University of Alberta

Factors influencing the physical activity level in a population with arthritis

By

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Abstract

Physical activity is recommended in the management of arthritis. This thesis utilized the CCHS 2007-2008 to 1) determine what factors modify physical activity in explaining the likelihood of having arthritis; and 2) what demographic, behavioural and medical factors influence physical activity among people with arthritis. Light activity respondents were more likely to have arthritis (OR = 1.11; 95% CI: 1.03, 1.21) than sedentary respondents and the magnitude and direction of this relationship varied across gender and age groups. Obesity (body mass index > 30.0 kg/m^2), high blood pressure (>/90mmHg, diastolic) and heart disease (ORs > 1.46) were associated with having arthritis. Among individuals with arthritis obesity or high blood pressure and smoking were associated with lower levels of activity. This study shows that individuals with arthritis are participating in light activity. Clinical management strategies for physical activity in arthritis should consider management of obesity, high blood pressure and heart disease.

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List of Abbreviations:

BRFSS – Behavioral Risk Factor Surveillance Survey

BMI – Body Mass Index

CCHS – Canadian Community Health Survey

CI – Confidence Interval

COPD – Chronic Obstructive Pulmonary Disease

DMARD – Disease Modifying Antirheumatic Drug

HBP – High Blood Pressure

HD – Heart Disease

NPHS – National Population Health Survey

NSAID – Non-Steroidal Anti-Inflammatory Drugs

NHIS – National Health Interview Survey

MET – Metabolic Equivalent of Task

OA – Osteoarthritis

OR – Odds Ratio

PA – Physical Activity

RA – Rheumatoid Arthritis

Chapter 1: Introduction

1.1 Overview

Arthritis is a public health concern because it is a leading cause of long-term disability in Canada.(1) It is widely accepted that physical activity is recommend for people with arthritis,(2,3) but despite the clinical benefits, people who have arthritis do not engage in the recommended levels of activity (30 minutes of cumulative moderate activity, five days a week).(4,5) Understanding the influential facets of physical activity, in relation to arthritis, has the potential to help identify key barriers to an active lifestyle and assist in the management of the disease. Using the Canadian Community Health Survey (CCHS) 2007-2008, the effect of physical activity on arthritis was investigated.

1.2 Statement of the Problem

Although etymologically defined as an inflammatory joint disease, arthritis is in itself a term that encompasses over one hundred different conditions and diseases, not all of which may be linked to systemic problems.(6) The most common forms of arthritis are osteoarthritis (OA) and rheumatoid arthritis (RA).(7) Manifestation of OA may result in severe pain, joint stiffness and possible joint deformities that may hinder everyday tasks.(8-11) Being able to participate in daily activities can be extremely challenging for individuals with arthritis, as stiffness and pain may deter performing functional activities.(12)

An active lifestyle is recommended by health professionals and exercise physiologists because it provides substantial health benefits (13-15), including primary and secondary prevention of chronic disease.(14,16) An active lifestyle promotes muscle strength and improves joint stability and function.(16) The Canadian Society for Exercise Physiology Society has published recommendations for physical activity, which are a minimum of 30 minutes (cumulative) of moderate activity, five days a week, which is consistent for all adults.(17,18) Despite documented health benefits, a high prevalence of physical inactivity is reported in the general population. Specifically, roughly 75% of the adult Canadians are not meeting minimal physical activity standards to achieve a healthy lifestyle.(19)

Although several American-based studies support a relationship between PA and arthritis (4,14,20-24)**,** few large population based studies have been conducted from a Canadian perspective. Therefore, there is a need to add to the growing body of literature surrounding physical activity and arthritis among the Canadian population.

1.3 Objectives

This thesis will examine the relationship between physical activity and arthritis using a Canadian national health survey, the Canadian Community Health Survey (CCHS). The CCHS will be used to identify the factors that influence the relationship between physical activity and arthritis. To fully understand this association of physical activity and arthritis, we will then identify behavioral and health factors that explain physical activity participation among persons with arthritis. For the purpose of this study, the most common forms of arthritis, OA and RA, will be studied.

The **primary objective** of this study is to determine demographic, behavioral and health factors that may explain the association between physical activity and arthritis in the Canadian general population.

The **secondary objective** is to determine what factors explain the amount of physical activity among Canadian respondents who report having with arthritis.

Research Questions:

a) What demographic, behavioural and health factors modify physical activity in explaining the likelihood of having arthritis?

b) What demographic, behavioural and health factors explain the amount of physical activity in people with arthritis?

1.4 Significance

Because over 4.6 million Canadians have arthritis (6)**,** and physical activity is an essential component of maintaining a healthy lifestyle (25), it is critical to understand what factors influence the relationship between physical activity and arthritis. Findings will provide useful information for clinicians in their effort to guide patients through the management of arthritis. As well, from a public health perspective, this study will help health promotion strategies in their continued effort to promote physical activity among individuals with arthritis.

Chapter 2: Literature Review

The following review will discuss clinical and epidemiological factors of OA and RA. Existing literature of PA in both the general population and people with arthritis will be examined. Although OA does affect the hands and spine, for purposes of this study, this review will focus only on weight-bearing joints, as PA typically involves the weight-bearing joints, the hip and knee.(26)

2.1 Joint Anatomy

A joint consists of bones, a joint capsule, articular cartilage and a synovial membrane (Figure 1-1). The joint is surrounded by a protective capsule that provides structural support, and is lined with the synovial membrane. This membrane secretes synovial fluid, a nutrient rich solution that nourishes cartilage in addition to lubricating and removing waste within the joint.(27) Encapsulated and nourished by the synovial membrane, articular cartilage is the flexible tissue that covers the end of each bone that forms the joint. This living tissue provides cushioning between the bones during impact and is further supported by the muscles and ligaments surrounding the joint.(27)

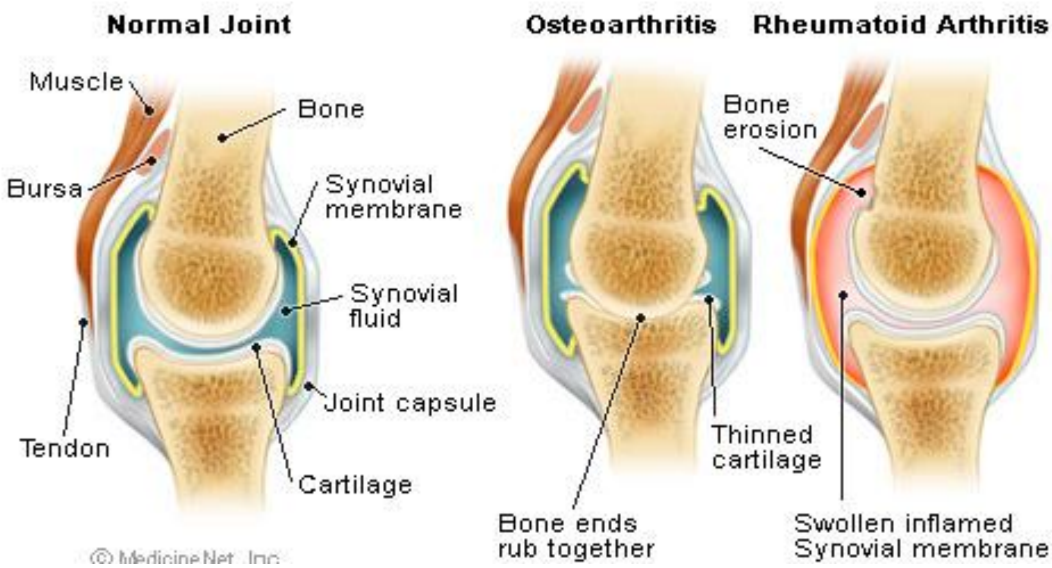

Figure 1-1: Anatomy of a knee joint with and without arthritis. Joint consists of a joint capsule, cartilage and a synovial membrane with synovial fluid.

SOURCE:MedicineNet.com
http://www.medicinenet.com/script/main/art.asp?articlekey=159457

2.2 Arthritis

Arthritis is a general term used to describe over one-hundred different diseases and disorders, contributing to a burden that accounts for the second and third most common chronic disease in women and men respectively.(10) According to Statistics Canada, in 2010 the number of individuals fifteen years or older who reported having arthritis as diagnosed by a health professional was an estimated 4.5 million or 16.1% of Canadians.(28) However, projections estimate the prevalence to rise to 21% by the year 2021(29), with the largest increase occurring in the age range of 55-64 years.(10) The prevalence of arthritis is of particular concern for older Canadians because the prevalence of physician-diagnosed arthritis accounted for over half of the population over 65 years.(29) It is not certain as to the exact cause in the increase of arthritis, although the increase likely is associated with an increase in OA.(29)

2.2.1 Osteoarthritis

Osteoarthritis, or degenerative arthritis, is considered to be the most common form of arthritis (27,30-34) and leading cause of disability in people 65 years of age or older.(30,35,36) Based on self-report, the prevalence of OA in 2005 was 13.9% in the USA (37) and 13.0% in Canada (2010).(38) Estimations indicate that the prevalence of OA for Canadian adults will continue to rise by nearly 26% by 2040 and for those who are over 70 years of age, the prevalence will reach 71%.(38)

Osteoarthritis is typically manifested in the joints of the hands, knees and hips and feet.(39,40) The primary symptoms are joint pain, stiffness, swelling, and accompanied muscle weakness and decreased physical function.(34) There are two types of OA, classified by the etiology: primary and secondary OA. Primary OA is the result of no underlying cause, but is associated with genetics and older age.(41) Secondary OA is the result of an injury, repetitive motion or cormorbid diseases.(42) The American College of Rheumatology has criteria for the classification of the hip and knee (consisting of a combined clinical and radiographic classification), commonly used in research.(43,44)

Physiologically, OA is the weakening of the structural and functional integrity of synovial joints, such as the joints in the knee, hip and hands.(34) OA is the degeneration of the joint due to loss of cartilage (27) in addition to alterations in subchondral bone and the formation of osteophytes.(34) When carrying a load, a normal joint distributes the weight evenly across the joint during movement; however, when there is a loss of cartilage or possible injury to the muscles or ligaments, the weight cannot be distributed evenly. This uneven weight distribution results in misalignment, further exacerbating the degradation process.(20)

Symptomatic OA most often includes a slow onset of pain in the synovial joints, which may be worsen with high intensity activities and may be reduced with rest.(27) Additionally, joint swelling and morning joint stiffness lasting at least 15 minutes are also common signs of OA,(6) and in rare cases, severe OA can present joint deformation, as well as ligament laxity.(45) Other signs, most often identified radiographically, include the presence of osteophytes, narrowing the space between the joints and the presence of subchondral and sclerosis cysts.(45)

2.2.1.1 Risk Factors of Osteoarthritis

Risk factors for developing OA have been identified in large longitudinal studies.(46,47) Older age, females, obesity and joint injury are among the well-known risk factors and will be discussed in further detail.

Age:

Evidence from epidemiological studies identifies older age as a factor for having OA.(47,48) Although a non-modifiable risk factor of arthritis, it is important to understand that OA is not necessarily a consequence of aging.(49) Aging of the musculoskeletal system, through events such as degeneration of the meniscus and bone degradation can increase the susceptibility of developing OA by means of other direct consequences, such as injury.(49)

A cross-sectional population survey that examined increasing prevalence of arthritis with increasing age, found that the highest prevalence of OA (59.3%) was from respondents who were 75 years of age or older.(48) When compared to respondents who were younger than 45 years of age, those who were over 75 years old had an odds ratio (OR) of 11.7 (95% CI: 8.1, 16.8) for the likelihood of having arthritis.(48) Although this study does provide evidence of an association between age and arthritis, it compares a very wide range of ages. Between the ages of 40 years and 70 years, many physiological changes may occur and therefore comparing these groups based on age alone may not be appropriate.

The Framingham Osteoarthritis Study, which reported several risk factors for OA among an elderly cohort, found that the prevalence of OA increased from 27.4%, for those less than 70 years, to 43.7%, for those over 80 years, with the greatest increase in prevalence occurring between the ages of 70-79 years to over

80 years of age (34.1%).(47) Findings from this cohort suggest that aging contributes to a higher likelihood of having arthritis.

Gender:

Women are more likely to have osteoarthritis.(50-52) A meta-analysis that investigated the incidence and prevalence of OA found that when compared to females, males had a lower Risk Ratio (RR) of having knee OA (RR = 0.63; 95% CI: 0.53, 0.75) and hand OA (RR = 0.81; 95% CI: 0.73, 0.90). When compared to females, males also had a lower risk of developing knee OA (Incidence RR = 0.55; 95% CI: 0.32, 0.94) and hip OA (IRR = 0.64; 95% CI: 0.48, 0.86).(53) Felson et al., using the Framingham Study cohort in a longitudinal design, identified that women were 1.8 times more likely to develop knee OA than men (95% CI: 1.1, 3.1)(46) A potential reason for the difference in likelihood was explained by an Australian prospective cohort study where after a 2.3-year follow up, researchers determined that women had a higher annual loss of cartilage (1.6%) than men (0.4%), which was likely due to hormonal factors.(50) A cross-sectional study looking at 7,500 respondents in Melbourne Australia showed that after adjusting for age, women had an OR of 1.5 (95% CI: 1.2, 1.8) compared to men for having OA.(48)

Obesity:

Obesity is another risk factor for developing degenerative arthritis.(38,54) A systematic review that examined obesity as a risk factor for OA of the hip or knee found 10 studies that used BMI as risk factor. Their findings supported a positive relationship between BMI and OA as individuals who were overweight or obese were at an increased risk of having OA of the hip or knee (OR between 1.6 to 15.4). The majority of the study designs that were included in this systematic review were cross-sectional.(55) Another systematic review that examined the odds of obesity for developing hip OA found similar results to Richmond et al. as investigators determined that being overweight or obese was associated with an OR $\geq$ 1.25 for developing hip OA. Investigators also found 3 studies that showed a dose-response relationship between increasing levels of obesity (BMI > 25 kg/m^2 and BMI >27 kg/m^2) and hip OA, suggesting that increasing weight was associated with increase in the likelihood of having OA.(56) A population based cross-sectional survey of 7,500 Australians found a significant relationship between self-reported obesity and the likelihood of having OA.(48) In this study, the univariate analysis showed that next to age, the largest determinant for having OA was obesity (OR = 1.9; 95% CI: 1.5,2.4). After adjusting for sex, age, area of residence, education level occupation group and income, odds ratio indicated that individuals who were obese (BMI>30 kg/m^2) were twice as likely to have OA than respondents who were of normal weight (OR =2.0; 93% CI: 1.6,2.6). Felson and Zhang explained that excess weight puts greater force onto weight-bearing joints, such as the knees and hip. This excess force, which can sometimes be approximately 2-3 times the body weight, can result in cartilage breakdown within the joint.(57)

It is difficult to determine from cross-sectional studies the direction of the association between BMI and arthritis. Cross-sectional designs are unable to conclusively determine whether arthritis is a result of excess weight due to obesity or if obesity is the result of inactivity due to pain and disability from arthritis. In the Framingham Study, subjects without arthritis were followed over ten years and a strong association was seen, as weight loss was associated with a reduced likelihood of developing symptomatic knee OA (OR =0.46; 95% CI: 0.24, 0.86 per 5-pound decrease).(20) A reduction in 2 or more BMI units resulted in nearly a 50% reduction in the odds of having symptomatic knee OA 10 years later.(20) This longitudinal design suggests that excess weight leads to higher likelihood of arthritis. Further support is seen in a meta-analysis of four randomized controlled trials found that pain (Pooled Effect Size = 0.20; 95% CI: 0.00, 0.39) and self-reported disability (Pooled Effect Size = 0.23; 95% CI: 0.04, 0.42) were reduced with a 5-6 kg loss in weight.(58) Although the effect sizes were considered small, they were still clinically significant.(58) Estimates indicate that if obesity rates decrease by 50% in Canada over the next ten years, 45,000 incident cases of OA could be avoided.(38)

Injury

Evidence from large-population studies have shown that acute joint damage is a risk factor for arthritis.(59-62) Typically, osteoarthritis results from injuries due excessive movements, causing degeneration of anatomical structures around the joint, in particular meniscus and anterior cruciate ligament tears.(63) A meta-analysis of 85 cohort and case-control studies found previous knee injury as a major risk factor (pooled OR=3.86; 95% CI: 2.6, 5.7) in the development of OA which was stronger than the effect seen with obesity.(64) A 14-year prospective cohort study that followed 1,436 adults 40 years of age or older, determined that individuals with a self-reported history of acute knee injury were more likely to develop OA than individuals who did not report injury (RR =7.4; 95% CI: 5.9, 9.4).

2.2.1.2 Treatment of osteoarthritis

OA can be treated with both pharmacological and non-pharmacological management strategies. Pharmaceutical management strategies that target specific biochemical receptors within the body, such as NSAIDs (Non-Steroidal Inflammatory Drugs), are commonly used to alleviate to allow a person to do activities.(65) However, excessive use of drug therapy can result in other health concerns, such as gastrointestinal and cardiovascular effects.(65,66) Exercise has been well documented to improve muscle strength, reduce pain and improve physical function among individuals with OA.(67-70) When conservative management has been exhausted, patients with moderate to advanced OA often undergo a total joint replacement, significantly improving quality of life.(71,72)

Over the past decade, several professional societies, such as the American College of Rheumatology (ACR), the European League Against Rheumatology (EULAR) and the Osteoarthritis Research Society International (OARSI), have published clinical recommendations to guide the management of knee and hip OA.(73-75) All three organization developed their recommendations through an expert panel consensus agreement process following an extensive review of literature. However, relative to the recent guidelines of EULAR and OARSI, the 2012 ACR guidelines for non-pharmacologic and pharmacologic therapy recommendations for the treatment of OA of the hip and knee included the broadest expert panel (ACR included physiatrists and geriatricians in the expert panel).(75) The 2012 ACR guidelines report that for both knee and hip OA, patients should use oral NSAIDs, acetaminophen, tramadol and intraarticular corticosteroid injections. The use of oral NSAIDs was recommended only for patients with knee OA as insufficient information was available to make the same recommendations for hip OA. Furthermore, patients with knee and hip OA were recommended not to take nutritional supplements, such as chondrolitin sulfate or glucosamine. As a non-pharmacological treatment option, the expert panel strongly recommends that patients with knee or hip OA engage in an exercise program that progresses to the addition of a strengthening program. The expert panel also recommends that patients with knee or hip OA who are overweight seek weight loss management. Other non-pharmacological recommendations include the use of a walking-aide when necessary.(75) These guidelines for exercise support the systematic reviews completed by the Ottawa Panel.

In addition, it is important to understand that the purpose of including the ACR guidelines in this review is to provide a brief understanding of the scope of both pharmacological and non-pharmacological recommendations. The guidelines provided by ACR, EULAR and OARSI contain several clinical caveats that are based on patient comorbidities, such as kidney disease, cardiovascular conditions or gastro-intestinal disorders.(75)

As explained above, OA is the most common form of arthritis and has a number of factors that are associated with the disease. In the next section, we will describe the literature surrounding another type of arthritis, rheumatoid arthritis.

2.2.2 Rheumatoid Arthritis

Although RA is not as prevalent as OA, (10,76) 1%, or almost 350,000 Canadians and an estimated 1.3 million American adults have RA.(77) Rheumatoid arthritis is a systematic autoimmune disease that initially targets the small joints in the hands and feet.(10) Although the etiology of RA is not well understood, it is typically characterized by synovial inflammation and swelling, cartilage and bone degradation, as well as systemic problems that affect the heart (78), lungs (79), kidneys (80) and blood.(81) The degradation of bones occurs as the immune system instructs the synovial membrane to overproduce cytokines, such as tumor necrosis factor (TNF). These cytokines create inflammation in the synovium and promote osteoclast differentiation, which erode bones within the joint.(82)

As seen with OA, destruction of bones and inflammation within the joint, swelling, pain, morning stiffness and joint deformities are common symptoms of RA.(10,76,83,84) However, RA differs from OA in that the joint pain tends to be symmetrical, morning stiffness last longer than 60 minutes, as well, fatigue and an associated fever may also occur.(76)

Clinical goals for treating RA is to bring the disease into remission through aggressive treatment during the early phase of the disease. This is in effort to help avoid permanent joint damage, and maintain physical function and quality of life.(85) Conventional treatment of RA using drugs consists Disease-Modifying Anti-rheumatic Drugs (DMARDs) and biologics. While analgesic and anti-inflammatory medications help individuals with acute symptoms, DMARDs and biologics are used for the long-term treatment of RA. The emergence of biologics for RA is effective in treating patients who are non-responsive to DMARDs. Biologics target inflammatory cells and reduce the progression of RA, improve physical function, as well as quality of life.(86) The 2012 ACR Recommendations suggest that early RA should be treated with DMARD monotherapy for all levels of disease activity if the prognosis is not poor. However, if the prognosis is poor, the recommendation is to treat RA with DMARD double and triple therapy in addition to anti-TNF biologics.

Despite advances in treatment and management strategies, evidence suggests that individuals with RA have a higher mortality rate than the general population.(87) A cross sectional study of 1042 patients with RA found a higher standard mortality ratio (SMR) relative to the general population (SMR = 2.64 and 1.71, respectively).(88) Literature indicates that 40% to as much as 50% of deaths among individuals with RA are due to cardiovascular conditions.(87,89,90)

2.2.2.1 Risk Factors of Rheumatoid Arthritis

Gender:

Women are found to have a higher incidence of RA than men, with incidence per 100,000 of 65.7 compared to 28.1, respectively.(91) An American study of 521 subjects were followed for a period of 25 years and determined that the incidence RA among women (65.7/100,000) was significantly higher than the incidence of men (28.1/100,000).(91) Furthermore, a systematic review of 19 observational studies that examined the prevalence of RA, based on the 1987 ACR criteria, for males was between 0.9 per 1000 to 7.4 per 1000, while females had a higher prevalence range of 2.9 per 1000 to 13.7 per 1000.(92) In a narrative review of gender differences in the susceptibility of having RA, the incidence of RA is higher among women relative to men in the years prior to menopause. Following menopause, the incidence of RA is similar among men and women, suggesting that hormonal differences play a role in the incidence of RA.(93,94)

Genetics:

There is strong evidence to suggest genetics is a risk factor for RA. Studies have indicated that lineage of family members with RA does pose a moderate risk of developing the disease; however, this risk is less than the genetic risk associated with type I diabetes or systemic lupus.(95) RA and human leukocyte antigen are closely associated with one another and studies have proven that alleles that are linked with RA have related amino-acid sequences called a "shared epitope". Homozygous for the shared epitope puts individuals at an increased risk of RA.(96) In a British twin study that examined the heritability of RA among 148 twin pairs, investigators found that the probability of having RA was 66% if one twin had RA.(97) In addition to the British study, a similar study of over 13,000 twins found the probability of RA among twins to be 65%.(98) Furthermore, research suggests that a strong genetic and environmental risk of RA exists for Aboriginal people as a 2005 review provides evidence that the alleles present in RA were common among community members. This suggests that RA within the Aboriginal community was partly due to common RA alleles being passed down through family members.(99)

Smoking:

Currently, smoking is considered the only confirmed environmental risk factor for RA.(96) A meta-analysis of 16 observational studies that focused on the impact of smoking on RA determined that current smokers had a higher odds ratio, particularly for males (OR=1.87; 95% CI: 1.49, 2.34) than non-smokers (females had an OR = 1.29; 95% CI: 0.94, 1.77).(100) The meta-analysis also included studies that focused on heavy smoking (20 or more pack-years of smoking) and determined that heavy male smokers were 2.31 times (95% CI: 1.55, 3.41) more likely of having RA than male non-smokers (heavy female smokers had an OR = 1.75; 95% CI: 1.52, 2.02) A prospective cohort study that looked the risk of RA due to smoking among 103,818 women between 1976 and 2002 determined that the risk of RA due to smoking had a latency period of 20 years. In other words, elevated risk of RA remained higher for individuals who quit smoking until 20 years following cessation.(101) Evidence suggests that the attributable risk of smoking for RA was as high as 25% (102); therefore, if smoking was eliminated from the general population, the disease burden of RA would be reduced by 25%.

2.3 Physical Activity

According to the World Health Organization, physical inactivity is the fourth leading attributable cause of global mortality.(103) The health benefits of physical activity are well documented in the literature in the primary and secondary prevention of numerous chronic diseases such as cardiovascular disease, cancer, high blood pressure, type 2 diabetes, and musculoskeletal diseases.(2,13) physical activity is often used synonymously with physical fitness in literature; however, they are two distinct entities. Physical activity refers to the movement of muscles with the purpose of engaging in an action, whereas physical fitness is the physiological state that the individual is in; whether they are capable of certain physical activities.(17)

Physical activity is the process of expending energy exceeding a pre-defined resting level by any movement of skeletal muscles. The total energy expenditure (TEE) is the amount of energy that the human body uses throughout the day and is composed of five components: basal metabolic rate; thermal effect of digesting food; body development (growth in children); pregnancy and lactation; and physical activity. Of these five components, physical activity is regarded to be the source of energy expenditure that can most easily be altered by behavior.(104)

To measure the energy expenditure of a specific physical activity, metabolic equivalent of task (MET) is a universal measure. A MET is defined as a ratio of the activity metabolic rate to the resting metabolic rate (RMR) (105,106) and is commonly used to assess the energy expenditure of a physical activity by measuring the amount of oxygen the body consumes. RMR is the amount of calories burned at rest and is equivalent to 1.0 MET. A MET is 1.0 kcal/kg/hour METs, and can range from 0.9 METs during sleep to 18 METs when an individual is running at 10.9mph.(106) Despite conventional use, the MET is not without limitations. The MET is the derivation of the VO_2 max (maximum level of oxygen uptake) of a 40 year old, 70-kg man at, a value of 3.5 ml 0_2/kg/min at rest (105); however the agreement over this value is not consistent,(107) since VO_2 is affected by age, gender and fitness.

A review of the use of the MET, done by Byrne et al. questions the generalizability of using the Resting Metabolic Rate (RMR) value (1.0kcal/kg/hour) in a population with variability.(105) Ainworth et. al supports this claim as investigators measured the RMR of 642 women and 127 men. They determined that the RMR varied significantly across age groups after adjusting for BMI. Individuals who were 60-75 years of age had a lower RMR (on average 2.3 0_2/kg/min) than those who were under 20 years of age (on average, 2.6 0_2/kg/min). Investigators suggest that the use of MET as a "one size fits all" fails to incorporate the variability of individuals, which may change the amount of energy they expend. They propose that a correction factor be developed for the accurate use of MET in identification and prescription of physical activity.(106)In light of these findings, the use of a correction factor to adjust for the age-related factors when categorizing the MET values is warranted.

A commonly used method of assessing of PA is to measure leisure time PA. Leisure time PA is the amount of activity that an individual engages outside the house or work environment. Such activities include running, jogging, biking and sports. This is the focus of health research as it is typically regarded as a factor that can be best modified at the discretion of the individual, whereas activity in the house or work are more or less constant.(108)

A systematic review of Canadian physical activity by Warburton and colleagues reaffirmed the current theory of a dose-response relationship between physical activity and the risk of chronic disease.(109) The review of the literature revealed a consensus of a curvilinear dose-response relationship where an increase in physical activity for individuals who were inactive led to the greatest reduction in relative risk of chronic diseases.(109)

According to the current Canadian Physical Activity Guidelines, adults 18 years and older (including individuals 65+ years) must accumulate a minimum of 150 minutes of moderate-to-vigorous-intensity physical activity (i.e. brisk walking to cross-country skiing) in blocks of 10 minutes 5-7 days per week to obtain health benefits.(2) This recommendation aligns with the World Health Organization guidelines (103) as well as the United States Surgeon General Report on physical activity.(13) Despite worldwide consensus on the health benefits of physical activity, a retrospective cohort study conducted between 2007 and 2009 showed that nearly 70% of an individual's waking hours were spent in sedentary activity and only 15.4% of Canadian adults obtained the recommended weekly physical activity.(19) These findings were based on direct measurement of physical activity using an accelerometer, and provide the most current evidence of physical activity using primary data collection for 2,832 respondents.(19) However, the Canadian Fitness and Lifestyle Research Institute (CFLRI) 2008 Physical Activity Monitor shows that a much higher proportion (48.0%) of Canadians are reaching recommended levels of physical activity.(110) Differences in findings may be due to the fact that the CFLRI uses the CCHS, an indirect measure, to assess leisure time physical activity, whereas the study done by Colley is a direct measure (accelerometer) of physical activity.

Due to high numbers of insufficient activity, as well as evidence of the health benefits of physical activity, the Federal Government of Canada, through Advisory Committee on Population Health and Health Security prepared The Integrated Pan-Canadian Healthy Living Strategy in 2005. One of the goals of this strategy is to increase the proportion of Canadians who participate in recommended levels of physical activity by 20%.(111)

2.3.1 Framework for explaining complexity of physical activity

Physical activity is a complex behavior that is influenced by multiple correlates.(112,113) Figure 2-2, outlines the conceptual framework for physical activity developed by Pettee et al.(113) This framework emphasizes that physical activity is a complex behavior, influenced by several correlates that ultimately provide either health enhancing or health compromising results. Pettee et al. suggest that while previous physical activity frameworks have been established, their proposed framework identifies a direct relationship between physical activity and the results of physical activity (i.e. physiological responses and associated changes in comorbidities, such as arthritis). Therefore, this framework was used to guide the analysis in this study.

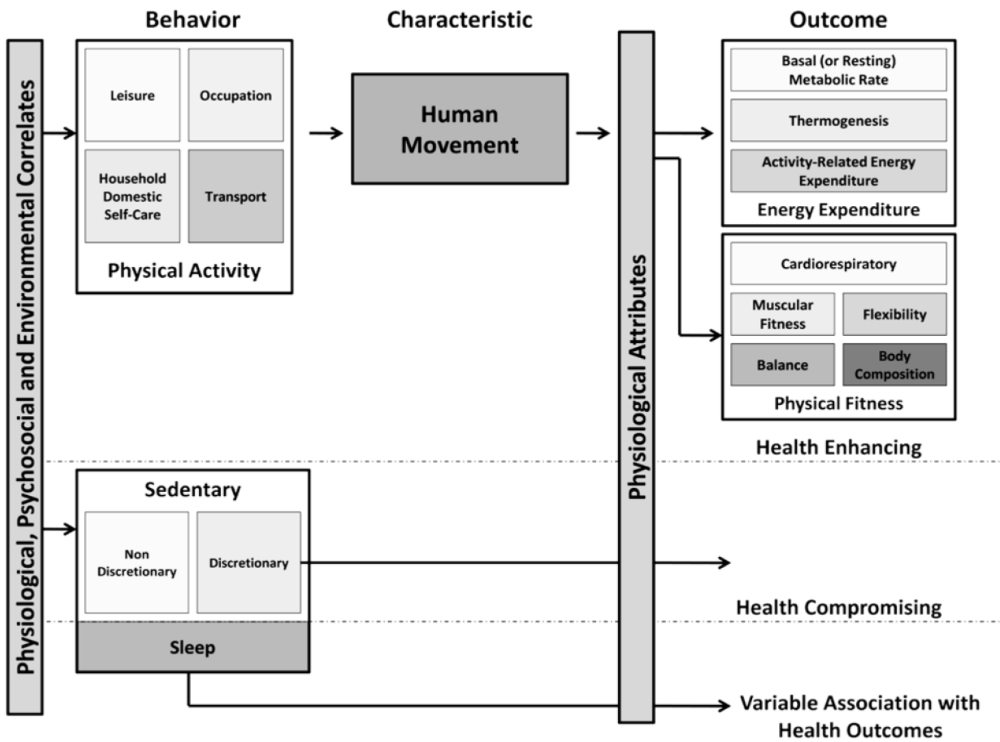

Figure 2-2: Framework explaining the relationship between physical activity and arthritis. Physical activity is a complex behavior that is influenced by several factors. Sourced from: Pettee Gabriel, K.K. et al. 2012, Framework for Physical Activity as a Complex and Multidimensional Behavior.(113)

2.3.2 Physical Activity: Measurement advantages and limitations

A number of approaches have been used to measure physical activity (or activity limitations). The most commonly used measures are direct measures (e.g. pedometers) and indirect measures (e.g. questionnaires). Direct measures, such as motion devices (e.g. pedometer, accelerometer), can provide excellent data related to physical activity and energy expenditure accounting for the daily lifestyle of the subject. However, when attempting to conduct large sample or population studies, the feasibility of motion sensors from a practical and cost standpoint bring challenges. Indirect measures, such as questionnaires, differ from direct measures, as they are easier to conduct on larger samples, less costly, and do not burden the normal lifestyle of subjects. Despite the benefits, indirect measures are dependent on self-report data and are subject to recall bias.(114)

It is important to discuss the level of agreement between self-report and direct methods when measuring physical activity. As noted above, utilizing questionnaires rather than direct methods can substantially offset the cost of the study. A systematic review of direct versus self-report measures for physical activity, there is modest agreement between the types of measures.(115) Some studies have shown that compared to direct measures, self report overestimates activity levels, while other studies have shown that self-report measures underestimate the level of activity.(115) Investigators recommend that future studies that use self-report measures, utilize the Compendium of Physical Activities to ensure that reported activities are standardized.(115)

2.4 Physical Activity and Arthritis

Given the importance of physical activity in the management of chronic disease, it is important to understand it in the perspective of arthritis. Meeting the recommended levels of physical activity of 150 minutes of moderate to vigorous activity per week, improve health outcomes, particularly for those living with arthritis, such as cardiovascular fitness and musculoskeletal health.(25,116) Evidence suggests that common symptoms of arthritis, including joint stiffness, pain, and fatigue are alleviated with recommended levels of physical activity.(117) In particular, physical activity has been shown to provide primary and secondary protection against cardiovascular disease, a prominent cause of death among individuals with RA, as well as promote joint and musculoskeletal health.(117) There exists a misunderstanding that all physical activity poses a risk of further exacerbation of injury or disease; however, proper exercise and adherence to recommendations is advised by a number of organizations, including The Arthritis Society (118), American Academy of Orthopaedic Surgeons(119), American College of Rheumatology(120) , and the Centre for Disease Control and Prevention.(121)

Several studies have shown that among individuals who have arthritis, a lower proportion do not reach recommended levels when compared to individuals who do not have arthritis.(4,14,21) In a cross-sectional study using a large American national database, Fontaine et. al studied whether adults with arthritis were obtaining the necessary levels of physical activity, as per the US Surgeon General report on Physical Activity and Health.(4) Among the 2001 U.S.A. population with arthritis, 61.8% were not attaining the recommended levels of physical activity and of these, 23.8% were classified as sedentary.(4) Hootman et.al observed similar findings using three national American surveys (National Health and Nutritional Examination Survey, National Health Interview Survey and Behvaioural Risk Factor Surveillance Survey) where 75.7% of the people with arthritis were inactive or insufficiently active. Of the individuals with arthritis who were reaching recommended levels of physical activity (29.3%), the majority (13.7%) were doing so through moderate intensity activity, as opposed to moderate-vigorous or vigorous activity.(14) When comparing to people without arthritis, the studies of Fontaine et. al (4) and Hootman et. al(14) elucidate that a higher percentage of respondents with arthritis are physically inactive or insufficiently active and a lower proportion reach recommended levels when compared to respondents without arthritis. Both studies did not adjust for the effect of age and therefore were subject to overestimating the proportional difference of respondents with arthritis who were physical inactive or insufficiently active with respondents who did not have arthritis. Furthermore, the severity of arthritis and intensity of physical activity were not examined.

Moreover, limited evidence explains the lower levels of physical activity among people who have arthritis. One such a study, based on the American National Behavioral Risk Factor Surveillance Survey (BRFSS), used a multivariate logistic regression where recent physical activity was the outcome. Investigators reported that men (OR = 1.29; 95% CI: 1.18, 1.41), higher education (OR = 2.38; 95% CI: 2.45, 3.26), or attended an arthritis education course (OR = 1.29; 95% CI: 1.14, 1.46) and advised by a physician to exercise (OR = 1.54; 95% CI: 1.41, 1.68) were associated with being physically active in people with arthritis.(23) Physical activity was treated as a dichotomous variable (yes/no) and did not adjust for the age related changes that occur with exercise.(23) Although this study provides a basic understanding of influential factors of physical activity among arthritis respondents, it is unclear as to the amount of physical activity associated with these factors.

Comparable findings were also seen in a Statistics Canada National Population Health Survey (NPHS 1996-1997), that investigated factors associated with physical inactivity among respondents who had arthritis (122); however, this study was exclusive to respondents who were 65 years or older and not generalizable to younger age groups. This study showed that factors associated with a higher likelihood of being physically inactive were being 75 years of age or older (OR = 2.90; 95% CI: 2.57, 3.27), having joint pain (OR = 2.00; 95% CI: 1.74, 2.31), reporting functional limitations (OR = 1.79; 95% CI: 1.57, 2.04), being female (OR = 1.49; 95% CI: 1.32, 1.68), being overweight (> 25.0 kg/m^2) (OR = 1.33; 95% CI: 1.16, 1.48) and having five comorbid conditions (back problems, chronic bronchitis/emphysema, heart disease, stroke and bowel disorder; OR = 1.11; 95% CI: 1.03, 1.20). The factors, which were protective against physical inactivity, were higher education (secondary education or more) (OR = 0.73; 95% CI: 0.65, 0.80) and infrequent alcohol consumption (OR = 0.83; 95% CI: 0.74, 0.93). Much like the study conducted by Fontaine et.al.(23), Kaplan and colleagues further elucidated factors that explain physical inactivity in respondents with arthritis, such as females (OR=1.49; 95% CI: 1.32, 1.68), older age (OR=2.90; 95% CI: 2.57, 3.27), functional limitations (OR=1.79; 95% CI: 1.57, 2.04), as well as being underweight (OR =1.84; 95% CI:1.53, 2.21) and overweight (OR=1.33; 95% CI:1.16, 1.48); however, physical activity along with a few other factors varied with age.(122) In the study by Kaplan et al, a single item question from NPHS was used to assess the physical activity level for all respondents, which failed to adjust for changes in activity due to aging. Older individuals who engage in a particular activity may be exerting energy that is consistent with an active lifestyle; however, due to a standardized question, that same activity may not reach the threshold of "active" for the average respondent. For instance, walking for 1 hour is not considered a vigorous activity for the average adult, but may be a rigorous exercise for an individual who is over the age of 70 years of age. Although the model put forth by Kaplan et.al does provide the foundation for future research, conclusions based on an age-dependent disease such as arthritis will have to be adjusted for age.

2.5 Behavioral, Demographic and Medical Factors: Relationship with physical activity

Numerous behavioural and medical factors independently influence the amount of physical activity an individual may engage in. Below is a description of the demographic, behavioral and medical factors that affect levels of physical activity.

2.5.1 Demographic factors:

Age:

As individuals age, cardiovascular and musculoskeletal changes occur in which the amount and intensity of physical activity diminishes.(123) A recent cross-sectional study using the National Health Interview Survey (NHIS) confirmed that the prevalence of recommended levels of physical activity was lower (4 to 10 percentage points) in older respondents, compared to younger respondents.(124) Reduced levels of activity as people age may be due to an accelerated decline in aerobic and anaerobic fitness (125), as well as a possible fear of over-working their body, potentially risking further pain or injury from falls.(126) Activity limitation is also seen with the added burden of chronic diseases (such as heart disease and arthritis) that hinder the functional capacity among older adults.(126,127)

Gender:

A recent study by Loprinzi and Cardinal observed higher rates of mean moderate-vigorous physical activity in adult men when compared to adult women (30.4 min/day versus 18.0 min/day, respectively), suggesting men are more active than women.(128) This is supported by a study done by Caspersen et al. who found that adult women (18 years of age or older) had a higher prevalence (27%) of leisure time physical inactivity than adult men (21%).(124) A Brazilian population study of 1,344 men and 1,756 found that women had a higher proportion of physical inactivity than men (29% more) and men had a statistically higher proportion of moderate and vigorous activity compared to women at a p-value <0.001 (10.8% versus 5.4%, respectively).(129)

Marital Status:

Using a cross-sectional survey design, Pettee et.al looked at marital status as an antecedent for physical activity in 3075 older adults.(130) In this study, men and women who were married participated in more exercise than those who were not married (burned nearly double the calories; 487.3 calories versus 256.5 calories).(130) Additionally, active husbands were nearly three times more likely to have an active spouse (OR=2.97; 95% CI: 1.73, 5.10).(130) This finding contradicts Kaplan et al., where respondents with arthritis who were single/widowed were less likely to be physically inactive.(122) The primary difference between the studies done by Pettee (130) and Kaplan (122) stem from their populations of interest. While Kaplan's design targeted respondents with arthritis, Pettee's population consisted of the general population.

Education:

Education and community support are both common factors considered in health research. Literature suggests that lower levels of education are associated with higher rates of OA.(131) A descriptive study investigating educational differences in physical inactivity illustrates that when compared to high education level (university or college), lower education levels (primary school only) were significantly associated with a higher likelihood of physical inactivity.(132) Having only received primary school education resulted in an odds ratio of 3.98 (95% CI: 1.87, 8.10) for physical inactivity.(132)

2.5.2 Behavioral factors:

Body Mass Index (BMI):

Several cross-sectional studies report a strong association between physical activity and obesity (133,134); however, there are few longitudinal studies that have attempted to understand the temporal relationship between the two.(135) There is considerable research surrounding this association, such as the work done by Petersen et al. who conducted a longitudinal study of over 5,000 respondents.(135) They found that respondents who were obese were more likely to be physically inactive relative to individuals who were normal weight (female OR =1.91; 95% CI: 1.39, 2.61; male OR = 1.5; 95% CI: 1.01, 2.22).(135) Godin et al. supported these findings clarifying the mechanism of BMI influencing the amount of physical activity in Canadian cohort.(136) Through the framework of the Theory of Planned Behavior, whereby an action (physical activity) is determined by intention and perceived difficulty, Godin and colleagues were able to determine that BMI status did, indeed, negatively influence the decision to engage in physical activity.(136) The authors suggest that reasons for reduced physical activity may be that individuals who are obese may experience more pain and overexertion and potentially are subjected to social obstacles associated with activity.

Alcohol:

Heavy alcohol consumption may be interpreted as unhealthy society behavior and therefore may lead one to assume a negative correlation with healthy behavior such as an active lifestyle; however, the literature suggests otherwise. The relationship between alcohol and physical activity is not definitive, as several studies provide contrary results: no association (137,138), positive association(139,140) and a negative association.(141) These studies, however, use smaller samples that are difficult to generalize to a larger population or they dichotomize the consumption of alcohol into categories that are often inconsistent, potentially resulting in misclassification. A recent study using the Behavioral Risk Factor Surveillance System (BRFSS) survey to investigate if alcohol consumption was significantly related to the number of minutes of physical activity concluded a positive correlation.(142) This study used a large national database with multiple measures of alcohol consumption and suggested that the resulting relationship may be attributed to alcohol consumption being a social convention following physical activity.(142) They also suggested that the relationship could be the result of frequent alcohol drinkers compensating for the extra calories by participating in more physical activities.(142) Another study using large population surveys, done by Smothers and Bertolucci, explored the behavioral pathway between alcohol and health benefits.(143) Their findings, after controlling for sociodemographic, health and health behavior variables, showed that moderate drinking had an OR of 1.84 (95% CI: 1.62, 2.10) for being physically active when compared to those who abstained. Interestingly, their results indicated that when compared to abstaining from alcohol, former, infrequent, occasional and light alcohol drinkers had an OR between 1.00 and 1.84 for participating in leisure-time physical activity.(143) Contrary to conventional thought, the theory of moderate alcohol being associated with healthy living is indeed further supported by literature surrounding heart disease (143-145) and considered a part of a lower-risk lifestyle.(146)

Smoking:

Smokers are typically unhealthier and have shorter lifespan than non-smokers.(147) Cigarette smoke raises the risk of a cardiac disease as it has been shown to increase inflammation, oxidative stress, and occurrence of thrombosis and cardiac dysfunction.(148,149) In relation to physical activity, literature suggests a negative association with smoking.(150) A systematic review, using 50 articles from 5 databases, investigating the relationship between physical activity and smoking found that 61% of the articles studied reported a negative association. A dose-response relationship was not found.(151)

Residential locale:

There is limited literature that observes the relationship between rural and urban differences in physical activity of adults. CCHS defines an urban region as an area of a population concentration of 1000 persons or greater with a population density of 400 persons per square kilometer or greater.(152) Based on findings from both American and Canadian populations, people residing in rural regions tend to be less active. Using the BRFSS in the United States found that after adjusting for age, race, education, gender and income, urban respondents had a higher likelihood of meeting recommended levels of physical activity (OR= 1.24; 95% CI: 1.00, 1.55) when compared to rural respondents. The authors suggested that physical activity differences seen between urban and rural regions might be related to social support and environmental factors;(153) People who live in rural regions documented limited recreational and exercise facilities accessible to them, as compared to those living in urban regions.(154) Furthermore, Wilcox and colleagues explained that women in rural regions engage in less activity than urban women because rural women are more confined by personal barriers such as care giving responsibilities .(155)

2.5.3 Chronic Conditions

Back problems:

Back pain is a prevalent condition within the Canadian general population (23.2%).(156) A 2012 systematic review of 7 studies determined that following pooling of data, there was no significant difference in physical activity levels between individuals with and without back pain.(157) This was further supported by an earlier systematic review that included 12 observational studies where investigators also found little evidence to support a relationship between physical activity and back pain.(158) However, despite not finding significant results, investigators from both systematic reviews acknowledged the health benefits of recommended physical activity, further adding that there was no that there is no evidence to suggest unfavorable effects in relation to back pain.(157,158) Hendrick et al. acknowledged that further research into the relationship between physical activity and back pain needed to be done, referencing the possibility of a "U-shaped" relationship found in one of the included studies.(158) A Dutch cross-sectional design, consisting of 8000 adults over the age of 25 years, determined that the relationship between physical activity and back pain was “U-shaped”. In other words, investigators found that relative to moderate physical activity, both low (OR =1.31; 95% CI: 1.08, 1.58) and high (OR=1.22; 95% CI: 1.00, 1.49) were both associated with back pain.(159) Investigators also determined that respondents who did not attained recommended levels of physical activity (30 minutes of moderate activity, 5 days per week) were 1.23 times more likely (95% CI: 1.05-1.45) to have lower back pain than respondents who did reach recommended levels. Furthermore, Huneweer et al. found that relative to respondents who were not sedentary (had some form of physical activity), respondents who were sedentary (did not participate in any activity) had a higher likelihood of having back pain (OR =1.41).(159)

High Blood Pressure:

Physical inactivity is associated with high blood pressure.(160) In a 50-year follow-up period, a longitudinal study of 14,998 male Harvard alumni found that individuals who did not participate in regular vigorous activity were at a 35% greater risk of developing high blood pressure than subjects who were vigorously active.(161) Furthermore, in a cross-sectional study of 775 adults between the ages of 45 and 75 years of age, a strong negative relationship was observed as lower levels of energy expenditure was associated with higher levels of blood pressure. When comparing the blood pressure of respondents with high energy expenditure to the blood pressure of low energy expenditure, investigators found a statistical and clinical difference. The difference between the highest quintile and lowest quintile of energy expenditure in systolic blood pressure was 6.3mmHg for males and 4.4 mmHg for females.(162)

Heart disease

High blood pressure is associated with heart disease (HD) which is the leading cause of mortality (19.8%) in the United States(163) and (32.1%) in Canada.(164) Using the BRFSS, 40% of respondents with HD reported reaching the total physical activity recommendations; this is compared to 49% of individuals who do not have HD (p-value <0.0001, age-standardized).(163) Neuhouser et al. supported these findings through quantified METs, reporting that on average, subjects with HD expend 560 METs/week compared to subjects without HD who expend 574 METs/week.(165) Zhao and colleagues suggest that respondents with severe HD may not wish to be physically active for fear of physiological repercussions resulting in detrimental health effects.(163)

Mental disorders

Literature suggests a negative association between mental disorders (such as depression and anxiety) and physical activity, that is, people with mental disorders are less likely to be active.(166,167) In a cross-sectional study of 8098 American respondents, people who participated in regular activity had a lower likelihood of having major depression (OR = 0.78; 95% CI: 0.63, 0.97). Such an association was similar between physical activity and other mental disorders, such as social phobia (OR = 0.65; 95% CI: 0.53, 0.80) and panic attacks (OR = 0.73, 95% CI: 0.56, 0.96).(166) A possible reason for this relationship proposed by the investigators is that persons with mental disorders may be less likely to join teams or participate in social exercise activities. Furthermore, they add that individuals who are depressed may not have the energy or desire to by physically active.(166)

Diabetes

Physical activity plays a pivotal role in the management and prevention of diabetes, much the same as other chronic conditions. Although it is well established that physical activity is protective against diabetes, activity levels among people with diabetes is not well understood.(168) It appears that people with diabetes are less active than those without diabetes. Based on a large American cohort, 42% of respondents with diabetes were inactive as compared to 27% of respondents without diabetes.(168) Although these findings are based on self-reported data that did not adjust for BMI or other comorbidities, this provides indication that physical inactivity is more prevalent among individuals with diabetes than compared to people without diabetes. Furthermore, using a cohort of nearly 2000 adults, Neuhouser et al. determined that a significant difference was found between METs/ week between subjects with diabetes and without diabetes. Respondent with self-reported diabetes participated in 443 METS/week while respondents without diabetes participated in 580 METS/week.(165)

Although physical activity plays a major role in the management of diabetes, people with diabetes are at risk of developing OA. Based on a large population-based study, the odds of having arthritis were 1.44 (95% CI: 1.35, 1.52) among individuals with diabetes, after adjusting for age, sex, education, and BMI.(169) A large cross-sectional study of the American general population found that the prevalence of arthritis among individuals with diabetes was high (52.0%) and that respondents who had arthritis and diabetes had an 8% higher prevalence of physical inactivity than respondents who just had diabetes alone. This would suggest that arthritis is an additional barrier to physical activity for those with diabetes.(170)

Respiratory Disorders

Respiratory disorders like asthma and chronic obstructive pulmonary disease (COPD) are linked to reduced oxygen intake and/or undue stress on the lungs and cardiovascular system. Given the physiological repercussions of respiratory disorders, physical activity levels among those with respiratory problems are lower.(171,172) A study that looked at physical activity levels with asthma reported significantly higher odds of not engaging in regular physical activity than those who did not have asthma (OR = 2.17; 95% CI: 1.26, 3.73).(171) Potential reasons for reduced activity in respondents with asthma may be due to fear of inducing an asthmatic attack or may be reflective of reduced cardiovascular fitness levels among those with asthma.(173) Furthermore, reduction in the amount of physical activity is one of the main symptoms of COPD.(174)

Lung problems have also been attributed to mortality among those with RA, accounting for nearly 10%-20% of deaths.(79) RA can be attributed to pleural diseases, airway diseases and interstitial lung disease as RA can affect all parts of the lung.(81)

Bowel disorder

Arthritis is common among individuals with bowel disorders, specifically Ulcerative Colitis and Crohn’s Disease.(175) In a systematic review of the epidemiology and pathophysiology related to arthritis and bowel disorders, investigators found that arthritis occurs in 31.5% to 39% of people with inflammatory bowel disease as compared to people without inflammatory bowel disease.(176) Literature suggests that there is considerable arthritic manifestation among individuals with bowel disorders, categorized into peripheral arthritis and ankylosing spondylitis.(177,178)

Bowel disorders such as Crohn’s Disease and Ulcerative Colitis, indeed, significantly benefit from an active lifestyle.(179) In a randomized control trial of 102 patients with bowel disorders, subject who were advised to increase their physical activity showed significant improvement in their symptoms as compared to the control group.(179) Much the same as other chronic conditions, those who have bowel disorders do not achieve the same active lifestyle as those who do not have disease.(180) Mack de et al. used the CCHS 3.1 to show difference in activity levels among persons with bowel-associated disorders compared to those without bowel disorders. Respondents who have Crohn's Disease or Ulcerative Colitis were more likely to be inactive (OR = 1.34; 95% CI: 1.12, 1.61) and less likely to be active (OR =0.69; 95% CI: 0.55, 0.87) indicating that bowel disorders are linked to lower levels of physical activity.(180)

2.6 Summary

The nature of this literature review covers a broad range of complex topics and definitions. Arthritis is an encompassing public health issue worldwide with an increasing prevalence. Physical activity has been an underutilized intervention in the management of chronic conditions, in particular, remedying the burden of arthritis. Additionally, further research is needed surrounding the physical activity barriers among individuals with arthritis. This thesis will further clarify the association between physical activity and arthritis by expounding the related influential components using data collected from a national health survey. Furthermore, this study will describe physical activity among individuals with arthritis. Information gained by this analysis may provide persons with arthritis and health professionals with a better knowledge to manage the disease and a healthy lifestyle.

Chapter 3: Methods

3.1 Data and Study Design

The data set used to answer the thesis objectives is from Canadian Community Health Survey (CCHS) 2007-2008 conducted by Statistics Canada. The CCHS is a cross-sectional survey used to gather information on health status, utilization, and health determinants that target persons 12 years of age and older living across all Provinces and Territories in Canada.(181)

The overall response rate of CCHS 2007-2008 for all health regions in the Provinces and Territories (Prince Edward Island, Newfoundland and Labrador, Nova Scotia, New Brunswick, Quebec, Ontario, Manitoba, Saskatchewan, Alberta, British Columbia, Yukon, Northwest Territories and Nunavut) of Canada was 76.4%. This survey covers 121 health regions serving 98% of the Canadian population. Excluded from collection are persons 1) living on reserve land and Crown Lands, 2) residing in institutions and remote regions, and 3) who are full-time members of the Canadian Forces.

An ongoing collection of data occurs year round and the data are released annually which consists of nearly 65,000 respondents; however, every two years, a larger data file is released containing a combined two-year data sample of 130,000 respondents. Annually released data consists of a collection that is done six times over a two-month period whereas the two-year data file consists of a collection that is done twelve times over a two-month period. Data collected for the 2007-2008 cycle occurred between January 2007 and December 2008.

The content within the survey was composed of three parts: Common, Optional and Rapid Response. Common content items were questions consistent for a period of 6 years across all provinces and answered by all respondents. One and two year common content items were questions that were introduced for one or two years and then removed, usually focusing on a particular theme. Optional content covered items that provinces or health regions had requested for further surveillance within their system. These items were specific to the region and not all respondents in Canada answered them. Rapid Response questions were items specified for cost-benefit analysis by organizations that require data on national health-specific estimates.(181) The items used in this study were from the common content of the CCHS.

Sampling Frame:

The CCHS uses three sampling frames: an area frame, telephone numbers and random digit dialing. The Labour Force Survey acts as the area frame, consisting of complex clusters that are stratified by health regions; 49% of the CCHS sample of households comes from the area frame. Telephone numbers are used to complement the area frame and are updated every 6 months. Numbers are also stratified by health region and are randomly selected within each region. Fifty percent of the CCHS sample of households is obtained using telephone numbers. Finally, 1% of the household sample is from random digit dialing whereby a ten-digit number is generated by randomly selecting each digit using a 100-number bank.

Case ascertainment: Arthritis

Within the CCHS 2007-2008 Cycle interview, persons with arthritis were identified by self-report. The exact wording used in the interview was: “Now I'd like to ask about certain chronic health conditions which you may have. We are interested in ‘long-term conditions’ that have lasted or are expected to last 6 months or more and that have been diagnosed by a health professional.” Respondents were asked, “Do you have arthritis, excluding fibromyalgia?” The possible responses to this question were “yes”, “no”, “do not know” or “refusal”. The validity of self-reported arthritis is fairly consistent with an 81% agreement with doctor-diagnosis.(182) The definition of arthritis in the CCHS was not provided; therefore an assumption was that arthritis encompassed all forms of the disorder, excluding fibromyalgia. Within the context of this study, we looked at arthritis that was reported in adults; therefore respondents who were less than 18 years of age or older were excluded from this analysis.

Exposure of interest: Physical Activity

Physical activity for each respondent was quantified using a derived variable (PACDEE), which measured the respondent’s total energy expenditure. The CCHS 2007-2008 surveyor asked, “Have you done any of the following in the past 3 months, that is, from [date three months ago] to yesterday?" Respondents were given 21 activities ranging from walking for exercise to playing soccer, as well as an "any other" option and "no physical activity" option (see appendix Table A-2). All activities were leisure time physical activities only and did not include occupational or household activities (the activities were derived from the 1988 Campbell Survey(183)). For each activity stated, respondents were asked, "In the past 3 months, how many times did you [participate in the identified activity]?" And "about how much time did you spend on each occasion?"

Total daily energy expenditure was calculated summing the energy expenditure of all activities the respondent participated in per day. The energy expenditure of a particular activity is the function of: 1) the frequency of activity over a year; 2) the average time spent on the activity (in hours) and; 3) the METs, or energy cost, associated with the activity divided by 365 to convert the energy expenditure into a daily figure, rather than yearly (Figure 3-1). Each activity has a level of intensity (low, moderate and high)(152); however, there were no questions in the CCHS based on the intensity of each activity because according to the Canadian Fitness and Lifestyle Research Institute (184), individuals have a tendency to overestimate the intensity of the activity they engage in. The approached used by the CCHS is to use the MET value made by the assumption of low intensity of each activity.(181) Following this assumption reduced the overestimation respondents may have reported. For example, if the respondent participated in swimming for exercise in the past 3 months, the MET value of low intensity swimming is 3 kcal/kg/hr.

Daily Energy Expenditure = (N x D x METvalue)/365

- N= number of times individual participated in activity over a 12 month period
- D= Average duration of activity in hours

Total Daily Energy Expenditure = Daily Energy Expenditure (activity 1) +Daily Energy Expenditure (activity 2) +… Daily Energy Expenditure (activity n).

Figure 3-1: Calculation of Total Daily Energy Expenditure. This calculation was used to categorize individuals into appropriate activity levels.

Total daily energy expenditure was used to quantify and categorize the respondents' absolute MET into appropriate activity levels. Activity levels were grouped according to a range of MET values derived from the average male (40 years old and 70-kg). Because aerobic capacity changes with age (185), it is not appropriate to assume the fitness level of an adult 65 years old is the same as a 40 year old. To accommodate for physiological changes of aging, particularly for a study focused on a chronic condition that is age-dependent, we re-categorized the METs according to the categories recommended by the US Surgeon General.(13) The absolute METs were classified into four activity levels (sedentary, light, moderate and vigorous) and stratified by age groups as shown in below in Table 3-1.

Table 3- 1: METs categorization for age groups

Intensity (METs)	Age 20-39 years	40-64 years	65-79 years	80+ years
Sedentary	<3.0	<2.5	<2.0	<1.25
Light	3.0-4.7	2.5-4.4	2.0-3.5	1.26-2.2
Moderate	4.8-7.1	4.5-5.9	3.6-4.7	2.3-2.95
Vigorous	≥7.2	≥6.0	≥4.8	≥3.0

Abbreviations: METS, Metabolic Equivalent of Task
Sourced: from the United States Office of the Surgeon General report: Physical Activity and Health: A Report of the Surgeon General (13)

Possible explanatory variables of physical activity were selected based on published evidence, and the framework outlined in Chapter 2. The variables were categorized into three groupings: demographic, behavioral and medical. The reason for these grouping is based on the premise that an individual's health is governed by factors that are modifiable (behavioral) and those that are non-modifiable (demographic).(186) Concurrent medical factors contribute to an individual's capacity to be healthy and are also dependent on demographic and behavioral factors; therefore, they were grouped separately.

Within the CCHS 2007-2008 questionnaire, respondents were asked about the status of any chronic conditions lasting 6 months or longer that were diagnosed by a health professional. The variable, "respiratory" was a derived variable consisting of an amalgamation of asthma, COPD and emphysema. The variable "mental health" included anxiety disorders and mood disorders. It should be noted that high blood pressure is typically defined as a systolic pressure greater than 140 mmHg and a diastolic pressure greater than 90mmHg. No values were identified when asking respondents whether they had high blood pressure.

Exclusions

The focus of this study was to describe the association of physical activity and arthritis in an adult Canadian population; therefore 11,121 respondents were excluded as they were less than 18 years of age at the time of the survey. Additionally, responses to questions in the survey that were either "don't know" or "refusal" were not included in the analysis.

3.2 Statistical Analysis

The analysis for the first objective of this research, consisted of answering the first objective, "what demographic, behavioral and health factors modify the association between physical activity and arthritis among the respondents?" A descriptive analysis was first conducted to describe the 120,838 respondents. Full univariate and multivariate analysis examined factors that explained arthritis. The analysis for the second objective addressed the research question, "what factors explain the physical activity levels among respondents with arthritis?" A similar approach was done as in part one, that is, a descriptive analysis followed by a full univariate and multivariate logistic regression were done, where physical activity was the outcome in persons with arthritis.

3.2.1 Statistical Analysis for Part One:

Respondents sampled in CCHS 2007-2008 survey were selected in the sample with unequal probabilities through complex survey selection scheme. Statistics Canada has provided sampling design weights (sampling weights) for this survey to account for this unequal probabilities selection for extrapolating sample estimates to the population under consideration. In general, these weights are inversely proportional to respondents selection probabilities. The weighted (with sampling weights as weights) descriptive statistics of the demographic, behavioral and medical factors identified in Appendix Table A-1 were determined for arthritis and non-arthritis groups.

Using the "tabulate" function, percentages of each factor category were calculated among arthritis and non-arthritis groups. Means were also calculated for the continuous variable, age. To assess association between ordinal variables, Kendall's tau was obtained; while for nominal variables, Cramer's v was obtained. The interpretations of these two measures are similar to correlation coefficient, which is used for interval variables and the values are shown in Table A-4 in the Appendix A.2.

To determine what demographic, behavioral and health factors modify the association between physical activity and arthritis among the respondents a univariate logistic regression, with response variable arthritis, was conducted. Significant (p-value < 0.05) variables were considered one at a time in a logistic regression, which included the factor under consideration and physical activity. Because arthritis and physical activity vary with age and gender, these 2 variables were entered in the model. If the interaction between the factor and physical activity was not significant, the interaction effect was excluded from the multivariate logistic regression model. Significance of the factor was tested using the post-estimation Wald's test (p-value <0.05). If the factor was not significant in the logistic regression (without interaction), a visual inspection of change in regression coefficient was done for possible confounding effect.

Factors significant on their own (main effects), factors that had significant interaction with physical activity, and confounders were considered in a multivariate logistic regression. Interacting effects deemed as clinically relevant, that were not extracted from the univariate analysis such as high blood pressure by heart disease and physical activity by heart disease, were also included in the multivariate analysis. The factors that were not significant (p-value > 0.05) were excluded in the final model. The final model included all significant variables to confirm significance using the post-estimation Wald's test (p-value <0.05).

Interaction effects were interpreted using the post-estimation lincom command in STATA to obtain the odds ratios and 95% confidence intervals. Age by gender interaction effects was significant with several key variables; therefore a stratified analysis by the 4-category age groups and gender was done.

Finally, among arthritis respondents, factors that can explain the physical activity levels were examined. Since physical activity is measured on three ordinal levels, ordinal logistic regression method was considered. This method is discussed in the next section below.

3.2.2 Statistical Analysis for Part Two:

To examine ordinal responses association with several factors, the proportional odds model under ordinal regression method is the approach that is typically recommended, provided that the underlying assumption about proportionality of odds is met for all levels of the response. That is, to study relationship between physical activity and a factor, for example BMI, the proportional odds assumption requires that odds ratios for BMI be the same for all levels of physical activity. However, if this assumption is not reasonable, the 'adjacent category logistic regression' is used as an alternative to proportional odds logistic regression model.

Ordinal regression, using "ologit" in STATA 12, was considered; however, the main assumption of ordinal regression is that the β coefficients for each category remain the same. In other words, we assume that the slopes for all categories are constant. If this assumption was violated then the adjacent-category model was considered because it does not assume a constant slope for each response category. To accomplish this, the outcome of physical activity was separated into two binary variables: 1) Sedentary versus Light or

Moderate/Vigorous activity; and 2) Sedentary or Light versus Moderate/Vigorous activity. Under the proportional odds model, the beta coefficients of each factor in the multivariate binary regression model 1 should be equal to their respective coefficients in model 2. In this case, the proportional odds assumption was violated.

A detailed description of the adjacent category model is given in Appendix A.3. Instead of comparing the probability of “success” for each category to a baseline, adjacent-category regression compares each category to the next highest category. In the case of physical activity, sedentary activity was compared to light activity and light activity was compared to moderate/vigorous activity. Using this method allows researchers to maintain the ordinality of the outcome without the assumptions of proportional odds. However, a limitation of this method is that it is unable to achieve a single parsimonious model.

Initially, percentages of each physical activity level (sedentary, light and moderate/vigorous) were calculated for each factor using the “tab” command. As part of the adjacent model, two separate multivariate binary logistic regression models were conducted comparing sedentary activity to light activity, and light activity to moderate activity. In both models, a univariate analysis was done to determine the association between the physical activity variable and the variables. Significance was tested using the Wald’s test ($p\text{-value}<0.05$) and variables that were statistically significant were used in the multivariate model. Following the multivariate analysis, variables from both models were combined. The combined set of variables were tested in a multivariate analysis for sedentary activity to light activity and light activity to moderate activity. This was done to ensure that the same variables were tested in both models for comparison. All variables were tested using the Wald's test (p-value <0.05) and significant variables were used for the final models. The final models were once again tested for significance at p-value <0.05 to confirm the models. Robust statistical significance levels for all tests were computed using bootstrap weights, which are provided by Statistics Canada. These are discussed in the next section.

3.3 Bootstrap Survey Weights

In order to assess the significance of an estimate (for example statistical significance of an odds ratio) the variance of the underlying estimate must be calculated. Since CCHS uses a complex survey design and the estimates are often complex (not a linear function of observations), no simple exact formulas are available to provide robust variances for the underlying estimates. Hence, users adopt approximation methods to seek variance estimates. Bootstrap, which is a re-sampling technique, is being used in CCHS which involves drawing replacement samples from the underlying sample; that is treating given sample as a finite population and drawing samples with replacement number of times. Such samples are called bootstrap replicates. Note that with replacement sampling scheme, the same unit get selected more than once and hence each unit in the original sample will have a different weights in these bootstrap replicates (re-samples). Bootstrap replicate weights are then obtained by combining re-sampling weights with original sampling design weights.

Bootstrap weights were designed into the syntax of STATA 12.0 using the svyset command (with pweight = wts_m). All analysis used the “SVY” commands in STATA 12.0 and was weighted. According to the 2007 CCHS Microdata File User Guide the weights were derived by treating the telephone and area frames independently. Hence, two separate weights under each sampling frame were provided in the 2007 CCHS Microdata File. Through a step called “integration”, these two weights (sampling weights and design weights) are combined to form the final sampling weights.

3.4 Ethics

Statistics Canada first reviewed this proposal and granted access to the confidential micro data file under strict security and guidelines at the Research Data Centre (see Appendix A.1). The University of Alberta Health Research Ethics Board, under Health Panel B, granted approval for this study (see Appendix A.1). While the research and analysis are based on data from Statistics Canada, the opinions expressed do not represent the views of Statistics Canada.

Chapter 4: Results

4.1.1 Prevalence of Arthritis and descriptive statistics of the population

The CCHS 2007-2008 data contained 131,959 respondents and in this population, 11,121 (8.4%) were excluded from the study due to the age restriction (excluded respondents <18 years of age). Among the remaining 120,838 respondents, who constitute the population for the study, the prevalence of self-reported arthritis diagnosed in the 6 months prior to the survey by a health care professional within the past 6 months, was 16.3%.

Table 4-1 contains a descriptive statistics of demographic, behavioral and medical factors of the respondents, stratified by reported arthritis status. The mean age of respondents with arthritis was 61.0 (SD 23.0) years, while respondents without arthritis were, on average 43.2 (SD 15.0) years old. Arthritis respondents were older as, 86.5% were over the age of 45 years, whereas 44.6% non-arthritis respondents were in the same age group. There were more females than males (with a ratio, 2:1) among respondents with arthritis, while an equal distribution of females and males were observed among the non-arthritis respondents. The average BMI of respondents with arthritis (27.7 kg/m^2) was higher than respondents without arthritis (25.6 kg/m^2). Compared to those without arthritis, there was a higher prevalence of obesity (overweight, obese class I, II and III) for respondents with arthritis.

On average, arthritis respondents reported having 1.9 (SD 3.0) chronic conditions, which was more than non-arthritis respondents with a similar mean 0.87 (SD 1.8). The three most prevalent medical conditions with respondents who had arthritis were, back problems not associated with arthritis (42.0%), high blood pressure (37.6%) and mental disorders (16.5%). Back problems (17.5%), high blood pressure (13.8%) and mental disorders (8.7%) were the three most commonly reported conditions among respondents without arthritis.

Among respondents who had arthritis, differences in the distribution of physical activity levels were observed; as nearly 72.0% reported a sedentary lifestyle; while only 8.8% engaged in a moderate or vigorous lifestyle. Although an overall similar physical activity trend was observed (71.0% sedentary) among respondents without arthritis, they participated in significantly more moderate or vigorous activity (11.4%) than respondents with arthritis (8.8%). The most common leisure time physical activities reported by respondents with arthritis and non-arthritis were walking for exercise and home exercises.

4.1.2: Univariate Logistic Regression for Likelihood of having Arthritis and measure of association

Table 4-1 also provides results from a univariate logistic regression analysis, with arthritis (binary scale) as the outcome. Compared to respondents who engaged in sedentary activity, individuals who participated in moderate or vigorous activity were less likely to have arthritis, OR=0.75 (95% CI: 0.70, 0.81).

Conversely, respondents who participate in light activity were more likely to have arthritis, OR=1.11 (95% CI: 1.03, 1.21). Further, a dose-response relationship was observed as increasing age was associated with an increasing likelihood of having arthritis. Among all the age groups, respondents who were 80 years of age or older had the highest likelihood of having arthritis (OR = 21.7; 95% CI: 19.7, 23.9). Females (OR=1.67; 95% CI: 1.60, 1.74) were over 1.5 times as likely to have arthritis relative to males. Respondents who reported being overweight had a higher likelihood of having arthritis (OR =1.53; 95% CI: 1.45, 1.61), compared to respondents who were normal/underweight (BMI$\leq$ 24 kg/m^2). Obese class I as well as obese class II/III was also associated with higher odds of having arthritis (OR= 2.00; 95% CI: 1.87, 2.14; OR = 2.81; 95% CI: 2.57, 3.07, respectively) than respondents who were normal/underweight. Back problems (OR = 3.41; 95% CI: 3.24, 3.57) high blood pressure (OR= 3.77; 95% CI: 3.59, 3.95) and heart disease (OR = 4.00; 95% CI: 3.72, 4.31) had the highest odds ratios of having arthritis among all chronic conditions.

Relative to respondents who did not drink alcoholic beverages, regular drinkers were 48% less likely to have arthritis, and occasional drinkers were 23% less likely to have arthritis. Respondents who were former smokers (OR=1.54; 95% CI: 1.46, 1.62) or current smokers (OR=1.12; 95% CI: 1.05, 1.19) were more likely to have arthritis.

To assess the measure of association among all factors Kendall's Tau and Cramers'v statistics were computed. Table A-4 in Appendix A.2 provides these measures. The resulting Kendall's Tau and Cramers'v statistics indicated that there was no association between each of the factors used in this study (Appendix Table A-4).

Table 4- 1: Demographic, behavioural and medical characteristics of respondents with arthritis and without arthritis

Characteristic	**Arthritis** (Unadjusted) **(N=27,234)**	**No reported arthritis** (Unadjusted) **(N=93,559)**	**Odds Ratio***	**95% CI**		**p-value**	**Missing (%)**
Physical Activity						<0.001	2.2
Sedentary (referent)	71.9	70.5	1.00				
Light	19.3	18.1	1.05	0.99	1.11	0.11	
Moderate/Vigorous	8.8	11.4	0.75	0.70	0.81	<0.0001	
AGE (years)						<0.001	0.0
18-44 (referent)	13.0	55.5	1.00				
45-64	44.3	33.3	5.47	5.08	5.90	<0.0001	
65-79	30.9	9.2	13.87	12.88	14.93	<0.0001	
80 or older	11.3	2.1	21.71	19.74	23.87	<0.0001	
Gender							0.0
Male (referent)	38.6	51.2	1.00				
Female	61.4	48.8	1.67	1.60	1.74	<0.0001	
Body Mass Index						<0.001	5.9
Normal/Underweight (<25.0 kg/m^2) (referent)	37.6	51.3	1.00				
Overweight (25.0 – 29.9 kg/m2)	37.3	33.3	1.53	1.45	1.61	<0.0001	
Obese class I (30.0 -34.9 kg/m2)	16.6	11.3	2.00	1.87	2.14	<0.0001	
Obese class II/III (>35.0 kg/m2	8.5	4.1	2.81	2.57	3.07	<0.0001	

Characteristic	**Arthritis** (Unadjusted) **(N=27,234)**	**No reported arthritis** (Unadjusted) **(N=93,559)**	**Odds Ratio***	**95% CI**		**p-value**	**Missing (%)**
Education						<0.001	2.9
High school not completed (referent)	29.4	13.3	1.00				
High school completed	16.0	17.0	0.42	0.39	0.46	<0.0001	
Any Post secondary	54.6	69.7	0.35	0.34	0.37	<0.0001	
Marital Status						<0.001	0.2
Single/Never Married (referent)	9.4	25.9	1.00				
Married/Common Law	64.9	63.5	2.82	2.62	3.04	<0.0001	
Divorced/Separated	25.7	10.7	6.68	6.16	7.23	<0.0001	
Sense of Belonging to Community						<0.0001	3.9
Weak (referent)	33.0	37.4	1.00				
Strong	67.0	62.7	1.21	1.15	1.27	<0.0001	
Residence							0.0
Urban (referent)	78.1	82.8	1.00				
Rural	21.9	17.3	1.35	1.28	1.41	<0.0001	
Smoking Status						<0.001	1.2
Never (referent)	30.8	38.0	1.00				
Daily/Occasional	21.2	23.5	1.12	1.05	1.19	<0.0001	
Former	48.0	38.5	1.54	1.46	1.62	<0.0001	
Alcohol Use						<0.001	1.5
Never (referent)	27.2	17.8	1.00				
Regular Drinker (≥1 drink/month)	53.6	67.0	0.52	0.49	0.55	<0.0001	
Occasional Drinker (<1 drink/month)	19.2	15.2	0.83	0.77	0.89	<0.0001	

Characteristic	Arthritis (Unadjusted) (N=27,234)	No reported arthritis (Unadjusted) (N=93,559)	Odds Ratio*	95% CI		p-value	Missing (%)
Back problems							0.2
No (referent)	58.0	82.5	1.00				
Yes	42.0	17.5	3.41	3.24	3.57	<0.0001	
Blood Pressure							0.4
No (referent)	62.4	86.2	1.00				
Yes	37.6	13.8	3.77	3.59	3.95	<0.0001	
Heart Disease							0.3
No (referent)	86.8	96.3	1.00				
Yes	13.2	3.7	4.00	3.72	4.31	<0.0001	
Diabetes							0.1
No (referent)	86.6	95.0	1.00				
Yes	13.5	5.0	2.96	2.75	3.19	<0.0001	
Bowel Disorder							0.2
No (referent)	90.5	96.4	1.00				
Yes	9.6	3.6	2.80	2.59	3.02	<0.0001	

Characteristic	**Arthritis** (Unadjusted %) **(N=27,234)**	**No reported arthritis** (Unadjusted %) **(N=93,559)**	**Odds Ratio***	**95% CI**		**p-value**	**Missing (%)**
Mental Disorder							0.1
No (referent)	83.20	91.3	1.00				
Yes	16.90	8.70	2.12	1.99	2.26	<0.0001	
Respiratory Disorder							0.04
No (referent)	84.70	92.40	1.00				
Yes	15.30	7.70	2.17	2.04	2.32	<0.0001	
Stomach and Intestinal Ulcer							0.3
No (referent)	92.90	97.50	1.00				
Yes	7.10	2.50	2.98	2.70	3.30	<0.0001	

* The unadjusted odds ratio represented the odds of having arthritis.
Mental Disorder includes depression, bipolar disorder, mania or dysthymia, or anxiety disorder.
Respiratory Disorder includes asthma, chronic bronchitis, emphysema, or chronic obstructive pulmonary disorder.

4.1.3 Identifying confounding effects:

From the univariate logistic analysis given in the previous section with arthritis as the outcome, we found that physical activity and all other factors were significant in explaining arthritis. To identify any confounding effects among these factors on the association between arthritis and physical activity, a logistic regression analysis was done taking all other factors (for example, education, BMI) into consideration one at a time along with physical activity and with arthritis as the outcome. Age, gender, age by gender interaction, as well as the interaction between physical activity and the underlying factor were also included. The results of this analysis are seen in Table 4-2, where the ORs for each factor did not change significantly compared to the ORs under logistic regression model analysis, given in the previous section (with physical activity alone as a factor). This confirms the absence of confounding effects between physical activity and other significant factors in understanding the association between physical activity and arthritis.

While no confounding effects among significant main effects were seen, a post- estimation Wald's test was done to identify significant factors for the multivariate model. Sense of community was the only main effect that was not significant while the rest were significant at $p\text{-value}<0.05$. The only interaction effect, other than age and gender that was significant was between physical activity and high blood pressure at $p\text{-value} < 0.05$ (Table 4-2).

Table 4- 2: Odds of having arthritis for light and moderate/vigorous activity after adjusting for age, gender, age by gender interaction and the factor

FACTOR	Light Activity OR (95% CI)	Moderate/Vigorous OR (95% CI)
PA alone	0.91 (0.86, 0.98)	0.74 (0.67, 0.80)
PA + Education *	0.94 (0.88, 1.00)	0.77 (0.71, 0.83)
PA + BMI *	0.98 (0.91, 1.04)	0.81 (0.75, 0.88)
PA + Marital Status *	0.92 (0.86, 0.98)	0.75 (0.69, 0.81)
PA + Sense of Belonging to Community *	0.92 (0.86, 0.98)	0.75 (0.69, 0.81)
PA + Residence *	0.91 (0.86, 0.97)	0.74 (0.68, 0.80)
PA + Smoking status *	0.92 (0.86, 0.98)	0.76 (0.70, 0.82)
PA + Alcohol use *	0.94 (0.88, 1.00)	0.76 (0.70, 0.82)
PA + Back problems *	0.94 (0.88, 1.01)	0.79 (0.73, 0.86)
PA + Diabetes *	0.93 (0.87, 0.99)	0.76 (0.70, 0.82)
PA + High Blood Pressure	1.00 (0.93, 1.08)	0.83 (0.76, 0.92)
PA + Bowel Disorder *	0.92 (0.86, 0.99)	0.75 (0.69, 0.81)
PA + Mental Disorder *	0.94 (0.88, 1.00)	0.77 (0.71, 0.83)
PA+ Heart Disease *	0.92 0.86, 0.98)	0.75 (0.70, 0.82)
PA + Ulcer *	0.92 (0.87, 0.99)	0.75 (0.69, 0.81)

* indicates adjusted for age, gender and age by gender interaction for each regression.
+ indicates the addition of the factor with PA
Abbreviations: PA, Physical Activity

4.1.4 Multivariate logistic regression:

The factors and interaction terms that were significant (p-value <0.05) following the Wald's test were considered in the multivariate logistic regression model. This model considered arthritis as the outcome variable and significant effects, as shown by univariate analysis, related to socio-demographic, behavioral and medical factors along with physical activity were included as factors (Table 4-3).

Compared to sedentary activity, respondents who participated in light physical activity were significantly more likely to have arthritis (OR =1.11, 95% CI: 1.03, 1.21). There was no significant relationship between arthritis and moderate-to-vigorous activity. Female respondents (OR =1.26, 95% CI: 1.10, 1.45) were more likely to have arthritis, compared to males. A dose-response relationship as observed as increasing level of BMI was associated with an increased likelihood of having arthritis. Relative to respondents who were normal weight or underweight, respondents who were overweight (OR =1.28, 95% CI: 1.20, 1.36), obese class I (OR =1.52, 95% CI: 1.40, 1.65), or obese class II/III (OR=2.18; 95% CI: 1.95, 2.44) had higher odds of having arthritis.

All medical factors considered in this analysis were significant for having arthritis in the model, with odds ratios between 1 and 2, with the exception of back problems (OR= 2.78; 95% CI: 2.62, 2.95). Diabetes had the smallest OR among all medical factors (OR= 1.14; 95% CI: 1.03, 1.25).

A number of social and behavioral factors that were significantly associated with having arthritis in the multivariate model. Marital status had the higher odds ratio, with respondents who were divorced/separated/widowed having nearly a 1.5 times (OR = 1.46; 95% CI: 1.31, 1.63) more likelihood of having arthritis than respondents who were single or never married. Similarly, respondents who were married or in a common-law relationship were 1.3 times more likely of having arthritis (OR=1.32; 95% CI: 1.20, 1.45) than single/never married. Smoking status also had a large effect as individuals who were either daily/occasional smokers had an odds ratio of 1.38 (95% CI: 1.27, 1.49) relative to individuals who did not smoke. Former smokers (OR =1.26; 95% CI: 1.19, 1.35) were also more likely than non-smokers to have arthritis. Furthermore, respondents who drank alcohol on a regular basis were 17% less likely to have arthritis, when compared to those who did not drink any alcohol (OR = 0.83, 95% CI: 0.79, 0.92).

Table 4- 3: Multivariate logistic regression describing the association of physical activity, demographic, behavioural and medical factors on arthritis

Characteristic	**Odds Ratio**	**95% CI**		**p-value**
Physical Activity				0.04
Sedentary (referent)	1.00			
Light	1.11	1.03	1.21	0.01
Moderate/Vigorous	1.00	0.91	1.12	0.85
AGE (years)				<0.0001
18-44 (referent)	1.00			
45-64	3.67	3.20	4.21	<0.0001
65-79	7.29	6.35	8.38	<0.0001
80 or older	12.02	10.00	14.44	<0.0001
Gender				
Male (referent)	1.00			
Female	1.26	1.10	1.45	0.001
BMI				<0.0001
Body Mass Index				
Normal/Underweight (<25.0 kg/m^2) (referent)	1.00			
Overweight (25.0 – 29.9 kg/m^2)	1.28	1.20	1.36	<0.0001
Obese class I (30.0 - 34.9 kg/m^2)	1.52	1.40	1.65	<0.0001
Obese class II/III (>35.0 kg/m^2	2.18	1.95	2.44	<0.0001
Education				<0.0001
High school not completed (referent)	1.00			
High school completed	0.81	0.74	0.87	<0.0001
Any post secondary	0.80	0.74	0.86	<0.0001
	1.00			
Marital Status				<0.0001
Single/Never Married (referent)	1.00			
Married/Common Law	1.32	1.20	1.45	<0.0001
Divorced/Separated/ Widowed	1.46	1.31	1.63	<0.0001
Smoking Status				<0.0001
Never (referent)	1.00			
Daily/Occasional	1.38	1.27	1.49	<0.0001
Former	1.26	1.19	1.35	<0.0001

Characteristic	Odds Ratio	95% CI		p-value
Alcohol Use				<0.0001
Never (referent)	1.00			
Regular Drinker (≥1 drink/month)	0.85	0.79	0.92	<0.0001
Occasional Drinker (<1 drink/month)	1.00	0.92	1.09	0.99
Residence				
Urban (referent)	1.00			
Rural	1.18	1.12	1.26	<0.0001
Back problems				
No (referent)	1.00			
Yes	2.78	2.62	2.95	<0.0001
Diabetes				
No (referent)	1.00			
Yes	1.46	1.35	1.59	<0.0001
Mental Disorder				
No (referent)	1.00			
Yes	1.65	1.53	1.79	<0.0001
Respiratory Disorder				
No (referent)	1.00			
Yes	1.68	1.54	1.84	<0.0001
Stomach or Intestinal Ulcer				
No (referent)	1.00			
Yes	1.79	1.56	2.04	<0.0001
Interactions	----------	--------	--------	-------------
Gender*AGE				<0.0001
Female:				
18-44	1.00			
45-64	1.89	1.77	1.99	<0.0001
65-79	2.74	2.62	2.85	<0.0001
80+	3.17	3.02	3.30	<0.0001

Characteristic	Odds Ratio	95% CI		p-value
HD*HBP				0.001
High BP				
No Heart Disease	1.00			
Heart Disease	2.17	1.81	2.60	<0.0001
Normal BP				
No Heart Disease	1.00			
Heart Disease	1.48	1.28	1.71	<0.0001
PA*HBP				0.0117
Sedentary activity				
Normal BP	1.00			
High BP	1.46	1.35	1.59	<0.0001
Light activity				
Normal BP	1.00			
High BP	1.63	1.43	1.86	<0.0001
Moderate/Vigorous activity				
Normal BP	1.00			
High BP	1.48	1.28	1.71	<0.0001

Abbreviations: PA, Physical Activity; BMI, Body Mass Index (kg/m^2); HD, Heart Disease; HBP, High Blood Pressure

Mental Disorder includes depression, bipolar disorder, mania or dysthymia, or anxiety disorder

Respiratory Disorder includes asthma, chronic bronchitis, emphysema, or chronic obstructive pulmonary disorder

4.1.5 Interaction

The logistic regression analysis in Table 4-3 shows that the ORs for having arthritis among respondents with high blood pressure were not consistent across all levels of activity. Figure 4-1 describes the prevalence of arthritis at different levels of physical activity, stratified by presence of high blood pressure. Our first observation was that a negative association was seen between arthritis prevalence and increasing intensity of physical activity (the prevalence of arthritis decreased with increasing levels of physical activity) for the individuals with high blood pressure, as well as individuals without high blood pressure. Secondly, the prevalence of arthritis among respondents who were sedentary and had high blood pressure was over 17% higher than respondents who were sedentary but had normal blood pressure.

Another significant interaction was seen between high blood pressure and heart disease. Overall, the prevalence for arthritis was highest for respondents who had heart disease and high blood pressure (28%) and lowest for respondents who did not have heart disease and did not have high blood pressure (1%) (Figure 4-2). Furthermore, among respondents with high blood pressure, the addition of heart disease was associated with a over two-fold risk of having arthritis, as opposed to having high blood pressure, alone. Among respondents without high blood pressure, individuals with heart disease were 1.5 times (95% CI: 1.28, 1.71) more likely to have arthritis than individuals who did not have high blood pressure or heart disease.

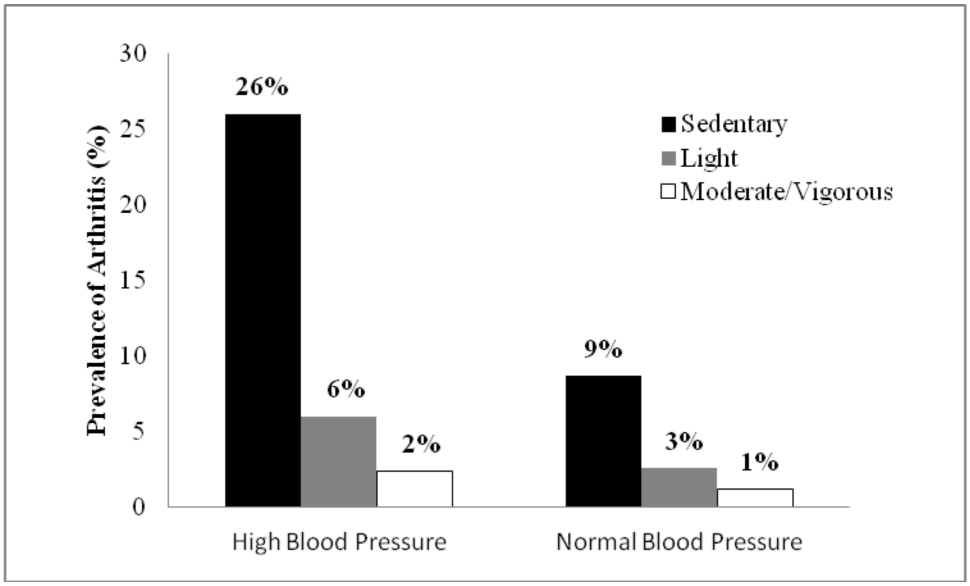

Figure 4- 1: Prevalence of arthritis by physical activity and blood pressure. A significantly high proportion of individuals with arthritis were sedentary and had high blood pressure.

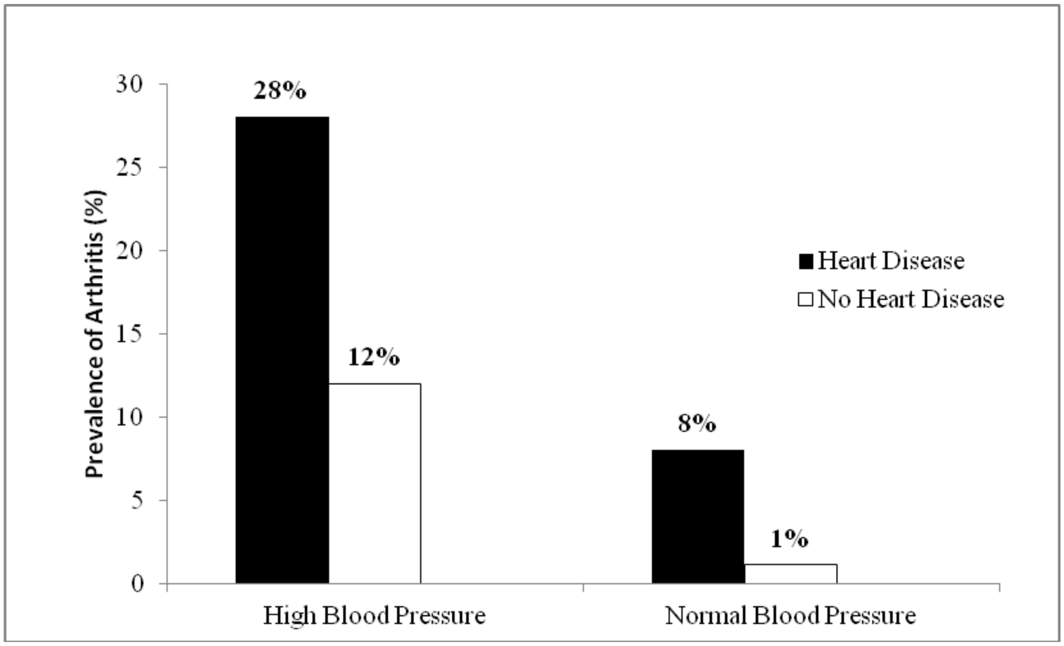

Figure 4- 2: Prevalence of arthritis by blood pressure and heart disease. Respondents with high blood pressure and heart disease had a significantly higher prevalence of arthritis, compared to respondents without heart disease and high blood pressure.

4.1.6 Age by gender multivariate stratification:

Results (Table 4-3) from multivariate logistic regression model fitted with arthritis as the outcome indicated that age, gender and age by gender interaction showed significant association with arthritis. Upon further analysis, a stratified (by age and gender) analysis found that physical activity was significant in three groups: a) females between the ages of 18-44 years, b) males between the ages of 65-79 years and c) males over 80 years. Table 4-4 provides a brief outline of significant variables while the specific values are seen in Appendix Table A-3. Older males were less likely to have arthritis if they participated in moderate/vigorous activity. Males who were between the ages of 65-79 years (OR= 0.79, 95% CI: 0.61, 0.96), as well as over the age of 80 years (OR =1.66, 95% CI: 1.08, 2.53) were less likely to have arthritis. A different observation was found for females. Females, between the ages of 18-44 years who participated in light activity (OR= 1.34; 95% CI: 1.05, 1.71) were more likely to have arthritis.

Body Mass Index:

BMI was a significant factor for both genders in all age groups, with increasing BMI having a positive association with having arthritis (OR ranged from 1.08 – 3.28), when compared to respondents who were normal weight or underweight. For females of all age groups, being overweight or obese (class I, II or III) was associated with having arthritis, with the highest OR attributed to 80+ year females who were obese class II/III (OR =3.11; 95% CI: 1.54, 6.29). Among younger males (18-44 years), only respondents who were obese class II/III were significantly associated with having arthritis, while males who were overweight or obese class I did not show an association. Being overweight among males was only significantly associated with arthritis for the 65-79 year and 80+ year age groups.

Chronic conditions:

Back problems, mental disorders and respiratory disorders were the only factors that were significant across all age groups and genders. Overall, among individuals with arthritis, back problems was the most prevalent chronic condition (Table 4-1) and had the highest odds of having arthritis (OR 2.1-3.4) (Appendix Table A-3). Heart disease was significant for both male and female respondents between the ages 65-79 years and only for female respondents between 45-64 years (OR = 1.5, 95% CI: 1.05, 2.03). A significant interaction effect between high blood pressure and physical activity was also found. Among male respondents over the age of 80 years with high blood pressure, light (OR = 2.03, 95% CI: 1.07, 3.84) and moderate/vigorous (OR = 2.56 95% CI: 1.37, 4.82) activity was associated with a higher odds of having arthritis.

Smoking Status:

Respondents smoking status was significant in the model for both males and females between the ages of 18-64 years and significant only for females aged 65-79. When compared to non-smokers, current smokers were significantly associated with having arthritis for respondents under the age of 65 years (OR between 1.17 and 1.56), while former smokers who were over the age of 44 years were more likely to have arthritis (OR between 1.17 and 1.43).

Alcohol Use:

Alcohol was strictly a significant factor for female respondents between 18-64 years in age as regular drinkers were less likely to be associated with arthritis when compared to female respondents who abstained (OR between 0.68-0.82). Females between the ages of 18-44 years were 32% less likely to have arthritis if they regularly drank alcohol, when compared to respondents who never drank. Similarly, female respondents who were between the ages of 45-64 years were 18% less likely to have arthritis, compared to respondents who never drank.

Table 4- 4: Significance of demographic, behavioural and medical factors, stratified by age and gender using 8 multivariate models corresponding to the different age and gender groups.

	18-44 years		**45-64 years**		**65-79 years**		**80+ years**	
	Male	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
Physical Activity		X			X		X	
BMI	X	X	X	X	X	X	X	X
Education		X	X	X	X		X	
Marital Status	X	X		X		X		
Smoke	X	X	X	X		X		
Alcohol		X		X				
Residence	X		X		X			
Back problems	X	X	X	X	X	X	X	X
High Blood Pressure	X	X	X	X			X	
Heart Disease				X	X	X		
Diabetes				X		X		
Bowel Disorder	X	X	X	X	X	X		X
Mental health	X	X	X	X	X	X	X	X
Respiratory Disease	X	X	X	X	X	X	X	X
Intestinal or Stomach Ulcer	X	X	X	X	X	X	X	
PA*HBP							X	
HD*HBP								

X Denotes p-value <0.05

Abbreviations: PA, Physical Activity; BMI, Body Mass Index; HBP, High Blood Pressure; HD, Heart Disease.

4.2 Part 2: Explanatory factors associated with physical activity level in persons with arthritis.

The analysis for study objective one demonstrated that physical activity is a significant factor in explaining arthritis among the general population and also showed that the strength of the relationship between physical activity and arthritis relied upon both the age and gender of the individual. This motivated us to examine the second objective, namely to identify factors that explained physical activity in persons with arthritis.

4.2.1 Distribution of factors:

Among respondents with arthritis, 71.9% were sedentary (Table 4-1). Respondents who engaged in light or moderate/vigorous activity level had a similar distribution of demographic and behavioral characteristics as respondents who were sedentary (Appendix Table A-5), with the exception of BMI. The distribution of BMI among respondents who were sedentary was different from individuals who participated in light or moderate/vigorous activity. Most notably, the highest proportion of sedentary activity was reported by individuals who were overweight (36.4%), compared to normal/underweight (35.5%), obese class 1 (17.9%), and obese class II/III (10.2%) (Appendix Table A-5). In contrast, the highest proportion of light activity, as well as moderate/vigorous activity was reported by normal/underweight respondents (42.0% and 47.4% respectively). Figure 4-3 shows that the proportion of physical activity at all levels decreases with increasing BMI; however, the proportion of sedentary activity was the lowest

(36%), relative to light (42%) and moderate/vigorous activity (47%) for normal/underweight respondents, where as the opposite trend was observed for obese class I and obese class I/II respondents.

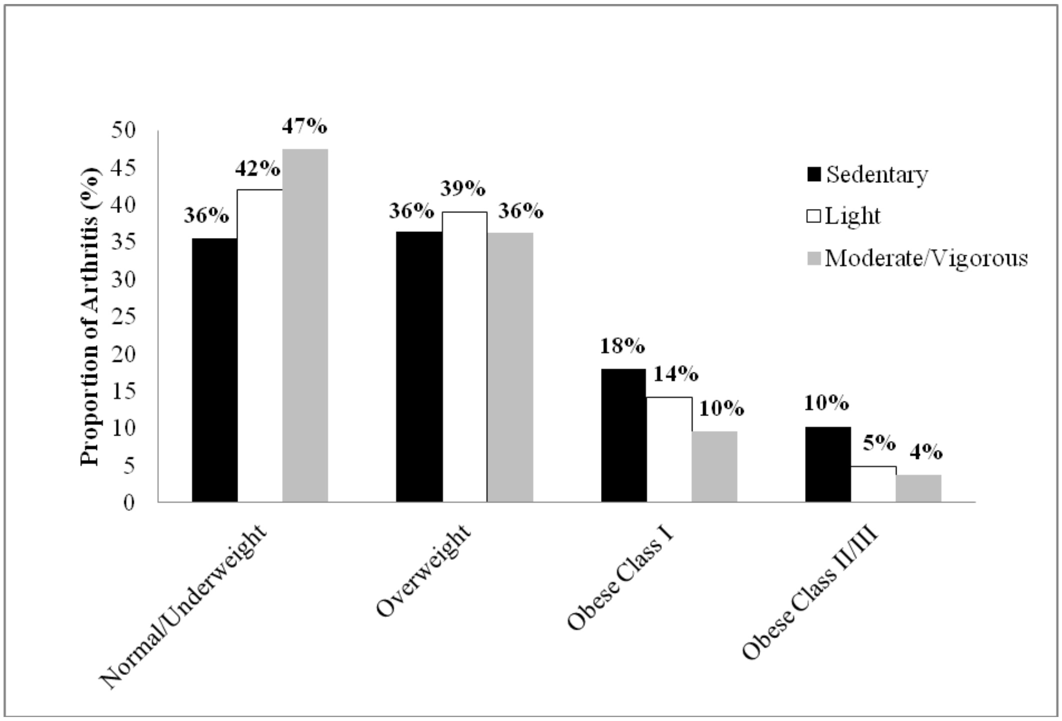

Figure 4- 3: Weighted proportion of physical activity for each body mass index (BMI) category. For individuals with arthritis, the proportion of physical activity at all levels decreases as BMI increases. Sedentary activity was the highest physical activity level among obese respondents with arthritis, compared to light and moderate/vigorous activity. (BMI categories: Normal/underweight = <25kg/m^2; Overweight = 25-29kg/m^2; Obese Class I = 29-35kg/m^2; Obese Class II/III = >35kg/m^2).

The most prevalent medical conditions among sedentary arthritis respondents were back problems (43.3%) and high blood pressure (38.8%) (Table A-4). Similarly, among respondents who participated in light activity level, as well as moderate/vigorous activity level, back problems (39.2% and 36.9%, respectively), and high blood pressure (33.1% and 29.7%, respectively) were the most prevalent chronic conditions. Figure 4-4 shows the trend in the proportions of physical activity level for respondents who did not have back problems was the opposite for respondents who did have high blood pressure. A similar trend was observed for the relationship between physical activity and high blood pressure. Figure 4-5 illustrates that the proportion of sedentary activity was the lowest (61%), relative to light and moderate/vigorous activity, for respondents who did not have high blood pressure. For respondents who did have high blood pressure, sedentary activity (39%) was the most prevalent activity.

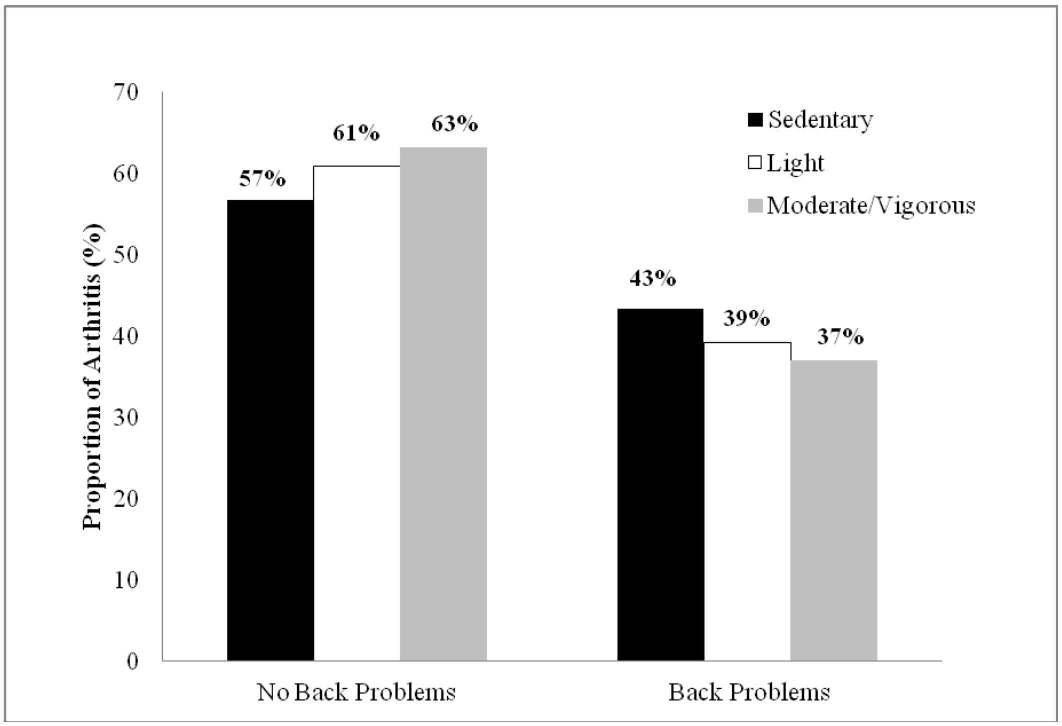

Figure 4- 4: Weighted proportion of physical activity for back problems. For individuals with arthritis who did not have back problems, the proportion of moderate/vigorous activity was the highest compared to other physical activity levels. Among individuals who did have back problems, sedentary activity had the highest proportion.

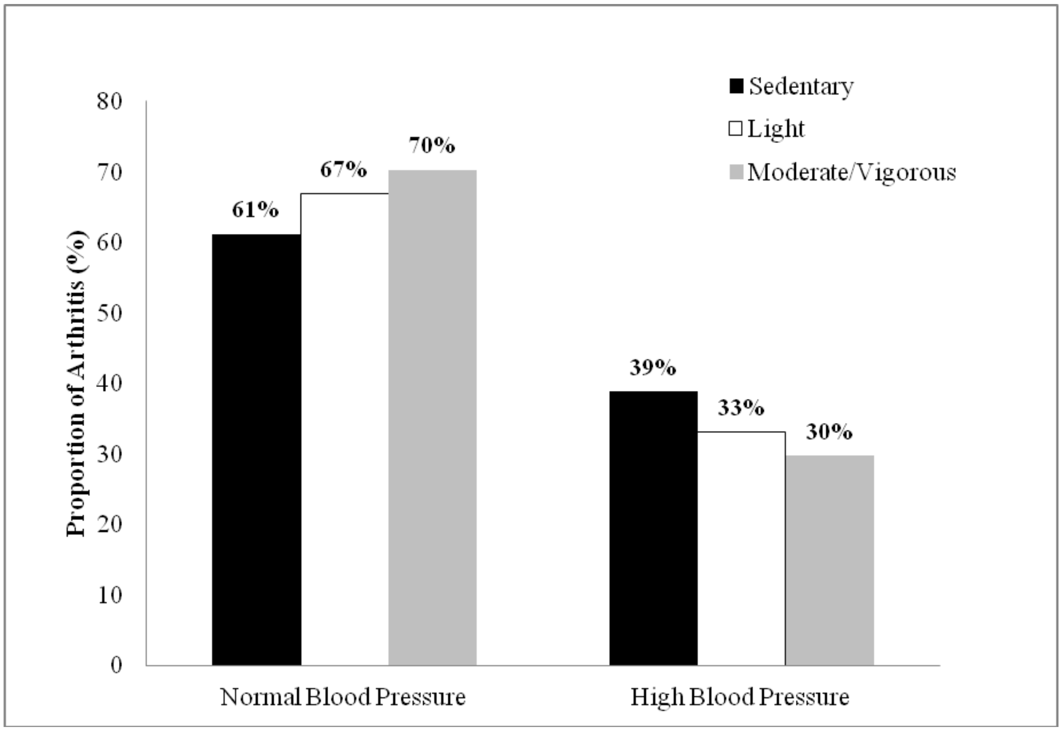

Figure 4- 5: Weighted proportion of physical activity for blood pressure. For individuals with arthritis, the proportion of physical activity at all levels decreased with the presence of high blood pressure. Sedentary activity was the highest physical activity level among high blood pressure respondents with arthritis, compared to light and moderate/vigorous activity.

Besides back problems and blood pressure, the next most prevalent chronic condition for respondents who were sedentary was mental disorders (18.1%). This is in contrast to respondents who participated in light or moderate/vigorous activity where the next most prevalent condition was respiratory disorders (13.8% and 13.2%, respectively). When compared to sedentary respondents, the absolute prevalence for all chronic conditions was lower among respondents who participated light activity or moderate/vigorous activity level.

4.2.2 Univariate logistic regression analysis with physical activity as the outcome variable:

When predicting the likelihood of sedentary activity compared to light activity level among respondents with arthritis, gender, BMI, education, sense of community belonging, smoking status, alcohol status, high blood pressure and mental disorders were all highly significant factors (p-value <0.0001). Age, marital status, diabetes, back problems and heart disease were also significant factors (p-value <0.05) (Table A-5 in Appendix 3.2).

In the univariate analysis, the model predicting the likelihood of light activity versus moderate/vigorous activity among respondents with arthritis had 7 significant factors that were all also significant in the sedentary versus light model. These significant factors were, age, gender, BMI, education, sense of community belonging, high blood pressure, and diabetes. Unlike the sedentary versus light model, (5 factors) marital status, smoking status, alcohol status, heart disease, and mental disorders were not significant in the light versus moderate/vigorous model. (Table A-5 in Appendix 3.2).

4.2.3 Multivariate logistic regression analysis with physical activity as the outcome variable:

Results from two models using adjacent category ordinal regression are shown on Table 4-5. Two binary logistic regression models; physical activity at sedentary versus light activity (Model 1), and physical activity at light versus moderate-to-vigorous (Model 2) were considered within the arthritis cohort.

Model 1: Sedentary activity versus light activity

Among all the significant factors, arthritis respondents who were obese class II/III had the greatest likelihood of sedentary (OR= 2.33; 95% CI: 1.84, 2.96) (Table 4-5). In addition, females were more likely to be sedentary when compared to males (OR = 1.27, 95% CI: 1.13, 1.43). Respondents who were current daily/occasional smokers (OR= 1.29; 95% CI: 1.06, 1.58) were also more likely to be sedentary. Age was also a significant factor as individuals with arthritis who were between the ages of 65-79 years were less likely to be sedentary when compared to respondents who were 18-44 years (OR= 0.70; 95% CI: 0.57, 0.85). Among all the factors, respondents who were regular drinker of alcohol were the least likely to be sedentary (OR = 0.73; 95% CI: 0.64, 0.83).

Model 2 Light activity category versus a moderate/vigorous activity:

Among all significant factors, arthritis respondents who had high blood pressure and smoked had the highest likelihood of participating in light activity, as opposed to moderate/vigorous activity (OR = 2.34; 95% CI: 1.42, 3.87). Females (OR = 1.08; 95% CI: 1.08, 1.53), respondents who were obese (obese class I) (OR = 1.61; 95% CI: 1.28, 2.03) and current daily/occasional smokers (OR= 1.75; 95% CI: 1.29, 2.37) were all associated with light activity (Table 4-5). Respondents who were 80 years or older (OR =0.67; 95% CI: 0.48, 0.95) as well as those who had post-secondary education (OR = 0.70; 95% CI: 0.57, 0.85) were less likely to be associated with light activity.

Comparing the two multivariate models, we found that age, gender, BMI, education, and smoking status were factors seen in both models. Arthritis respondents who were female, obese class II/III, and were current smokers were more likely to participate in the lower level of activity, while older respondents and individuals with post-secondary education were less likely to participate in lower levels of activity. Three factors were different between the models: sense of belonging to community was significant in Model 1 only, alcohol status was significant in Model 1 only, and the interaction effect between high blood pressure and smoking was significant in Model 2 only (Table 4-5).

Table 4- 5: Multiple logistic regression using adjacent-category analysis among respondents with arthritis

	Model 1: sedentary activity VS Light activity(reference)				Model 2 Light activity VS Moderate/Vigorous activity (reference)			
Factor	**OR**	**95% CI**		**p-value**	**OR**	**95% CI**		**p-value**
AGE (years)				<0.0001				<0.0001
18-44	Ref							
45-64	0.95	0.77	1.16	0.60	1.31	0.97	1.76	0.08
65-79	0.70	0.57	0.85	<0.0001	1.11	0.82	1.50	0.50
80+	0.80	0.63	1.03	0.08	0.68	0.48	0.95	0.03
Gender								
Male	Ref							
Female	1.27	1.13	1.43	<0.0001	1.29	1.08	1.53	<0.001
BMI								
Normal/Underweight (<25.0 kg/m^2)	Ref							
Overweight (25.0 – 29.9 kg/m^2)	1.16	1.03	1.31	0.015	1.16	0.97	1.38	0.11
Obese class I (30.0 - 34.9 kg/m^2)	1.54	1.32	1.80	<0.0001	1.61	1.28	2.03	<0.0001
Obese class II/III (>35.0 kg/m^2)	2.33	1.84	2.96	<0.0001	1.41	0.95	2.1	0.09
Education								
High school not completed	Ref							
High school completed	0.92	0.77	1.09	0.32	0.82	0.64	1.05	0.11
Any post secondary	0.76	0.67	0.87	<0.0001	0.70	0.57	0.85	<0.0001

Factor	Outcome: sedentary activity VS Light activity (reference)				Outcome: Light activity VS Moderate/Vigorous activity (reference)			
	OR	**95% CI**		**p-value**	**OR**	**95% CI**		**p-value**
Sense of Belonging to Community								NS
Weak	Ref							
Strong	0.79	0.70	0.89	<0.0001				
Smoke								
Never	Ref							
Current (daily/occasional)	1.29	1.06	1.58	0.01	1.75	1.29	2.37	<0.0001
Former	0.92	0.79	1.07	0.27	1.22	0.96	1.54	0.11
Alcohol								NS
Never	Ref							
Regular (1/month or more)	0.73	0.64	0.83	<0.0001				
Occasional (<1/month)	0.96	0.82	1.12	0.60				
Mental Disorder								
No	Ref							
Yes	0.92	0.77	1.09	0.32	0.82	0.64	1.05	0.11
HBP *smoke				NS				0.02
Never								
Current (daily/occasional)					2.34	1.42	3.87	<0.001
Former					1.63	1.01	2.62	0.44

Abbreviations: NS, Not significant; BMI, Body Mass Index; HBP, High Blood Pressure
Mental Disorder includes depression, bipolar disorder, mania or dysthymia, or anxiety disorder
Respiratory Disorder includes asthma, chronic bronchitis, emphysema, or chronic obstructive pulmonary disorder

Chapter 5: Discussion

Using the CCHS 2007-2008 dataset from Statistics Canada, the relationship between physical activity and arthritis was explained by demographic, behavioural and medical factors among 120,838 Canadian respondents. Using logistic regression, we investigated the effect of physical activity on the likelihood of having arthritis. We further explained what demographic, behavioural and medical factors influenced physical activity, an important component of arthritis management(25,187), among respondents with arthritis.

In our population sample, the prevalence of arthritis for respondents 18 years of age or older, was 16.3%, which was higher than the prevalence of diabetes (6.8%) heart disease (5.6%) or cancer (1.8%).(188) This proportion is similar to the 2009 prevalence rate of 16.0%, reported by the Public Health Agency of Canada for over 4,500 individuals 20 years of age or older.(189) In comparison, American population-based studies using self-reported professionally diagnosed arthritis report higher prevalence rates (for 2004-2005), between 21.5% and 35%.(23,77)

Looking at the distribution of our population, we found that compared to respondents without arthritis, individuals with arthritis were mostly female, older, had a higher mean BMI (27.7 kg/m^2) and had a higher prevalence of back problems, heart disease and high blood pressure. This is congruent with the findings from cross-sectional population study of over 130,000 Canadian respondents.(190) Using the CCHS 2005, Kaptein and colleagues reported that respondents with arthritis were also older (over 66% were over the age of 65 years), female (63%), and overweight or obese (62%).(190)

The distribution of physical activity was similar for respondents with and without arthritis. The majority of respondents with arthritis (72%) and without arthritis (71%) were sedentary, while approximately 10% participated in moderate-to-vigorous activity (9% for respondents with arthritis and 11.4% for respondents without arthritis), a level that is recommended by the Canadian Society for Exercise Physiology for increased health benefit.(2) The prevalence of sedentary activity among individuals with arthritis is variable as previous Canadian studies report rates 57%-60% of inactivity.(190,191) This is different from our analysis where 72% of respondents with arthritis were sedentary. This difference is likely related to a different method of classifying physical activity. Our study constructed a classification methodology that was specific to the age of the respondents (see Chapter 3) unlike others who did not report age adjustment for physical activity. It is possible that younger respondents (less than 25 years of age), who would be classified in light activity, may be sedentary after accounting for age. This is concerning, as previous estimates of sedentary activity may be conservative, ultimately underestimating its prevalence in the population. Given this distribution of physical activity, potential influential factors were further examined to identify factors that may explain the patterns exhibited by individuals with and without arthritis.

In the multivariate model, light activity was moderately associated (OR=1.11; 95% CI: 1.03, 1.21) with arthritis in comparison to sedentary activity; however, no association between arthritis and moderate/vigorous activity was found. This implies that individuals with arthritis were participating in light activity, but were not reaching the recommended levels. Our findings agree with a population-based survey of over 200,000 American respondents with arthritis, where 39% were physically inactive, while over 60% were classified as insufficiently active; suggesting that the majority of respondents with arthritis were engaged in some form of activity comparable to light activity.(4) One may speculate that respondents who had arthritis were participating in physical activity to strengthen muscles and reduce further degradation of cartilage.(25) Our results indicate that perhaps individuals with arthritis are aware of the health benefits of physical activity in the management of arthritis and are therefore attempting to adhere to activity recommendations. A cross-sectional study of over 10,000 American adults with arthritis determined that people with arthritis were more inclined (OR=1.22; 95% CI: 1.12, 1.32) to participate in physical activity if their health care provider had recommended activity participation.(192) This further lends support to the notion that given the appropriate information (in this case health professionals recommending physical activity for managing arthritis), people with arthritis are, at the very least, attempting to manage arthritis with physical activity. In addition to identifying the general relationship between arthritis and physical activity, we were also able to describe among which categories of age and gender physical activity was an important factor in explaining arthritis, which were females between the ages of 18-44 years and males over 65 years of age.

When we adjusted for significant demographic (not including age and gender effects), behavioural and chronic conditions, we found that physical activity was significant in the model for males over the age of 65 years as well as for females between the ages of 18-44 years. Males between the ages of 65-79 years, who participated in moderate-to-vigorous activity, were 36% less likely to have arthritis than respondents who participated in sedentary activity. A large population-based study of over 132,000 Canadians found that among men between 65-74 years of age who were physically active, the prevalence of arthritis was lower, as compared to lower levels of activity, which had a higher prevalence of arthritis.(193)

Contrary to the findings reported in men 65-74 years of age, males 80 years of age or older who participated in moderate/vigorous activity were more likely to have arthritis than respondents who were sedentary. This implies that older males who had arthritis were reaching recommended levels of activity. This finding was reported by the U.S. Surgeon General Report on physical activity which found that overall, males 75 years of age or older, had a higher prevalence of leisure time physical activity, compared to males in younger age groups.(13) Previous studies that defined physical activity did not adjust for METs, with consideration for age; therefore investigators did not find active individuals who were 80 years of age or older, because the activity level was based on a younger male. Following an age-adjustment, this thesis did, indeed, find that males 80 years of age or older with arthritis were meeting the recommended levels of activity. Another possible reason as to why we do not see the same relationship among males in the 65-79 year age group is that males in this age group may still be employed, as evidence suggests people are working past the conventional retirement age (194); therefore, males with arthritis in this age group who may not have the same amount of leisure time to participate in physical activity as older individuals. However, one can speculate that because we did not know the severity of disease, individuals who were alive at 80 years of age or older, had less severe arthritis and therefore able to participate in higher levels of activity. Continuing with this scenario, if individuals with severe arthritis were included, the results may not have been as significant. Despite the severity, our population indicated that males 80 years of age or older who participated in moderate/vigorous were more likely to have arthritis.

We also found that light activity as associated with having arthritis (OR=1.34; 95% CI: 1.05, 1.71) for females between the ages of 18-44 years. This subgroup accounted for less than 13% of the total general population and less than 3% participated in light activity. Although significant, this cannot be generalized, as the sample of young females is small. To our knowledge, no other studies have reported this activity level in this group.

The type of activity may also be a factor in determining the level of physical activity reported. Walking is the most common activity reported for all ages with or without arthritis (193) and due to a lower cardiorespiratory capacity among older adults, walking or gardening may be a moderate-to-vigorous activity, while only considered light activity for younger adults.(13) Individuals with arthritis may be more comfortable walking for exercise rather than participating in other strenuous activities; therefore, male respondents over the age of 80 years who had arthritis and excess leisure time, were engaging in moderate-to-vigorous activity (for their age group) such as walking.

Another interesting observation was a significant interaction between high blood pressure and physical activity in explaining arthritis. Figure 4-1 suggests that the prevalence of arthritis was much higher among sedentary respondents who had high blood pressure, as compared to sedentary respondents with normal blood pressure. Essentially, the prevalence of arthritis among sedentary respondents was associated with the presence high blood pressure. Because of the cross sectional design, we were unable to ascertain whether the high blood pressure was a result of being sedentary or whether the HBP inhibited the activity. From a clinical perspective acetaminophen and NSAIDs, common pain relieving medications taken by individuals with arthritis, had a strong association with high blood pressure.(195-198) Faselis and colleagues found that among 265 patients with resistant hypertension, 88% were due to NSAIDS.(198) NSAIDs and acetaminophen are said to hinder the production of prostaglandins, a natural regulator of blood pressure within the body; therefore leaving the human system unable to maintain blood pressure at a normal level.(196)

Interestingly, many of the drugs, (non-steroidal anti-inflammatory drugs) taken by those who have arthritis (typically OA), increase their blood pressure by nearly 5.0mmHG.(199) An increase between 5-6mmHg is considered a clinically important difference in blood pressure where a 67% increase in stroke or a 15% increase in heart disease has been observed.(200) In a literature review of the effect analgesics and NSAIDs have on blood pressure, the authors determined that both analgesics and NSAIDs result in high salt and fluid retention, resulting in high blood pressure.(201)

The interaction between high blood pressure and heart disease was also significant. The prevalence of arthritis among individuals with high blood pressure also depended on whether the respondent had heart disease. The effect of heart disease, coupled with high blood pressure, on the prevalence of arthritis was more than 4-fold greater than just having high blood pressure alone. Furthermore, the prevalence of arthritis was more than doubled when respondents had high blood pressure and heart disease, compared to heart disease only (Figure 4-2). It has been earlier established that respondents with arthritis often take medications that lead to a higher likelihood of having high blood pressure (10-13), which is a well-known risk factor for heart disease. A meta-analysis of 61 studies that looked at the association of high blood pressure and heart disease, identifying high blood pressure as a modifiable risk factor for heart disease. Investigators further outlined that a reduction in systolic blood pressure of 10mm Hg was associated with a 30% reduction in the risk of heart disease. We did not, however, find a three-way interaction among HBP, heart disease and activity, which would indicate that these three factors were not significant in explaining arthritis, together.

Interestingly, we found that BMI, high blood pressure, and heart disease were factors that not only had significantly high odds ratios, but also were also present in interaction effects. Out of the 3 factors, respondents who were obese class II/III had the highest OR for having arthritis (OR=2.18; 95% CI: 1.95, 2.44). High levels of BMI is a known risk factor for osteoarthritis through increased stress on weight-bearing joints (46); however, in addition to the direct mechanical effect on joints, high levels of BMI have been shown to have a metabolic influence on cartilage.(202) High BMI, as well as high blood pressure are two disorders that are part of Metabolic Syndrome (MetS). Metabolic syndrome (MetS) is a group disorders (which include high blood pressure and high BMI) that is used to identify individuals who are at an increased risk of cardiovascular disease, and has been shown to be positively associated with arthritis.(203) Therefore, the significance of these modifiable factors comes as no surprise. A cross-sectional study of 7,714 American adults found that the prevalence of MetS among individuals with OA was 59%, whereas the prevalence among individuals who did not have OA was only 23%.(204) Investigators further determined that individuals with OA were 5.26 times more likely to have MetS, compared to individuals who did not have OA.(204) The association between MetS and OA suggests that a subgroup of OA may also be due to a series of metabolic disorders. Importantly, through weight loss and proper medication, MetS is preventable and treatable.(205)

Our earlier findings, based on a multivariate logistic regression analysis, indicated that individuals who participated in light activity were associated with arthritis. We wanted to further understand what factors explained physical activity in this cohort of respondents with arthritis. We conducted a preliminary analysis based on an ordinal regression model with physical activity as the outcome variable (sedentary, light and moderate-to-vigorous activity). The model diagnostics indicated the underlying assumption of the proportional odds model was violated and we used the adjacent-category ordinal regression as an alternative to proportional odds model. Unlike the proportional odds model, which allows one model to be developed for the 3 levels of physical activity, the adjacent-category model can compare only 2 categories at a time, hence two separate models that explained physical activity. The comparisons included: 1) sedentary versus light; and 2) light versus moderate-to-vigorous activity. The advantage of using the adjacent-category analysis was that we were able to focus on two groups of individuals with arthritis: respondents who participated in minimal to no activity, where factors associated with sedentary activity were identified; as well as respondents who were more active, where we identified factors associated with light activity, as opposed to moderate-to-vigorous activity. Although this method develops two models, it still maintains ordinality; which is important as ordered physical activity levels was a primary variable in our study.

We found several demographic, behavioral and medical factors that explained physical activity among respondents with arthritis. The largest effect was attributed to BMI in relation to sedentary activity. Respondents with arthritis who were obese class II or III (35 kg/m^2or higher BMI) were over two-fold more likely to be sedentary than those who were normal or underweight (OR = 2.33; 95% CI: 1.84, 2.96). Similarly, obese class I (30.0 -34.9 kg/m2 BMI) respondents with arthritis were more likely to engage in light activity than moderate-to-vigorous activity (OR= 1.61; 95% CI: 1.28, 2.03); however, the effect was not as large as the effect comparing sedentary and light activity. Overall, this shows that among individuals with arthritis, increased BMI was associated with lower levels of physical activity. An American population study of over 17,000 respondents with arthritis found similar results as increased BMI was shown to have a lower affinity to physical activity.(23) Investigators found that respondents who were obese class I, II and III (BMI) were 37%, 46% and 62%, respectively, less likely to participate in recent exercise or physical activity compared to respondents who were had a normal BMI. This can potentially be explained through the framework of Theory of Planned Behavior, whereby an action (physical activity) is determined by intention and perceived difficulty. Higher levels of BMI can create more pain and exertion making it more difficult to continue an active lifestyle, resulting in lower levels of activity.(136) Furthermore, high BMI is a component of MetS, which as explained before, is a series of disorders that identify individuals who have an increased risk of cardiovascular disease, and is associated with arthritis.(203,204,206) A prospective longitudinal study that investigated the relationship between physical activity and MetS (high BMI in particular) among individuals with OA determined that following nearly 5 months of physical activity intervention, patients showed improvement in joint function and a reduction in BMI.(206) Investigators also found that increased physical activity improved other metabolic indicators of MetS, such as high blood pressure and diabetes.(206)The investigators suggested that the observed findings indicated a cyclical process between physical activity, MetS, and arthritis. In other words, increased activity levels reduce excessive weight, and improve high blood pressure, resulting in alleviated symptoms of arthritis, which in turn allows individuals to participate in more activity.

Another interesting finding was the significant interaction between high blood pressure and smoking in explaining physical activity. Among respondents with high blood pressure, current smokers were over 2 times more likely to participate in light activity (as opposed to moderate-to-vigorous activity) than non-smokers with high blood pressure. The likelihood of light activity seemed to be amplified when respondents had both high blood pressure and smoking (OR=

2.34; 95% CI: 1.42, 3.87) than just smoking alone (OR=1.29; 95% CI: 1.06, 1.58)). Smoking is independently associated with high blood pressure(207), but also associated with lower levels of activity(151), which in turn, is a risk factor for high blood pressure.(208) In a 14-year prospective cohort study of 8,251 male subjects who smoked, investigators found that compared to non-smokers, smokers were at a 1.13 times risk of having hypertension.(209) Additionally, smoking has been shown to have a negative association with physical activity due to poor lung function(151) and oxidative stress.(147) These findings imply that respondents who smoke and have high blood pressure are more likely to participate in lower levels of activity rather than higher intensity levels of activity.

Alcohol was a significant factor in the model that compared sedentary and light activity. Respondents who consumed regular alcohol were less likely to be sedentary than those who regularly drank (OR = 0.73; 95% CI:0.64, 0.83). This reveals that respondents who drank alcohol on a regular basis were participating in more activity than respondents who did not regularly drink. A review of literature surrounding alcohol consumption and physical activity showed a positive association similar to our results;(139,140,142,143) French et al. found that ten extra drinks per month correlated to a 2.0% increase in vigorous exercise, in addition to light and moderate drinking being associated with a 9.0% and 14.3% increase in vigorous activity, respectively. They explained that regular consumption of alcohol was associated with increased activity because regular drinkers often consume in social gatherings following physical activity.

Additionally, they suggested that increased activity may be the result of consciously working off the extra calories of alcohol consumption.(142)

To our knowledge, this is the first study to use adjacent-category analysis with physical activity as the outcome among a population of individuals with arthritis. Moreover, individuals who are sedentary may possess characteristics that are significantly different from people who participate in any activity. Such characteristics may include being female, older age, overweight and obese as well as lower education.(23) This finding indicates that among individuals with arthritis, respondents who participated in light activity were more similar to respondents who participated in moderate-to-vigorous activity.

This study had several strengths, in particular, methodologically related factors, that give credence to the results. One of the most impactful strengths of our study was the large sample size. The use of the Canadian Community Health Survey 2007-2008 provided data that was representative of the Canadian general population except for those residing on Crown land, reserves, institutions, remote regions or respondents who worked full time in the Canadian Forces. To our knowledge, this is the most recent study to use a large Canadian sample size in a study examining factors that influence the relationship between arthritis and physical activity. A study done by Kaptein and Badley used the CCHS 2005 data with over 131,000 respondents; however, their design consisted only of a proportional analysis rather than a regression analysis.(190)

Another strength of the analysis was the re-categorization of the METs according to the categories recommended by the US Surgeon General Report on physical activity. The activity levels of active, moderately active and inactive, in the CCHS, are based on the ability of the average 40 year old male (70-kg); therefore the use of this metric on a population that is predominantly older than 40 years of age may not be appropriate. Re-categorizing the levels of activity using the METs outlined for each age group in the US Surgeon General Report allows an appropriate level of activity to correspond to the age of the respondent.

This study used a validated survey developed by Statistics Canada. The CCHS is a survey used to measure health and wellbeing of the Canadian population. High quality data is procured through computer-assisted interviews (CAI), which contain programmed editing to check for inconsistent answers. Furthermore, once completed, the process allows for immediate feedback to interviews and respondents for quality accuracy. Additionally, health indicators undergo a continual process of validation. Furthermore the CCHS allowed for complex sampling weights, providing robust data to make inferences.

Another strength of this study was that given that the assumptions of the proportional odds model were violated, an adjacent-category analysis was adopted. While a nominal regression analysis would have provided a single parsimonious model, the strength our analysis was in the fact that ordinality of physical activity was maintained. This allowed us to make conclusions based on increasing activity levels.

In light of the strengths of this study, five key limitations should be recognized, many of which center on measurement issues. First and foremost, our analysis was cross-sectional in design and as such, we were unable to determine causation. For instance, we were not able to definitively attribute the likelihood of arthritis to a level of physical activity because we did not know which came first, the activity level or the onset of arthritis. This is a common limitation among cross-sectional designs (210); however, associations can be identified and causations cannot be made. To look at causation, we would need a non-observation study design, such as a randomized control trial (RCT); however, RCTs typically have much smaller sample sizes, have limited external validity given the strict inclusion criteria and can take time and costs.(211) Despite being unable to determine causation, we were still able to identify factors that influence physical activity and arthritis.

An unavoidable shortcoming in our design was that the CCHS was comprised of self-reported data, specifically reporting physical activity and height /weight. For example physical activity was vulnerable to the use of self-reported physical activity which is recognized in the literature (212,213), it is possible that respondents over estimated the level of activity they participated in. In their review of limitations in physical activity data, Katzmarzyk and Tremblay found that when physical activity was measured repeatedly over time, respondents tended to increase their level of physical activity. They stated that because physical activity is now becoming more socially desirable, respondents would respond by reporting higher levels.(104) In a large systematic review, investigators explored whether a trend emerged between self-reported data and direct measurement in relation to physical activity.(115) Their study revealed a lower correlation between self-reported and direct measurements of physical activity; however, no discernible trend was observed (i.e. investigators whether self-reported measurement overestimated or underestimated physical activity in comparison to direct measurement). In the context of our study, the probability of physical activity overestimation is not reliant upon whether respondents had arthritis or not, and would therefore would be non-differential.

Much like physical activity, BMI was subject to possible limitations associated with self-reported data as it is often underestimated in questionnaires and could consequently underestimate our results.(214) It is possible that other demographic and behavioral factors were also underestimated or overestimated.

A third limitation of our design was that the CCHS questionnaire did not ask about the severity of arthritis nor differentiated between RA and OA. Studies have explored what physicians have used to assess the severity of arthritis and indicated that physical activity and function was consistently one of the criteria used to determine how severe a patient's arthritis was.(215-217) If the level of physical activity is dependent on the severity, a high prevalence of advanced arthritis may be a possibility in this cohort of respondents who were sedentary. Additionally, being able to identify the type of arthritis whether it is RA or OA would have provided more insight, as these diseases are remarkably different.

This study was limited to using the Adjacent-Category model, obtaining two different models for measuring physical activity among those with arthritis. Rather than a single parsimonious model, our study was confined to separating sedentary activity and moderate-to-vigorous activity. A proportional odds model would have been our initial choice; however, due to the underlying assumption being violated, the alternative adjacent-category analysis was used. However, an important point to address is that given the unavoidable nature of the response variable in which the underlying assumptions of the proportional odds model was violated, we chose to maintain ordinality by using the adjacent-category model rather than a nominal regression.

Arthritis is a painful and debilitating disease on its own; however, the addition of a sedentary lifestyle reduces the health benefits such as cardiovascular strength, normal blood pressure, diabetic control and weight loss among others, leaving people vulnerable so a plethora of additional chronic problems.(218) The findings from this study underscore the relationship between physical activity and arthritis with the hope of identifying vulnerable populations and barriers to activity.

Chapter 6:Conclusions and Recommendations

This study used the Canadian Community Health Survey, cycle 2007-2008, to elucidate information on the relationship between arthritis and physical activity. From 2007-2008, the prevalence of arthritis was 16.3% in a population where sedentary activity was highly prevalent among individuals with (72%) and without arthritis (71%).

Obtaining the recommended levels of physical activity is beneficial in both the prevention and management of arthritis. This thesis showed that although the majority of people with arthritis are not attaining the recommended levels of physical activity to remain healthy, they were more likely to participate in light activity instead of being sedentary. The implications of this suggest that current efforts to education the public on the benefits of physical activity in the management of arthritis are having a mild impact. Although individuals with arthritis are attempting to better manage arthritis with light physical activity, recommended levels of physical activity are not being reached; which may be due to other comorbid conditions. Considering individuals with arthritis are participating in light activity, it would be beneficial to understand what health strategies are having the greatest impact on physical activity improvement. Having better understanding of successful health strategies would inevitably help physical activity strategies to ensure individuals with arthritis reach higher levels of activity.

The results of this thesis provide evidence that the relationship between arthritis and physical activity varies across age and gender. Arthritis management programs may be able to utilize this information to focus further physical activity regiments on “high risk” age groups and gender. For example, our results imply that the primary target for promoting physical activity to prevent arthritis would be individuals between the ages of 65-79 years of age. Clinicians who to treat patients in this age group should be aware that their patients may stand to benefit the most from an increase in physical activity.

From a clinical perspective, we found that high blood pressure, heart disease, and in particular BMI, were significant modifiable factors that influenced physical activity and arthritis. Individuals who had high rates of BMI, high blood pressure or heart disease were highly likely to have arthritis. Furthermore, these three modifiable factors are potential barriers for reaching recommended levels of activity among individuals with arthritis. Therefore clinicians treating arthritis should specifically consider care plans that manage obesity, high blood pressure and cardiovascular diseases.

These findings also provide direction to public health initiatives. The Public Health Agency of Canada identifies a number of public policies that focus on reducing obesity, including subsidy programs, infrastructure plans and marketing restrictions; however, formalizing a national program focused primarily on individuals with arthritis would certainly go a long way in reducing obesity and increasing activity.

Despite the large body of literature surrounding arthritis, an ever changing demographic in Canada creates need for continual research. Through future research and the implementation of new strategies, new influential factors emerge and thus studies such as this are required to add to the growing body of literature. Overall, this cross-sectional study further elucidated the factors that explain arthritis among the general population, as well as provided insight into the influential elements that explain physical activity among individuals with arthritis.

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ppendix

A.1: Ethics and Research Data Centre Approval

Centres de données de recherche / Research Data Centres
RDC CDR

Research Data Centers Program **Programme des centres de données de recherche**

June 25, 2013

11-SSH-UAB-2748

Dear RDC Researcher:

Your Research Data Centre project entitled "***Factors influencing the physical activity level in a population with arthrits" has*** expired (or will be expiring) on ***7/31/2013***

Please take this opportunity to assess the next steps for your project and learn about your contractual obligations as a deemed employee under the Statistics Act. Information attached to this letter will assist principal investigators in closing a contract, extending a contract, or revisiting a contract at a later date for future work.

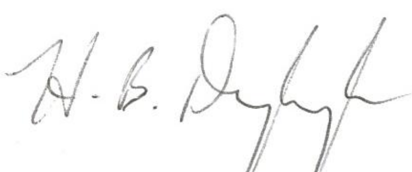
The additional sections will remind all researchers of their obligation to maintain the confidentiality of Statistics Canada microdata, and provide instructions on the return of security swipe cards, the appropriate way to dispose of sensitive statistical information stored in the RDC and provide information on the retention and disposal of project files.

If you have any questions regarding this information, please feel free to discuss with an RDC Analyst.

Finally, to ensure the continued success of the RDC program, your feedback is important to us. Enclosed is a brief questionnaire regarding various aspects of your work in the RDC. The survey should take no more than 5 minutes to complete and can be returned by email to:

MAD-HOOU@statcan.gc.ca **.**

We look forward to future collaboration and, of course, welcome new RDC proposals. Your RDC analyst will be happy to discuss new research opportunities with you.



Director, Microdata Access Division
Statistics Canada

Tel - : (613) 951-0501 *Fax* - : (613) 951-4272
email: heather.dryburgh@statcan.gc.ca

Health Research Ethics Board

308 Campus Tower
University of Alberta, Edmonton, AB T6G 1K8
p. 780.492.9724 (Biomedical Panel)
p. 780.492.0302 (Health Panel)
p. 780.492.0459
p. 780.492.0839
f. 780.492.9429

Approval Form

Date:	May 16, 2011
Principal Investigator:	Catherine Jones
Study ID:	Pro00021837
Study Title:	Factors Influencing the physical activity level in a population with arthritis
Approval Expiry Date:	May 14, 2012

Thank you for submitting the above study to the Health Research Ethics Board - Health Panel . Your application has been reviewed and approved on behalf of the committee.

This study involves the secondary analysis of anonymous StatsCan data.

A renewal report must be submitted next year prior to the expiry of this approval if your study still requires ethics approval. If you do not renew on or before the renewal expiry date, you will have to re-submit an ethics application.

Approval by the Health Research Ethics Board does not encompass authorization to access the patients, staff or resources of Alberta Health Services or other local health care institutions for the purposes of the research. Enquiries regarding Alberta Health Services administrative approval, and operational approval for areas impacted by the research, should be directed to the Alberta Health Services Regional Research Administration office, #1800 College Plaza, phone (780) 407-6041.

Sincerely,

Doug Gross, Ph.D.
Associate Chair, Health Research Ethics Board - Health Panel

Note: This correspondence includes an electronic signature (validation and approval via an online system).

UNIVERSITY OF ALBERTA   Alberta Health Services   Covenant Health

A.2 Tables

Table A- 1: Description of the CCHS survey and categorization methods for demographic, behavioural and medical factors

Demographic	CCHS Survey Questions	Categorization
Age (years)	"What is your age"	18-44 45-64 65-79 80+
Gender	"Is [respondent name] male or female?	Male Female
Marital Status	"What is [respondent name]'s marital status?	Single/Never Married Married/Common-Law Divorced/Widowed/Separated
Education (derived variable)	"What is the highest grade of elementary or high school have ever completed?" "Did you graduate from high school?" "Have you received any other education that could be counted towards a degree, certificate or diploma from an educational institution? "What is the highest degree, certificate or diploma you have obtained?"	High school not completed High school completed Any Post Secondary
Location of Residence (derived variable)	Respondent address information. CCHS defines an urban region as an area of a population concentration of 1000 or greater with a population density of 400 per square kilometer or greater.	Urban Rural
Health Utility Index (derived variable)	Based on an aggregation of 7 derived variables.	-------
Sense of belonging to community	"How would you describe your sense of belonging to your local community?"	Very strong? Somewhat strong? Somewhat weak? Very weak?
Behavioral		
Smoking Status	"At the present time, do you smoke cigarettes daily, occasionally or not at all?"	Never Occasional Regular
Alcohol Status	"During the past 12 months, that	Never

(derived variable)	is, [date one year ago] to yesterday have you had a drink of beer, wine, liquor or any other alcoholic beverage?" "During the past 12 months, how often did you drink alcoholic beverages?"	Occasional Regular
Medical	Long term conditions that are expected to last/ have lasted 6 months or more and been diagnosed by a health professional.	
High Blood Pressure	"Do you have high blood pressure?"	Yes/No
Heart Disease	"Do you have Heart Disease?"	Yes/No
Back Problems	"Do you have back problems, excluding fibromyalgia and arthritis?"	Yes/No
Diabetes	"Do you have diabetes?"	Yes/No
Bowel Disorder	"Do you suffer from a bowel disorder such as Crohn's Disease, Ulcerative colitis, Irritable Bowel Syndrome or bowel incontinence?"	Yes/No
Intestinal or stomach Ulcer	"Do you have intestinal or stomach ulcers?"	Yes/No
Mental Disorder	"Do you have anxiety disorder such as a phobia, obsessive-compulsive disorder or a panic disorder?" "Do you have mood disorder such as depression, bipolar disorder, mania or dysthymia?"	Yes/No
Physical Activity	"Have you done any of the following in the past 3 months, that is, from [date three months ago] to yesterday?"	Walking for exercise Gardening or yard work Swimming Bicycling Popular or social dance Home exercises Ice hockey Ice skating In-line skating or rollerblading Jogging or running Golfing Exercise class or aerobics Downhill skiing or snowboarding Bowling

	Baseball or softball
	Tennis
	Weight-lifting
	Fishing
	Volleyball
	Basketball
	Soccer
	Any other
	No physical activity

Table A- 2: Nomenclature and categorization of independent and dependent variables

Variable	CCHS Nomenclature	Categorization
Physical Activity	PACDEE PACDPAI	Sedentary Light Moderate-to-vigorous
Age	DHH_AGE	18-44 45-64 65-79 80+
Gender	DHH_SEX	Male Female
Body Mass Index (BMI)	HWTADWTK; HWTADHTM; HWTADBMI	Normal/Underweight (<25.0 kg/m^2) Overweight (25.0 – 29.9 kg/m^2) Obese class I (30.0 -34.9 kg/m^2) Obese class II/III (>35.0 kg/m^2)
Marital Status	DHH_MS	Single/Never Married Married/Common-Law Divorced/Widowed/Separated
Education	EDUDR04	< High school High school Grad Post-Secondary
Region	GEODUR2	Urban (population concentration of 1,000 or more + population density of >399 per square km Rural
Sense of Belonging to Community	GEN_10	Very strong Somewhat strong Somewhat weak Very weak
Smoking Status	SMKA_202	Never Daily/Occasional Former
Alcohol	ALC_3	Never Regular Drinker (1/month or more) Occasional Drinker (<1/month)
Arthritis	CCC_051	Yes/No
Back Problems	CCC_061	Yes/No
High Blood Pressure	CCC_071	Yes/No
Heart Disease	CCC_121	Yes/No
Diabetes	CCC_101	Yes/No

Bowel Disorder	CCC_171	Yes/No
Mental Disorder	CCC_280	Yes/No
	CCC_290	
Respiratory Disorder	CCC_031	Yes/No
	CCC_091	
	CCC_141	
Ulcer	CCC_141	Yes/No

Table A- 3: Multivariate model explaining arthritis across age and gender

	18-44						45-64						65-79						80+					
	Male			Female			Male			Female			Male			Female			Male			Female		
Factor	**OR**	**95% CI**		**OR**	**95% CI**		**OR**	**95% CI**		**OR**	**95% CI**		**OR**	**95% CI**		**OR**	**95% CI**		**OR**	**95% CI**		**OR**	**95% CI**	
Physical Activity																								
Sedentary	1			1			1			1			1			1			1			1		
Light	1.16	0.885	1.53	1.34	1.05	1.71	1.18	0.989	1.41	1.03	0.902	1.17	0.925	0.783	1.09	0.942	0.814	1.09	1.312	0.839	2.05	0.84	0.597	1.18
Moderate/Vigorous	1.11	0.808	1.53	0.838	0.615	1.14	0.98	0.801	1.2	1.11	0.9	1.37	0.794	0.659	0.957	0.739	0.605	0.903	1.654	1.08	2.53	0.878	0.58	1.33
BMI																								
Normal/Underweight	1			1			1			1			1			1			1			1		
overweight	1.08	0.849	1.37	1.415	1.14	1.75	1.18	0.995	1.39	1.17	1.03	1.33	1.38	1.18	1.62	1.4	1.24	1.59	1.356	1.01	1.812	1.46	1.2	1.79
obese class1	1.28	0.925	1.77	1.67	1.28	2.2	1.23	1.02	1.49	1.4	1.18	1.65	1.819	1.488	2.22	2.01	1.65	2.44	1.68	1.11	2.53	1.73	1.2	2.49
obese class II/III	2.52	1.67	3.8	2.17	1.61	2.92	1.92	1.46	2.51	1.92	1.57	2.34	2.44	1.78	3.36	2.35	1.8	3.07	3.28	0.757	14.18	3.11	1.54	6.29
Education																								
<high school				1			1			1			1						1					
High school grad				0.728	0.519	1.02	0.71	0.57	0.89	0.745	0.625	0.89	0.847	0.654	1.1				0.67	0.419	1.07			
post secondary				0.698	0.523	0.932	0.72	0.61	0.84	0.713	0.616	0.83	0.746	0.642	0.866				0.694	0.527	0.915			
Marital Status																								
Single/Never Married	1			1						1						1								
Married/Common Law	1.73	1.35	2.21	1.63	1.29	2.04				1.28	1.06	1.54				1.33	1	1.77						
Divorced/Seperated	3.57	2.33	5.47	1.96	1.44	2.68				1.4	0.14	1.71				1.46	1.08	1.97						
Smoking Status																								
Never	1			1			1			1						1								
Daily/Occasional	1.56	1.44	2.4	1.85	1.48	2.31	1.48	1.22	1.79	1.17	1.01	1.36				0.922	0.764	1.11						
Former	1.26	0.954	1.65	1.3	1.05	2.6	1.43	1.2	1.7	1.17	1.04	1.33				1.24	1.09	1.42						
Alcohol																								
Never				1						1														
Regular Drinker				0.676	0.521	0.876				0.823	0.709	0.96												
Occasional Drinker				0.959	0.728	1.26				1.05	0.875	1.25												
Rural Urban																								
Urban	1						1						1											
Rural	1.54	1.26	1.88				1.29	1.13	1.48				1.2	1.04	1.39									

Table A- 4: Measure of association, cramers' V/Kendall's Tau-b (round weights)

	PA	gender	Age	Education	BMI	marital status	Community	Smoking	Alcohol	BP	Diabetes	HBP	BD	MD	rural/ urban	HD	Ulcer	RD
PA	1.000	0.073	0.029	0.054	-0.071	0.051	0.085	0.053	0.068	0.038	0.034	0.034	0.020	0.045	0.014	0.014	0.019	0.013
Gender		1.000	0.045	0.011	0.167	0.147	-0.006	0.140	0.186	0.026	-0.025	0.017	0.080	0.094	-0.109	-0.025	0.006	0.042
AGE			1.000	-0.205	0.104	0.328	0.093	0.145	0.116	0.097	0.218	0.404	0.047	0.039	0.064	0.287	0.045	0.032
Education				1.000	-0.061	0.096	0.012	0.064	0.127	0.052	0.114	0.160	0.012	0.033	0.086	0.123	0.066	0.043
BMI					1.000	0.098	0.047	0.069	0.059	0.065	0.176	0.208	0.027	0.064	0.069	0.070	0.034	0.060
Marital status						1.000	0.078	0.108	0.070	0.071	0.100	0.194	0.035	0.076	0.078	0.120	0.032	0.038
Community							1.000	0.062	0.022	0.017	-0.013	-0.035	0.010	0.066	-0.051	-0.007	0.016	0.011
Smoking								1.000	0.147	0.078	0.051	0.097	0.030	0.105	0.057	0.066	0.040	0.043
Alcohol									1.000	0.023	0.125	0.093	0.035	0.057	0.019	0.087	0.039	0.024
BP										1.000	0.047	0.079	0.089	0.131	0.029	0.068	0.092	0.082
Diabetes											1.000	0.253	0.020	0.018	0.010	0.173	0.025	0.036
HBP												1.000	0.039	0.048	0.031	0.223	0.052	0.045
BD													1.000	0.115	0.015	0.043	0.121	0.057
MD														1.000	-0.008	0.041	0.088	0.097
rural/ urban															1.000	0.013	0.007	-0.006
HD																1.000	0.057	0.069
Ulcer																	1.000	0.054
RD																		1.000

Abbreviations: PA, Physical Activity; BMI, Body Mass Index; BP, Back Problems; HBP, High Blood Pressure; BD, Bowel Disorder; MD, Mental Disorder; HD, Heart Disease; RD, Respiratory Disorder

Table A- 5: Description of respondents with arthritis by sedentary, light and moderate/Vigorous activity.

Factor	Sedentary (%)	Light (%)	Moderate/ vigorous (%)
AGE		**	†††
18-44	14.30	12.79	14.67
45-64	46.87	43.07	37.96
65-79	29.10	34.78	32.12
80+	9.72	9.35	15.24
Gender		***	†
Male	35.70	43.39	47.75
Female	64.30	56.61	52.25
BMI		***	†
Normal/Underweight (<25.0 kg/m^2)	35.51	42.03	47.43
Overweight (25.0 – 29.9 kg/m^2)	36.38	38.96	36.34
Obese class I (30.0 -34.9 kg/m^2)	17.92	14.20	9.53
Obese class II/III (>35.0 kg/m^2)	10.19	4.82	3.71
Education		***	††
High school not completed	30.49	24.88	19.60
High school completed	16.52	14.98	13.70
Any Post secondary	52.99	60.13	66.70
Marital Status		**	
Single/Never Married	63.84	68.45	66.47
Married/Common Law	26.35	23.11	24.17
Divorced/Separate	9.81	8.44	9.36
Sense of belonging to Community		***	†
Weak	35.23	28.79	25.16
Strong	64.77	71.21	74.84
Smoking Status		***	
Never	23.60	17.84	14.05
Daily/Occasional	45.75	53.55	54.36
Former	30.66	28.62	31.58
Alcohol Use		***	
Never	51.04	61.49	65.44
Regular Drinker (≥1 drink/month)	20.48	16.96	15.62
Occasional Drinker (<1 drink/month)	28.48	21.55	18.94

Factor	Sedentary (%)	Light (%)	Moderate /vigorous (%)
Residence			
Urban	78.36	78.17	77.06
Rural	21.64	21.83	22.94
Back problems		*	
No	56.72	60.82	63.09
Yes	43.28	39.18	36.91
Blood Pressure		***	†
No	61.24	66.91	70.33
Yes	38.76	33.09	29.67
Heart Disease		*	
No	86.94	88.65	88.25
Yes	13.06	11.35	11.75
Diabetes		**	†
No	85.91	89.9	91.46
Yes	14.09	10.70	8.54
Bowel Disorder			
No	90.18	91.28	92.28
Yes	9.82	8.72	7.72
Mental Disorder		***	
No	81.87	86.17	87.61
Yes	18.13	13.22	12.39
Respiratory Disorder			
No	84.35	86.17	86.83
Yes	15.65	13.83	13.17
Intestinal and Stomach Ulcer			
No	92.61	93.95	93.48
Yes	7.39	6.05	6.52

* p-value <0.05 comparing Light versus Sedentary activity
**p-value <0.001 comparing Light versus Sedentary activity
***p-value<0.0001 comparing Light versus Sedentary activity
† p-value<0.05 comparing Moderate/Vigorous versus Light activity
†† p-value <0.001 comparing Moderate/Vigorous versus Light activity
††† p-value<0.0001 comparing Moderate/Vigorous versus Light activity

Abbreviations: BMI, Body Mass Index

Mental Disorder includes depression, bipolar disorder, mania or dysthymia, or anxiety disorder

Respiratory Disorder includes asthma, chronic bronchitis, emphysema, or chronic obstructive pulmonary disorder

A.3: A Brief Description of Adjacent-Category Ordinal Regression:

To examine ordinal responses association with several factors typically proportional odds model approach is recommended, provided its underlying assumption about proportionality of odds is met for all levels of the response. The proportional odds model holds the assumption that the β coefficients for each category remain the same. In other words, we assume that the slopes for all categories (j) are constant. This assumption was not met for the outcome physical activity; therefore an alternative approach called the adjacent-category analysis (219) was adopted to examine the association between ordinal outcome physical activity within arthritis group and with other social behaviour and medical factors. The ordinal response variable physical activity had three categories: sedentary, light and moderate/vigorous.

As an alternative to the proportional odds model, the adjacent-category model does not assume a constant slope for each response category; however it still maintains the ordinality of the response variable. Instead of comparing the probability of "success" for each category to a baseline, adjacent-category regression compares each category to the next highest category. In the case of physical activity, sedentary activity was compared to light activity and light activity was compared to moderate/vigorous activity. A limitation of this method is that it is unable to achieve a single parsimonious model. In mathematical notation we fit the following models based on adjacent category approach:(220)

By denoting three levels of ordinal response physical activity, sedentary activity, light activity and moderate/vigorous activity by 1,2,3, respectively, we represent two logistic models as

$$\log\left(\frac{\Pr ob(PA = "1" \mid X_1, X_2, ..., X_k)}{\Pr ob(PA = "2" \mid X_1, X_2, ..., X_k)}\right) = b_0^1 + b_1^1 X_1 + ... + b_k^1 X_k \quad \textbf{--------model (1)}$$

$$\log\left(\frac{\Pr ob(PA = "2" \mid X_1, X_2, ..., X_k)}{\Pr ob(PA = "3" \mid X_1, X_2, ..., X_k)}\right) = b_0^2 + b_1^2 X_1 + ... + b_k^2 X_k \quad \textbf{--------model (2)}$$

Abbreviations: PA, Physical Activity