

PHYSICAL ACTIVITY HABITS IN OLDER ADULTS WITH KNEE
OSTEOARTHRITIS

By

ELIZABETH A. CHMELO, M.S.

A Thesis Submitted to the Graduate Faculty of
WAKE FOREST UNIVERSITY GRADUATE SCHOOL OF ARTS AND SCIENCES
in Partial Fulfillment of the Requirements

for the Degree of

MASTER OF SCIENCE

In the Department of Clinical and Population Translational Science

AUGUST 2010

Winston-Salem, North Carolina

Committee Members:

Barb Nicklas, Ph.D., Advisor

Michael Berry, Ph.D., Chairman

Cralen Davis, MS

Claudine Legault, Ph.D.

Gary Miller, Ph.D.

DEDICATION

This thesis is dedicated to Dr. Eric Hall. I am honored to have you as a mentor. From my first experience with higher education at Elon, you were instrumental in showing me that learning doesn't end in the classroom or with a degree but is a lifelong process. I could never fully express my appreciation of your time, guidance, and friendship. Thank you for helping me get where I am today.

This thesis is also dedicated to my family, who have loved and supported me through every stage of my life. I appreciate your constant presence, encouragement, and love. I'm blessed to have the two of you as my parents, role models, and friends. Thank you for all of the opportunities you have given me and the sacrifices you have made to allow me to live the life I have.

ACKNOWLEDGEMENTS

I would like to formally thank:

Dr. Barbara Nicklas, for being my advisor. I am thankful to have you as my thesis advisor. I value your strong work ethic and your commitment to participants, staff, and colleagues. Thank you for the opportunity to have an authentic academic and professional experience. I enjoy working with you immensely. In this environment, I am able to cultivate the better parts of myself and my abilities.

Dr. Michael Berry, for serving as my thesis chair. I'm not sure how you got roped into this but I'm happy to have a familiar face chairing my committee. You are a constant reminder that research can be fun and it's never a bad time for a stats song. Thank you for being a mentor throughout both master experiences.

Cralen Davis, for serving on my thesis committee and your endless hours of data analysis and processing. I appreciate your light-hearted attitude and your patience with my numerous requests. I also appreciate your time and willingness to explain statistics to me. I would not have been able to finish this without your help.

Dr. Claudine Legault, for serving on my thesis committee. I value your knowledge in statistics and your ability to see the big picture. Thank you for your guidance and thoughts during the data analysis.

Dr. Gary Miller, for serving on my thesis committee. I am grateful for your knowledge and expertise working with accelerometers. You were able to provide insight into the world of accelerometers and data cleaning. Thank you for your time and direction.

Michelle Gordon, Charlotte Crotts, Lindsay Gordon, and the rest of the ladies in the GRC, for your attitudes and dedication to making a difference. I am grateful to be working with such amazing people that continually raise the bar. Every day is different and exciting. I'm fortunate to be able to say I look forward to coming to work every day and I truly enjoy my job.

TABLE OF CONTENTS

DEDICATION	2
ACKNOWLEDGEMENTS	3
LIST OF ABBREVIATIONS	5
LIST OF TABLES AND FIGURES	6
ABSTRACT	7
CHAPTER I: REVIEW OF LITERATURE	9
Specific Aims	18
CHAPTER II: PHYSICAL ACTIVITY HABITS OF OLDER AUDLTS WITH KNEE OSTEOARTHRISITS	21
Introduction	22
Subjects and Methods	23
Results	27
Discussion	30
Conclusion	33
CHAPTER III: OTHER ANALYSIS	44
REFERENCES	51
APPENDIX A	63
APPENDIX B	65
CURRICURUM VITA	66

LIST OF ABBREVIATIONS

6-minute Walk	6m W
Light physical activity	LPA
General Linear Model	GLM
Moderate physical activity	MPA
Osteoarthritis	OA
Non-Steroidal Anti-Inflammatory Drugs	NSAID
Physical activity	PA
Physical activity energy expenditure	PAEE
Physical Activity for Senior Exercise	PASE
Short Physical Performance Battery	SPPB
Vigorous physical activity	VPA
Western Ontario McMasters Universities Osteoarthritis Index	WOMAC

LIST OF TABLES AND FIGURES

TABLES	Page
Table 1: Participant Demographics	34
Table 2: Participant Physical Characteristics and Physical Function	35
Table 3: Participant Daily Physical Activity	36
Table 4: Correlations Between Physical Activity Variables and Participant Demographic and Physical Characteristics	37
Table 5: Relationship Between Physical Activity and Physical Function	38
Table 6: Results from Stepwise Models for Physical Activity Variables with Participant Demographic and Physical Characteristics	39
Table 7: Results from Four Separate Models for Physical Function with Each Physical Activity Measures	40
Table 8: Participant Physical Characteristics and Physical Function	49
Table 9. Participant Daily Physical Activity	50
 FIGURES	
Figure 1: Plot of Age and Daily Steps	41
Figure 2: Plot of Age and PAEE	42
Figure 3a: Ethnicity and Minutes of LPA	43
Figure 3b: Ethnicity and PAEE	43

ABSTRACT

Elizabeth Ashlee Chmelo

PHYSICAL ACTIVITY HABITS IN OLDER ADULTS WITH KNEE OSTEOARTHRITIS

Thesis under the direction of Barbara Nicklas, Ph.D., Department of Gerontology and Geriatric Medicine.

Osteoarthritis (OA) is a chronic, debilitating disease that is the leading cause of disability and functional limitations in adults¹⁻³. It is estimated that 15.8 million Americans between the ages of 25 and 74 have moderate to severe OA⁴. The most common symptoms of OA are joint pain, stiffness, and functional limitations. Previously, osteoarthritis was thought to be a result of “wear and tear” on the joints and physical activity was not an encouraged treatment. Now, it has become widely recognized that regular physical activity may benefit people with OA and may be a cost-effective treatment option for managing OA, symptoms such as reducing pain, improving muscle strength, and improving balance^{5,6}. Recent self-report findings indicate that only 18% of men and 14% of women aged 65-74 achieve the physical activity recommendations of ≥ 30 minutes on at least 5 days a week⁷⁻⁹. Previous research that examines physical activity levels and relevant outcomes in individuals with knee OA are limited due to inadequate measurement tools and differences in study design. Objectively assessing physical activity habits in this population will help in the prescription of more beneficial treatment options.

The purpose of this study is to objectively assess the physical activity habits of older adults with knee OA; and to examine the relationship between physical activity and

OA symptoms, such as functional limitations and pain. One-hundred and sixty participants (a sub-set of participants from the Intensive Diet and Exercise for Arthritis (IDEA) trial) wore an accelerometer for at least 4 days of 10 hours, which evaluated the number of steps/day, physical activity energy expenditure/day (PAEE), minutes of light physical activity (LPA), and minutes of moderate - vigorous intensity physical activity/day (MVP/VPA). Pearson correlations and manual step-wise regression analyses were used to examine the relationships between physical activity and physical function and pain in older adults with knee OA.

Results show that the total steps/day was 6209 (1459-15,949 steps) and PAEE averaged 237 ± 124 (33-790) kcal/day. Total steps/day, PAEE, and minutes of MPA/VPA tended to be lower in individuals who were older. Being female was associated with less PAEE. There was a positive association between being white and steps/day, PAEE, minutes of LPA, and minutes of MPA/VPA. A higher SPPB score, which is indicative of greater lower extremity function, was associated with minutes of MPA/VPA. PA habits in this population were below the public health recommended levels. Participants who were more physically active in terms of total steps/day and PAEE had better overall physical function than those who achieved fewer total steps/day.

CHAPTER 1: REVIEW OF LITERATURE

Osteoarthritis (OA) is the most prevalent form of arthritis in the US, affecting approximately 21 million American adults¹⁰. Roughly one-half of those aged 65 years and older and 85% of those 75 and older, have OA¹¹. OA, the leading cause of disability in older adults, is characterized by degeneration of the cartilage that often leads to pain, functional limitations, and mobility disability around the effected joint¹².

Comprehensive OA treatment plans are characterized by proper diet, medication compliance, and participation in physical activity. Recently, physical activity has been considered a safe and an effective treatment option for improving physical function and pain in older adults with knee OA¹³. Randomized clinical trials show that physical activity decreases pain and improves muscle strength and physical function. However, little is known about the physical activity habits of older adults with knee OA nor how variations in physical activity relate to OA symptoms such as physical function and pain. Gaining a better understanding of this may aid in the development of effective clinical and community interventions that prevent or delay disability in older adults with knee OA.

Osteoarthritis Management

Osteoarthritis is defined as a group of diseases and mechanical abnormalities involving the degradation of the joints, resulting in a gradual loss of cartilage^{7,14}. Osteoarthritis accounts for more than 25% of visits to primary care physicians and one-half of all NSAID's (Non-Steroidal Anti-Inflammatory Drugs) prescriptions. It is estimated that 80% of the population will have radiographic evidence of OA by the age

of 65^{15,16}. The underlying cause of cartilage degeneration may be from a variety of factors including: hereditary, developmental, metabolic, and mechanical stress, or a combination of any of these factors¹⁷. Joint damage and chronic pain as a result of OA may lead to muscle atrophy, decreased mobility, and poor balance, which further limits functional ability. Because of this, knee OA is the leading cause of physical disability in older adults^{18,19}.

The prevalence of OA increases with advancing age and can affect any joint in the body, but most often affects the hands and knees, and is more frequent in women, especially in those age ≥ 50 years²⁰. Individuals with OA typically perform lower on physical function tests, score lower on the Western Ontario and MacMaster Universities Osteoarthritis Index (WOMAC), and have increased difficulty with walking tasks. Besides age, prominent risk factors for knee OA include inactivity, overweight or obesity, ethnicity, and previous injury^{6,10,21,22}.

Osteoarthritis is a chronic condition that worsens over time. Without a medical cure for OA, treatment options focus on slowing the progression of the disease and symptoms management. The primary goals of current OA treatment are to decrease physical disability and pain, improve physical function, and reduce or slow cartilage degradation. Contemporary therapies include pharmacological, surgical, and physical activity interventions. Pharmacologic therapies include pain relief medications, NSAID's, glucocorticoid injects, and colchicines. However, as discussed below, emerging evidence shows that physical activity may be an effective strategy to prevent and restore declines in function caused by OA²³.

Evidence for Recommending Physical Activity Treatments for OA

Historically, physical activity was believed to increase the risk of knee OA because OA was thought to be “wear and tear arthritis” or part of the aging process. However, recent research studies demonstrate that increasing physical activity significantly improves function and pain in older adults with knee OA ^{5,24,25}. Thus, regular physical activity is now recognized as a safe, multifaceted treatment to improve many factors that lead to disability in individuals with knee OA ^{10,13}.

The current American College of Rheumatology (ACR) recommendations include physical activity as a treatment strategy for adults with OA ²⁶. Older adults with knee OA who engage in regular physical activity have less pain, improved function, and delayed disability ^{27,28}. The effects of physical activity on the development of OA are less clear, especially in overweight and obese, older adults. However, the health benefits of physical activity in managing OA symptoms are evident. Therefore, regular physical activity should be encouraged in individuals with OA to help reduce physical impairments and the burden of co-morbidities.

Short-term and long-term physical activity studies suggest that individuals with knee OA improve physical capacity and report less pain and disability with exercise training ²⁹⁻³³. One study that supports this is the Fitness Arthritis and Seniors Trial (FAST). FAST examined the effects of 18-month structured exercise programs on self-reported disability in 450 older adults with knee OA. Participants were randomized to aerobic exercise, resistance exercise, or a health education program. Post interventions, both exercise groups (aerobic and resistance) reported less knee pain and scored higher on measures of physical function compared to the health education group ⁵.

The Arthritis, Diet, and Activity Promotion Trial (ADAPT) expanded these results. ADAPT was a randomized, single-blind, 18-month, clinical trial that examined the effects of four treatment groups a) healthy lifestyle control, b) dietary weight loss, c) structured exercise, or d) combined exercise and dietary weight loss on physical function measures, pain, and mobility in older overweight or obese adults with knee OA. Results from this trial showed that the exercise group significantly improved their 6-minute walk distance. The diet and exercise group showed significant improvements in physical function, 6-minute walk distance, stair-climb time, and knee pain. These results suggest that a combination of dietary weight loss and moderate exercise improves pain and measures of mobility in older adults with knee OA more so than diet alone or a healthy control group¹⁸. Healthcare providers can play an important role in delaying the disease process and expediting rehabilitation in older adults with knee OA by recommending physical activity as part of their patients' treatment plans.

Physical Activity Habits in Osteoarthritis Participants

Even though adults who are physically active have lower morbidity and mortality rates than inactive adults, over one-half of U.S. adults do not engage in physical activity levels consistent with public health recommendations³⁴. The 2001 *Behavior Risk Factor Surveillance Survey on Physical Activity* (BRFSS) assessed seven variables related to physical activity via self-report: physical activity at work, moderate physical activity (defined as brisk walking, bicycling, vacuuming, gardening, or anything else that causes small increase in breathing or heart rate, performed at least 10 minutes at a time); number of days per week of moderate physical activity; total time per day spent doing moderate

physical activity; vigorous physical activity (defined as running, aerobics, heavy yard work, or anything else that causes a large increase in breathing or heart rate, performed for at least 10 minutes at a time); number of days per week of vigorous physical activity; and total time per day spent doing vigorous physical activity. From these responses, participants could be classified into physically inactive (defined as no moderate- or vigorous- intensity physical activity, or <10 minutes of either moderate- or vigorous- activity per week), insufficiently active (defined as moderate-intensity physical activity <5 days per week or <30 minutes per day or vigorous-intensity physical activity <3 days per week of <20 minutes per day), or meeting public health recommendations for physical activity. Results showed approximately 24% of community-dwelling adults with OA were completely inactive and 38% reported insufficient levels of physical activity. The inactive individuals had less education, were more likely to be African American, and were over the age of 65²². Understanding why this is the case would help researchers and physicians better recommend treatment options to older adults with OA.

Physical inactivity is a risk factor for body mass gain and obesity among adults³⁵. This undesirable lack of physical activity and resultant increase in obesity compromises functional status and is linked to increased risk factors for chronic diseases³⁵. Conversely, higher physical activity is associated with lower prevalence of obesity and co-morbidities such as diabetes, cardiovascular disease, and hypertension¹⁰. The present physical activity guidelines for healthy adults from the American College of Sports Medicine (ACSM) and the American Heart Association (AHA) advise participating in physical activity for 30 minutes a day, 5 days a week at a moderate intensity or 20 minutes a day, 3 days a week at a vigorous intensity³⁶. Specifically for people with knee OA, the

Exercise and Physical Activity Conference recommends accumulating 30 minutes of at least moderate-intensity physical activity (≥ 3 METS) on at least 3 days of the week⁷. Although vigorous physical activity (VPA; ≥ 6 METS) is encouraged, certain types of weight-bearing VPA, such as running, may prevent participants with knee OA from participating due to pain and discomfort. Therefore, accumulating 30 minutes/day of moderate and vigorous physical activity (≥ 3 METs) may be potentially beneficial and a realistic goal for older adults with knee OA^{7,36}.

Despite these recommendations, adults with OA are significantly less likely than those without OA to engage in recommended levels of moderate-vigorous activity. In 2002, the National Health Interview Survey assessed physical activity among individuals with and without OA using a similar self-report physical activity measure as the *BRFSS* survey. Data from this survey showed that 24% of adults with OA were inactive and had lower physical activity levels compared to adults without OA. Among women, physical inactivity was associated with being minority, having anxiety/depression, and needing special equipment to aid mobility, such as walkers or canes³⁷. Among men, physical inactivity was associated with greater pain. In line with previous research, overall physical inactivity was associated with older age, less education, and existing functional limitations^{22,37}.

Quantifying Physical Activity

Physical activity is defined as bodily movements produced by skeletal muscles that result in increased energy expenditure. The energy expended varies according to frequency, intensity, duration, and type of activity³⁸. Due to its complexity, physical

activity is difficult to quantify. There are several subjective and objective methods of measuring physical activity levels, such as questionnaires, activity logs or diaries, and motion devices. No single instrument is exact in measuring physical activity levels in all populations. The method in which physical activity is measured should depend on the study's purpose, population, and outcomes ³⁹.

The most common form of subjective physical activity measures are self-report questionnaires. These questionnaires are efficient when working with large populations, are relatively easy to administer, and non-invasive on the part of the participants. Some of the most commonly used questionnaires ask individuals questions regarding the frequency, duration, and intensity of their physical activity, similar to what was used in the *BRFSS* survey. Other commonly used surveys include the International Physical Activity Questionnaire (IPAQ), the Community Health Activities Model Program for Seniors (CHAMPS), and the Physical Activity for Senior Exercise (PASE). The IPAQ is a 7-item questionnaire that measures physical activity by estimating activity during the previous week. Then, based on the estimated energy expenditure, participants can be categorized as according to their activity level; inactive, minimally active, or physically active ⁴⁰. The CHAMPS questionnaire is designed to estimate weekly frequency and duration of physical activity in seniors. The CHAMPS questionnaire provides estimated caloric expenditure per week and frequency of physical activity ⁴¹. The Physical Activity Scale for the Elderly (PASE) is a 10-item questionnaire that assesses individuals' activity over the preceding week ⁴². The PASE has been validated and shown to be significantly correlated with pedometer readings in older adults ⁴³. The primary disadvantages of questionnaires are that they are limited by recall bias, are subjective to interpretation, and

floor/ceiling effects, which come from participants under/over reporting physical activity levels ⁸.

The most common objective method for measuring physical activity is the use of motion devices, such as pedometers and accelerometers. Motion devices are sensitive to walking and objectively quantify physical activity as a continuous variable. Because of this, pedometers and accelerometers have become a reliable and valid tool for measuring physical activity in numerous populations ⁴⁴⁻⁴⁷.

Pedometers objectively measure physical activity by detecting vertical acceleration. Most pedometers have a spring-suspended horizontal lever arm that moves up and down in response to vertical displacement of the hips during ambulatory movement. The lever arm opens and closes an electrical circuit with each movement allowing the number of steps to be counted ⁴⁸. Pedometers are small, relatively inexpensive devices, worn at the hip to track daily number of steps. Pedometers have become popular tools for motivating and monitoring physical activity, as they offer immediate feedback to the individual, in the form of number of steps, minutes of activity, and distance walked ⁴⁵. Unfortunately, pedometers do not capture upper body movement, nor do they differentiate intensity levels or speeds, which would better describe physical activity. Another limitation of pedometers is that the accuracy of the pedometer may vary due to waist circumference, pelvic tilt, walking speed, and the quality of the pedometer ^{49,50}.

Accelerometers are also devices that objectively measure physical activity. Accelerometers detect changes in gravitational forces based on body movement and by sampling vertical acceleration, and measure the rate or intensity of movement.

Accelerometers have been shown to estimate energy expenditure well in structured and non-structured activities and can be calibrated individually to improve accuracy in total energy expenditure estimates⁴⁷. There are several different kinds of accelerometers; uni-axial, bi-axial, and tri-axial. The most commonly used accelerometers are uni-axial. Uni-axial accelerometers measure movement in the vertical plane. Bi-axial and tri-axial accelerometers are designed to detect movement in the anteroposterior and/or lateral planes⁵¹. Accelerometers record activity counts and estimate steps, total energy expenditure, and physical activity energy expenditure. This information can then be separated into intensity levels; light, moderate, and vigorous⁵². Similar to pedometers, accelerometers are worn on the hip and cannot measure water activities or upper body movements. The Kenz® Lifecorder EX is a uni-axial accelerometer that tracks step counts and time spent in various intensity levels. This information can be exported for data analysis. This device in particular, divides physical activity into activity-intensity levels ranging from 0.5 (lowest) to 9 (highest). These intensity levels are correlated with MET levels and produce a reasonably accurate measure of energy expenditure⁴⁷. Also, unlike pedometers, this accelerometer can be blinded to not give the wearers feedback. This feature allows researchers to assess physical activity habits without the influence of visual feedback from the device.

Since the most common form of activity for older adults is walking⁵³, accelerometers are an acceptable tool to measure step counts, intensity level, and energy expenditure. Previous research used accelerometers to describe physical activity levels in older adults; however, those cohorts were small and did not include disability status or anthropometric measurements^{3,8,54}. One large population-based study objectively

assessed physical activity levels in older adults found that only 2.5% (6/238) of participants achieved recommended physical activity levels⁸. Results also showed that age, general health, disability, and body mass index were independent predictors of total steps/day counts. Whether these findings apply to a diseased or disabled population, such as older adults with knee OA, is unknown.

Specific Aims

Osteoarthritis is a significant public health concern affecting 15.8 million Americans between the ages of 25 and 74 years¹⁰. Osteoarthritis is a chronic, debilitating disease that causes disability and functional compromise, pain, joint stiffness, and muscle weakness^{1,3}. Osteoarthritis, specifically knee OA, is the leading cause of physical disability in older adults^{55,56}.

Currently there is no cure for OA. Commonly prescribed therapies focus on reducing pain and maintaining physical function. An increasing body of evidence shows that physical activity is an effective therapy in the treatment of OA^{21,31,32}. Participation in physical activity may be a potential strategy to delay the onset of disability, improve physical function, and decrease pain^{13,21,32,57}. Among older adults with knee OA, little is known about the influence of participant characteristics and how they are related to physical activity. For example, individuals may exhibit radiographic evidence of knee OA, but may not demonstrate symptoms of knee OA such as pain. Therefore, defining a population with knee OA who may respond well to physical activity would be beneficial in providing effective and efficient treatment options to reduce the overall burden of OA.

The proposed study is an ancillary to the Intensive Diet and Exercise for Arthritis (IDEA) trial. The overall goal of IDEA is to compare the effects of three 18-month interventions: a) exercise only, b) intensive dietary weight loss only, and c) exercise and intensive dietary weight loss only, on inflammatory biomarkers and knee joint loads in overweight and obese middle-aged and older (>55 years) adults with knee OA. The IDEA study enrolled 454 participants from communities in and around Winston-Salem, NC. The exclusion criteria are included in Appendix A. The proposed research will examine data related to physical activity, physical function, and pain in a subset of 160 participants.

The purpose of this study is to identify whether variation in daily physical activity is related to age, gender, ethnicity, education, obesity status, or knee pain among older adults with knee osteoarthritis, and to determine whether daily physical activity is associated with levels of physical function in these individuals.

Specific aim 1: To determine demographic correlates of daily physical activity among middle-aged and older, obese adults with knee osteoarthritis.

Hypothesis: Participants with low levels of physical activity will be older, female, less educated, in the minority population, and have a higher BMI status.

Specific aim 2: To evaluate whether daily physical activity is associated with severity of knee osteoarthritis as assessed by self-reported pain.

Hypothesis: Participants with low levels of physical activity self-report higher levels of pain compared to those with greater physical activity levels.

Specific aim 3: To determine whether daily physical activity is associated with levels of physical function in these individuals.

Hypothesis: Participants with low levels of physical activity will have lower SPPB scores and cover less distance during the 6-minute walk test compared to those with greater physical activity levels.

Understanding the physical activity habits of older adults with knee OA and the factors related to physical activity in this population will help healthcare providers better target prevention and treatment programs.

CHAPTER 2: PHYSICAL ACTIVITY HABITS IN OLDER ADULTS WITH KNEE OSTEOARTHRITIS

ABSTRACT

Background: To objectively assess physical activity habits using accelerometers, and to examine the relationship between physical activity and physical functioning, in 160 older (66 ± 6 years old), obese (body mass index 33.5 ± 3.7 kg/m²) individuals with knee osteoarthritis.

Methods: Physical activity was assessed using uni-axial accelerometers (physical activity variables: total steps/day, minutes of activity in intensity levels, physical activity energy expenditure). Physical function was assessed by the 6-min walk, a battery of lower extremity function, and a self-report pain and function questionnaire. Pearson correlations and general linear models were used to analyze the relationship between physical activity and participant characteristics and physical function. **Results:** The total steps/day was 6209 (1459-15,949) and PAEE averaged 237 ± 124 kcal/day (33-790) in this population. Total steps/day, PAEE, and minutes of MPA/VPA tended to be lower in individuals who were older. Being female was associated with less PAEE. There was a positive association between being white and steps/day, PAEE, minutes of LPA, and minutes of MPA/VPA. Both the 6-min walk distance and lower extremity function was better in those who had higher total steps/day, higher PAEE, and higher minutes of MPA/VPA. **Conclusions:** This study objectively measured physical activity habits in older adults with knee OA. PA habits in this population were below recommended physical activity guidelines. Participants who were more physically active in terms of

total steps/day and PAEE had better overall physical function than those who achieved less total steps/day.

INTRODUCTION

Osteoarthritis (OA) is a degenerative disease that affects the cartilage in and around the joints and is the leading cause of disability in older adults^{7,14,58}. OA affects approximately 50% of individuals aged 65 and over, and 85% of those 75 and older¹¹. Symptomatic OA causes joint pain, functional limitations, and for some, the need of assistance with activities of daily living⁷. Being physically active may play a role in preventing OA, delaying declines in physical functioning and reducing OA symptoms⁷. Even with the known benefits of physical activity and the recommendations from the American College of Rheumatology to be physically active, only 38% of adults with OA achieve the physical activity guidelines of 30 minutes a day, 5 days a week at a moderate intensity^{22,36,37,59}.

Therapies that selectively target increasing physical activity have been shown to be effective for improving physical function and reducing pain in older adults with knee OA^{21,60}. For example, data from randomized controlled trials showed that physical activity, and physical activity in combination with dietary weight loss, effectively improve physical function and reduce pain in older adults with knee OA^{5,61}. Although it is known that adults with chronic disease are less physically active than their healthy counterparts, little is known about the physical activity habits in older adults and how those habits affect physical functioning, especially in those with OA. An understanding of this may result in the development of clinical and community interventions to prevent

disability and improve physical function as a result of OA. Therefore, the primary purpose of this study is to identify whether variation in daily physical activity is related to age, gender, ethnicity, obesity status, or knee pain among older adults with knee OA; and to determine whether daily physical activity is associated with levels of physical function and pain in these individuals.

SUBJECTS AND METHODS

Participants

The current study used a sub-sample of the participants involved in the Intensive Diet and Exercise for Arthritis (IDEA) trial. Complete details of the IDEA trial design and methodology have been reported elsewhere⁶². IDEA was a single-blind, single center, 18-month, randomized, controlled trial that examined the effects of three interventions on biomechanical and inflammatory OA disease pathways: exercise only, intensive dietary weight loss only, and exercise in combination with intensive dietary weight loss.

Men and women in and around Forsyth County, NC were recruited through local advertisement. The IDEA study enrolled 454 ambulatory, community-dwelling persons age ≥ 55 years with: (1) grade II-III (mild to moderate) radiographic tibiofemoral OA or tibiofemoral plus patellofemoral OA of one or both knees; (2) $27.0 \leq \text{BMI} \leq 40.5 \text{ kg/m}^2$; and (3) a sedentary lifestyle, defined as not participating in a program that incorporates more than 30 minutes per week of formal exercise within the past 6 months. Physical activity data were objectively collected using accelerometers in a random sample of approximately one-half of the participants (n=187).

Exclusion criteria (**Appendix A**) included a serious medical condition that precluded safe participation in an exercise program such as coronary artery disease, severe hypertension, peripheral vascular disease, stroke, chronic obstructive pulmonary disease, active cancer (other than skin cancer), anemia, dementia, liver disease, type 1 diabetes, type 2 diabetes, taking thiazolidinediones, blindness, psychiatric disease, osteoporosis, ligament or cartilage damage from an acute event, Mini-Mental score <70, CES-D score >17, inability to complete the 18-month study or unlikely to be compliant, inability to walk without a cane or other assistive device, participation in another research study, medical history that would prohibit a knee MRI (pacemaker, defibrillator, implanted metal objects, etc.), excessive alcohol consumption of ≥ 21 drinks per week, lives > 50 miles from site or plans to leave are ≥ 3 months during the next 18-months, and an inability to complete the trial protocol in the opinion of the clinical staff, because of frailty, illness, or other reasons.

Measures

Measures of anthropometrics. Body weight, height, and hip and waist circumference were obtained. Body mass index was calculated as mass divided by height squared. Participants were weighed without shoes or heavy clothing.

Demographics. Demographic characteristics were obtained through self-report questionnaires, and included age, sex, ethnicity, income, and years of education.

Physical activity. The Kenz® Lifecorder EX accelerometer (Suzuken CO., LTD) was used to quantify physical activity levels and patterns. The Kenz® Lifecorder EX activity monitor unit is small and lightweight and was firmly attached to a belt or waistband of the participant's clothing during all waking hours (excluding time for swimming or

bathing) for seven consecutive days. The Kenz® Lifecorder EX measures step counts, total daily energy expenditure (TDEE), physical activity energy expenditure (PAEE), and physical activity intensity levels over the course of a day. This data can be stored on the device for up to 6 weeks. A maximum pulse over 4 seconds is taken as the acceleration value and activities are categorized based on intensity levels (1 or minimal intensity to 9 or maximal intensity). When the sensor detects three acceleration pulses or more for four consecutive seconds, the activities are recognized as physical activity. If an acceleration pulse is not immediately followed by another acceleration pulse then it is not counted as a 0 but as a 0.5. This assumes isolated spurts of acceleration to be changes in posture and not physical activity. Based on previous research, the intensity levels are closely related and approximate metabolic equivalents⁴⁷. Activities can then be categorized by intensity levels; light (LPA; <3 METs), moderate (MPA; 3-6 METs), and vigorous (VPA; >6 METs)⁴⁷. The display of the Lifecorder EX was locked, giving the participant no feedback regarding their daily steps, activity minutes, or PAEE. This was to ensure an unbiased assessment of the participant's physical activity habits. Accelerometer diaries were also kept during the seven days to note the time of day participants put on the device and took off the device. If the participant did not wear the device at all, this was to be noted in the diary.

To be included in our analyses, the device must have been worn for a minimum of 10 hours a day for at least 4 of the 7 days of a week. These guidelines were based on study findings from the Look AHEAD trial, who used the same minimum device wear inclusion criteria⁶³. Accelerometer data were uploaded onto a computer and analyzed.

Pain and function. Pain and function were assessed using the self-report Western Ontario McMasters Universities Osteoarthritis Index (WOMAC) ⁶⁴. This version asks participants to indicate on a scale from 0 (none) to 4 (extreme) the degree of difficulty experienced performing activities of daily living in the last 48 hours due to knee OA. Scores are totaled to generate a summary score ranging from 0-68; lower scores indicate greater pain and lower function.

Measures of physical performance. Mobility was measured with the 6-minute walk (6 min W) distance. Participants were told to walk as far as possible in 6 minutes on an established course. Participants were not given feedback during the test. Results from the six-minute walk distance are correlated with symptom-limited maximal oxygen consumption ($r=0.53$) ⁴⁷.

The Short Physical Performance Battery (SPPB) was used to assess lower extremity function in older adults. The battery involves three physical performance measures including preferred gait velocity, repeated chair rises, and a standing balance test. Results from each of the three tests are scored with 0 indicating inability to perform the test to a 4 indicating highest function. Scores from the three tasks were tallied for the final SPPB score, which ranged from 0 (lowest physical performance) to 12 (highest physical performance) ⁶⁵.

Statistical Analysis

All analyses were performed with the use of SAS software, version 9.2 (SAS Institute, Inc., Cary, NC), and significance was assessed using an α of 0.05. Participant characteristics are reported as mean \pm SD or as frequency and percent.

Pearson correlations analyses were performed to examine the relationships between physical activity variables and participant characteristics and measures of physical function. All objective PA measures were significantly correlated with each other ($p < 0.01$) ranging from 0.26-0.92, therefore, all of these measures were chosen for further analyses. In addition, a manual stepwise regression analysis was used to evaluate the relationship between physical activity (steps/day, PAEE, LPA, MPA/VPA) and participant characteristics and measures of physical function. The full models included age, gender, race, BMI, WOMAC pain, and gender by BMI interaction. A p-value less than 0.05, or a main effect and an interaction with p-value less than 0.05 was kept. The models used to assess the relationship between physical activity and physical functions were adjusted for age, gender, race, BMI, and gender by BMI interaction. All multivariate models controlled for treatment group, days between intervention start and accelerometer start date (lag time), and group by lag time interaction. Results are presented in the tables below.

RESULTS

Participant Demographics and Physical Characteristics (Tables 1 and 2). Statistical analyses were restricted to only those participants with complete accelerometer data ($n=160$). Those who were excluded from the analysis had inconsistent accelerometer diaries, or less than 4 days of 10-hours wearing the device ($n=29$). Participant demographics are shown in **Table 1**. Overall, the sample was an average age of 66 ± 6 ranging from 55 to 84 years, and predominately female (69% vs. 31 % male). The

population was predominately white (82% vs. 18% African American), fairly well educated (71% attended college), and 57% were retired.

Table 2 denotes the participants' physical characteristics and physical function. Their obesity is reflected by a high BMI status. Physical function was assessed by the 6-minute walk distance (6m W) and the Short Physical Performance Battery (SPPB). These functional assessments reflected typical ability; the average SPPB score was 11 ± 1 and the average 6m W distance was 478 ± 79 meters. Pain was assessed using the Western Ontario McMasters Universities Osteoarthritis Index (WOMAC). The average pain score was 5.8 indicating mild pain. The functional portion of the self-report WOMAC averaged 22.3 ± 10.5 indicating difficulty performing activities of daily living. *Participant Physical Activity Habits (Table 3) and Predictors of Physical Activity (Table 4)*. Physical activity is reported as 5 separate variables; total steps/day, physical activity energy expenditure (PAEE), minutes spent in light physical activity (LPA), moderate physical activity (MPA), and vigorous physical activity (VPA). Light physical activity included activities requiring between one and three METS while activities requiring at least three METS were classified as MPA and activities requiring more than six METS were classified as VPA. The total steps/day for the participants was low, 6209 total steps, with a large (10-fold) inter-individual variability. Interestingly, only 7.5% (n=12) of this population met the public health goal of $\geq 10,000$ steps per day. On average, participants spent 131 minutes a day performing light activities (LPA). Although the average minutes/day spent performing moderate - vigorous activities was low, only 1 individual spent zero minutes/day participating in moderate - vigorous physical activity.

Data from 160 participants who had complete accelerometer data were combined and regression analyses were used to determine the independent predictors of physical activity (**Table 4**). Simple correlation analyses showed that less physical activity (lower total steps/day, PAEE, and MPA/VPA) was related to older age (**Figure 1 and 2**). Being female was associated with lower PAEE, and being white was significantly associated with higher levels of physical activity (**Figure 3**). No associations were observed between BMI, WOMAC Pain, and variables of physical activity.

We next performed a stepwise regression analyses to determine the independent predictors of each of the physical activity variables (steps/Day, PAEE, LPA, MPA/VPA). The model included each physical activity variable and age, gender, ethnicity, BMI, WOMAC pain, intervention group, lag time, and intervention group by lag time. Results showed that lower total steps/day, less PAEE, and less MPA/VPA were still related to greater age ($p=0.008$, <0.001 , 0.008 , respectively) (**Table 6**). Being white was still associated with greater steps per day, greater PAEE, greater LPA, and greater MPA/VPA ($p<0.001$, 0.007 , 0.012 , 0.003 , respectively). BMI, WOMAC pain, and education were not significant in any model.

Relationship between Physical Activity and Physical Function (Table 5). Next, we examined whether physical function was associated with physical activity. Results showed that two measures of physical function (6m W and SPPB) were associated with physical activity, indicating that better function is related to greater levels of physical activity. For example, individuals with greater 6 m W distance had more total steps/day, greater PAEE, and more minutes of MPA/VPA. On average, higher total steps/day was associated with greater 6 minute walk distances. A higher SPPB score, which is

indicative of greater lower extremity function, was associated with greater minutes of MPA/VPA ($p=0.008$). Knee-strength and the self-reported measure of physical function (WOMAC) were not associated with physical activity variables.

Separate models for physical function with each physical activity variables were fitted (**Table 5**) and models were adjusted for age, gender, race, BMI, intervention group, lag time, and intervention group by lag time (**Table 7**). All significant results demonstrated a positive association, such that greater total steps/day, greater PAEE and greater minutes of MPA/VPA ($p=0.002$, <0.001 , and <0.001 , respectively) were associated with greater 6 minute walk distances. Greater minutes of MPA/VPA ($p=0.008$) were also associated with higher SPPB scores in these analyses.

DISCUSSION

Research shows that the majority of adults in the U.S. are inactive regardless of the known benefits of physical activity³⁴, yet this research lacks an understanding of older adults' physical activity habits, especially in populations with chronic diseases, such as knee OA. Only a small percentage of our population (7.5%) met the current the physical activity recommendations. Our findings also provide evidence of an association between objectively measured physical activity and gender, age, ethnicity, and physical function. Greater physical activity was evident in younger vs. older, white vs. African American, and male vs. female. One of the most common OA symptoms is pain however; self-reported pain was not associated with physical activity, which indicates pain may not be a limiting factor for individuals with knee OA.

Current physical activity guidelines from ACSM suggest accumulating 30 minutes a day, 5 days a week at a moderate intensity (≥ 3 METS) or 20 minutes a day, 3 days a week at a vigorous intensity (≥ 6 METS). The guidelines specifically for knee OA recommend 30 minutes a day of at least moderate- intensity physical activity (≥ 3 METS) on at least 3 days of the week^{7,10,36}. Findings from this study support previous research, using self-report measures of physical activity, that older adults with knee OA do not meet physical activity guidelines^{35,37,59}. On average, our participants were moderately active (MPA) for less than 10 minutes a day, and spent an average of only 131 minutes a day performing light physical activity (LPA). Participants walked an average of 6209 steps/day, which is consistent with a review suggesting that healthy older adults accumulate between 6,000-8,000 steps/day, and older adults with chronic diseases accumulate 3500-5550 steps/day^{66,67}. Since physical inactivity increases with age and higher MPA/VPA was associated with physical function, it may be practical and necessary to encourage MPA/VPA to older adults with knee OA as a part of their regular treatment plan to help maintain or improve leg strength and mobility. In addition, our study confirms prior research findings that indicate besides age, prominent risk factors for physical inactivity in individuals with knee OA are more likely to be female and minority^{6,10,21,22}.

Our findings may have important clinical implications for health professionals who are recommending physical activity for older adults with knee OA. First, in addition to educating participants about the benefits of physical activity, health care providers should encourage physical activity that is specific to the individual's demographics (such as age, gender, and ethnicity) and functional ability. Physical activity can be achieved in

various forms; health care providers should be sensitive to predisposing factors when recommending physical activity as an additive to activities of daily living or as recreation. Second, health care providers should recommend physical activity as an effective treatment strategy for OA. Individuals, who were more physically active, had less functional limitations than those who were less physically active. Also, physical activity has been shown to have positive effects on disability, muscle strength, flexibility, and pain^{21,68,69}. Thus, increasing physical activity may be one method of preserving physical function and maintaining independence in older adults with knee OA.

The present study has several strengths. The measurement of physical activity by accelerometers allowed us to objectively evaluate physical activity, where previous studies were limited by subjective measures such as questionnaires. In addition, the study was conducted in older, overweight or obese men and women that had radiographical evidence of knee OA. This population is already at increased risk of disability, and by gaining a better understanding of the physical activity habits in this population, we can more appropriately recommend treatment options to delay the progression of OA and prevent disability. Certain limitations are inherent in this study. Most importantly, this study was a cross-sectional design and we cannot assume directionality or causality. In addition, these study findings are only generalizable to a population of overweight or obese, older adults with knee OA. Third, accelerometers lack the ability to capture water-based activities such as swimming, and upper body activities such as weight lifting, thus underreporting some activity levels. Although accelerometers are an acceptable tool for measuring physical activity, the Lifecorder Ex accelerometer has only been validated in a younger, healthy, population^{70,71}. Also, the

Lifecorder Ex accelerometer has set, predetermined intensity levels and cannot be manually adjusted to capture more or less physical activity based on the intensity level. It would have been beneficial to assess less intense activity in this population, as they may not have been able to achieve a moderate intensity activity, recorded in the accelerometer as 3-6. Future research may want to look at redefining low, moderate, and vigorous physical activity for the older adult population, especially as they are assessed by accelerometers.

Despite these limitations, the findings from this study have important ramifications for refining current guidelines for recommending physical activity to older adults with knee OA. These findings contribute to the knowledge of physical activity habits among older adults with OA and emphasize the importance of encouraging physical activity as a strategy for managing OA symptoms and delaying disability.

CONCLUSION

This study objectively measured physical activity habits in older adults with knee OA. Individuals with knee OA accumulate little MPA/VPA (<10 min/day), not achieving recommended levels for physical activity. It was found that participants that were more active had better physical function scores than those who were less active. Therefore, describing this specific population is useful in promoting physical activity and developing more effective treatment options for older adults with knee OA.

Table 1. Participant Demographics (n=160)

<u>Characteristics</u>	<u>N</u>	<u>%</u>
Ethnicity		
White	132	82
African American	28	18
Sex		
Male	50	31
Female	110	69
Education		
High school or less	46	29
College	73	46
Post graduate	41	25
Income		
< \$35,000	44	28
\$35,000-\$75,000	66	41
> \$75,000	50	31
Employment		
Currently Employed	49	31
Retired	91	57
Other	20	12

Table 2. Participant Physical Characteristics and Physical Function (n=160)

<u>Characteristics</u>	<u>Mean +SD</u>	<u>Minimum</u>	<u>Maximum</u>
Age (years)	66 ± 6	55	84
BMI (kg/m²)	33.5 ± 3.7	27.0	40.5
WOMAC pain score	5.8 ± 2.8	0	14.0
WOMAC function score	22.3 ± 10.5	0	48.0
6-Minute Walk Distance (m)	478 ± 79	249	768
SPPB score	11.0 ± 1.2	8.0	12.0
*Knee Strength (N)	229 ± 85	46	469

*note Knee Strength n=122

Table 3. Participant Daily Physical Activity (n=160)

	<u>Mean + SD</u>	<u>Minimum</u>	<u>Maximum</u>
Average Steps/day	6209 ± 2554	1459	15,949
PAEE (kcal/day)	237 ± 124	33	790
LPA (min/day)	131 ± 40	32	264
MPA (min/day)	10.0 ± 8.3	0	39.4
VPA (min/day)	0.6 ± 1.6	0	12.2

Table 4. Correlations between Physical Activity Variables and Participant Demographic and Physical Characteristics (n=160)

Variable	Steps/Day	PAEE	LPA	MPA/VPA
1. Age	r=-0.205 (0.009)	r=-0.255 (0.001)	r=-0.077 (0.333)	r=-0.222 (0.005)
2. Female	r=-0.067 (0.399)	r=-0.243 (0.002)	r=0.0688 (0.388)	r=0.094 (0.237)
3. White	r=0.244 (0.002)	r=0.202 (0.010)	r=0.198 (0.012)	r=0.210 (0.008)
4. BMI	r=-0.054 (0.500)	r=0.130 (0.102)	r=-0.070 (0.377)	r=-0.063 (0.429)
5. WOMAC Pain	r=-0.082 (0.302)	r=-0.116 (0.144)	r=-0.044 (0.583)	r=-0.144 (0.070)

r= Pearson correlation coefficient (p value)

Bolded values are significant

Table 5. Relationship between Physical Activity and Physical Function (n=160)

Variable	WOMAC Function	6-min W	SPPB	Knee Strength (n=122)
1. Steps/day	-0.071 (0.371)	0.379 (<.0001)	0.240 (0.002)	0.130 (0.152)
2. PAEE	-0.085 (0.284)	0.435 (<.0001)	0.197 (0.013)	0.226 (0.012)
3. LPA	-0.058 (0.465)	0.137 (0.085)	0.195 (0.013)	-0.040 (0.663)
4. MPA/VPA	-0.074 (0.351)	0.391 (<.0001)	0.315 (<.0001)	0.088 (0.333)

r= Pearson correlation coefficient (p value)

Bolded values are significant

Table 6. Results from Stepwise Models for Physical Activity Variables with Participant Demographic and Physical Characteristics (n=160)

Variable	Steps/Day β (SE)	PAEE β (SE)	LPA β (SE)	MPA/VPA β (SE)
1. Age	-82.3 (30.7) p=0.008	-5.8 (1.5) p<0.001	-	0.3 (0.1) p=0.003
2. Female	-	71.8 (19.6) p<0.001	-	-
3. White	1750 (507) p<0.001	64.6 (23.8) p=0.007	20.7(8.1) p=0.012	5.2 (1.7) p=0.003

The full model consisted of age, gender, ethnicity, BMI, WOMAC Pain, intervention group, lag time (days between accelerometer and intervention start) intervention group by lag time. Results are only presented in the table below for variables retained in the model.

SE = Standard Error

Table 7. Results from Four Separate Models for Physical Function with Each Physical Activity Measures (n=160)

Variable	WOMAC Function β (SE)	6-min W β (SE) p=0.002	SPPB β (SE)	Knee Strength (n=122) β (SE)
1. Steps/day	-	0.01 (0.002) p=0.002	-	-
2. PAEE	-	0.2 (0.05) p<0.001	-	-
3. LPA	-	-	-	-
4. MPA/VPA	-	2.9 (0.66) p<0.0001	0.03 (0.01) p=0.008	-

Model is adjusted for age, gender, race, BMI, intervention group, lag time (days between accelerometer and intervention start) intervention group by lag time. Only significant results are presented in the table.

Figure 1. Plot of Age and Total Daily Steps

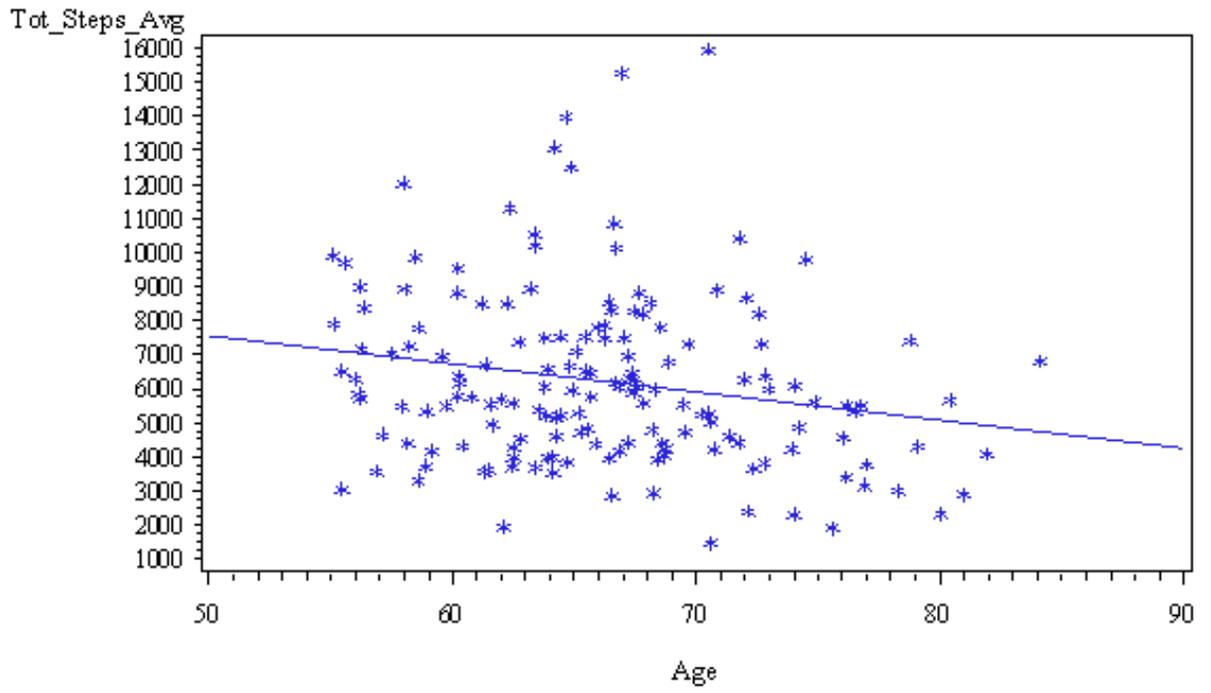
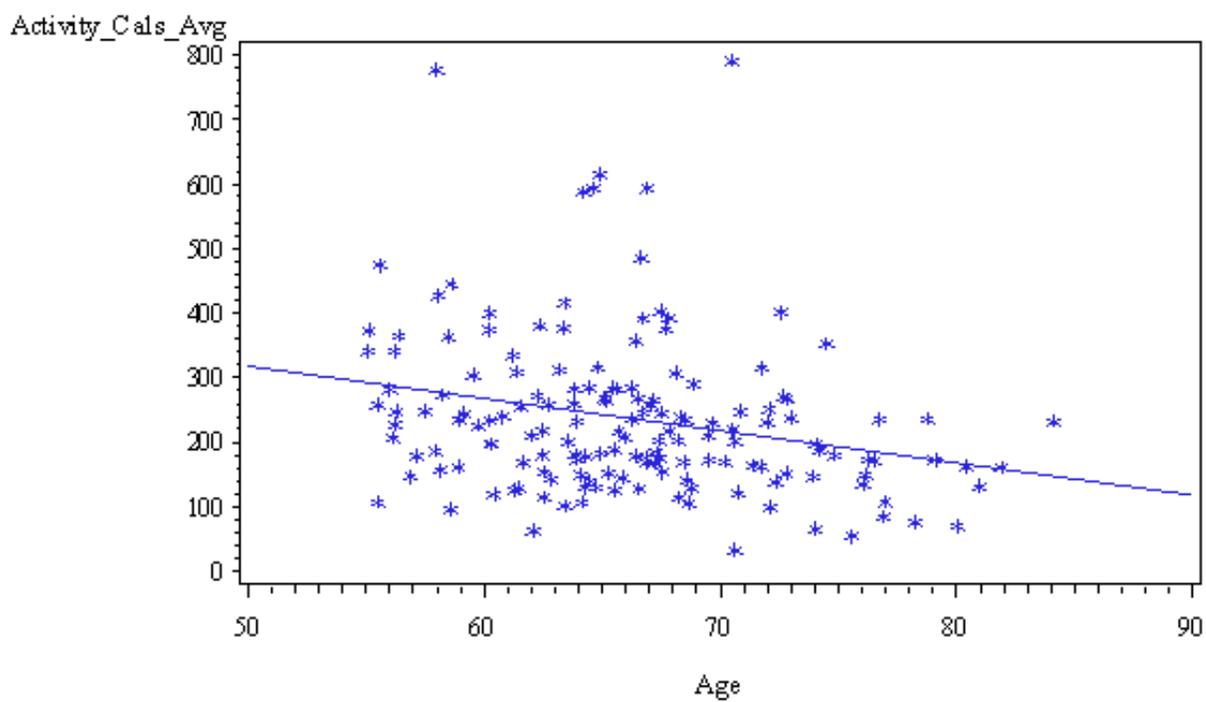
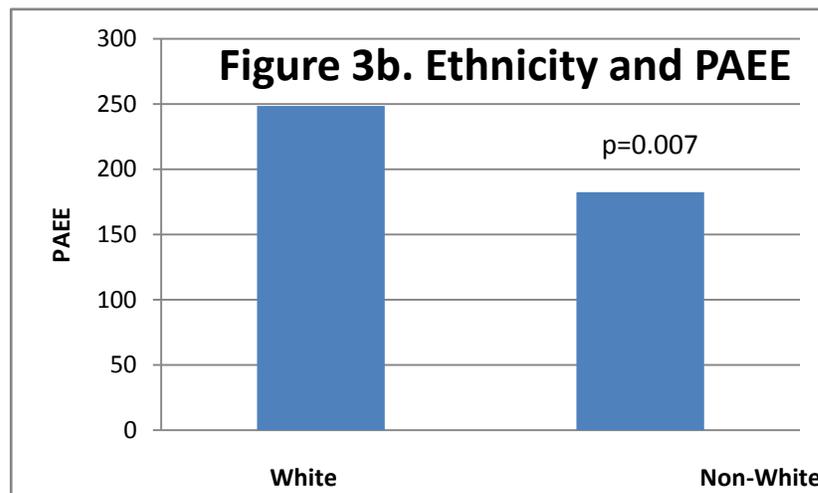
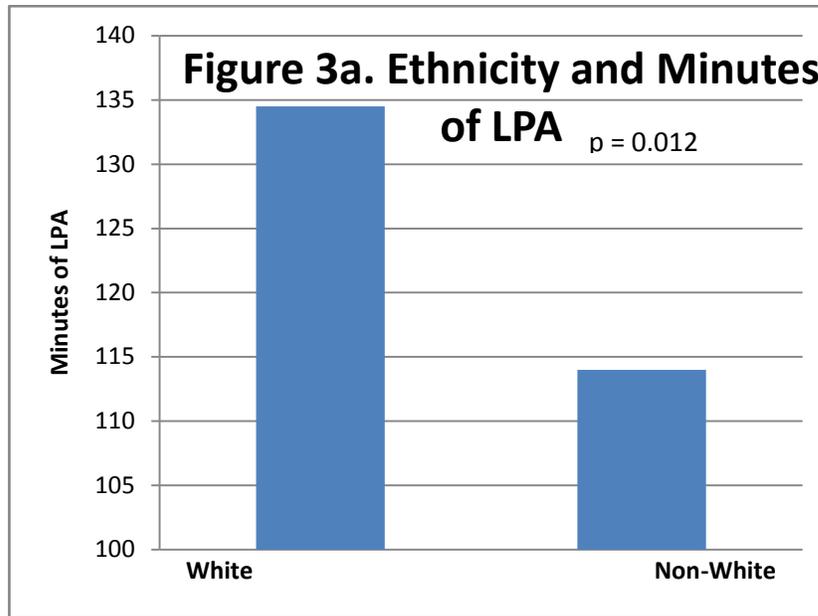


Figure 2. Plot of Age and Physical Activity Energy Expenditure





CHAPTER 3: OTHER ANALYSIS

The purpose of this study was to objectively assess physical activity habits using accelerometers, and to examine the relationship between physical activity and physical functioning and pain, in 160 older individuals with knee osteoarthritis. This was accomplished by examining the relationship between physical activity variables (total steps/day, physical activity energy expenditure (PAEE), minutes spent participating in physical activity and intensity level), and participant characteristics and physical functioning. The findings from the present study support previous research using self-report measures of physical activity, that older adults with knee OA do not meet the physical activity guidelines of ≥ 30 minutes a day, 5 days a week at a moderate intensity, or 20 minutes a day, 3 days a week at a vigorous intensity^{7,10,36}. On average, our participants were moderately physically active (MPA) for less than 10 minutes a day, spending an average of 131 minutes a day performing light physical activity (LPA). Our participants walked an average of 6209 steps/day, which is consistent with a review suggesting that healthy older adults accumulate between 6,000-8,000 steps/day, and older adults with chronic diseases accumulate 3500-5550 steps/day^{66,67}. Being female was associated with less PAEE and there was a positive association between being white and physical activity. Our study results confirm previous research, indicating that besides age, prominent risk factors for physical inactivity in individuals with knee OA are being female, and a minority^{6,10,21,22}.

Given the limitations of this study, to fully explain the physical activity habits in older adults with knee OA, a larger, observational cohort study done in a free-living environment is warranted. Such studies may want to examine a) objective and subjective

assessments of physical activity, b) severity of the OA disease, and c) clearly define physical activity and intensity levels.

Objective measures of physical activity, specifically accelerometers, are feasible and provide researchers with detailed information regarding physical activity habits in older adults with knee OA. Accelerometers have the advantage of providing information regarding intensity level and duration of activity, caloric information, and time-stamped information; however, they do not provide information regarding upper body movement or water-based activities. Standardizing accelerometer wear time criteria, (minimal wear time for a day and minimal number of days the device needs to be worn) has important implications for participants and the overall generalizability of results. Coupling accelerometers with another assessment tool, such as a self-report questionnaire or a detailed activity log, may more inclusively describe physical activity habits in older adults with knee OA.

Another thing to be aware of with the assessment of physical activity is the time in which those measures are assessed. For example, in the current study the accelerometer, in some cases, was worn during intervention and recorded that exercise time, therefore we needed to control for lag time in the analyses. This was important to note because of the two-week lag time (14 days between intervention and accelerometer use). Future research should assess physical activity prior to the start of intervention to obtain a true assessment of the normal physical activity habits in older adults before beginning a physical activity program.

Out of curiosity, we ran other analyses based on the previous sample population, only including data from individuals that had accelerometer data obtained prior to the

start of intervention and met the other inclusion criteria (n=29). Descriptive statistics are shown below in **Tables 6 and 7**. This population was 67 ± 6 years old and obese. Interestingly, the physical activity variables were slightly different. This sample was less active than the full sample, only accumulating 5649 ± 2421 total steps/day (still with a 10-fold inter-individual variability), and an average PAEE of 196 ± 98 kcal/day (vs. 237 ± 124 kcal/day in the full sample). This sample performed 135 minutes of light physical activity over the course of the day and 7 minutes of moderate physical activity. Overall, this sample had lower physical function scores compared to the full sample. Due to the small sample size, further correlational or GLM were not run to assess the relationship between physical activity and physical characteristics and physical function. These differences illustrate the importance of appropriately assessing physical activity prior to the start of a physical activity intervention.

Expanding this, current research should assess severity of OA disease. Individual differences in K-scores, physical function, and OA symptoms such as pain, would provide a better understanding of the physical activity habits of older adults with knee OA, not only of those who volunteer for a physical activity trials, as they do not reflect the general population. The more we understand about individual's normal physical activity habits, the better we can make physical activity recommendations and prescribe appropriate treatment options. It would also be of interest to describe the physical activity habits of active older adults, what they are doing, and how long are they doing it. It may also be of importance to assess how physical function and OA symptoms change over time as this may be attributed to the participation in physical activity.

In the literature, the terms physical activity and exercise are often used interchangeably; however, these terms have different meanings. Clearly, defining physical activity would help reduce speculations to what may or may not be included in physical activity. This would also help describe other activities older adults commonly participate in. Future research should also define intensity and type of activity, as they too are subjective and open for interpretation. What is low intensity activity for one individual may be moderate activity for another. Without consistent and clear definitions, these components of physical activity are left vague and exposed to interpretation. As researchers and advocates of public health, how can we provide public guidelines and ask individuals to follow them when so much of the guidelines are subjective? Universal descriptions and a universal understanding of physical activity would make results more generalizable and guidelines easier to follow.

Future research should examine the dissemination of the physical activity guidelines. It would be of interest to see how individuals are being informed about the physical activity guidelines, what information is provided to them, and how they are being held accountable to the guidelines. For example, if a physician encourages a patient to increase their activity (or for argument sake, prescribes them physical activity), do the physicians advise the patients on how to become physically active, and how long and how often should they be physically active? Low compliance to physical activity guidelines may in part be due to the breakdown in communication, clear and concise physical activity recommendations.

The aforementioned suggestions may aid in truly describing physical activity habit in older adults with knee OA and may have important implications recommending

physical activity as a treatment option for managing OA symptoms. Physical activity is an essential part of life and should be recommended in all populations, especially in older adults with knee OA, to maintain and improve physical function and independence.

Table 8. Participant Physical Characteristics and Physical Function (n=29)

<u>Characteristics</u>	<u>Mean +SD</u>	<u>Minimum</u>	<u>Maximum</u>
Age (years)	67 ± 6	56	77
BMI (kg/m²)	32.8 ± 3.8	27.0	40.3
WOMAC pain score	6.1 ± 3.0	1	14.0
WOMAC function score	22.9 ± 10.4	5	40.0
6-Minute Walk Distance (m)	467 ± 77	313	592
SPPB score	10.7 ± 1.3	8.0	12.0
*Knee Strength (N)	216 ± 80	60	346

*note Knee Strength n=27

Table 9. Participant Daily Physical Activity (n=29)

	<u>Mean + SD</u>	<u>Minimum</u>	<u>Maximum</u>
Average Steps/day	5649 ± 2421	1459	15,258
PAEE (kcal/day)	195.9 ± 98.2	33.3	593.6
LPA (min/day)	134.5 ± 39.4	50.3	263.9
MPA (min/day)	6.6 ± 6.5	0	23.1
VPA (min/day)	0.1 ± 0.2	0	1.2

Reference List

- (1) Davis MA, Ettinger WH, Neuhaus JM, Mallon KP. Knee osteoarthritis and physical functioning: evidence from the NHANES I Epidemiologic Followup Study. *J Rheumatol*. 1991;18:591-598.
- (2) Fried LP, Young Y, Rubin G, Bandeen-Roche K. Self-reported preclinical disability identifies older women with early declines in performance and early disease. *J Clin Epidemiol*. 2001;54:889-901.
- (3) Talbot LA, Gaines JM, Huynh TN, Metter EJ. A home-based pedometer-driven walking program to increase physical activity in older adults with osteoarthritis of the knee: a preliminary study. *J Am Geriatr Soc*. 2003;51:387-392.
- (4) Lawrence RC, Helmick CG, Arnett FC et al. Estimates of the prevalence of arthritis and selected musculoskeletal disorders in the United States. *Arthritis Rheum*. 1998;41:778-799.
- (5) Ettinger WH, Jr., Burns R, Messier SP et al. A randomized trial comparing aerobic exercise and resistance exercise with a health education program in older adults with knee osteoarthritis. The Fitness Arthritis and Seniors Trial (FAST). *JAMA*. 1997;277:25-31.

- (6) Kaplan MS, Huguet N, Newsom JT, McFarland BH. Characteristics of physically inactive older adults with arthritis: results of a population-based study. *Prev Med.* 2003;37:61-67.
- (7) American Geriatric Society Panel on Exercise and Osteoarthritis. Exercise Prescription for Older Adults With Osteoarthritis Pain: Consensus Practice Recommendations. *J.Am.Geriatr.Soc.* 49, 808-823. 2001.
- (8) Harris TJ, Owen CG, Victor CR, Adams R, Cook DG. What factors are associated with physical activity in older people, assessed objectively by accelerometry?. *Br J Sports Med.* 2009;43:442-450.
- (9) National Centre for Social Research. Health Survey for England 2004. 2005. London, Department of Health.
- (10) Farr JN, Going SB, Lohman TG et al. Physical activity levels in patients with early knee osteoarthritis measured by accelerometry. *Arthritis Rheum.* 2008;59:1229-1236.
- (11) vos-Comby L, Cronan T, Roesch SC. Do exercise and self-management interventions benefit patients with osteoarthritis of the knee? A metaanalytic review. *J Rheumatol.* 2006;33:744-756.

- (12) Troiano RP. Can there be a single best measure of reported physical activity?
Am J Clin Nutr. 2009;89:736-737.
- (13) Minor MA, Hewett JE, Webel RR, Anderson SK, Kay DR. Efficacy of physical conditioning exercise in patients with rheumatoid arthritis and osteoarthritis.
Arthritis Rheum. 1989;32:1396-1405.
- (14) Perrot S, Poiraudeau S, Kabir-Ahmadi M, Rannou F. Correlates of pain intensity in men and women with hip and knee osteoarthritis. Results of a national survey: The French ARTHRIX study. *Clin J Pain.* 2009;25:767-772.
- (15) Green GA. Understanding NSAIDs: from aspirin to COX-2. *Clin Cornerstone.* 2001;3:50-60.
- (16) Merkle D, McDonald DD. Use of recommended osteoarthritis pain treatment by older adults. *J Adv Nurs.* 2009;65:828-835.
- (17) Meijer EP, Goris AH, Wouters L, Westerterp KR. Physical inactivity as a determinant of the physical activity level in the elderly. *Int J Obes Relat Metab Disord.* 2001;25:935-939.
- (18) Messier SP, Loeser RF, Miller GD et al. Exercise and dietary weight loss in overweight and obese older adults with knee osteoarthritis: the Arthritis, Diet, and Activity Promotion Trial. *Arthritis Rheum.* 2004;50:1501-1510.

- (19) van Gool CH, Penninx BW, Kempen GI et al. Effects of exercise adherence on physical function among overweight older adults with knee osteoarthritis. *Arthritis Rheum.* 2005;53:24-32.
- (20) Lawrence RC, Felson DT, Helmick CG et al. Estimates of the prevalence of arthritis and other rheumatic conditions in the United States. Part II. *Arthritis Rheum.* 2008;58:26-35.
- (21) Baker K, McAlindon T. Exercise for knee osteoarthritis. *Curr Opin Rheumatol.* 2000;12:456-463.
- (22) Fontaine KR, Haaz S. Risk factors for lack of recent exercise in adults with self-reported, professionally diagnosed arthritis. *J Clin Rheumatol.* 2006;12:66-69.
- (23) Wang G, Helmick CG, Macera C, Zhang P, Pratt M. Inactivity-Associated medical costs among US adults with arthritis. *Arthritis Rheum.* 2001;45:439-445.
- (24) Chamberlain MA, Care G, Harfield B. Physiotherapy in osteoarthrosis of the knees. A controlled trial of hospital versus home exercises. *Int Rehabil Med.* 1982;4:101-106.

- (25) Thomas KS, Muir KR, Doherty M, Jones AC, O'Reilly SC, Bassey EJ. Home based exercise programme for knee pain and knee osteoarthritis: randomised controlled trial. *BMJ*. 2002;325:752.
- (26) van Baar ME, Dekker J, Oostendorp RA et al. The effectiveness of exercise therapy in patients with osteoarthritis of the hip or knee: a randomized clinical trial. *J Rheumatol*. 1998;25:2432-2439.
- (27) Keysor JJ, Jette AM. Have we oversold the benefit of late-life exercise? *J Gerontol A Biol Sci Med Sci*. 2001;56:M412-M423.
- (28) Shih M, Hootman JM, Kruger J, Helmick CG. Physical activity in men and women with arthritis National Health Interview Survey, 2002. *Am J Prev Med*. 2006;30:385-393.
- (29) Ettinger WH, Jr., Afable RF. Physical disability from knee osteoarthritis: the role of exercise as an intervention. *Med Sci Sports Exerc*. 1994;26:1435-1440.
- (30) King AC, Rejeski WJ, Buchner DM. Physical activity interventions targeting older adults. A critical review and recommendations. *Am J Prev Med*. 1998;15:316-333.
- (31) Messier SP, Royer TD, Craven TE, O'Toole ML, Burns R, Ettinger WH, Jr. Long-term exercise and its effect on balance in older, osteoarthritic adults:

results from the Fitness, Arthritis, and Seniors Trial (FAST). *J Am Geriatr Soc.* 2000;48:131-138.

- (32) Minor MA. Exercise in the treatment of osteoarthritis. *Rheum Dis Clin North Am.* 1999;25:397-415, viii.
- (33) Murphy SL, Strasburg DM, Lyden AK et al. Effects of activity strategy training on pain and physical activity in older adults with knee or hip osteoarthritis: a pilot study. *Arthritis Rheum.* 2008;59:1480-1487.
- (34) Pate RR, Pratt M, Blair SN et al. Physical activity and public health. A recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. *JAMA.* 1995;273:402-407.
- (35) Haapanen N, Miilunpalo S, Vuori I, Oja P, Pasanen M. Association of leisure time physical activity with the risk of coronary heart disease, hypertension and diabetes in middle-aged men and women. *Int J Epidemiol.* 1997;26:739-747.
- (36) Chodzko-Zajko WJ, Proctor DN, Fiatarone Singh MA et al. American College of Sports Medicine position stand. Exercise and physical activity for older adults. *Med Sci Sports Exerc.* 2009;41:1510-1530.

- (37) Fontaine KR, Heo M, Bathon J. Are US adults with arthritis meeting public health recommendations for physical activity? *Arthritis Rheum.* 2004;50:624-628.
- (38) Bassett DR, Jr. Validity and reliability issues in objective monitoring of physical activity. *Res Q Exerc Sport.* 2000;71:S30-S36.
- (39) Stewart AL, Mills KM, King AC, Haskell WL, Gillis D, Ritter PL. CHAMPS physical activity questionnaire for older adults: outcomes for interventions. *Med Sci Sports Exerc.* 2001;33:1126-1141.
- (40) Craig CL, Marshall AL, Sjostrom M et al. International physical activity questionnaire: 12-country reliability and validity. *Med Sci Sports Exerc.* 2003;35:1381-1395.
- (41) Stewart AL, Mills KM, Sepsis PG et al. Evaluation of CHAMPS, a physical activity promotion program for older adults. *Ann Behav Med.* 1997;19:353-361.
- (42) Washburn RA, Smith KW, Jette AM, Janney CA. The Physical Activity Scale for the Elderly (PASE): development and evaluation. *J Clin Epidemiol.* 1993;46:153-162.

- (43) Washburn RA, Ficker JL. Physical Activity Scale for the Elderly (PASE): the relationship with activity measured by a portable accelerometer. *J Sports Med Phys Fitness*. 1999;39:336-340.
- (44) Araiza P, Hewes H, Gashetewa C, Vella CA, Burge MR. Efficacy of a pedometer-based physical activity program on parameters of diabetes control in type 2 diabetes mellitus. *Metabolism*. 2006;55:1382-1387.
- (45) Bravata DM, Smith-Spangler C, Sundaram V et al. Using pedometers to increase physical activity and improve health: a systematic review. *JAMA*. 2007;298:2296-2304.
- (46) Cyarto EV, Myers AM, Tudor-Locke C. Pedometer accuracy in nursing home and community-dwelling older adults. *Med Sci Sports Exerc*. 2004;36:205-209.
- (47) Kumahara H, Schutz Y, Ayabe M et al. The use of uniaxial accelerometry for the assessment of physical-activity-related energy expenditure: a validation study against whole-body indirect calorimetry. *Br J Nutr*. 2004;91:235-243.
- (48) Tudor-Locke C, Williams JE, Reis JP, Pluto D. Utility of pedometers for assessing physical activity: construct validity. *Sports Med*. 2004;34:281-291.

- (49) Fudge BW, Wilson J, Easton C et al. Estimation of oxygen uptake during fast running using accelerometry and heart rate. *Med Sci Sports Exerc.* 2007;39:192-198.
- (50) Hendelman D, Miller K, Baggett C, Debold E, Freedson P. Validity of accelerometry for the assessment of moderate intensity physical activity in the field. *Med Sci Sports Exerc.* 2000;32:S442-S449.
- (51) Chen KY, Bassett DR, Jr. The technology of accelerometry-based activity monitors: current and future. *Med Sci Sports Exerc.* 2005;37:S490-S500.
- (52) Hawkins MS, Storti KL, Richardson CR et al. Objectively measured physical activity of USA adults by sex, age, and racial/ethnic groups: a cross-sectional study. *Int J Behav Nutr Phys Act.* 2009;6:31.
- (53) Tudor-Locke CE, Myers AM. Challenges and opportunities for measuring physical activity in sedentary adults. *Sports Med.* 2001;31:91-100.
- (54) Ekelund U, Brage S, Griffin SJ, Wareham NJ. Objectively measured moderate- and vigorous-intensity physical activity but not sedentary time predicts insulin resistance in high-risk individuals. *Diabetes Care.* 2009;32:1081-1086.
- (55) Messier SP. Obesity and osteoarthritis: disease genesis and nonpharmacologic weight management. *Rheum Dis Clin North Am.* 2008;34:713-729.

- (56) Hart LE, Haaland DA, Baribeau DA, Mukovozov IM, Sabljic TF. The relationship between exercise and osteoarthritis in the elderly. *Clin J Sport Med.* 2008;18:508-521.
- (57) Hootman JM, Macera CA, Ham SA, Helmick CG, Sniezek JE. Physical activity levels among the general US adult population and in adults with and without arthritis. *Arthritis Rheum.* 2003;49:129-135.
- (58) Felson DT, Niu J, Clancy M, Sack B, Aliabadi P, Zhang Y. Effect of recreational physical activities on the development of knee osteoarthritis in older adults of different weights: the Framingham Study. *Arthritis Rheum.* 2007;57:6-12.
- (59) Fontaine KR, Heo M. Changes in the prevalence of US adults with arthritis who meet physical activity recommendations, 2001-2003. *J Clin Rheumatol.* 2005;11:13-16.
- (60) Ettinger WH, Jr. Physical activity, arthritis, and disability in older people. *Clin Geriatr Med.* 1998;14:633-640.
- (61) Messier SP, Loeser RF, Mitchell MN et al. Exercise and weight loss in obese older adults with knee osteoarthritis: a preliminary study. *J Am Geriatr Soc.* 2000;48:1062-1072.

- (62) Messier SP, Legault C, Mihalko S et al. The Intensive Diet and Exercise for Arthritis (IDEA) trial: design and rationale. *BMC Musculoskelet Disord*. 2009;10:93.
- (63) Miller, G. D. Effects of Varying Accelerometry Criteria on Physical Activity: The Look AHEAD Study. 2010.
- (64) Bellamy N. Pain assessment in osteoarthritis: experience with the WOMAC osteoarthritis index. *Semin Arthritis Rheum*. 1989;18:14-17.
- (65) Guralnik JM, Simonsick EM, Ferrucci L et al. A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission. *J Gerontol*. 1994;49:M85-M94.
- (66) Tudor-Locke C, Hart TL, Washington TL. Expected values for pedometer-determined physical activity in older populations. *Int J Behav Nutr Phys Act*. 2009;6:59.
- (67) Tudor-Locke CE, Myers AM. Methodological considerations for researchers and practitioners using pedometers to measure physical (ambulatory) activity. *Res Q Exerc Sport*. 2001;72:1-12.

- (68) Dipietro L. Physical activity in aging: changes in patterns and their relationship to health and function. *J Gerontol A Biol Sci Med Sci*. 2001;56 Spec No 2:13-22.
- (69) Dunlop DD, Semanik P, Song J, Manheim LM, Shih V, Chang RW. Risk factors for functional decline in older adults with arthritis. *Arthritis Rheum*. 2005;52:1274-1282.
- (70) Yamada S, Baba Y. [Validity of daily energy expenditure estimated by calorie counter combined with accelerometer]. *J UOEH*. 1990;12:77-82.
- (71) Yamada S, Baba Y. [Assessment of physical activity by means of a calorie counter combined with an accelerometer]. *Sangyo Igaku*. 1990;32:253-257.

APPENDIX A

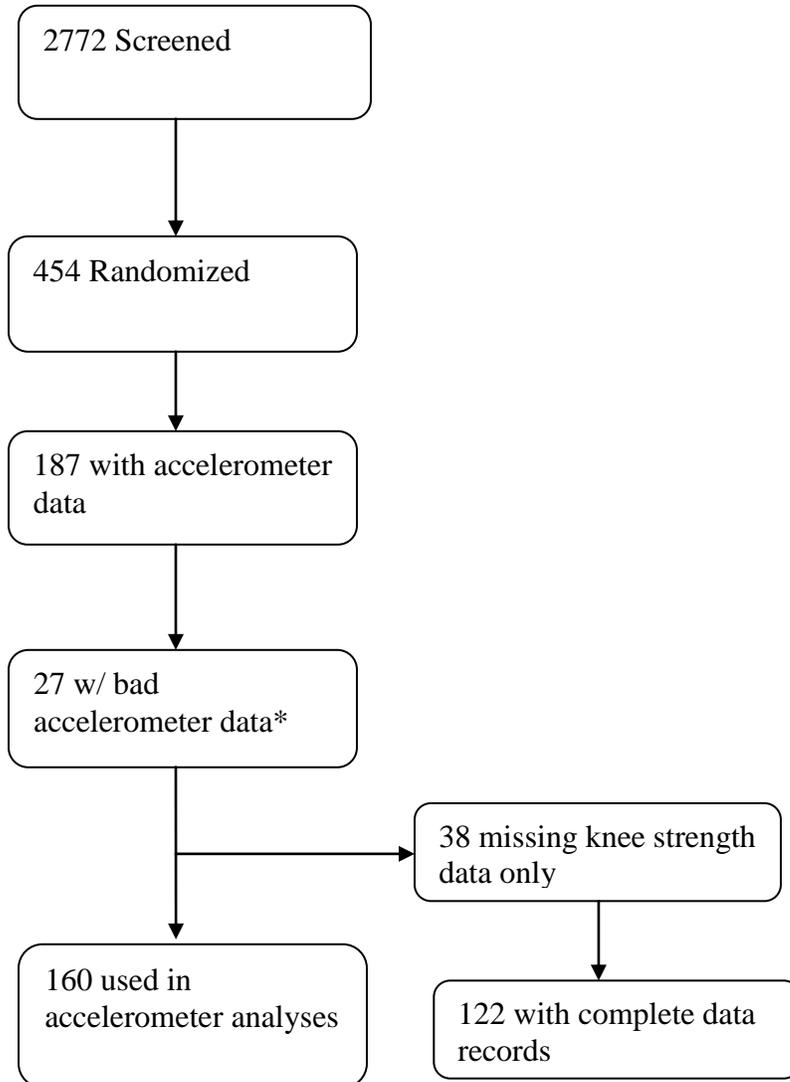
Exclusion Criteria

Criteria	Exclusion	Method
Significant co-morbid disease that would pose a safety threat or impair ability to participate, <u>previous acute knee injury, or knee OA other than tibofemoral</u>	Symptomatic or severe coronary artery disease; severe HTN; active cancer, other than skin cancer; anemia; dementia; liver disease; COPD; peripheral vascular disease; inability to walk without an assistive device; blindness; osteoporosis, ligament or cartilage damage from acute event; <u>type 1 diabetes; type 2 diabetes on thiazolidinediones agents; failure to complete GXT or positive test</u>	Medical history; physical exam; GXT; knee x-ray sunrise view
Ability and willingness to modify dietary or excess behaviors	Unwillingness or inability to change eating and physical activity habits due to environment; cannot speak and read English	Questionnaire, assessment by interventionists
Excess alcohol use	≥ 21 drinks per week	Questionnaire
Inability to finish 18-month study or unlikely to be compliant	Lives >50 miles from site or planning to leave area ≥ 3 months during the next 18 months	Medical history
Conditions that prohibit knee MRI	Pacemaker, severe claustrophobia, defibrillator, implanted metal objects in leg, neurostimulator, magnetic aneurysm clip, any kind of metal implant or foreign metal objects in the body, such as bullets, shrapnel, metal silvers,	Medical history

	etc.	
Significant cognitive impairment	Diagnosis of dementia or a Mini-Mental State Exam (3MSE) score <70	Medical history, 3MSE
Recent knee injection or surgery	Knee injection within the past 1 month or knee surgery in the past 6 months.	Eligibility Questionnaire, Medical History

APPENDIX B

Participant Flow Chart



*Note: bad accelerometer data means data fell outside the valid window, had inconsistent wear log data, or less than 4 days of 10-hour wearing the device

CURRICULUM VITAE

A. PERSONAL INFORMATION

Name Elizabeth A. Chmelo, M.S.

Professional Address Wake Forest University School of Medicine
Section on Gerontology and Geriatric Medicine
Winston-Salem, NC 27104
(336) 713-8518
echmelo@wfubmc.edu

B. EDUCATION

Graduate: Wake Forest University School of Medicine
Winston-Salem, NC
M.S., Clinical and Population Translational Science
Thesis: Physical Activity Habits in Older Adults with Knee
Osteoarthritis August, 2010

Wake Forest University
Winston-Salem, NC
M.S., Health and Exercise Science May, 2007
Thesis: Fear of Falling in Older Adults

Undergraduate Elon University
Elon, NC
B.S., Exercise Science May, 2005

C. PROFESSIONAL EXPERIENCE

2009 to present **Clinical Study Coordinator; Improving Muscle for Functional Independence Trial (I'M FIT); Wake Forest University School of Medicine, Section on Gerontology and Geriatric Medicine, PI: Barbara Nicklas, PhD;** Randomized controlled trial funded by the NIA to determine whether the addition of caloric restriction to a resistance training program improves muscle and overall function in older, overweight and obese men and women

2009 to 2010 **Exercise Physiologist; Physical Activity and Total Health Study (PATH); Wake Forest University Public Health Science, PI: Capri Foy, PhD;** Randomized controlled trial funded by the NIA that examines the effects of pro-social behaviors on physical activity in older adults

2009 to 2010 **Data Collector; Women's Health Initiative Memory Study-Epidemiology of Cognitive Health Outcomes (WHIMS-**

- 2007 to 2009 **ECHO); Wake Forest University Public Health Science, PI: Michelle Naughton, PhD and Maggie Dailey, PhD;** conduct telephone cognitive assessments on the WHIMS cohort
Exercise Physiologist; Cooperative Lifestyle Intervention Program (CLIP); Wake Forest University, PI: W. Jack Rejeski, PhD; Randomized controlled trial funded by the NIH that examined the effect of 3 groups: physical activity only, a combination of physical activity and weight loss, and successful aging education group on mobility disability in older adults who were overweight and had a history of cardiovascular disease or the metabolic syndrome
- 2007 to present **Supervisor for Healthy Exercise & Lifestyle Programs (HELPS) and Graded Exercise Testing; Wake Forest University**

D. GRANTS, SCHOLARSHIPS, AWARDS

- 2007 Wake Forest University Student Alumni Travel Grant
- 2006 Southeast American College of Sports Medicine Student Research Award
- 2003-2005 Elon University Research Assistantship

E. SCHOLARLY ACTIVITY: REFEREED PUBLICATIONS

E.1. Published Manuscripts

Chmelo, E.A., Hall, E.E., Miller, P.C., & Sanders, K.N. Mirrors and Resistance Exercise, Do They Influence Affective Responses? Journal of Health Psychology, 2009 Nov;14(8):1067-74.

Rejeski, W., Marsh, P., **Chmelo, E.,** Rejeski, J., & Gregg, E. Obesity, Intentional weight loss and Physical Disability in Older Adults: Obesity Review, 2009 Nov 17.

Marsh, A.P., **Chmelo, E.A.,** Katula, J.A., Mihalko, S.L., & Rejeski, W.J. Should Physical Activity Programs be Tailored when Older Adults have Compromised Function? Journal of Aging and Physical Activity, 2009, 17, 294-306.

Miller, P.C., Hall, E.E., **Chmelo, E.A.,** Morrison, J.M., DeWitt, R.E., Kostura, C.M. The Influence of Muscle Action on Heart Rate, RPE, and Affective Responses to Upper-Body Resistance Training. Journal of Strength and Conditioning Research, 2009 Mar;23(2):366-72

Rejeski, W., Marsh, P., **Chmelo, E.,** Prescott, A., Dolbrosielski, M., Walkup, M., Espeland, M., Miller, M., Kritchevsky, M. The Lifestyle Interventions and Independence

for Elders Pilot (LIFE-P): Two-Year Follow-up. The Journals of Gerontology. Series A, Biological Science and Medical Science, 2009 Apr;64(4):462-7. Epub 2009 Jan 30.

E.2. Conference Presentations

Chmelo, E., Marsh, A., Katula, J., Mihalko, S., & Rejeski, W. (May 2007). WALK+: A Novel Walking Intervention for Older Adults at Risk for Mobility Disability. American College of Sports Medicine. New Orleans, LA.

Chmelo, E., Kolakowski, E., Mihalko, S., Levine, E. & Ribisl, P. (March 2007). Physical Activity and Function: The Value of Assessment Prior to Surgical Intervention for Breast Cancer. Society of Behavioral Medicine. Washington, DC.

Mihalko, S.L., Anderson, R.T., McCoy, T., **Chmelo, E.**, Kolakowski, E., Rogers, S., Levine, E., & Ribisl, P. (March 2007). Research on Optimal Recovery Practices in Breast Cancer: The RESTORE Trial. Society of Behavioral Medicine. Washington, DC.

Chmelo, E., Mihalko, S., Katula, J., Marsh, A., & Rejeski, W. (February 2007). Correlation of Fear of Falling in Older Adults at Risk for Mobility Disability. Southeast American College of Sports Medicine. Charlotte, NC.

Hall, E.E., **Chmelo, E.A.**, Sanders, K.N., & Miller, P.C. (June 2006). Does a Mirrored Environment Influence the Affective or Perceptual Responses to Resistance Exercise? North American Society of Psychology of Sport and Physical Activity. Denver, CO. Abstract published in *Journal of Sport and Exercise Psychology*, 28, Supplement, S79.

Chmelo, E., Sanders, K., Hall, E., (February 2006). Mirror, Mirror on the Wall: Affective and State Anxiety Responses Following Resistance Training. Southeast American College of Sports Medicine. Charlotte, NC.

Hall, E., **Chmelo, E.**, DeWitt, R., Kostura, C., Morrison, J. & Miller, P. (August 2005). Do You Feel the Pump? Examination of affective responses to different modes of resistance training in college females. In T. Morris (Ed.), *Proceedings of the 11th World Congress of Sport Psychology*. Sydney, Australia: International Society of Sport Psychology.

Chmelo, E., Hall, E., DeWitt, R., Morrison, J., Kostura, C., & Miller, P. (January 2005). State Anxiety Responses in College-Aged Females to Different Resistance Training Modes. Southeast American College of Sports Medicine. Charlotte, NC.

Kostura, C.M., Miller, P.C., Morrison, J., DeWitt, R., **Chmelo, E.**, & Hall, E.E. (January 2005). Assessment of Resistance Training Using HR and RPE: A Preliminary Evaluation. Southeast American College of Sports Medicine. Charlotte, NC.

Chmelo, E., Hall, E., DeWitt, R., Morrison, J., Kostura, C., & Miller, P. (March 2004). Determining Affective Responses in College-Aged Females after Acute Bouts of Resistance Training. National Conference of Undergraduate Research. Indianapolis, IN.

Chmelo, E., Clark, M., Cash, L. (June 2003). Implementation of Regional Anatomy into Undergraduate Pedagogy. American Anatomist Association. Philadelphia, PA.

F. PROFESSIONAL DEVELOPMENT

2009	Pilot Project Skills Development Seminar
2008	Blood Borne Pathogen Safety Training
2008	Study Coordinator 101 Workshop
2005 - Present	CITI certified
2004 - Present	American Heart Association - Basic Life Support Provider

G. PROFESSIONAL COMMUNITY ACTIVITIES

Short Physical Performance Battery Training: Conducted training workshops for undergraduate students; designed to implement safe and consistent training techniques

Physical Assessments and Fitness testing on adult (>50 years old) men's soccer team; designed to create an exercise training program