slemenda compared the quadriceps strength between people with and without radiographic disease and found that for every 10ft.lbs increase in knee-extensor strength, the associated odds of having radiographic knee OA was 20% lower. This number increased to 29% if symptomatic knee OA was used as the criterion (Slemenda et al., 1997). Future research needs to examine if a similar trend can be seen between quadriceps strength and clinical consequences of the disease.

There is a need for more work to be completed that explores the relationship between knee OA progression and muscle strength. Perhaps other properties of muscle such as the length of muscle fibres (flexibility) or muscle power (muscle work rate) are more closely tied to progression than muscle strength alone. To-date no study has looked at muscle power as it relates to physical performance exclusively in a sample of adults with knee OA. Most activities that involve mobility, such as walking, stair climbing and rising from a chair involve the muscles that surround the knee joint. People with knee OA report lower rates of participation in leisure activities, travel and social events (Gignac, Backman & Davis, 2008), suggesting that overtime, the knee muscles could atrophy due to disuse, affecting a person's ability to participate. Understanding what aspects of the knee muscles best correlates with functional tasks would help guide intervention strategies designed for people with knee OA.

2.6 Muscle Power

Despite a high number of publications exploring muscle strength, strength does not correlate well with radiographic or clinical progression of knee OA (Segal et al., 2009; Sharma et al., 2003). Perhaps other functions of muscle are more closely related to disease progression, such as muscle power. Muscle power is defined as the rate of work performance, or the product of strength and velocity (Newton-metres*radians/second) (Sayers, 2007), and is most often reported in Watts (W).

As one ages, the decline observed in muscle power is much greater than the losses observed in muscle strength (Bosco & Komi, 1980; DeVito et al., 1998; Young & Skelton, 1994). One study found in older adults between the ages of 65-89 years, the losses in isometric muscle strength were equivalent to 1-2% per year, while the losses in muscle power were closer to 3.5% per year (Skelton et al., 1994). Despite knowing that power decreases at an elevated rate as we age, interventions focused on strength and balance make up the bulk of rehabilitation programs intended for older adults with mobility limitations (Bean, Vora & Frontera, 2004). However, muscle power is gaining recognition as an important factor related to physical performance (Bassey et al., 1992; Bean et al., 2010; Bean et al., 2003; Foldvari et al., 2000), and researchers are exploring the benefits of training muscle power in older adults (Sayers, Gibson & Cook, 2012; Sayers, 2007).

For muscle power, much of the research to-date has focused on the elderly and considerably more studies have been conducted exclusively on women. In healthy older women self-reported levels of disability are predictive of leg power capabilities ($r=-0.47$, $p<0.001$), explaining up to 40% of the observed variance (Foldvari et al., 2000). The particular importance of muscle power in women may be due to the fact that women show faster declines in muscle power as compared to men (Skeleton et al., 1994) and thus the relationship between physical performance and capacity measurements like muscle power are more pronounced.

In healthy aging, physical performance measures have strong correlations with mobility and muscle power (Bassey et al., 1992; Bean et al., 2010; Bean et al., 2003; Bean et al., 2002; Foldvari et al., 2000; Skelton et al., 1994). Physical performance measurements are recognized for their clinical importance as representations of a person's mobility status and are important screening tools for the assessment of mobility in older adults (Studenski et al., 2003). The scores on such performance tests are predictive of adverse events such as falls, mortality rates, and disability, even after controlling for the presence of disease (Bean et al., 2003; Guralnik et al., 2000; Guralnik et al., 1994).

Commonly used performance measures to assess mobility include stair climbing, maximal gait speed and stepping unaided onto boxes of varying heights (boxes from 10-50 cm) (Bean et al., 2010; Gur & Cakin, 2003; Skelton et al. 1994). After controlling for age and body mass, leg extensor power is a stronger determinant of performance on functional tasks such as chair rise time (Bassey et al., 1992; Skelton et al., 1994), timed stair climbs (Bassey et al., 1992) and gait speed (Bassey et al., 1992; Bean et al., 2002) when compared to leg extensor strength. This relationship persists in the presence of pathology, for people with chronic illnesses and in older adults with mobility limitations (Bassey et al., 1992; Bean et al., 2008; Bean et al., 2002). Leg strength also correlates well to performance measures in mobility limited adults; however leg power has been shown to explain up to 8% more of the variance on many physical performance tasks (Bean et al., 2002).

Bean and colleagues wanted to exclusively explore the relationship between muscle power and physical performance. A large sample (n=1,032) of older adults over the age of 65 with mild to moderate mobility limitations, defined as a mean score of 10.5 +/- 2.1 on the Short Physical Performance Battery (SPPB) were recruited (Bean et al., 2003). The SPPB is a group of tests including an assessment of standing balance, a timed usual-pace walk of 4 metres and a timed test of five repetitions of rising and sitting in a chair. Scores on the SPPB have predicted future hospitalizations, the need for home nursing visits, as well as disability and mortality rates in older adults (Guralnik et al., 2000; Guralnik et al., 1994). For this study, both power and strength were found to influence the risk towards mobility limitations, but low muscle power was associated with a two to three time greater likelihood of mobility issues when compared to low muscle strength (Bean et al., 2003). The researchers concluded that muscle power is a more influential proximal determinant of mobility status in older adults than muscle strength (Bean et al., 2003).

Rehabilitation intervention studies provide further evidence that muscle power is strongly related to physical performance in aging and age-related pathology. Identifying physical factors that lead to the most clinically important difference in mobility outcomes is essential for developing an effective intervention program. In another study by Bean and colleagues, the scores obtained on the SPPB were used to evaluate two separate exercise interventions in a group of community dwelling older adults (n=116, age= 75.2 y ± 6.7). After controlling for age and baseline values on the SPPB, leg power was the only attribute associated with statistically significant changes on the SPPB as a result of the training program (Bean et al., 2010). Although this study could not conclude that one intervention technique was superior to the other, it did confirm that muscle power, independent of muscle strength, was strongly related to physical performance in mobility limited older adults (Bean et al., 2010).

2.6.1 Muscle Power and Physical Performance in Knee Osteoarthritis

In comparison to studies of healthy aging, less work has been invested in exploring a role for muscle power in knee OA. People with knee OA have lower absolute strength values in the lower extremity muscles, particularly in the quadriceps muscle group (Dekker, Tola & Aufdemkampe, 1993; Segal et al., 2009; Slemenda et al., 1997). The degree of quadriceps weakness often correlates with the intensity of knee pain, which in turn can relate to the severity of mobility limitation (Dekker et al., 1993; Rejeski et al., 2001). It can be hypothesized that muscle power values in people with knee OA would be lower than healthy matched controls. Reasoning for this hypothesis are the same as those proposed for why decreases in muscle strength are seen within this patient population. Reasons include disuse atrophy and high pain levels, each of which limits a person's ability to participate in physical activities (Hatfield, Hubley-Kozey & Stanish, 2011; Slemenda et al., 1997). Furthermore, with prolonged disuse, muscle power declines at a faster rate than the decline observed in muscle strength (Skeleton et al., 1994).

Best practice for the treatment of knee OA currently does not include any specific interventions to address losses in muscle power (Zhang et al., 2010). This is in spite of the fact that research shows muscle power to be a closer physical determinant to many daily tasks among healthy and mobility limited older adults (Bassey et al., 1992; Bean et al., 2010; Bean et al., 2003; Foldvari et al., 2000). Research exploring the relationship between muscle power and physical performance in a population of people diagnosed with knee OA is needed to better inform best practice evidence in the assessment and treatment of this condition.

2.7 Self-Efficacy Theory

Finally, much work has linked self-efficacy as a factor influencing the clinical progression of knee OA. Self-efficacy is a psychological construct referring to a person's confidence and beliefs in their abilities to successfully perform a specific task (Bandura, 1977). Self-efficacy is part of the Social Cognitive Theory (SCT) first proposed by Canadian psychologist Albert Bandura in 1977. This theory examines the bidirectional and interactive relationship between a person's cognitive processes, their environment and their behaviours (Billek-Sawhney & Reicherter, 2004). In the context of SCT, self-efficacy beliefs mediate behaviour choices based on the person's perception of their capabilities (Bandura, 1977). Bandura proposed that the true capabilities of a person are not as important as the person's beliefs pertaining to those capabilities when predicting behaviours (Bandura, 1997).

Bandura describes four sources of self-efficacy that could potentially contribute to a person's self-efficacy beliefs. These sources can be applied to a variety of health behaviours ranging from smoking cessation to cardiovascular disease prevention programs. In people with knee OA, self-efficacy beliefs have a positive relationship with a person's mobility status, both in actual performance and through self-reported measures of perceived physical function (Harrison, 2004; Maly, Costigan & Olney, 2007; Maly, Costigan & Olney, 2006; Maly et al., 2005; Rejeski et al., 2001). Self-efficacy beliefs could therefore be used as a predictive tool when studying the mobility status and mobility changes seen in people with knee OA, linking clinical progression to self-efficacy beliefs.

According to Bandura, the most important source of self-efficacy is obtained through positive personal experiences when one is mastering a specific task. These positive experiences build a robust belief in one's self-efficacy for that given task, while failures undermine it (Bandura, 1998). In a population of mobility limited adults, having a successful experience overcoming a challenging task, such as climbing the stairs with ease or independently walking a mile, will serve to raise the self-efficacy beliefs within that person for that specific task. The person then becomes more likely to attempt the activity in the future, further increasing their capacity to do so.

The second source of self-efficacy is vicarious experience. Social modeling can influence behaviour change if people observe others similar to themselves successfully completing certain activities. This point is especially true if the observer believes they possess capabilities that are closely matched to the skills of the person they are observing. Observing the successful performance of others helps to transmit knowledge and teach effective skills for managing and overcoming environmental demands (Bandura, 1998). Witnessing a peer with similar mobility limitations successfully complete a task will serve to elevate the self-efficacy beliefs within the observer, increasing the likelihood that they too will attempt the task.

The third source of self-efficacy ties the ideas of social influences to persuasion, suggesting verbal encouragement as a method used to strengthen self-efficacy beliefs. Verbal encouragement can persuade people to mobilize greater effort and sustain it through feelings of self-doubt. Depending on who delivers the message, this source of efficacy can contribute to positive behaviour change (Bandura, 1998). As an example, having verbal encouragement come from a trained rehabilitation specialist in regards to someone's walking ability is more likely to increase self-efficacy beliefs for walking compared to a situation where no encouragement is given, or if the encouragement comes from a less credible source.

Lastly, Bandura proposes that people judge their capabilities for a particular task based upon their somatic and emotional states. People will interpret their stress levels and tension reactions as signs of inefficacy (Bandura, 1998). If a person with mobility limitations has anxiety towards crossing a lengthy intersection in their neighbourhood, it is unlikely they will attempt the task. In people with knee OA, the pain and joint stiffness they experience will influence their efficacy beliefs towards many tasks of physical mobility, and overtime lead to a reduction in activity and possible de-conditioning. It is these four sources of efficacy laid out by Bandura that researchers and clinicians can utilize to predict and explain various health behaviours.

2.7.1 Self-Efficacy and Physical Performance in Knee Osteoarthritis

Self-efficacy beliefs have a strong relationship with physical performance in a wide range of patient populations (Bosscher et al., 1995; Harrison, 2004; Lorig & Holman, 1993; Schunk, 1995). Self-efficacy beliefs mediate a person's level of motivation, as well as the moods and attitudes they have towards a given behaviour (O'Leary, 1985; Strecher, DeVellis & Becker, 1986). Thus, these beliefs contribute to a person's willingness to participate in health-promoting activities. This willingness to participate is essential for the maintenance of mobility and prevention of disability, especially in chronic conditions like knee OA. It can be hypothesized that in people with knee OA, having strong self-efficacy beliefs for physical tasks and strong self-efficacy beliefs towards pain management, will increase the likelihood that they will remain active in spite of their symptoms, and thus maintain a certain level of mobility.

In knee OA research, self-efficacy beliefs show stronger relationships with physical performance, more so than several other capacity measurements. One research report looked at the relative contributions that pathology, pain, balance and self-efficacy had on physical performance in 50 older women diagnosed with knee OA (mean age = 69.2 +/- 8.8 y) (Harrison, 2004). Physical performance was assessed using stair climbing, sit-to-stand from a chair and a timed 20 m walk. When an average physical performance score was used as the dependent variable, functional self-efficacy scores and balance accounted for 42% of the variance observed in physical performance (Harrison, 2004). Interestingly, age, pain and self-reported function did not influence the regression model, all of which are factors normally thought to be strongly associated with physical performance. Rejeski and colleagues found similar results in their sample of knee OA participants (n=79), though in their model, pain was included as a factor which helped explain physical performance (Rejeski et al., 1996).

To fully test self-efficacy beliefs and the ability for these beliefs to predict physical performance, biomechanical, psychosocial and physical factors should ideally be included. In 2005, Maly and colleagues evaluated the relative contributions that psychosocial and mechanical variables had with a variety of physical performance measures in people diagnosed with knee OA. Performance measures included the six minute walk test (SMWT), the timed up and go test (TUG) and a timed stair climbing task (Maly et al., 2005). Independent variables included the mechanical variables of knee strength and body mass index (BMI), while psychosocial variables were captured using questionnaires focusing on the domains of depression, anxiety and self-efficacy. Functional self-efficacy explained the greatest amount of variance within the SMWT, TUG, and stair climb scores, explaining 45% of the variance (Maly et al., 2005). The mechanical variables of knee strength and BMI explained some of the variance seen in physical performance, but neither of the other psychosocial variables (depression or anxiety) had a significant impact (Maly et al., 2005).

Self-report measures pertaining to physical function are often used in place of physical performance measures in a clinical setting. Self-efficacy beliefs are able to explain the variability observed on self-report measures (Gaines, Talbot & Metter, 2002; Harrison, 2004). Self-efficacy and pain explain up to 74% of the variance seen on a self-reported function questionnaire in a group of people with knee OA (Harrison, 2004). Similar results have been reported by Gaines and colleagues, but statistical significance was only found in women (Gaines et al., 2002).

Interventions utilizing self-management strategies have tested the use and the effectiveness of programs that aim to enhance self-efficacy beliefs. A program designed to enhance self-efficacy beliefs through cognitive behavioural therapy in a group of rheumatology patients was able to significantly increase the intention to pursue activities of daily living, even if patients reported the activity to be painful (O'Leary, Shoor & Lorig, 1988). Lorig and colleagues have shown similar results within the OA population, where self-efficacy intervention programs were able to reduce pain and increase self-reported levels of physical function (Lorig & Holman, 1993).

Although there is strong evidence demonstrating a relationship between self-efficacy beliefs and one's physical performance, it is likely not the only factor, and thus studies should be conducted examining the predictive capabilities of both psychosocial and biomechanical determinants. Self-efficacy theory and traditional biomechanics should both be included to help predict the physical performance seen in people with knee OA. A three year longitudinal study exploring the roles of psychosocial, mechanical and neuromuscular factors on physical performance in people with knee OA (Sharma et al., 2003) demonstrated that factors protecting against a poor performance outcome included strength, self-efficacy, social support and the amount of physical activity the participant performed each week (Sharma et al., 2003). Understanding the degree to which self-efficacy beliefs affect the physical performance capabilities seen in people with knee OA could be a valuable step in the development and design of intervention programs aimed at slowing the decline towards disability.

2.8 Purpose and Hypothesis

Knee OA is a progressive condition affecting a person's physical performance and mobility. The mobility changes seen in progressive knee OA are highly individualized and vary widely from person to person (Creamer, 2004). While quadriceps muscle strength is implicated in the incidence of knee OA, currently there are no studies that examine the influence of knee extensor power on physical performance in people with knee OA. Similarly, no study to date has examined the relative influence that knee extensor power, as compared to self-efficacy beliefs, has on physical performance in people with knee OA. Thus, the purpose of this study was to evaluate the relative contributions of knee extensor strength, knee extensor power and self-efficacy beliefs surrounding one's ability to manage their pain, by way of the SMWT, a timed stair ascent and a timed stair descent task among community dwelling older adults diagnosed with knee OA.

It was hypothesized that in adults diagnosed with symptomatic knee OA, self-efficacy beliefs would have the strongest relationship with the physical performance tasks, explaining the greatest amount of variance observed when compared to muscle strength and muscle power (Maly et al., 2005). Self-efficacy beliefs affect a person's confidence in their ability to manage the symptoms associated with knee OA, and thus over time, these beliefs become a strong predictor of their mobility status (Rejeski et al., 2001; Rejeski et al., 1996). Muscle power correlates with physical functioning to a greater degree than muscle strength in healthy older adults (Skelton et al., 1994), so it was hypothesized that knee extensor power would relate more strongly with physical performance and explain more of the variance among participants with knee OA as compared to knee extensor strength. However, the contribution from muscle power would not exceed that of personal self-efficacy beliefs.

This study is valuable as it will provide insight into the relative contributions that psychosocial and physical variables may have on physical performance tasks in a population of community dwelling adults with knee OA. It is unique as the predictive capabilities of muscle power have not been compared to that of self-efficacy beliefs within this patient population, yet both variables have the potential to strongly influence mobility. The information gained from this study will facilitate and guide future research examining possible intervention strategies to address mobility limitations in adults with knee OA.

Chapter Three: Methods

3.1 Research Design

This cross-sectional study was one component of a larger cohort investigation of the role of biomechanics in the progression of knee OA. To capture participants' physical performance, the dependent variables chosen were a timed stair ascent, a timed stair descent and the six minute walk test (SMWT). The independent variables chosen were the following: demographic information including age and body mass index; pain evaluated via a numeric pain rating scale (NPRS); maximal voluntary isometric muscle strength measurements for the knee extensors; knee extensor power at 25, 50 and 75% of participants achieved maximal voluntary isometric contraction (MVIC); as well as the total score, and sub-scale scores obtained on the Arthritis Self-Efficacy Scale (ASES). A Biodex System 2 Isokinetic Dynamometer was used to collect knee extensor strength and knee extensor power data. Time needed for data collection was approximately one hour.

3.2 Participants

A sample of community dwelling adults diagnosed with clinical knee osteoarthritis (OA) was chosen to address the objectives of this study. The clinical guidelines set forth by the American College of Rheumatology (ACR) were used to make a clinical diagnosis of knee OA (Altman et al., 1986). These criteria include having knee pain on most days of the month and at least three of the following six criteria: 50 years of age or older; stiffness lasting less than 30 minutes; crepitus; bony tenderness; bony enlargement; no warmth to the touch (Altman et al., 1986). To be included in the study, other inclusion criteria consisted of having an age between 40-70 years and written informed consent (Appendix B). Exclusion criteria included having a diagnosis of other forms of arthritis (e.g., rheumatoid arthritis), active non-arthritic disease (e.g., gout), conditions that might be exacerbated by the protocol (e.g., unstable angina), current/past use of intra-articular therapies (e.g., cortisone injections) or previous knee surgeries (e.g. high tibial osteotomies). In addition, potential participants were excluded if they required an adaptive walking aid such as a cane or a walker on a regular basis; sustained lower extremity trauma within the past 3 months; had ipsilateral hip or ankle conditions; radiation therapy or were pregnant (Appendix C).

Participants were recruited at one rheumatology and two orthopedic surgery clinics located at St. Joseph's Healthcare, in Hamilton, Ontario, Canada. Two recruitment methods were utilized:

1. At the rheumatology clinic, a list of potential participants who signed a consent form, authorizing contact for research studies, were contacted by mail or during a clinic visit. A clinic receptionist provided potential participants a letter of information. This letter included a detailed description of the study and contact information for the research assistant to call if they were interested in participating.

2. Within the two orthopaedic surgery clinics, flyers were posted to inform and invite potential participants to the research study. Contact information for a research assistant was included in this flyer. Potential participants called the research assistant if interested in the study.

From both recruitment methods, a research assistant responded to potential participants with the purpose, protocol, risks and benefits of the study. Potential participants who expressed an interest were screened for the inclusion and exclusion criteria. A goal of 30 participants was set, with a final sample size of 33 participants.

3.3 Variables

3.3.1 Dependent Variables

Timed Stair Tasks

A timed stair task was chosen as the main dependent variable as research studies have shown ascending a flight of stairs to be an indirect measure of muscle power capacity (Bean et al., 2003). Few studies have focused on the more challenging task of stair climbing, yet difficulty with this daily activity is a common complaint among women with knee OA (Rejeski et al., 1998). Stair climbing is also likely difficult for men with knee OA, but minimal research has been completed in this area to date. The timed stair climb was split into separate ascent and descent tasks, each to be included as an individual dependent variable in this study. This separation was done as the biomechanical demands placed on the knee joint are different for stair ascent than they are for stair descent (Protopapadaki et al., 2007). In older adults, ascending a flight of stairs requires maximal isometric extensor strength, while the demands of descending a flight of stairs actually exceed a person's maximal isometric capacity (Samuel et al., 2011). This finding suggests people likely utilize different muscle functions to descend a flight of stairs safely (Samuel et al., 2011). It is reasonable to argue that in people with knee OA, the factors affecting the ability to ascend or descend a flight of stairs may be different.

A standard stair case of 9 steps with railings on both sides was used. Each participant was given the same instructions prior to performing the first trial. Participants were asked to climb the stair case as quickly and as safely as possible. They were asked to remain at the top of the stair case and wait for further instruction. Participants were advised they could use the handrails if they wished, but it was not required. Running or jogging up the stairs was not permitted. It was stressed that the main goal of the task was to see how fast they could climb a set of stairs without compromising their own safety. A stopwatch was used to record the time for each trial. Time began when the participant lifted their foot off the floor and time stopped when both feet were on the ground at the top of the staircase.

Instructions were then given to descend the same flight of stairs as quickly as possible. It was again stressed that the main goal was to see how fast they could complete the task without compromising their safety. Use of the handrail was permitted, but not required and participants were told they were not to run or jog down the stairs. Time started when the participant's foot lifted from the ground and stopped when both feet were planted at the bottom of the stairs. Each stair trial was completed once more to obtain two time measures for ascent and two time measures for descent, recorded to one tenth of a second. The times achieved were averaged to obtain one time for stair ascent and one time for stair descent for each participant.

Pain ratings using the NPRS were obtained after the second ascent trial and after the second descent trial. The time of each trial, pain values, whether the railing was used and the step pattern chosen (either an alternating step pattern or a step-too pattern) were recorded (Appendix D). Completion of the stair trials took approximately 2 minutes.

Six Minute Walk Test (SMWT)

The SMWT was also chosen as a dependent variable. The SMWT is a simple, safe, easy to administer submaximal exercise test commonly used in clinical practice (Du et al., 2009). The test was first developed to assess the exercise capacity of people with cardiac and respiratory problems, but has since been used with a variety of populations as a measure of physical functional capacity (Du et al., 2009). The test itself is a self-paced walking test in which participants are instructed to cover as much distance as possible in six minutes. Participants are permitted to stop, sit and rest, speed up or slow down, but the timer is never stopped during the six minute test duration. Generally a distance of less than 300 meters is considered as a cut-off for increased risk of mortality (Troosters, Gosselink & Decramer, 1999). A flat, level surface measuring 100 feet and a stop watch is typically used to complete the test. The SMWT has been shown to provide information related to the assessment of both pain and function in people with knee OA (Stratford, Kennedy & Woodhouse, 2006). Test-retest reliability for the SMWT in a sample of elderly patients with coronary artery disease was found to be quite high, with reported ICC's ranging from 0.75 to 0.97 (Gayda et al., 2004).

For this thesis study, a flat rectangular loop of hallway measuring 50.6 meters was used. Participants walked in a counter clockwise direction alongside a researcher keeping time with a stopwatch. Standard instructions for the SMWT were read to each participant prior to beginning the test and verbal encouragement was provided at 1 minute intervals throughout the walk as per the SMWT guidelines (ATS, 2002). A distance measuring wheel held by the researcher recorded the distance in meters covered by each participant. A chair was placed in the hall prior to testing and participants were made aware that if they needed to sit and rest during the test they could do so. However, no participant used the chair during this data collection (Appendix E).

3.3.2 Independent Variables

Independent variables included strength and power of the knee musculature of the most painful knee, measured on a Biodex System 2 Isokinetic Dynamometer, and self-efficacy beliefs which were measured with a standardized questionnaire. First, each participant was carefully seated into the Biodex and the appropriate seat adjustments were made. Adjustments included moving the seat height up or down so the center of the leg attachment aligned with the lateral joint line of the knee. Anterior and posterior seat adjustments were made if necessary to ensure the thigh extended beyond the seat length by two finger widths. The length of the leg attachment was adjusted if needed so the leg strap was two finger widths above the participant's calcaneus. Two straps were used to secure the torso of the participant, applied in a criss-cross fashion. A waist belt and a thigh belt were also applied. A cuff around the distal leg was secured with a Velcro strap.

Participants were informed that they should feel secure and that the straps could be adjusted at any time. Once participants felt secure, they were instructed to bend and straighten their knee to become accustomed to the movement and resistance sensation of the machine. Participants could stop the test at any time by verbally stating their desire to stop, or by pressing a red comfort stop button on the Biodex.

Knee Extensor Strength

Muscle strength was recorded as the participant's maximal voluntary isometric contraction (MVIC) achieved for the knee extensor muscles. Torque measurements produced by the Biodex system have been shown to be reliable and valid with measurement error recorded at 0.40 Nm (less than 1% difference) between trials (Drouin, 2004). For this study, MVIC's were recorded at 60 degrees of knee flexion. Previous work examining the activation patterns of muscles through the use of electromyography have found that maximum voluntary isometric contraction torques for the quadriceps muscle occur at 60 degrees of knee flexion (Zhang, 2007). Five knee extension trials were recorded. The length of each isometric contraction was five seconds, with five seconds rest between each contraction. The maximum extension torque achieved was recorded to calculate the values needed for the power assessments. Verbal encouragement was provided throughout testing to best ensure a maximal effort.

Knee Extensor Power

Muscle power was recorded using the isotonic mode on the Biodex for the knee extensor muscle group. Power values were obtained for the resistance levels of 25%, 50% and 75% of each participant's MVIC. A total of 10 isotonic extensor contractions were completed for each resistance level. Previous work in the repeatability of power measures in older adults found that most achieved a maximum power output within six repetitions (Robertson et al., 1998), and fatigue was not a factor during a ten repetition protocol (Bassey & Short, 1990). Researchers have found the isotonic mode to be highly reliable when testing velocity-dependent power, with ICC values ranging from 0.94 to

0.98 (Power et al., 2011). These values were however collected at the ankle joint in healthy, younger individuals. Despite this, several studies have been completed to test the reliability of the Biodex at the knee joint using the isokinetic mode with excellent reliability results (Diaconescu et al., 2011; Hartmann et al., 2009).

Collecting three power values was chosen for two reasons. Previous research exploring peak muscle power at the knee joint found that 70% of MVIC was the value at which most people achieved their highest power output (Bean et al., 2002). However, this was found to be true in healthy older adults without symptomatic knee OA, so lower values of 25% and 50% were also included in this study of older adults with clinical knee OA. To keep data collection consistent, the order of isotonic trials remained the same, moving from 25% to 50% and finishing with 75% MVIC in order to minimize the impact of fatigue. Verbal encouragement was given to best ensure a maximal effort (Appendix F).

Self-Efficacy

The Arthritis Self-efficacy Scale (ASES) was used to assess self-efficacy beliefs. The ASES is a self-report questionnaire used to measure a person's self-efficacy in their ability to manage pain, physical function and other health related variables. It was developed in 1989 through consultations with people who were attending community-based education programs for the treatment of various forms of arthritis (e.g. osteoarthritis, rheumatoid arthritis) (Lorig et al., 1989). The sample used in the scales development had a mean age of 63.7 years (Lorig et al., 1989). The scale consists of 20 items. The version of the ASES used in this study has three subscales: pain (5 items), function (9 items), and other symptoms (6 items). Each item is scored from 10-100 by recording the measurement marked by the participant along a visual analog scale. Higher scores correspond to greater self-efficacy beliefs. Internal reliability (Cronbach coefficient alpha) for the three subscales of pain, function and other symptoms are 0.76, 0.89, and 0.87, respectively (Lorig et al., 1989). Test-retest reliability for the three subscales range from 0.85 to 0.90 (Lorig et al., 1989).

To complete the ASES questionnaire, each participant was asked to read the standard set of instructions outlined at the top of the first page prior to answering the questions. If clarification was needed while completing the questionnaire, the participant was asked to refer back to the standard set of instructions and told to answer each question as they best interpreted it. Completion of the questionnaire took approximately 5 minutes. The total ASES score, as well as the subscale scores, were calculated and used as independent variables capturing self-efficacy beliefs (Appendix G).

3.3.3 Covariates

Pain and body mass index (BMI) were determined to be covariates for this study. Knee pain affects gait performance in adults with knee OA (Sowers et al., 2006; van Dijk et al., 2010). The presence of knee pain is highly correlated with the performance on a timed stair climb task in women with knee OA (Sowers et al., 2006). Forces across the knee joint during walking and stair-climbing are two to four times the normal body weight of a person (Alonge, Babatunde & Aderinke, 2009), so having a higher BMI could negatively impact a person's ability to complete physical performance tasks, and thus was chosen as a covariate.

Pain was assessed using the NPRS. This self-report pain method is very frequently used in clinical practice due to its ease of administration and high rate of responsiveness (Chapman et al., 2011). A 2-point change on the NPRS represents a clinically meaningful change that exceeds measurement error (Childs, Piva & Fritz, 2005). The NPRS was administered on two occasions; the first being knee pain pertaining to the involved side during the timed stair ascent, and the second during the timed stair descent. Since it was hypothesized that the demands placed on the knee would be different for each task, pain was assessed separately for stair ascent and stair descent. Instructions were given by the researcher prior to starting the stair trials and it was asked that the participant rate their knee pain on a scale from 0 to 10. A pain value of 0 represented no knee pain, while a rating of 10 represented the worst pain imaginable in their knee. Participants rated their pain after the second stair trial. BMI was calculated from height and body mass measurements recorded in the laboratory.

3.4 Protocol

Data collection began with measuring body mass (kg) and height (m) of each participant. Participants were then brought into the hallway to complete the SMWT. Next participants were taken to a stairwell adjacent to the lab to complete the stair ascent and descent tasks. The ASES was then completed. The last step of data collection involved the knee strength and knee power measures obtained using the Biodex System 2 Isokinetic Dynamometer.

Biodex collection began with the isometric contractions. Upon completion, participants were given 5 minutes of rest and offered water. Torque calculations were computed to represent 25%, 50% and 75% of the maximal knee extensor torque just achieved by each participant. Ten isotonic contractions for the knee extensors were than completed with resistance set at 25% of MVIC. This isotonic protocol was repeated two more times with resistance set at 50% and 75% of MVIC.

Raw time, torque and velocity data were downloaded from the Biodex into a Microsoft Excel 2010 spreadsheet. From the maximal voluntary isometric trials, torque was recorded at 10 Hz. From these torque values, a line graph was constructed to analyze the peak of each contraction. Positive peaks represented extension torques. The maximum Excel function was used to find the absolute peak torque value of each contraction. Each of the 5 peak extensor torques were converted from ft-lbs to Newton-metres (Nm) (1 ft-lb *1.356). An Excel spreadsheet was created to compare the peak extension torques among participants. An average torque value across all 5 peaks was commuted for the knee extensor muscles to represent knee extensor strength.

Similar to the isometric data, isotonic data consisting of raw time, torque and velocity were downloaded from the Biodex as a notepad file and transferred into a Microsoft Excel 2010 spreadsheet. Data was again recorded at 10 Hz. Torque values were converted from ft-lb to Nm. Velocity values were converted from degrees/second to radians/second (1 degree/second*0.0175). This allowed power to be calculated by multiplying the columns of torque in Nm by velocity in radians/second to obtain power values in Watts (W). A line graph was constructed to analyze the power curves. The maximum excel function was used to find the 10 extension peaks for each of the 25%, 50% and 75% power tests. A single average value for extensor power was calculated in excel and utilized contractions three-to-seven. This was done to maintain consistency in comparing five isometric torque contractions to five power contractions.

3.5 Data Analysis

SPSS version 15.0 software was used for data analysis. Descriptive statistics (mean, minimum, maximum and standard deviation) for the dependent variables, independent variables and the covariates were calculated. An additional table of descriptive statistics (mean and standard deviation) was also constructed to compare women to men on all variables. Due to the imbalance of women to men (n=28, to n=5 respectively) within the sample, analysis was completed to evaluate whether the 5 men were statistically different than the 28 women. An ANOVA was run to examine homogeneity of variance among variables in men and women. Independent t-tests were completed on all demographic, dependent, independent and covariate variables. These comparisons were completed to assess the appropriateness of maintaining a sample size of 33.

Lastly, a paired sample t-test was run on the NPRS values to examine whether differences in pain intensity existed between stair ascent and stair descent.

Three Pearson correlation coefficient tables were created to compare the dependent variables with each of the following variable groupings: knee extensor strength (Nm/kg) and knee extensor power (W); ASES total score and each of the ASES subscale scores; and covariates. Adjusted p-values using Bonferroni corrections were completed due to the number of comparisons being made within each table. Also, 95% confidence intervals were calculated for each comparison. The correlations were used to inform the decisions made regarding which independent variables were to be included in the regression models.

Peak knee extensor power values for all participants using the 25% MVIC isotonic protocol were compiled into a bar graph (Figure 3.1). This graph was completed to assess which trial the absolute peak power value occurred. This graph was also completed to assess whether using a mean peak extensor power value, represented by five contractions within the ten contraction protocol, was appropriate.

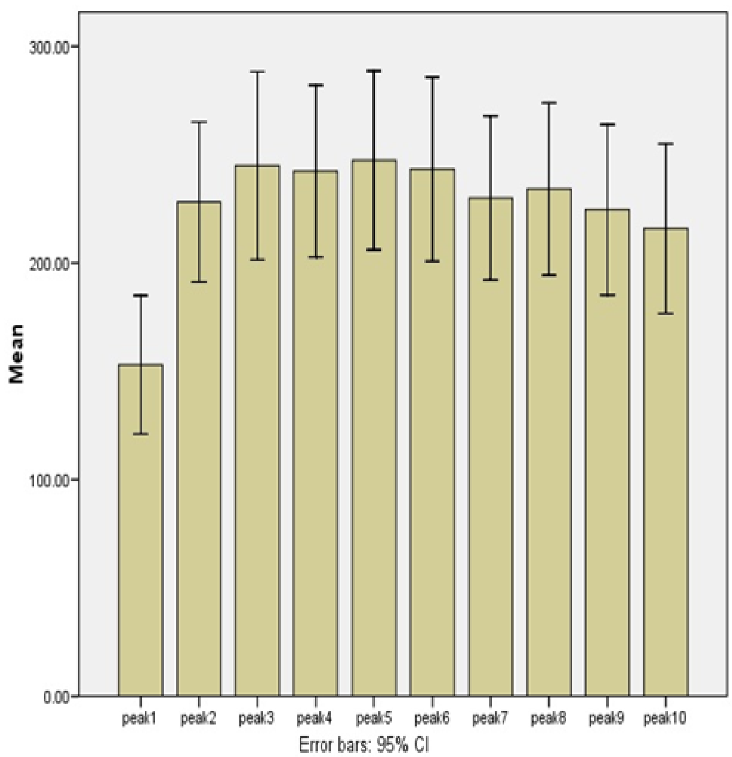


Figure 3.1 – Mean power in Watts (W) along the y-axis and contractions one through ten of the isotonic protocol for 25% MVIC along the x-axis. Each bar represents the mean peak power achieved among all participants for that particular contraction. Error bars represent a 95% confidence interval. Bar graph also shows the first contraction at lower power values and a slight decrease in contractions eight through ten which may represent fatigue. An average of contractions three to seven was chosen to represent mean peak extensor power.

To answer the primary research question, stepwise linear regression models were created for each dependent variable with $p<0.05$ being considered statistically significant. Scatterplots for dependent to independent variable relationships were plotted to ensure linear relationships and homogeneity of variance was also assessed by observing the breath on these plots. A two block design was used for each regression analysis. The covariates included BMI and an average NPRS value. These were entered stepwise into block one. Since power (W) and strength (Nm/kg) were so closely related [$r = 0.581$, $p<0.03$ CI 0.35, 0.75], separate regression models were created for each of mean peak extensor power and mean extensor strength. For the power regression, mean peak extensor power at 25% MVIC and the ASES score for the pain subscale were entered stepwise. For the strength regression, mean extensor strength and the ASES score for pain were entered in a stepwise fashion. A total of six regression models were created. Collinearity values were assessed to ensure independence between the independent variables.

Chapter 4: Results

Descriptive statistics of the demographic information for all participants is presented in Table 4.1. Table 4.2 shows the comparison of demographic information between the women and men in the sample. This comparison was completed due to the imbalanced ratio of women (n=28) to men (n=5) within the sample. The analysis found the variances of all variables to be equal for the men and women. Independent t-tests revealed that women and men statistically differed on only one variable; mean peak extensor power (W) [$t_{31} = -2.71$, $p<0.01$]. All other variable comparisons were considered to be statistically similar.

Table 4.1: Descriptive statistics including demographic information, dependent and independent variables, for the entire study sample (n=33, 28 women).

Variables	Mean	SD	Minimum	Maximum	Missing Data (n)
Demographics					
Age (y)	61.1	6.2	41.0	69.0	0
Body Mass (kg)	76.3	17.3	51.0	117.0	0
Height (m)	1.63	0.07	1.46	1.78	0
BMI (kg/m^2)	28.6	5.9	19.7	40.9	0
Waist Circumference (cm)	91.0	17.0	62.4	125.0	0
Average NPRS	1.5	1.9	0.0	7.5	0
Dependent Variables					
Stair Ascent (s)	4.5	1.4	2.6	10.5	0
Stair Descent (s)	4.2	1.8	2.5	10.6	0
SMWT (m)	501.7	92.6	245.8	695.9	0
Independent Variables					
Peak Extensor Strength (Nm)	121.3	44.2	41.6	222.0	0
Peak Extensor Strength (Nm/kg)	1.63	0.63	0.60	3.49	0
Peak Extensor Power 25% (W)	272.7	124.9	43.4	600.3	0
Peak Extensor Power 50% (W)	253.6	93.1	83.5	524.8	2
Peak Extensor Power 75% (W)	189.0	88.6	43.4	442.6	5
ASES Total score (/30)	23.1	4.7	11	30	0
ASES pain subscale (/10)	7.0	1.9	3	10	0
ASES function subscale (/10)	8.4	1.6	2	10	0
ASES other subscale (/10)	7.7	2.2	1	10	0

SD = Standard Deviation BMI = Body Mass Index; NPRS = Numeric Pain Rating Scale; SMWT = Six Minute Walk Test; ASES =Arthritis Self-Efficacy Scale

Table 4.2: Descriptive statistics comparing women (n=28) to men (n=5) in the sample

Variable	Women (Mean ± SD)	Men (Mean ± SD)
Demographics		
Age	61.3 ± 6.4	60.0 ± 5.7
Height (m)	1.6 ± 0.1	1.7 ± 0.1
Body Mass (kg)	74.1 ± 16.1	88.3 ± 20.5
BMI (kg/m^2)	28.3 ± 6.1	29.9 ± 5.2
Average NPRS	1.5 ± 2.0	1.4 ± 1.1
Dependent Variables		
Stair Ascent (s)	4.5 ± 1.5	4.5± 0.8
Stair Descent (s)	4.2 ± 1.9	4.1 ± 1.2
Six Minute Walk Test (m)	504.3 ± 82.9	487.0 ± 147.9
Independent Variables		
Peak Extensor Strength (Nm)	116.7 ± 41.1	146.6 ± 57.4
Peak Extensor Strength (Nm/kg)	1.63 ± 0.63	1.67 ± 0.58
Peak Extensor Power 25% (W)	248.1 ± 100.0	410.8 ± 170.8
ASES Total score (/100)	23.3 ± 5.0	22.0 ± 3.1
ASES pain subscale score (/10)	7.2 ± 1.9	6.0 ± 1.6
ASES function subscale score (/10)	8.3 ± 1.7	9.0 ± 0.7
ASES other subscale score (/10)	7.8 ± 2.3	7.2 ± 1.5

SD = Standard Deviation
BMI = Body Mass Index; NPRS = Numeric Pain Rating Scale; ASES = Arthritis Self-Efficacy Scale

Scatterplots were created to graphically depict the relationship between the dependent and independent variables. These relationships are shown in Figures 4.1 to 4.9. Pearson correlation coefficients are presented in Tables 4.3, 4.4 and 4.5. After Bonferroni correction, mean extensor strength corrected for body mass (Nm/kg) was significantly correlated with each of the dependent variables. The strongest correlation with mean extensor strength was observed with stair descent times [-0.596 p<0.003; CI -0.78,-0.37] (Table 4.3). For the Arthritis Self-Efficacy Scale (ASES), the subscale score for pain was correlated with stair descent time [-0.538, p<0.001; 95% CI -0.72,-0.29]. No other self-efficacy subscale reached statistical significance (Table 4.4). There were no statistically significant relationships between any of the dependent variables and age;

body mass index (BMI); or average numeric pain rating scale (NPRS) (Table 4.5). The ASES subscale for pain demonstrated the strongest correlations with the dependent variables and was therefore chosen as the self-efficacy variable used in the regression analyses (Table 4.4).

Table 4.3: Pearson correlation coefficients for mean extensor strength (Nm/kg) and mean peak extensor power (W)

* Correlation is significant at the 0.05 level (2-tailed)
** Correlation is significant at the 0.01 level (2-tailed)
Bonferroni Correction (0.05/10 comparisons) p<0.005
(95% Confidence Interval)

	Ascent (s)	Descent (s)	SMWT (m)	Mean Peak Ext. Power 25% (W)	Mean Ext. Strength (Nm/kg)
Ascent	1	***0.934** (0.88,0.96)***	***-0.670** (-0.80,-0.47)***	-0.404* (-0.13,-0.62)	***-0.578** (-0.74,-0.34)***
Descent	***0.934** (0.88,0.96)***	1	***-0.619** (-0.77,-0.40)***	***-0.479** (-0.68,-0.22)***	***-0.596** (-0.78,-0.37)***
SMWT	***-0.670** (-0.80,-0.47)***	***-0.619** (-0.77,-0.40)***	1	0.360* (0.08,0.59)	***0.579** (0.35,0.75)***
Mean Peak Ext. Power	-0.404* (-0.13,-0.62)	***-0.479** (-0.68,-0.22)***	0.360* (0.08,0.59)	1	***0.581** (0.35,0.75)***
Mean Ext. Strength	***-0.578** (-0.74,-0.34)***	***-0.596** (-0.78,-0.37)***	***0.579** (0.35,0.75)***	***0.581** (0.35,0.75)***	1

Table 4.4: Pearson correlation coefficients for Arthritis Self Efficacy Scale (ASES)

* Correlation is significant at the 0.05 level (2-tailed)
** Correlation is significant at the 0.01 level (2-tailed)
Bonferroni Correction (0.05/21 comparisons) p<0.002
(95% Confidence Interval)

	Ascent (s)	Descent (s)	SMWT (m)	ASES Total (/100)	ASES Pain (/10)	ASES Function (/10)	ASES Other (/10)
Ascent	1	***0.934** (0.88,0.96)***	***-0.670** (-0.80,-0.47)***	-0.427* (-0.64,-0.16)	***-0.526** (-0.71,-0.28)***	-0.380* (-0.61,-0.10)	0.193 (-0.10,0.46)
Descent	***0.934** (0.88,0.96)***	1	***-0.619** (-0.77,-0.40)***	-0.418* (-0.63,-0.14)	***-0.538** (-0.72,-0.29)***	-0.367* (-0.60,-0.08)	-0.171 (-0.44,0.13)
SMWT	***-0.670** (-0.80,-0.47)***	***-0.619** (-0.77,-0.40)***	1	0.450** (0.18,0.66)	0.384* (0.10,0.61)	0.337 (0.05,0.57)	0.384* (0.10,0.61)
ASES Total	-0.427* (-0.64,-0.16)	-0.418* (-0.63.-0.14)	0.450** (0.18,0.66)	1	***0.708** (0.53,0.83)***	***0.827** (0.71,0.90)***	***0.905** (0.83,0.95)***
ASES Pain	***-0.526** (-0.71,-0.28)***	***-0.538** (-0.72,-0.29)***	0.384* (0.10,0.61)	***0.708** (0.53,0.83)***	1	0.304 (0.01,0.55)	0.417* (0.14,0.63)
ASES Function	-0.380* (-0.61,-0.10)	-0.367* (-0.60,-0.08)	0.337 (0.05,0.57)	***0.827** (0.71,0.90)***	0.304 (0.01,0.55)	1	***0.770** (0.62,0.87)***
ASES Other	-0.193 (-0.10,0.46)	-0.171 (-0.44,0.13)	0.384* (0.10,0.61)	***0.905** (0.83,0.95)***	0.417* (0.14,0.63)	***0.770** (0.62,0.87)***	1

Table 4.5: Pearson correlation coefficients for covariates

* Correlation is significant at the 0.05 level (2-tailed)
** Correlation is significant at the 0.01 level (2-tailed)
Bonferroni Correction (0.05/15) p<0.003
(95% Confidence Interval)

	Ascent (s)	Descent (s)	SMWT (m)	Age (y)	BMI (kg/m^2)	Average NPRS 0-10
Ascent	1	***0.934** (0.88,0.96)***	***-0.670** (-0.80,-0.47)***	0.370* (0.09,0.60)	0.251 (-0.04,0.51)	0.422** (0.15,0.64)
Descent	***0.934** (0.88,0.96)***	1	***-0.619** (-0.77,-0.40)***	0.370* (0.09,0.60)	0.194 (-0.11,0.46)	0.455** (0.19,0.66)
SMWT	***-0.670** (-0.80,-0.47)***	***-0.619** (-0.77,-0.40)***	1	-0.081 (-0.36,0.22)	-0.376* (-0.60,-0.10)	-0.487** (-0.68,-0.23)
Age	0.370* (0.09,0.60)	0.370* (0.09,0.60)	-0.081 (-0.36,0.22)	1	-0.161 (-0.43,0.14)	0.180 (-0.12,-0.23)
BMI	0.251 (-0.04,0.51)	0.194 (-0.11,0.46)	-0.376* (-0.60,-0.10)	-0.161 (-0.43,0.14)	1	0.125 (-0.17,0.40)
Average NPRS	0.422** (0.15,0.64)	0.455** (0.19,0.66)	-0.487** (-0.68,-0.23)	0.180 (-0.12,0.45)	0.125 (-0.17,0.40)	1

Figure 4.1: Negative relationship between mean extensor strength and stair ascent. Participants with the greatest extensor strength ascended the stairs the fastest (r = -0.578, p<0.005).

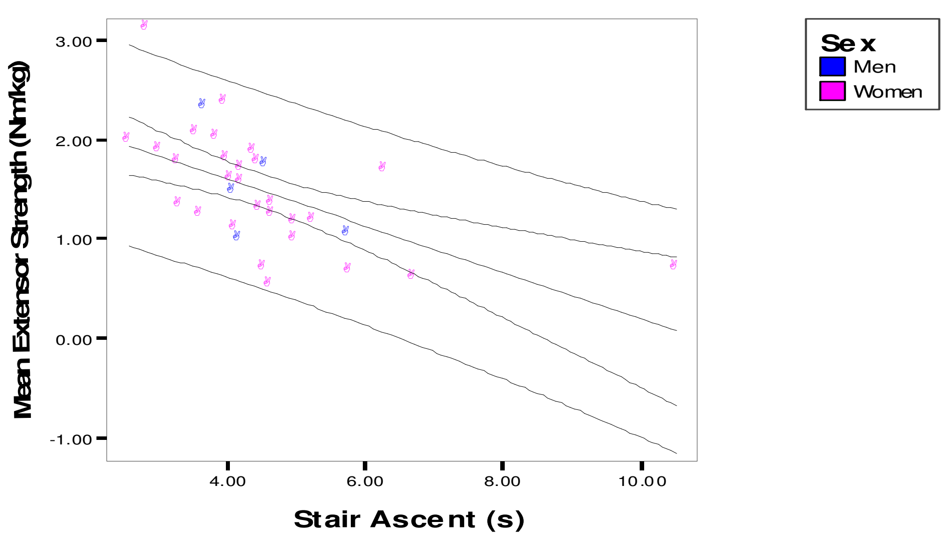


Figure 4.2: Negative relationship between mean extensor strength and stair descent. Participants with the greatest extensor strength descended the stairs the fastest (r = -0.596, p<0.005).

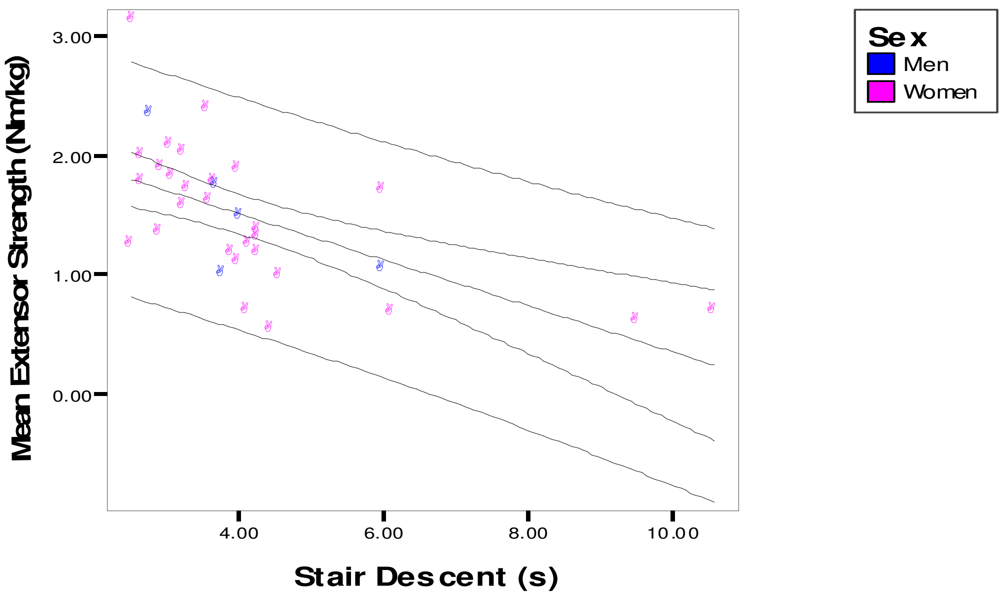


Figure 4.3: Positive relationship between mean extensor strength and six minute walk. Participants with the greatest extensor strength covered the most distance on the SMWT (r = 0.579, p<0.005).

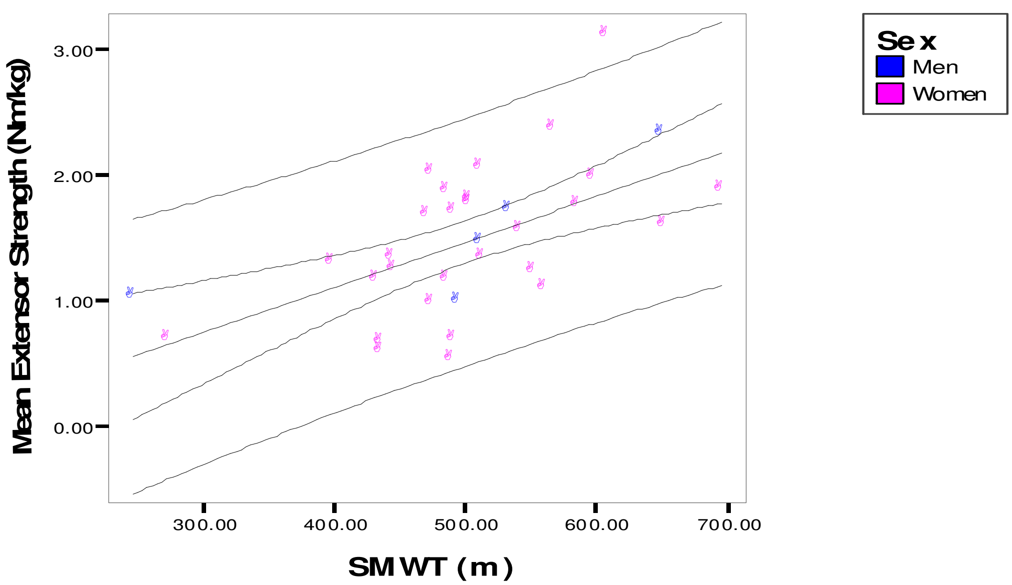


Figure 4.4: Negative relationship between mean peak extensor power and stair ascent. Participants with the greatest extensor power ascended the stairs the fastest (r = -0.404, p<0.05).

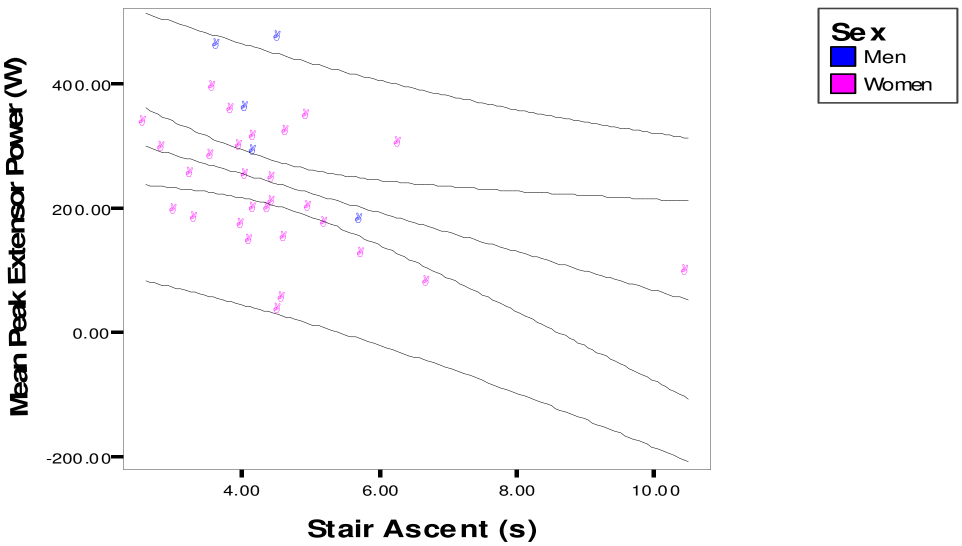


Figure 4.5: Negative relationship between mean peak extensor power and stair descent. Participants with the greatest extensor power descended the stairs the fastest (r = -0.479, p<0.005).

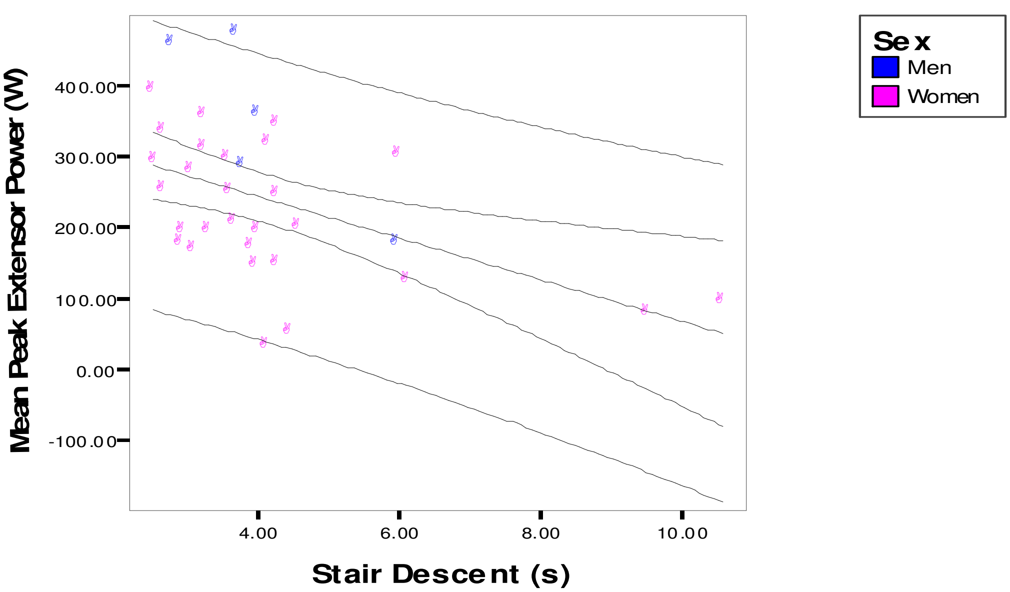


Figure 4.6: Positive relationship between mean peak extensor power and six minute walk. Participants with the greatest extensor power covered the most distance on the SMWT (r = 0.360, p<0.05).

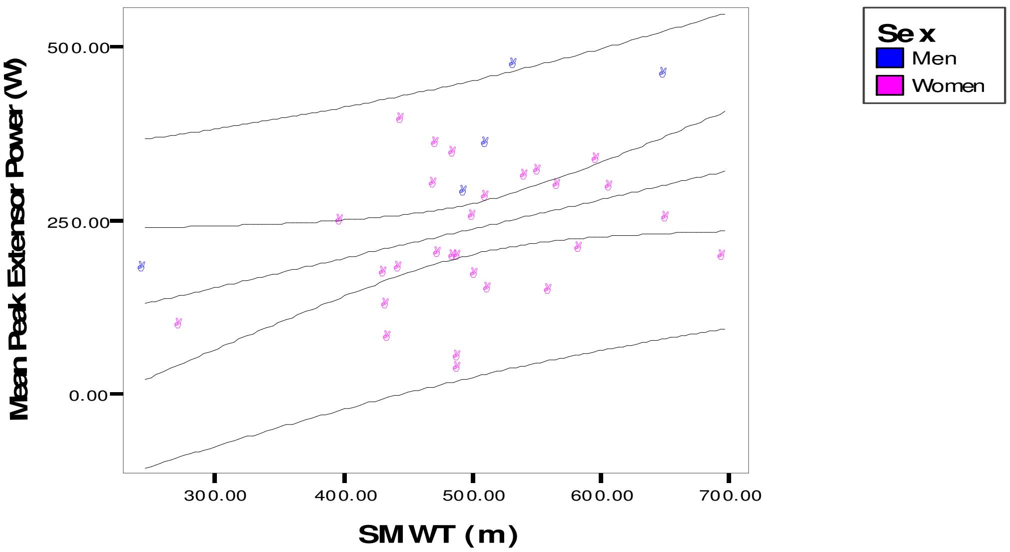


Figure 4.7: Negative relationship between arthritis self-efficacy for pain and stair ascent. Participants with higher self-efficacy beliefs for pain ascended the stairs the fastest (r = -0.526, p<0.002).

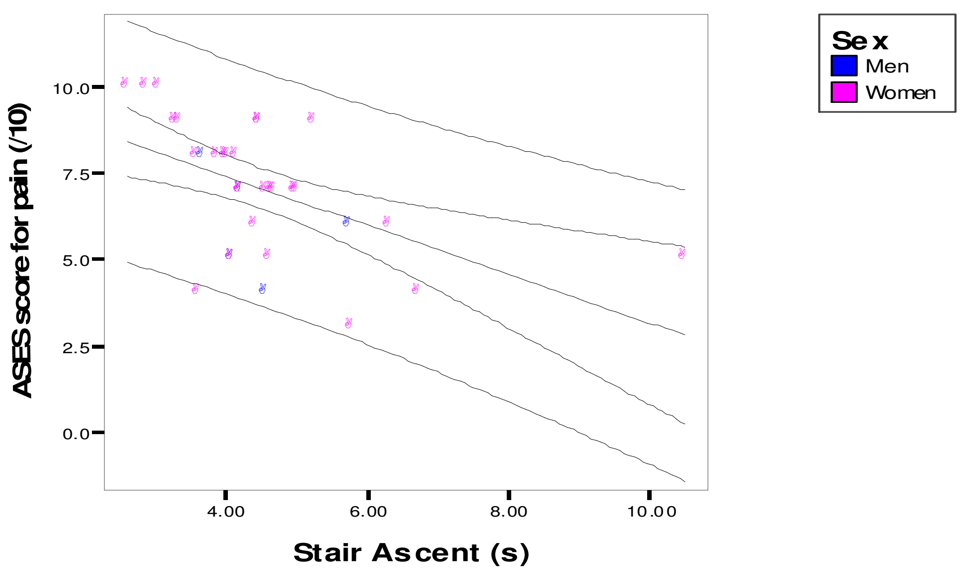


Figure 4.8: Negative relationship between arthritis self-efficacy for pain and stair descent. Participants with higher self-efficacy beliefs for pain descended the stairs the fastest (r = -0.538, p<0.002).

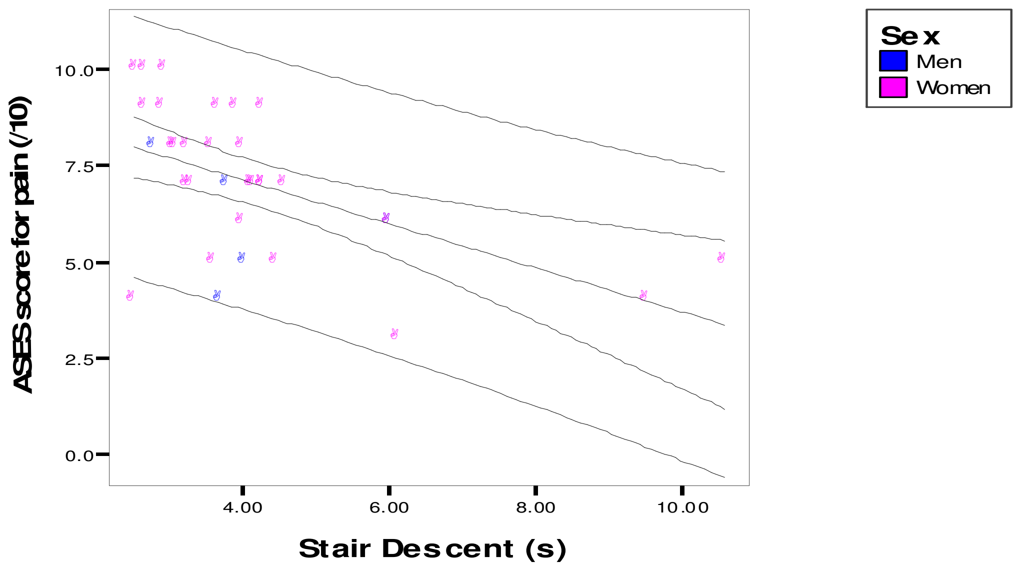
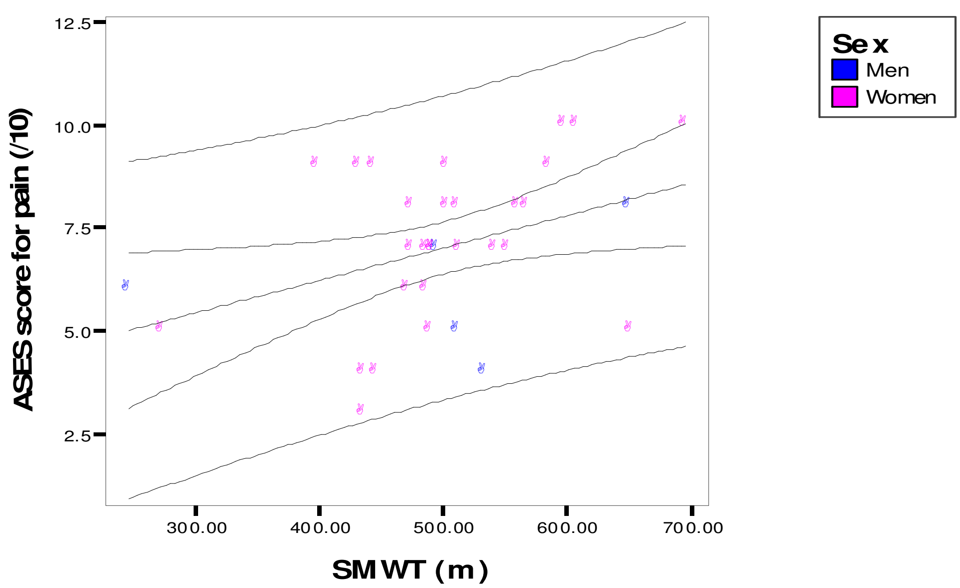


Figure 4.9: Positive relationship between arthritis self-efficacy for pain and six minute walk. Participants with higher self-efficacy beliefs for pain covered the most distance on the SMWT (r = 0.384, p<0.05).



Stepwise linear regression models are summarized in Table 4.6 to Table 4.11. For stair ascent, the model which explained the greatest amount of variance included the average NPRS score, ASES for pain and mean peak extensor power, which together explained 34.7% of the variance. For stair descent, the same variables were included and accounted for 42.7% of the variance. The best regression model for the SMWT included the average NPRS and BMI, explaining 29.4% of the variance.

Table 4.6: Summary of linear regression analysis with stair ascent as the dependent variable; use of mean extensor strength (Nm/kg)

Variable	R Squared	Adjusted R Squared	Unstandardized Beta	P value
NPRS	0.178	0.152	0.311	p=0.014
NPRS + mean ext. strength	0.348	0.305	-1.22	p=0.009

Table 4.7: Summary of linear regression analysis with stair ascent as the dependent variable; use of mean peak extensor power (W)

Variable	R Squared	Adjusted R Squared	Unstandardized Beta	P value
NPRS	0.178	0.152	0.311	p=0.014
NPRS + ASES pain	0.309	0.263	-0.313	p=0.024
NPRS + ASES pain + mean peak ext. power	0.408	0.347	-0.005	p=0.035

NPRS = Numeric Pain Rating Scale; ASES = Arthritis Self-Efficacy Scale

Table 4.8: Summary of linear regression analysis with stair descent as the dependent variable; use of mean extensor strength (Nm/kg)

Variable	R Squared	Adjusted R Squared	Unstandardized Beta	P value
NPRS	0.207	0.181	0.423	p=0.008
NPRS + mean ext. strength	0.377	0.335	-1.55	p=0.008

Table 4.9: Summary of linear regression analysis with stair descent as the dependent variable; use of mean peak extensor power (W)

Variable	R Squared	Adjusted R Squared	Unstandardized Beta	P value
NPRS	0.207	0.181	0.423	p=0.008
NPRS + ASES pain	0.333	0.288	-0.389	p=0.024
NPRS + ASES pain + mean peak ext. power	0.480	0.427	-0.007	p=0.008

NPRS = Numeric Pain Rating Scale; ASES = Arthritis Self-Efficacy Scale

Table 4.10: Summary of linear regression analysis with six minute walk test as the dependent variable; use of mean extensor strength (Nm/kg)

Variable	R Squared	Adjusted R Squared	Unstandardized Beta	P value
NPRS	0.237	0.212	-23.5	p=0.004
NPRS + BMI	0.338	0.294	-4.5	p=0.041

Table 4.11: Summary of linear regression analysis with six minute walk test as the dependent variable; use of mean peak extensor power (W)

Variable	R Squared	Adjusted R Squared	Unstandardized Beta	P value
NPRS	0.237	0.212	-23.5	p=0.004
NPRS + BMI	0.338	0.294	-4.5	p=0.041

NPRS = Numeric Pain Rating Scale; BMI = Body Mass Index

The assumptions for linear regression were met to allow for linear regression analysis. Graphs were constructed to show a linear relationship between the independent and dependent variables and to examine homogeneity of variance between variables. Diagnostic statistics revealed no collinearity between the independent variables. Variables were checked to ensure they had a normal distribution.

Chapter Five: Discussion

5.1 Overview

This thesis aimed to examine the relative contribution that knee extensor strength, knee extensor power and self-efficacy beliefs had on the performance of everyday tasks in people with knee osteoarthritis (OA). Stair ascent and stair descent were influenced by self-reported pain, self-efficacy beliefs for pain and knee extensor power. Walking performance assessed by the six minute walk test (SMWT) was not influenced by strength, power or self-efficacy beliefs. This study found the determinants of stair climbing performance and the determinants of walking performance to be different in people with knee OA, highlighting the need to examine a variety of physical performance measures when studying this patient population. This study found knee power to be an important determinant of physical performance in people with knee OA, adding new information to the current body of literature.

5.2 Determinants of Stair Climbing Performance

Knee Extensor Power and Knee Extensor Strength

The regression models for mean peak extensor power explained more of the total variance in both the stair ascent and stair descent tasks when compared to mean extensor strength. Previous studies have found similar results, finding knee power to be a stronger determinant of physical performance compared to knee strength in healthy older adults (Bassey et al., 1992; Bean et al., 2002; Skelton et al., 1994). Examples of physical tasks studied in the past include timed chair rise, maximal gait speed, stair ascent and standing balance. This is the first study to examine knee power as it relates to performance exclusively in a sample of people with knee OA, and is one of few studies that has examined the physical determinants of descending a flight of stairs.

The current study found that in people with knee OA, mean peak extensor power explained up to 9% more of the total variance seen on the stair descent task when compared to the mean extensor strength model. Similar results were found for the stair ascent task, but the total contribution of power to stair ascent variances was only 4%. Comparable results have been reported in a sample of mobility limited older adults (n=45, 34 women; aged 65-83 years), with power explaining up to 8% more of the total variance compared with strength in stair climbing, chair rise time, maximum gait speed and balance (Bean et al., 2002). Stair climbing was assessed with a timed stair ascent task only. Consistent with the results of the current thesis, leg power was found to be strongly related to leg strength, yet in both studies, power had a greater influence on physical performance. This suggests that power is likely a separate attribute in the explanation of variance seen on physical tasks in mobility limited adults.

Several differences do exist between this study and previous work examining knee power. This study was the first to examine knee power using the isotonic protocol on the Biodex System 2 isokinetic dynamometer. A double leg press machine, known as a 'power rig' is often used to assess leg power in older adults (Barker et al., 2004; Bassey et al., 1992; Bean et al., 2002; Skelton et al., 1994). With the power rig, pre-set resistance levels similar to the 25%, 50% and 75% protocol used in this study have been used (Bassey et al., 1992; Bean et al., 2002; Skelton et al., 1994). However, the original power rig protocol asks for one maximal power output effort for each pre-set resistance (Bassey

& Short, 1990). The peak power achieved among any resistance level chosen is used as the power variable. The lack of consistency within the selected resistance when comparing participants is a potential limitation of the power-rig protocol, as well as the inability to calculate an average power over multiple repetitions. The protocol developed for this thesis allows for average power to be calculated as well as absolute peak power. Within our participant sample, peak power was never achieved on the first repetition, presenting a valid argument against using a one-repetition based protocol when assessing leg power.

Assessing the importance of leg power on both a stair ascent and stair descent task is another unique feature of this study. No study has examined the contribution of muscle power to physical performance by separating stair ascent and stair descent into two separate tasks. Part of the rationale for separating these stair tasks was that people with knee OA demonstrate different muscle functioning capabilities when compared to healthy adult controls (Yu, Wu & Wang, 2006). Comparing healthy adults to adults with knee OA, the difference between eccentric muscle capabilities is greater than the differences seen on concentric muscle capabilities (Yu et al., 2006). Ascending a flight of stairs requires different muscle properties than descending a flight of stairs (Samuel et al., 2011), so assessing both tasks in a sample of people with knee OA is important.

In 2003, Gur and Cakin did separate stair ascent and stair descent in a sample of women with bilateral knee OA (n=18, 56 ± 10 y) (Gur & Cakin, 2003). The main study objective was to examine the relationship between muscle cross-sectional area, concentric muscle force and eccentric muscle force for both the quadriceps and hamstring muscles during functional tasks. Function was assessed by way of a 15m walk, chair rise task, timed stair ascent and timed stair descent. Cross-sectional muscle area did not significantly predict stair climbing performance among the participants. However, certain muscle ratios contributed strongly to explaining the variance observed on stair ascent and stair descent among the women. For the stair ascent task, concentric quadriceps to eccentric hamstring ratios explained 81% of the variance. For stair descent, 61% of the variance was explained by the concentric hamstring to eccentric quadriceps ratio (Gur & Cakin, 2003).

Gur and Cakin's study is important clinically as it shows that from a muscle function stand point, ascending and descending a flight of stairs represent two separate tasks in women with knee OA. Although this thesis did not find differences between the determinants for stair ascent and stair descent, the relative contributions from mean peak extensor power and self-efficacy for pain did differ. Perhaps in an older sample or in people with more advanced stages of knee OA, the differences would become more pronounced.

Self-efficacy for Pain

Self-efficacy for pain appeared to be the strongest correlated domain to each of the dependent variables. This is contrary to previous studies examining self-efficacy beliefs in people with knee OA. Previously, functional self-efficacy scores have been shown to relate more strongly with physical performance on tasks such as the SMWT, timed up and go and stair climbing (Harrison, 2004; Maly, Costigan & Olney, 2006; Maly, Costigan & Olney, 2005; Rejeski et al., 1996). Self-efficacy for pain has strong links to pain catastrophizing behaviours (Shelby et al., 2008; Somers et al., 2009), but demonstrates weaker correlations when related to physical performance in people with knee OA (Maly et al., 2005). This study was able to show that self-efficacy for pain is in fact strongly related to the physical performance differences seen in people with knee OA.

Reasons for this difference may be explained by the way in which self-efficacy was measured, the nature of the physical tasks chosen, and the characteristics of the participant sample. Rejeski and colleagues found that self-efficacy beliefs were very important in explaining physical performance differences among a sample of community dwelling adults with knee OA (n=79, 68.8 ± 6.4y) (Rejeski et al., 1996). For Rejeski et al. study, self-efficacy beliefs were captured by an eleven point confidence ladder in which participants rated their level of certainty in their abilities to complete a specific task immediately prior to completing that task (Rejeski et al., 1996). This method of self-efficacy measurement may be superior to a more global measurement tool, as self-efficacy beliefs are highly domain and situation specific (Bandura, 1977). The way in which self-efficacy beliefs are measured likely affect the results.

By using the Arthritis Self-Efficacy Scale (ASES) in this thesis, a broader sense of self-efficacy beliefs within the person was likely captured. This could explain why the functional self-efficacy domain was not as significantly related to stair ascent and descent when compared with self-efficacy for pain. Bandura has noted a mismatch between the assessment method for self-efficacy and the behaviour of interest will reduce the strength of the relationship (Bandura, 1998). Asking participants to rate their self-efficacy beliefs for stair ascent and stair descent may strengthen the relationship between functional self-efficacy scores and physical performance for stair climbing.

Ascending and descending a flight of stairs is a challenging task for people with knee OA, and may be more affected by a person's confidence in their abilities to control pain as compared to their confidence towards general functional tasks. The lower-impact activities such as walking 40 m, standing from a chair or lifting a heavy object that were used by Rejeksi and by others who have found similar results, may be more influenced by functional self-efficacy beliefs as pain is not as relevant in these more basic tasks.

Demographics of the sample also likely contribute to the differences seen among studies. Age is a factor that could have affected the results. The mean age of our sample (61.1 ± 6.2 y) was eight to ten years younger than the mean age of samples in other studies looking at self-efficacy and physical performance (Maly et al., 2006; Maly et al., 2005). As a person ages, the expectations surrounding musculoskeletal pain may change. It becomes more acceptable to have 'aches and pain' as one ages, and could be why our sample felt less confident in their abilities to manage their pain.

Self-efficacy for Pain and Knee Extensor Strength

An interesting finding within this study was the strong relationship between self-efficacy for pain and mean knee extensor strength ($r=0.551$, $p<0.001$). This strong correlation explains why self-efficacy for pain did not appear in the final regression models for strength and each of stair ascent and stair descent. This relationship between self-efficacy beliefs and strength has also been reported by Rejeski and colleagues. As an example, one study examined the effects that knee pain, knee strength, and self-efficacy beliefs had on the progression of functional decline in older adults with knee pain over a 30 month period (n=480, 71.8 ± 5 y) (Rejeski et al., 2001). A combined stair ascent and descent task was used as the physical performance measure. The variables demonstrating the strongest relationship to stair climb time were knee strength ($r = -0.63$, $p<0.001$) and self-efficacy beliefs specific to the stair climbing task ($r = -0.53$, $p<0.001$) (Rejeski et al., 2001). Rejeski interpreted these results to mean that possessing high self-efficacy beliefs are protective when people are challenged with deteriorating function. The self-efficacy beliefs in Rejeski's study were able to predict functional decline, but only in the participants who had poor baseline knee strength (Rejeski et al., 2001).

From Rejeski's work and considering the results of the present thesis, it appears that people who hold higher self-efficacy beliefs, whether for a specific functional task or in their ability to control pain, will be more likely to persist with physical activities that will aid in maintaining muscular strength. For this thesis, people with the strongest self-efficacy beliefs surrounding their abilities to manage pain had the strongest knee extensor muscles. Overtime, higher self-efficacy beliefs for pain could be protective against the functional decline associated with knee OA.

Self-Reported Pain

For each of the stair regression models, self-reported pain captured with the numeric pain rating scale (NPRS) explained the greatest amount of variance. Subjective pain reports have a well-established relationship to performance on functional tasks in people with knee OA (Maly et al., 2005; Rejeski et al., 2001; Rejeski et al., 1996; Sharma et al., 2003). Self-reported pain measures offer insight into a person's mobility status and are often used to guide treatment options. Pain has been shown to be a good predictor of whether or not a person with knee OA will undergo a total joint replacement (TJR) (Zeni & Synder-Mackler, 2009), making self-reported pain a key outcome measure in any study looking at functional decline or disability. The results from this thesis support the existing literature of strong relationships between self-reported pain and physical performance in people with knee OA.

5.3 Determinants of Performance on the Six Minute Walk Test

Self-efficacy for pain, mean peak extensor power and mean extensor strength did not contribute to the regression models for the six minute walk test (SMWT). Self-reported pain captured with the NPRS and body mass index (BMI) were the only variables contributing to the variance observed on the SMWT. Previous studies examining the determinants of the SMWT in people with knee OA have found variable results. Maly and colleagues reported functional self-efficacy beliefs to be a key determinant of performance on the SMWT in people with knee OA, with less significant contributions from knee strength, BMI and range of motion (ROM) (Maly et al., 2005; Maly et al., 2006). Sample demographics between this thesis and the studies mentioned are similar. The differences in SMWT determinants could however be related to the way in which strength data was collected. In the Maly et al. study, an isokinetic protocol was used which differs from the isometric protocol used in this thesis. The current sample demonstrated considerably stronger knee extensor strength (mean=121.3 ± 44.2 Nm) compared to the participants in the Maly et al. study (mean=63.8 ± 29.0 Nm) (Maly et al., 2006). Demonstrating greater muscle force capabilities appears to allow one to complete endurance tasks such as the SMWT with greater ease, and thus self-efficacy beliefs for pain or knee extensor power are not as influential in a group with greater overall muscle strength.

Stair climbing is a more challenging task than walking, especially in a sample of people with a pathology affecting the knee joint. The loads associated with stair climbing exceed the load demands of walking (Protopapadaki et al., 2007), which could be why self-efficacy beliefs, knee extensor power and knee extensor strength appeared in the stair regression models, but were not included in the SMWT regression models. Results from this thesis highlight the need to examine a broader range of functional tasks when assessing the mobility status of people with knee OA. The performance limitations associated with knee OA vary from person to person, which is why choosing a variety of physical performance tasks with varying difficulty levels is needed to capture the abilities of all participants within a sample.

5.4 Clinical Relevance

Training Knee Power in People with Knee OA

Physical activity programs aimed at improving or maintaining function in people with knee OA have been studied heavily in the rehabilitation literature. Training knee extensor power specifically is a newer concept within this literature (Sayers, Gibson & Cook, 2012; Sayers, 2007). Strengthening protocols designed for people with knee OA vary widely and the results from these protocols have been mixed (Latham et al., 2004). The current recommendations for resistance training in adults encourages slow-velocity contractions at high torque values (~50-80% 1RM), where the primary goal is improving muscle strength (ACSM, 2000). However, several researchers have shown muscle power correlates to a greater extent on physical performance when compared to muscle strength, suggesting that training speed may also be important, if not more important to the maintenance of physical functioning (Bassey et al., 1992; Bean et al., 2002; Skelton et al., 1994).

Training muscle power in older adults has been shown to be effective and safe. Sayers and colleagues conducted a pilot study on 12 healthy community dwelling older adults, with inclusion criteria involving a subjective complaint of limitation in mobility or function (3 men, 9 women, age = 74.6 ± 1.9 y) (Sayers, 2007). Participants were randomized into a strength training group, a velocity training group or a control group (Sayers, 2007). After 12 weeks on the assigned program, the exercising groups had each increased their absolute peak power production capabilities to a similar extent. However, both peak strength and peak velocity increased in the velocity trained group, whereas improvements in the strength trained group were only seen for peak strength. The groups also differed in their rates of perceived exertion, with the velocity group having average ratings of 12.6, while the strength group had average ratings of 15.4 (Sayers, 2007). This becomes important in exercise programs geared towards older adults and is especially true for adults with knee OA. Exercises that require less resistance but more speed may be perceived as more tolerable, yet lead to the same benefit. Lower rates of exertion help improve adherence rates, adding to the long-term benefit of exercise (Sayers, 2007).

The effectiveness of high speed power training at lower strength productions (~40% of 1 RM) has also been studied in a population of adults with knee OA (n=33, 67.6 ± 6.8y) (Sayers et al., 2012). The results from this study were similar to Sayers previous study, in that both the speed trained group and the strength trained group improved in overall peak power production at the knee joint. However, the velocity trained group alone made improvements in both strength and speed making it a more effective training method when compared to resistance training alone (Sayers et al., 2012). Unfortunately, the groups did not differ on the functional task outcomes (Berg Balance Scale, 400 m walk, and timed chair rise). If more challenging tasks requiring faster movements were tested, differences between groups may have been evident (Sayers et al., 2012). The timed stair ascent and timed stair descent tasks used within this thesis may have found these differences. The high speed training programs studied to date improve self-reported function and pain to a similar extent as strength training protocols, warranting further investigation of power protocols in the future (Sayers et al., 2012; Sayers, 2007).

Self-efficacy Beliefs

Self-management techniques are an effective strategy in the management of chronic conditions like knee OA (Chodosh et al., 2005). Among the techniques, self-efficacy training is an integral component to the success of many programs (Coleman et al., 2012). Promoting self-efficacy beliefs and teaching strategies for increasing these beliefs, has been shown to be a superior intervention strategy to education alone in a group of people with arthritis (Lorig & Holman, 1993). Enhancing one's self-efficacy can lead to long-term changes in health behaviours regarding exercise adherence, disease coping strategies and an overall improvement in quality of life (Coleman et al., 2012). As an example, a research group from Australia developed a program focusing on self-management techniques geared towards people with OA of the knee (OAK). A blinded, randomized trial (n=146, 65 ± 8 y) found that participants who completed the OAK program had improvements in self-reported pain and function scores, as well as short-term changes in their timed-up-and-go test, as well as demonstrated increases in hamstring strength (Coleman et al., 2012).

A systematic review assessing the effectiveness of self-efficacy training in the management of knee OA does not currently exist due to the lack of research, variability in the study methods used and small sample sizes used (Marks, 2001). Results from this thesis provide a rationale for further investigation of self-efficacy training, especially around the management of pain in people with knee OA. Self-efficacy beliefs for pain related strongly to the performance seen on a stair ascent and a stair descent task, a commonly encountered daily task. Pain management is extremely important in people with knee OA as they may be hesitant to participate in activities for fear of pain, fear of causing damage to the joint and/or progression of the condition. Enhancing self-efficacy beliefs surrounding one's ability to manage their pain and empowering them through education classes surrounding the benefits and safety of various exercise programs will help people better manage their knee OA.

5.5 Future Research Considerations

The improvements in physical performance that occur due to training are affected by the type of physical training chosen, but also by the participant's confidence in their abilities to carry out the specific aspects of the program (Rejeski et al., 1998). Self-efficacy predicts performance related disability over and above physiological capabilities in people with knee OA, independent of the pain experienced by the participant (Rejeski et al., 1996). Researchers need to examine both physical as well as psychosocial training in order to maximize the success of intervention programs aimed at people with progressive, chronic conditions such as knee OA. Research studies designed to explore power training, in conjunction with more established techniques that utilize self-efficacy beliefs are needed in the future.

The results from this thesis reinforce the importance of pain, control beliefs for pain and muscle properties as determinants of physical performance in adults with knee OA. Additional research needs to examine a broader range of physical tasks, in an older population as well as in a population of adults with more severe knee OA. The importance of muscle power and the protective nature of high self-efficacy beliefs may be more suited to longitudinal study designs which should be explored in the future.

5.6 Limitations

The sample demographics limit the generalizability of the current thesis. The sample was quite young (61.1 ± 6.2y), and demonstrated strong scores on the performance and capacity measures. An older sample, or a sample of people with more advanced knee OA, may produce different results. The stair ascent and stair descent task did not prove to be as challenging a task as was originally thought, and could explain why power was not more strongly correlated to stair performance. Choosing a more challenging power task such as jumping onto boxes or jumping onto a force plate, as previous power protocol have described (De Vito et al., 1998; Forte & Macaluso, 2008;

Larsen et al., 2009), was avoided in this study design due to the likelihood of participants experiencing joint pain. It is still felt that these tasks should be avoided within this participant population, however increasing the number of stairs climbed or increasing the number of stair climbing trials completed may have improved the results.

Chapter Six: Conclusion

Knee osteoarthritis (OA) is the number one cause of adult disability and presents a major challenge to the health care system. Understanding what factors are most directly related to physical performance in people with knee OA will help guide future intervention studies that will hopefully improve upon guidelines for the treatment and management of the condition. Knee extensor power is a novel physical factor that needs further exploration in the study of people with knee OA. Research continues to show strong relationships between self-efficacy beliefs and physical performance in people with knee OA, suggesting that more intervention studies focused on self-management strategies to improve physical function are warranted.

The present study was able to show the importance that both physical and psychological factors have on the physical performance of people with knee OA. The results highlight the need for further investigations surrounding muscle power in this patient population, as well as highlighted the known importance that self-efficacy beliefs have on one's physical performance.

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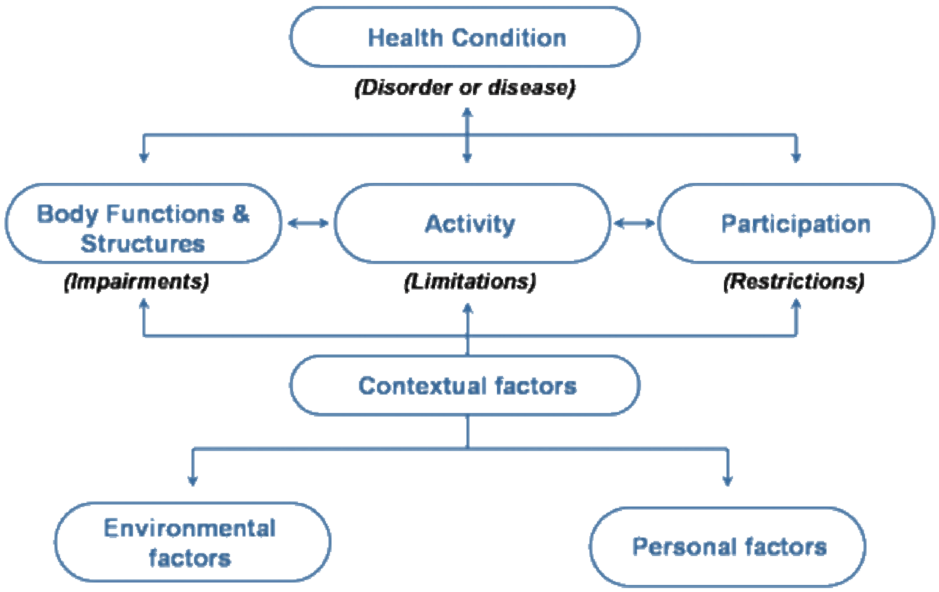
Appendix A: International Classification of Functioning, Disability and Health



http://www.rehab-scales.org/international-classification-of-functioning-disability-and-health.html

Appendix B: Participant Consent Form

Clinical Outcomes and Tissue Changes in Knee Osteoarthritis: A Novel Approach Using Cumulative Knee Load

Consent

I have read the Letter of Information, have had the nature of the study explained to me and I agree to participate. All questions have been answered to my satisfaction. I will receive a signed copy of this form.

Participant Name (please print)	Participant Signature	Date

I confirm that I have explained the nature and purpose of this study to the participant named above. I have answered all questions.

Person Obtaining Consent	Signature	Date

Principal Investigator	Signature	Date

Appendix C: Participant Inclusion and Exclusion Criteria Tracking Form

Participant Screening and Tracking

Inclusion Criteria (American College of Rheumatology Clinical Criteria):

Age between 45 and 70 years of age?	**Yes**	**No**
Knee pain on most days of the week?	**Yes**	**No**
Less than 30 minutes of morning stiffness?	**Yes**	**No**
Crepitus with active range of motion?	**Yes**	**No**
Bony enlargement?	**Yes**	**No**
Bony tenderness to palpation?	**Yes**	**No**
Signs of inflammation (warmth, swelling)?	**Yes**	**No**

Exclusion Criteria:

Any other forms of arthritis (rheumatoid, psoriatic)?	**Yes**	**No**
Knee surgery? Excluded: high tibial osteotomy, joint replacement, ligament repair Included: unrepaired lax ligament, arthroscopic debridement (or "clean up"), hyaluronic acid injections including "synvisc"	**Yes**	**No**
Do you use a cane or other helping aid to get around? Excluded: unable to ambulate 20' without an aid	**Yes**	**No**

Do you have an unstable heart condition? Excluded: physician-advised restrictions to physical activity	**Yes**	**No**
Have you injured your hip, knee, or ankle in the past three months? If so, which leg?: ___________________	**Yes**	**No**
Are you currently receiving cancer treatment?	**Yes**	**No**
Are you/could you be pregnant?	**Yes**	**No**

Notes:

Which knee will be studied (circle)? **LEFT** **RIGHT**

Identification:

Last Name		First Name	
Sex		Birthdate	
			(MM/DD/YYYY)

Phone Numbers	Home	
	Office	

Mobile	

Email		Alternate Email	

Home Address:

Mailing Address (if different from Home Address)

***Please put an asterisk beside preferred mode of communication**

Emergency Contact:

This person will be contacted in the unlikely event of an emergency

Name		
Relationship to You		
Phone Numbers	Home	
	Office	
	Mobile	

Email	

Alternate Contact:

This person will be contacted if we are unable to reach you by phone at your residence for two weeks.

Name		
Relationship to You		
Phone Numbers	Home	
	Office	
	Mobile	
Email		

Appendix D: Stair Ascent and Stair Descent Data Collection Form

Stair-Climbing

Standard 9 step stair case (with hand rail), digital stop watch, Numeric Pain Rating Scale

Stair Ascent

Instructions: "Climb the stairs as quickly as possible, without compromising your safety. You may use the hand rail. Do not run or jog. I will start timing as soon as your foot leaves the ground. I will stop timing as soon as both feet are planted on the top step. Ready…set…go."

1) Indicate the time needed to complete task is seconds

	Time (sec)	NPRS
Trial 1		
Trial 2		

2) Indicate the pattern of stepping with an 'X'

Alternating Steps	
Step Together	
Both alternating and step together	

3) Use of hand rail? YES ☐ NO ☐

Stair Descent

Instructions: "Descend the stairs as quickly as possible, without compromising your safety. You may use the hand rail. Do not run or jog. I will start timing as soon as your foot leaves the ground. I will stop timing as soon as both feet are planted on the ground. Ready…set…go."

1) Indicate the time needed to complete task is seconds

	Time (sec)	NPRS
Trial 1		
Trial 2		

2) Indicate the pattern of stepping with an 'X'

Alternating Steps	
Step Together	
Both alternating and step together	

3) Use of hand rail? YES ☐ NO ☐

Appendix E: Six Minute Walk Test Instructions and Data Collection Form

Six Minute Walk Test

Instructions

"The object of this test is to walk as far as possible for 6 minutes. You will walk in a circle in this hallway for 6 minutes. Six minutes is a long time to walk, so you will be exerting yourself. You will probably get out of breath or become exhausted. You are permitted to slow down, to stop, and to rest as necessary. You may lean against the wall while resting, but resume walking as soon as you are able."

"Remember that the object is to walk AS FAR AS POSSIBLE for 6 minutes, but don't run or jog. Start now, or whenever you are ready."

5 minute remaining: "You are doing well. You have 5 minutes to go."

4 minutes remaining: "Keep up the good work. You have 4 minutes to go."

3 minutes remaining: "You are doing well. You are halfway done."

2 minutes remaining: "Keep up the good work. You have only 2 minutes left."

1 minute remaining: "You are doing well. You have only 1 minute to go."

15 seconds remaining: "In a moment I'm going to tell you to stop. When I do, just stop right where you are."

**If the patient stops walking during the test and needs a rest, do not stop the timer.

Scoring

BORG score upon completing:	
Distance in METERS covered in 6 minutes:	

Appendix F: Knee Strength and Knee Power Data Collection Form

Strength Assessments

Participant's mass (lbs):	

Isometric & Isokinetic Peak Torque

Record peak torque values from the comprehensive report, using one decimal place:

	EXTENSOR Peak Torque	FLEXOR Peak Torque
Isometric		

Isotonic Power

Select resistance offered per trial:

	25% Peak Torque	50% Peak Torque	75% Peak Torque
Knee Extensors			
Knee Flexors			

Record peak power values from the comprehensive report, using one decimal place:

	EXTENSOR Peak Power	FLEXOR Peak Power
Isotonic		

Appendix G: Arthritis Self-Efficacy Scale

Arthritis Self-Efficacy Scale

In the following questions, we'd like to know how your arthritis pain affects you. For each of the following questions, please mark an "X" on the line which corresponds to your certainty that you can now perform the following tasks.

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

Very Moderately Very Certain

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

Very Moderately Very Certain

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

Very Moderately Very Certain

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

Very Moderately 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 Moderately Very Certain

We would like to know how confident you are in performing certain daily activities. For each of the following questions, please circle mark an "X" on the line which corresponds to your certainty that you can perform the tasks as of now, without assistive devices or help from another person. Please consider what you routinely can do, not what would require a single extraordinary effort.

AS OF NOW, HOW CERTAIN ARE YOU THAT YOU CAN:

1. Walk 100 feet on flat ground in 20 seconds?

Very Moderately Very Certain

2. Walk 10 steps downstairs in 7 seconds?

Very Moderately Very Certain

3. Get out of an armless chair quickly, without using your hands for support?

Very Moderately Very Certain

4. Button and unbutton 3 medium sized buttons in a row in 12 seconds?

Very Moderately Very Certain

5. Cut 2 bite-sized pieces of meat with a knife and fork in 8 seconds?

Very Moderately Very Certain

6. Turn an outdoor faucet all the way on and all the way off?

Very Moderately Very Certain

7. Scratch you upper back with both your right and left hands?

Very Moderately Very Certain

8. Get in and out of the passenger side of a car without assistance from another person and without physical aids?

Very Moderately Very Certain

9. Put on a long-sleeve front-opening shirt or blouse (without buttoning) in 8 seconds?

Very Moderately Very Certain

In the following questions, we'd like to know how you feel about your ability to control your arthritis. For each of the following questions, please mark an "X" on the line which corresponds to the certainty that you can now perform the following activities or tasks.

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

Very Moderately Very Certain

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

Very Moderately Very Certain

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

Very Moderately Very 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 Moderately Very Certain

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

Very	Moderately	Very Certain

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

Very	Moderately	Very Certain