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Pain and Physical Function in a Socioeconomically Diverse Sample of Black and White Adults

Angela Sardina
University of South Florida, asardina@mail.usf.edu

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by

Angela Sardina

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Co-Major Professor: Ross Andel, Ph.D.
Co-Major Professor: Alyssa A. Gamaldo, Ph.D.
Cathy McEvoy, Ph.D.
Alan B. Zonderman, Ph.D.
Shanthi Johnson, Ph.D.

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DEDICATION

This dissertation is dedicated to my parents, Susan and Jorge Sardina. Thank you for teaching me that it is okay to go out on a limb, and for encouraging me to be the best version of myself. I also dedicate this dissertation to the late Dr. Linda L. Buettner, for setting me on the path to which I am currently traveling. Thank you for showing me my way.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Musculoskeletal pain alters physiological function and these changes may be evidenced as early as middle age. Previous research has concluded that middle-aged adults are a high-risk group for chronic pain and report functional limitations similar to older adults. However, few studies have explored the unique individual factors (e.g., sociodemographic, health, and psychosocial characteristics) that may drive the pain experience; and more research is needed that examines the relationships between musculoskeletal pain and physical function, using objective performance measures, in a sample of racially and socioeconomically diverse adults.

Data from the Healthy Aging in Neighborhoods of Diversity across the Life Span Study (HANDLS) were analyzed across two cross-sectional studies. The first study examined the association between subjective (self-reported) and objective measures of pain (passive range of motion) of the hands, neck and low back. Additionally, this study explored the unique predictors that may be associated with inconsistency between subjective and objective measurements of pain. Results indicated weak but significant correlations between subjective and objective hand-pain measurements. However, there were no significant correlations identified between subjective and objective neck-pain measurements, or subjective and objective low back pain measurements.

Three binary logistic regression models were conducted to explore the relationship between sociodemographic (Model 1), health (Model 2), and psychosocial characteristics (Model 3) of consistent and inconsistent pain measurements for each pain site. There were no significant

relationships between sociodemographic, health, or psychosocial characteristics and consistent and inconsistent hand pain measurements. However, individuals who reported a history of depressive symptoms were nearly 1.8 times more likely to report inconsistent neck pain. Follow-up analyses to explore two-way interactions across unique predictors identified that individuals with a history of depressive symptoms, who were below poverty status, were nearly 3 times more likely to report inconsistent neck pain. Additionally, females, individuals with a greater number of comorbidities, and those with a history of depressive symptoms tended to demonstrate inconsistent low back pain. Follow-up analyses identified that those who identified a history of depressive symptoms, and reported the quality of their neighborhood as "poor" to "fair", were 3.3 times more likely to demonstrate inconsistent low back pain measurements.

The second study examined the relationship between pain, pain interference and a global measure of physical function. Additionally, the study investigated whether relationships between pain, pain interference, and global physical function were moderated by sociodemographic characteristics (e.g., age, sex, race, and measures of socioeconomic status). In multivariable regression analyses, musculoskeletal pain was significantly associated with physical function, particularly among middle-aged and older individuals. Additionally, pain interference was significantly associated with physical function, particularly among older adults.

This dissertation strives to further our understanding of the unique factors that contribute to individualized pain experiences among under-represented populations, and to identify functional deficits that may be evidenced earlier in the life course. Furthermore, this dissertation is intended to motivate further research that explores appropriately timed non-pharmacological interventions that are tailored to the needs of diverse groups, in efforts to reduce musculoskeletal pain, pain interference, and sustain functional independence in later life.

CHAPTER ONE:

INTRODUCTION

The older adult population is expanding rapidly due to the aging of the baby boomer generation, as well as advancements in treatment and care, which are facilitating greater longevity (Gitlin, 2006). However, with greater longevity, individuals are at a higher risk of developing chronic conditions and comorbidities (i.e., co-occurring chronic conditions) that impact health and functional independence in later life. Particularly, nearly 41 million Americans over the age of 50 will develop chronic conditions (e.g., hypertension, musculoskeletal conditions such as arthritis, diabetes, and cardiovascular diseases; Gitlin, 2006) resulting in greater morbidity and mortality (Desai, Zhang, & Hennessy, 1999; Gitlin, 2006). One of the most commonly referenced symptoms associated with chronic conditions is pain, which is estimated to affect nearly 100 million Americans (Institute of Medicine, 2011).

Musculoskeletal pain, or pain in the muscles and joints, is typically identified through subjective reports of the pain experience. In primary care settings, complaints of musculoskeletal pain often elicit further clinical examination (e.g., range of motion) of the affected area, which aid in the diagnosis of underlying pathology, and dictate treatment approaches (Hagen, Harms-Ringdahl, Enger, Hedenstad, & Morten, 1997). Examining an individual's range of motion, an objective indicator of pain, following subjective complaints of pain would suggest that there is an association between motion and pain. Little research has examined whether an individual's subjective report of pain is an accurate representation of underlying pathology. Pain complaints

could be a reflection of psychological disturbances and not necessarily a result of pathophysiology (McGregor, Dore, McCarthy, & Hughes, 1998). Thus, it is important to understand the potential reasons for pain complaints, which subsequently, can improve the type of treatment prescribed to an individual.

Of the research that has explored the relationship between subjective and objective indicators of pain (e.g., pain experienced during passive range of motion), inconsistencies in pain reporting have been identified (e.g., subjective pain reported, however no pain evidenced on passive range of motion; Hagen et al., 1997; McGregor et al., 1998). Particularly, McGregor and colleagues (1998) identified weak relationships between subjective and objective indicators of pain, which suggest that these indicators may be moderated by unique social factors. For example, inconsistencies in pain reporting may vary by individual pain perception, as well as sociodemographic (e.g., age, race, and socioeconomic status), psychosocial (e.g., depression; Casten, Parmelee, Kleban, Lawton, & Katz, 1995; Croft & Rigby, 1994; Fuentes, Hart-Johnson, & Green, 2007; McGregor et al., 1998), and health-related factors (e.g., comorbidities and obesity; Shiri, Karppinen, Leino-Arjas, Solovieva, & Viikari-Juntura, 2010). Thereby reports of pain across subjective and objective indicators may not be an accurate reflection of underlying pathology; rather they may be a product of these individual characteristics (e.g., low socioeconomic status) and/or an individual's psychological state. The research available has not thoroughly investigated the relationships between subjective and objective indicators of the pain experience. More so, studies have not fully explored these relationships across a racially and socioeconomically diverse group of individuals. To better guide treatment approaches for musculoskeletal pain, it is imperative to explore the sociodemographic, health, and psychosocial

characteristics that may drive consistent and inconsistent pain measurements across individuals (Hagen et al., 1997; McGregor et al., 1998).

Among older populations, musculoskeletal pain is associated with psychological symptoms (e.g., depression; Casten et al., 1995) and reduced quality of life (Rustøen et al., 2005). Additionally, physical function may be a particularly prominent correlate of pain, as individuals who report musculoskeletal pain also describe greater impairments in physical function (Weiner et al., 2003; Weiner, Rudy, Morrow, Slaboda, & Lieber, 2006), and report pain that is considered disabling and interferes with normal work (pain interference; Jordan, Thomas, Peat, Wilkie, & Croft, 2008). These relationships between pain, pain interference, and physical function may be evidenced as early as middle age, as this cohort is considered to be at high risk for chronic musculoskeletal pain (Rustøen et al., 2004). Moreover, middle-aged individuals have reported functional limitations that are similar to older cohorts (Covinsky, Lindquist, Dunlop, & Yelin, 2009). On objective performance measures, musculoskeletal pain was significantly associated with poorer performance on measures of lower-body strength (Hall, Mockett, & Doherty, 2006; O'Reilly, Jones, Muir, & Doherty, 1998) and balance (Byl & Sinnott, 1991), as well as mobility-related impairment (Mottram, Peat, Thomas, Wilkie, & Croft, 2008) among middle-aged adults. While these studies suggest that pain may be associated with physiological changes earlier in the life-course, only a few studies have examined these relationships (Byl & Sinnott, 1991; Covinsky et al., 2009; Mottram et al., 2008; Peat, Thomas, Wilkie, & Croft, 2006).

Furthermore, prior research that has explored the pain and physical function relationship has not adequately attempted to examine how sociodemographic characteristics may explain varying pain experiences, as well as moderate the relationship between pain and physical

function. Females, minorities (e.g., Blacks), and those of lower socioeconomic status (SES) are at greater risk of experiencing musculoskeletal pain (Johannes, Le, Zhou, Johnston, & Dworkin, 2010; Patel, Guralnik, Dansie, & Turk, 2013; Portenoy, Ugarte, Fuller, & Haas, 2004). Furthermore, these same groups are more likely to exhibit worse performance on measures of physical function (e.g., upper- and lower-body strength and balance; Kuh et al., 2005; Portenoy et al., 2004), particularly if pain was present (Hicks et al., 2005; Yagci, Cavlak, Aslan, & Akdag, 2007).

Given minority subgroups, particularly Blacks, are more likely than their White counterparts to have lower levels of SES (e.g., low education, risk for poverty, and low income), it is difficult to determine whether health and well-being varies strictly by race, strictly by SES, or by a combination of race and SES (LaVeist, 2005). The coupling between race and SES may explain racially segregated, highly populated neighborhoods where residents are likely to perceive social disadvantage and community disorder. Additionally, minority-aging scholars have further suggested the social disadvantage often experienced by members of the Black community may encourage perceptions and behaviors, such as effortful coping, reflective of perseverance (Bennett et al., 2004; James, 1994). While these relationships are observed across minority groups, no research to date has explored in sufficient detail, the dynamic and complex relationships that exist between sociodemographic characteristics and pain as it relates to objective physical function among younger- to middle-aged adults, particularly across a racially and socioeconomically diverse sample.

Guided by the Motor Adaptation to Pain Theory (Figure 1; Hodges & Tucker, 2011), this dissertation examined the relationship between subjective and objective musculoskeletal pain, and sociodemographic, health, and psychosocial characteristics that may explain discrepancies in

pain measurements. Additionally, this dissertation explored the relationship between musculoskeletal pain and physical function among a socioeconomically diverse group of middle-aged Black and White adults. Data from the Healthy Aging in Neighborhoods of Diversity across the Life Span Study (HANDLS; Evans et al., 2010) was utilized for the proposed research. HANDLS is a prospective, epidemiologically based study designed to disentangle the complex interactions between race, SES, and health outcomes, to understand health disparities across the life course.

The HANDLS study recruited 3,720 community dwelling Black and White adults between the ages of 30-64, from 13 pre-determined contiguous neighborhoods to reflect a representative sample of those residing throughout Baltimore, Maryland (Evans et al., 2010). HANDLS is a longitudinal study to be conducted over the course of 20-years, with data collection occurring approximately every 3-4 years. The uniqueness of the HANDLS study lies in its thorough assessment of demographic (e.g., race, poverty status, and education), physical health (e.g., arthritis, heart disease, obesity, and/or diabetes), and psychosocial parameters (e.g., depression, effortful coping, and neighborhood rating) within a large socioeconomically diverse sample of young, middle-aged, and older adults. Using data from the HANDLS data, this dissertation included two studies to examine specific aims.

Study 1

Study 1 sought to address the following research questions:

Research Question 1:

Is there a relationship between subjective and objective pain?

Research Question 2:

What are the unique correlates that contribute to consistent and inconsistent pain reporting in subjective and objective pain measurement?

To answer these questions, this study incorporated a sample of adults ranging in age from 30-64 to gain a better understanding of the relationships between subjective and objective measures of musculoskeletal pain across age groups. Using both pain measures, this study also aimed to identify individual characteristics (e.g., sociodemographic, health, and psychosocial factors) that may explain differences in pain experience and pain behavior, which manifests earlier in the life course, particularly in the hands, neck, and low back. As a result, Study 1 examined the following aims:

Aim 1:

To examine the relationship between subjective and objective musculoskeletal pain (i.e., pain identified upon passive range of motion), across the hands, neck, and low back.

Aim 1 Hypotheses: Subjective musculoskeletal pain of the hands, neck, and low back would demonstrate weak or non-significant correlations with objective musculoskeletal pain in the same bodily locations.

Aim 2:

To explore which individual characteristics (e.g., sociodemographic, health, and psychosocial factors) are unique correlates of consistent and inconsistent subjective and objective pain.

Aim 2 Hypotheses: Adults with consistent subjective and objective reports of pain would be older, have higher levels of education, are above poverty status, and report a greater number of comorbidities. In contrast, those with inconsistent subjective and objective pain symptoms would have lower levels of education, be below poverty status, display more effortful coping

(e.g., higher "John Henryism"), exhibit higher levels of depressive symptoms, report a history of depressive symptoms, and identify poorer neighborhood ratings.

Study 2

As a follow-up to Study 1, Study 2 sought to answer the following research questions:

Research Question 1:

Are musculoskeletal pain and pain interference significantly associated with physical function?

Research Question 2:

Do sociodemographic characteristics (e.g., age, race, sex, and measures of SES) moderate the relationships between musculoskeletal pain, pain interference, and physical function?

Study 2 explored the relationships between musculoskeletal pain, and pain interference, and physical function (e.g., a global measure of upper- and lower-body strength, balance, and gait abnormalities). This study incorporated two aspects of subjective pain. The first aspect includes subjective reports of musculoskeletal pain in the hands, neck, low back, joint/s and muscle/s; as well as whether pain experienced in the past four weeks interferes with daily work (pain interference). Study 2 was designed to expand upon earlier research, which suggested that the relationships between pain and poorer physical function begin earlier in the life course (Byl & Sinnott, 1991; Covinsky et al., 2009; Hall et al., 2006; Mottram et al., 2008). Additionally, study 2 was one of the first studies that further explored the complex interactions across sociodemographic characteristics using a variety of SES-based measures, particularly as it pertained to the relationship between musculoskeletal pain and physical function.

Exploring the complex interactions between sociodemographic variables is critical due to the highly subjective nature of the pain experience. Individuals experience, perceive, and describe pain differently. As a result, cultural differences of the pain experience may influence psychometric properties of pain measures across groups (Gélinas et al., 2008; Katz & Melzack, 1999). Because of the individualized nature of the pain experience, it is important to understand musculoskeletal pain earlier in the life course, its relationship with performance measures; and to understand how sociodemographic characteristics (e.g., differences across race, sex, and/or various measures of SES) may moderate this relationship. With greater awareness of the unique factors that contribute to individualized pain experiences, it will guide appropriately timed interventions, as well as interventions that are tailored to the needs of different groups. As a result, Study 2 proposed the following aims:

Aim 1:

To explore the relationship between musculoskeletal pain, pain interference, and physical function.

Aim 1 Hypotheses: Both musculoskeletal pain and pain interference would be significantly associated with poorer physical function.

Aim 2:

Examine whether the relationship musculoskeletal pain and physical function is moderated by sociodemographic characteristics (e.g., age, race, sex, and across measures of SES).

Aim 2 Hypotheses: Adults who self-identify as Black, have lower levels of education, poorer reading literacy, or fall below poverty status, would demonstrate worse physical functioning, particularly if they experience musculoskeletal pain and pain interference.

The proposed studies incorporated only those with valid data for all measures (e.g., pain, health, and psychosocial variables), which is consistent with other research that has used the HANDLS data (Beydoun et al., 2009; Thorpe, Simonsick, Zonderman, & Evans, 2016). While using only complete data in these studies may increase potential bias within the sample, multiple imputation may lead to similar biases due to the large percentage of missingness across pain, health, psychosocial, and physical function variables. Furthermore, both studies included numerous indicators of SES, in efforts to disentangle the effects of racial and socioeconomic disparities in physical function. Inclusion of only one variable (e.g., years of education) would not adequately distinguish between racial and socioeconomic disparities in pain and physical function (Braveman et al., 2005). Thus, these studies incorporated two forms of education (i.e., self-reported years of education, as well as the Wide Range Achievement Test (3rd edition), which is an objective indicator of reading literacy and education quality (WRAT-III; Wilkinson, 1993), as years of education may not be an adequate representation of education quality (Manly, Jacobs, Touradji, Small, & Stern, 2002). Additionally, poverty status was also considered within these studies.

CHAPTER TWO:

THEORETICAL FRAMEWORK

Note to Reader

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Historical Theoretical Models

Early theories that strive to explain the pain experience are largely one-dimensional. These theories often focus on physiological function, or the psychological, cognitive, and social experience (e.g., Gate Control Theory, and operant and classical conditioning). Affective and emotional models, as well as the Cognitive-Behavioral Theory, begin to place greater emphasis on the connection between the mind and body. However, these earlier theories fall short in fully explaining the interactions across individualized physical, psychological, and social factors that contribute to the experience of pain. As a result, the more recent biopsychosocial model incorporates these theories into one conceptual model and provides a more comprehensive view of the pain experience (Gatchel, 2004). While the common denominator across these various theories is physiological/biological function, consideration of the interactions among physiological, psychological, and social components of pain promotes a more extensive understanding of the pain experience and the relationship between musculoskeletal pain and physical function.

The Biopsychosocial Model

The biopsychosocial model considers the relationships and interactions between the biological, psychological, social processes that shape individual perception of the pain experience, as well as pain behavior (Turk & Flor, 1999). Flor and Turk (2013) suggest that pain is a multidimensional experience in which the psychological, social, and cognitive factors result in maladaptive biological responses to pain (e.g., altering of posture and movement, or avoidance of physical activity altogether). These physiological responses to pain produce feedback loops (e.g., continuous and ongoing interactions that produce deleterious effects between the mind and body), which further reinforce the pain experience. As we continue to understand musculoskeletal pain and the relationship between pain and physical function, it is important to consider two major biopsychosocial-based theories: The Fear-Avoidance Theory (Lethem, Slade, Troup, & Bentley, 1983) and the Motor Adaptation to Pain (MAP) Theory (Hodges & Tucker, 2011).

Fear-Avoidance Model

The Fear-Avoidance model, developed by Lethem and colleagues (1983), strives to explain why some individuals who experience acute pain from noxious stimuli (actual or potential tissue damaging event), convert to chronic pain (e.g., pain that persists greater than 3-6 months or longer than what is considered normal tissue healing; Johannes et al., 2010), whereas others do not. Derived from early research on back pain, the authors observed two extremes as it relates to coping responses: confrontation and avoidance. When confronting pain, the individual experiences a reduced fear of pain over time. However, those who avoid pain are cognizant of

the pain, and behaviorally avoid activities or restrict movements that are perceived to provoke pain of greater intensity (Lethem et al., 1983).

Moreover, avoidance of activity (e.g., physical or social engagement) is linked to poorer physical performance and reduced psychological health (Lethem et al., 1983). The physiological consequences of avoidance range from reduced strength to loss of mobility, which exacerbates the pain experience and reinforces the avoidance process. From a psychological standpoint, avoidance of physically engaging activities increases the sensitivity to pain, thereby resulting in more pain and subsequent decline in functional abilities. For example, individuals may experience positive and negative reinforcement (e.g., classical conditioning). Positive reinforcement (e.g., relief from pain) and negative reinforcement (e.g., greater pain upon movement; Fordyce, Shelton, & Dundore, 1982) lead to maladaptive responses if uncorrected, such as greater intensity of pain, and reduced engagement in physical and social activities (Fritz, George, & Delitto, 2001; Lethem et al., 1983). The final psychological consequence is ultimately asynchrony between the level of pain one experiences and the actual pathology present.

The strength of the Fear-Avoidance model lies in its biopsychosocial approach to understanding pain and physical function, and its applicability across various chronic conditions (Bishop, Ferraro, & Borowiak, 2001; Mackichan, Adamson, & Gooberman-Hill, 2013). However, it is unclear whether this model would explain the relationship between pain and physical function among younger- to middle-aged samples, as well as across racially and/or socioeconomically diverse groups. Specifically, the theory does not explain the process related to more subtle changes in motor function (e.g., redistribution of activities between and within muscles to complete action, redistribution of load to provide short-term relief, and individual ability to compensate), which occur earlier in the pain experience. These subtle changes in motor

function may be observed among individuals who display more confrontational, or active-based, coping strategies when in pain (Hodges & Smeets, 2015).

The Motor Adaptation to Pain Theory

The MAP theory (Hodges & Tucker, 2011) adopts a biopsychosocial model through the incorporation of the psychological, social, and cognitive impact of musculoskeletal pain on various aspects of physical function (e.g., strength, balance, and mobility); and considers more confrontational or active coping strategies, adopted by those in pain. Therefore, this theory may provide a better explanation as to why pain serves as a mechanism for physiological changes earlier in the life course. As illustrated in the model (Figure 1), Hodges and Tucker (2011) posit that pain produces unique reactions across various levels of the nervous system (e.g., brain and spinal cord; Hodges & Smeets, 2015). These reactions to pain result in physical modifications associated with motor output. Subsequent physical modifications can range from subtle to major. Subtle physical modifications, such as the redistribution of activity between muscles (e.g., stiffness and the recruitment of other muscles to execute a movement) or change in loading patterns (e.g., shift the center of posture posteriorly), are adopted to provide short-term relief from pain. Major changes (e.g., excess loading on structures unable to handle weight distribution, or activity avoidance) as identified in the Fear-Avoidance model, may result in long-term consequences if proper posture and movement are not restored. In this context, long-term consequences may result over time, which include: deconditioning and/or general persistence of symptoms (Hodges & Smeets, 2015; Hodges & Tucker, 2011), and potentially result in poor mobility and falls as compensatory abilities decrease (Ferrucci et al., 2016). In addition to physical changes, the MAP Theory indicates that the feedback loop between pain and physical modifications are dependent upon the interaction of unique individual characteristics

(e.g., sociodemographic factors such as age, sex, race, SES, physical and psychological health, active coping, and environment; Hodges & Smeets, 2015; Hodges & Tucker, 2011).

The MAP Theory provides a useful framework for this dissertation because, besides being empirically supported, it focuses on the notion that pain may begin earlier in the life course and may result in subtle changes in physical function. Much of the literature that examined the relationship between pain and physical function is conducted in aging populations as limitations are often identified, and more easily observable in older adulthood (Melzer, Gardener, & Guralnik, 2005). However, recent research by Rustøen and colleagues (2005) suggest that middle-aged individuals are experiencing similar levels of pain; and self-reported limitations as individuals who are 20-30 years older (Covinsky et al., 2009). Additionally, earlier studies that incorporated objective performance measures amongst those younger in age have concluded that musculoskeletal pain was significantly associated with worse strength (Hall et al., 2006; Hicks et al., 2005; O'Reilly et al., 1998; Patel et al., 2013), poorer balance (Brumagne, Janssens, Janssens, & Goddyn, 2008; Byl & Sinnott, 1991; Leveille, Bean, Ngo, McMullen, & Guralnik, 2007; Lihavainen et al., 2010), and impaired gait (Mottram et al., 2008; Peat et al., 2006; Rantanen, Guralnik, Ferrucci, Leveille, & Fried, 1999). These findings offer preliminary support; however, more research is needed amongst this group.

Furthermore, while this age group may not exhibit observably significant declines in physical function, as seen among older populations, it is important to consider that this age group may also have a greater ability to compensate for deficits. Specifically, young- to middle-aged individuals may possess greater functional reserve, resulting in a wider range of compensatory strategies, as compared to someone who is older (Ferrucci et al., 2016). These compensatory strategies may make it difficult to identify changes in physical function and performance

occurring within this population. As a result, current research focused on older populations may be missing indicators of functional change (e.g., reduced strength, altered balance, and gait abnormalities) that are occurring earlier in the life course (Ferrucci et al., 2016).

Moreover, the main premise of the MAP theory stresses that pain alters physiological function. This theory broadly supports the idea that individuals who present with musculoskeletal pain typically exhibit a gradual onset of pain symptoms in early- to middle-adulthood, with sporadic symptoms of pain and remission from pain as one ages (Mourão, Blyth, & Branco, 2010). Continuous physiological modifications may be related to feedback loops, between pain and the central nervous system, which start at younger age and progress over time. The rate of progression is an individual experience, which is largely dependent on sociodemographic characteristics, comorbidities, psychosocial and health factors, as well as functional reserve across each individual. This dissertation did not include longitudinal analyses to test the changes in physiological function as indicated in the MAP theory; rather it focused on specific pathways. As a result, a conceptual model based on the MAP theory was developed to understand the role of pain on physical function outcomes (Figure 2).

Proposed Conceptual Model Based on the Motor Adaptation to Pain Theory

This conceptual model proposed that musculoskeletal pain, which begins earlier in the life course produces neuromuscular changes and leads to physiological modifications. It is possible that these physiological modifications to pain ultimately lead to pain interference, or pain that interferes with normal work or function, and eventually progresses and translates to poorer physical function. Specifically, if pain remains uncorrected individuals may demonstrate reduced strength, which progresses to impaired balance, and eventually reflects in gait

abnormalities with age, thereby increasing susceptibility to falls over time. Previous literature has identified significant relationships supporting the connection between strength, balance, mobility, and musculoskeletal pain in younger- to middle-aged individuals (Hall et al., 2006; O'Reilly et al., 1998).

For example, middle-aged individuals with knee pain demonstrated less activation within painful muscles, which reduced strength and increased muscle recruitment to execute the movement (O'Reilly et al., 1998; Tucker & Hodges, 2010). These findings suggest that musculoskeletal pain may contribute to subtle physical modifications that reduce strength during execution of an action or movement. Strength is a critical component for maintaining the center of posture (center of gravity) and preserving balance (Brumagne, Cordo, & Verschueren, 2004). The relationships between chronic musculoskeletal pain, strength and balance are evidenced at earlier ages and are expected to gradually decline over time, if left untreated (Hodges & Tucker, 2011). Physiological modifications may be subtle (e.g., stiffening of the muscles surrounding the painful area) or major (e.g., redistribution of load) in response to pain, and are implemented to elicit short-term relief. However, if these physiological modifications persist, it could eventually reflect in the quality and fluidity of movement as one continues to age (Hodges & Smeets, 2015; Hodges & Tucker, 2011).

The main premise of this conceptual model suggests that musculoskeletal pain, whether pathological or psychosomatic in nature, may alter physical function with changes occurring as early as younger- to middle-age. These alterations are greater than what is to be expected with normal age-related decline. Over time, the individual compensates through physiological modifications, until functional reserves are exhausted and compensation is no longer possible (Ferrucci et al., 2016). As a result, long-term consequences as indicated by the MAP theory are

reflective of losses in reduced physical performance, poorer mobility, and potentially lead to falls with age. To test this conceptual model, study 1 focused on the first pathway. Particularly, the first study explored pain prevalence in younger to older adults and examined the unique contributions of individual characteristics that may diversify the pain experience across age groups. Study 2 explored two aspects of subjective pain (e.g., experience with pain and pain interference) and their relationship with a global measure of physical function that considered upper- and lower-body strength, balance performance, and mobility related impairments.

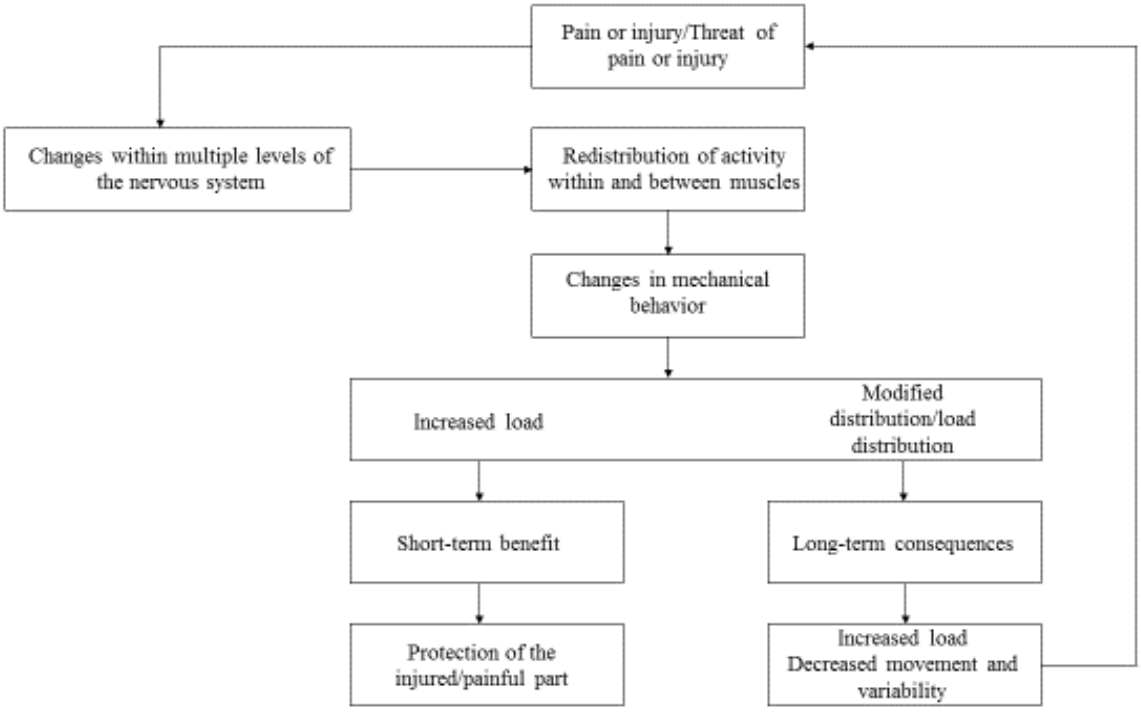

Figure 1. Motor Adaptation to Pain (MAP) Theory. This model was previously published in PAIN (Hodges & Tucker, 2011) and is illustrated here with permission of Wolters Kluwer Health, Inc (see Appendix 1A).

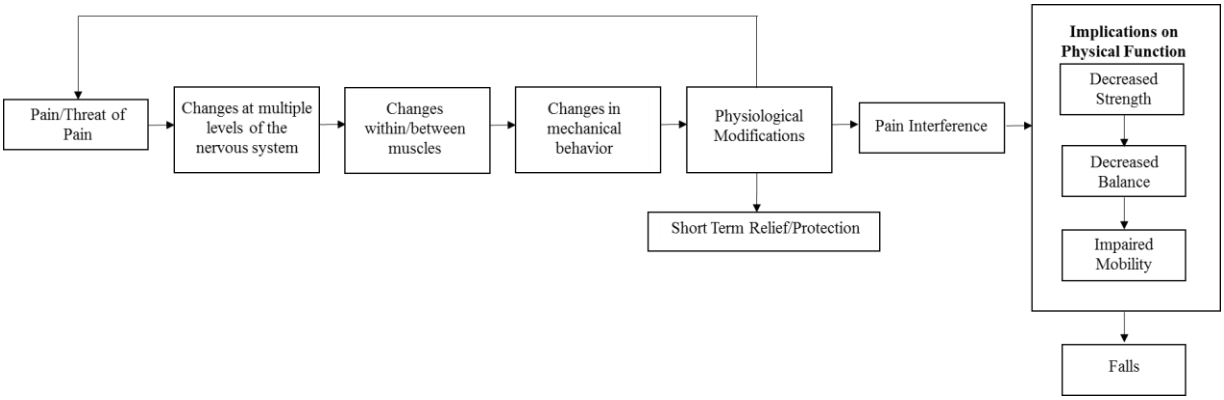

Figure 2. Adapted Conceptual Model of the Motor Adaptation to Pain (MAP) Theory incorporating measures of physical function. This conceptual model was reproduced from Hodges and colleagues (2013).

CHAPTER THREE: STUDY 1: CROSS-SECTIONAL EXAMINATION OF SUBJECTIVE AND OBJECTIVELY INDICATED MUSCULOSKELETAL PAIN AS IT RELATES TO SOCIODEMOGRAPHIC, HEALTH, AND PSYCHOSOCIAL CHARACTERISTICS

Introduction

Pain is defined as an unpleasant sensory and emotional experience that is often linked with chronic conditions or perceived tissue damage (Merskey, 1986). Musculoskeletal pain, or pain that pertains to the muscles and joints, is one of the most commonly reported symptoms associated with disability across the lifespan (Patel et al., 2013). Pain may be non-specific, widespread, or localized to specific regions such as the low back or neck (Viniol et al., 2013; Weiner et al., 2003), and is considered a clinical problem when symptoms persist without any indication of specific pathology (Bergman, 2007). Musculoskeletal pain is typically identified by self-report of presence, location, intensity, and frequency. However, musculoskeletal pain that is present during clinical visits typically warrants further investigation to identify whether abnormalities in the affected joint are also present upon objective examination (e.g., pain indicated upon passive range of motion of the affected area; McGregor et al., 1998). Past research has concluded that relationships between subjective and objective indicators of pain were weak (McGregor et al., 1998), which may be a result of unique sociodemographic, health, and psychosocial factors (Teske, Daut, & Cleeland, 1983).

However, little research to date has examined musculoskeletal pain earlier in the life course, particularly using subjective and objective measures of pain. Specifically, research that has examined the associations between sociodemographic, health, and psychosocial factors (e.g., age, race, medical conditions, and neighborhoods), on both subjective and objective musculoskeletal pain, is limited. Development of a more comprehensive understanding of the pain experience, earlier in the life course, will translate to more timely interventions (e.g., physical or cognitive-behavioral therapies), which are tailored to the unique needs across diverse groups. Specifically, if pain is psychosomatic, or inconsistent with pathological findings, it may be an indication of underlying psychological distress and/or exaggerated illness behavior (McGregor et al., 1998). Psychosomatic pain may require different treatment approaches than what is typically prescribed for pain that is considered secondary to abnormality or disease. Causes of pain that are improperly diagnosed and untreated, or unresolved musculoskeletal pain that interferes with normal work, may have implications on physical function and contribute to disability. As a result, more research is needed that identifies individual characteristics that contribute to different pain experiences.

Pain and Sociodemographic Characteristics

Chronic conditions become more prevalent with age and are associated with greater risk of experiencing musculoskeletal pain. Hence, a great deal of literature has focused on the pain experience among older adults (Leveille et al., 2009; Rudy, Weiner, Lieber, Slaboda, & Boston, 2007). However, recent studies suggest that middle-aged individuals are a high-risk group for chronic musculoskeletal pain with prevalence rates mirroring those of older populations (Mottram et al., 2008; Rustøen et al., 2005). Particularly, Covinsky and colleagues (2009)

concluded that middle-aged adults reported experiencing functional limitations that are commonly observed among individuals who are two or three decades older. While studies suggest that musculoskeletal pain is prevalent across middle-aged adults, most have solely focused on the subjective reports of pain within this population and have not considered a commonly used method of passive manipulation of the affected area during clinical examination, which aims to diagnose the underlying cause of the pain and may dictate treatment approaches.

Incorporating objective indicators of pain may serve as a more impartial measure that complements self-reported pain indices, as subjective questionnaires may be biased by psychological and psychosocial factors (Cox et al., 2000). Additionally, weak relationships between subjective and objective reports suggest that these indices may tap into different constructs of the pain experience. Thus, inclusion of objective measures may assist in differentiating pain that is psychosomatic from pain that is secondary to underlying pathology. However, more research is needed that examines the association between objective indicators and subjective reports of pain. Of particular importance is greater awareness regarding individual characteristics (e.g., sociodemographic, health, and psychosocial) that may contribute to inconsistent pain reporting, thus stimulating more accurate diagnoses and appropriate treatment approaches among a diverse younger- and middle-aged population (Cox et al., 2000; Hagen et al., 1997; McGregor et al., 1998).

Moreover, past studies have concluded that females, Blacks (Fuentes et al., 2007; Green, Baker, Sato, Washington, & Smith, 2003), those with higher body mass index (Weiss, 2014), and individuals of lower socioeconomic status (Johannes et al., 2010; Patel et al., 2013; Portenoy et al., 2004) were more likely to experience chronic musculoskeletal pain. Furthermore, Blacks demonstrate significantly more chronic pain, particularly affective pain (e.g., depression-related

or emotionally-based; Fuentes et al., 2007; Von Korff, Ormel, Keefe, & Dworkin, 1992), and were more likely to reside in neighborhoods of lower socioeconomic status (Green & Hart-Johnson, 2012), which has been previously linked to disabling pain (Jordan et al., 2008). Minimal research has strived to disentangle the complex interactions between sociodemographic characteristics, particularly racial and socioeconomic disparities on the pain experience. Therefore, further investigation is warranted due to differences between racially and socioeconomically diverse groups, which may be attributed to preventable psychosocial factors (e.g., obesity, poor neighborhood environment, and/or inappropriate coping mechanisms; Croft & Rigby, 1994).

Additionally, while racial disparities have been previously associated with chronic musculoskeletal pain, SES may explain the pain and race relationship (Green & Hart-Johnson, 2012; Portenoy et al., 2004). Particularly, racial minorities are more likely to experience lower SES, which represents an overlap between race and SES (LaVeist, 2005). This overlap produces confounding effects of racial and socioeconomic disparities, and inhibits the ability to understand the relationships between sociodemographic factors that reflect the pain experience. For example, some studies that incorporated measures of race and SES have concluded that controlling for a variety of measures of SES reduces the magnitude of, or eliminates, racial disparities in the pain experience (Portenoy et al., 2004; Williams, 1996), particularly if social factors were equalized (LaVeist, Pollack, Thorpe, Fesahazion, & Gaskin, 2011). More research is required that aims to disentangle race and measures of SES, as well as identify the unique contributions of health and psychosocial factors within subjective and objective measures of musculoskeletal pain.

Health and Psychosocial Characteristics of Pain

Other factors that contribute to differences in the pain experience are associated with health, psychosocial, and coping factors. With regard to health, comorbid conditions were associated with pain, particularly musculoskeletal pain of greater intensity (Urquhart et al., 2011). Furthermore, psychological factors (e.g., depression; Clay et al., 2015; López-López, Montorio, Izal, & Velasco, 2008) and environmental characteristics (reduced access to healthcare or deprived neighborhood conditions; Jordan et al., 2008) are associated with greater prevalence of musculoskeletal pain across age groups. This is particularly true across neighborhoods of lower socioeconomic status and greater deprivation, as these areas were associated with more disabling pain exhibited by individuals with poorer coping skills (Jordan et al., 2008). For example, Baker and Green (2005) concluded that younger and middle-aged Blacks and Whites demonstrated greater levels of depression, greater pain intensity, and poorer coping skills than their older counterparts. The authors suggested that age-related differences across racial groups may be associated with a greater ability for the older adult to implement effective coping mechanisms that are more proportional to changes in psychological and physical health. These coping mechanisms may be more effective with age as they are based on learned strategies developed over time, and may aid in reducing psychological distress that is often associated with the experience of pain. Additionally, older adults may also have greater thresholds for pain, and when coupled with lower levels of expectations pertaining to one's physical capabilities, it may minimize the level of distress experienced when in pain. Hence, the experience of pain may be particularly distressing earlier in the life course. While the findings across these studies suggest that unique sociodemographic, health, and psychosocial characteristics may explain differences

in the pain experience, it is unclear how these characteristics might contribute to consistent and inconsistent measurements of pain.

As a result, the purpose of this study was to: 1) Examine the relationship between subjective and objective pain across the hands, neck, and low back; and, 2) Explore which individual characteristics (e.g., sociodemographic, health, and psychosocial factors) are unique correlates of consistent and inconsistent subjective and objective pain. It was hypothesized that subjective musculoskeletal pain of the hands, neck, and low back, would demonstrate weak or non-significant correlations with objective musculoskeletal pain in the same bodily locations. Additionally, adults with consistent subjective and objective reports of pain would be older, have higher levels of education, are above poverty status, and report a greater number of comorbidities. In contrast, those with inconsistent subjective and objective pain symptoms would have lower levels of education, be below poverty status, display more effortful coping (e.g., higher "John Henryism"), exhibit higher levels of depressive symptoms, report a history of depressive symptoms, and identify poorer neighborhood ratings. Furthermore, this research tested the first element of the conceptual model (Figure 2) as adapted from the Motor Adaptation to Pain theory.

Methodology

Participants

Participants in this study came from the Healthy Aging in Neighborhoods of Diversity across the Life Span Study (HANDLS; Evans et al., 2010). HANDLS is a 20-year longitudinal study designed to examine the influences of sociodemographic factors, specifically race and SES on health outcomes over time. Participants from study 1 included community dwelling,

socioeconomically diverse Blacks and Whites, aged 30-64 (*n* = 887; see Figure 3 for participant flow chart). Only those with valid data for all measures (e.g., sociodemographic, health, psychosocial and musculoskeletal pain variables) were included in the current study. HANDLS recruited participants from 13 pre-determined groups of contiguous census tracts located within Baltimore, Maryland. Data collection occurred in two phases. First, an in-home interview was conducted to collect subjective information (e.g., health status and psychosocial information). Secondly, Medical Research Vehicles parked within each neighborhood, collected data from objective measures (e.g., clinical examination and physical performance). All participants were compensated for their time. The current study utilized cross-sectional data from HANDLS Wave 1, which was collected over approximately 4½ years (2004-2009). HANDLS was approved by the Institutional Review Board at the National Institute of Environmental Sciences at National Institutes of Health. All participants provided written informed consent. This study was approved by the Institutional Review Board at the University of South Florida.

Measures of Pain as Outcome Variables.

Information regarding pain was obtained as part of the participant's medical history, as well as objectively during clinical examination. Participants needed to have valid data on the subjective and objective pain measures of the hand, neck, and low back to be included in the analyses.

Subjective pain. A physician or nurse practitioner collected a detailed medical history in a structured interview, in which participants indicated whether they have experienced neck pain and/or low back pain ("no" = 0, "yes" = 1) in the last 12 months from data collection. Hand pain was derived from the following question: "Is pain or arthritis in the hands worse recently?" ("no"

= 0, “yes” = 1). Subjective pain sites were examined individually (e.g., subjective hand pain, subjective neck pain, and subjective low back pain). An overall pain measure (subjective pain) was developed and dichotomized as “yes” or “no”. Therefore, if participants indicated “yes” (1) to any of the following pain sites than they were classified as “yes” (1) for overall subjective pain.

Objective pain. Objective pain is a component of the physical examination. The physician or nurse practitioner manipulated the limb/joint through its full range of motion, and looked for any evidence/indication of pain upon passive range of motion (e.g., verbalizing pain, moaning, and/or facial expressions). The clinicians used their judgment as to whether pain was “absent” (0) or “present” (1) during the examination. The nurse practitioners were trained by the physician to also conduct the examination. Objective pain was examined for the following areas: left- and right-hand, neck, and low back pain. Overall hand pain was used, which was a composite of left- and right-hand pain. If participants indicated pain in either hand, total hand pain was “yes” (1). Objective pain sites were examined individually (e.g., objective hand pain, objective neck pain, and objective low back pain), and an overall pain measure was dichotomized across the three pain measures, to which a “yes” (1) response across any of the sites represented overall objective pain.

Independent Variables

Sociodemographic Variables. Demographic data were collected during in-home visits. Age was grouped to distinguish “younger” (0; age 30-39), “middle-aged” (1; age 40-54), and “older” (2; age 55+). Sex represented “males” (0) and “females” (1). Race was coded as “Black” (1) or “White” (0). Various socioeconomic variables were incorporated in efforts to disentangle

the complex relationships between race and SES. Poverty status was determined by poverty guidelines published by the U.S. Department of Health and Human Services (2004), which is consistent with the time data collection began for this wave. Poverty status was based on poverty guidelines set forth in 2004, and was defined by HANDLS as, "below poverty status" (0), which included those who subjectively reported income at or below 125% of the poverty level, and "above poverty status" (1), which included those who reported income over 125% of the poverty level (Evans et al., 2010). Education was collected as total years of education, and was based on the highest level or grade attained. Education was included within the current study's analyses as a continuous variable. The Wide Range Achievement Test-III (WRAT-III; Wilkinson, 1993) is used as an objective measure of reading literacy and education quality. Scores were determined by a participant's ability to recognize and correctly pronounce letters and words, in which a total score was derived. The total WRAT-III score remained continuous with an overall range of "low reading literacy" (0) to "high reading literacy" (57).

Health Variables. Health-related factors were obtained during medical history interview, in which participants indicated "yes" (1) or "no" (0) to being asked if they have/had the following health conditions: 1) fracture, 2) hypertension, 3) hyperthyroidism and 4) hypothyroidism, 5) stroke, 6) diabetes, 7) osteoarthritis, 8) rheumatoid arthritis, and 9) gout. To maximize the sample size, and reduce exclusion due to missing data, spearman correlations were conducted between aforementioned health variables and overall subjective and objective pain. The following health variables demonstrated significant relationships with either subjective or objective pain, and were incorporated into analyses: 1) fracture (correlated with subjective pain; $r = 0.10$, $p = .006$); 2) hypertension (correlated with subjective pain; $r = 0.10$, $p = .005$); 3) hyperthyroidism (correlated with subjective pain; $r = 0.09$, $p = .008$); and hypothyroidism

(correlated with subjective pain; $r = 0.09$, $p = .008$). A sum score was calculated in which this group of health-related factors were coded as comorbidities (possible range of health conditions = 0 - 4). Due to unequal distribution with higher levels of comorbidities, health conditions was further collapsed as "no health conditions" (0), "one health condition" (1), and "2 or more health conditions" (2). The categorized health condition variable was incorporated into the analyses. Height and weight of each participant were measured by HANDLS. Body mass index (BMI) was calculated as weight (kg) divided by height (m^2). BMI remained continuous within the analyses.

The Center for Epidemiologic Studies Depression Scale (CES-D; Radloff, 1977) was used to measure depressive symptomology of the sample. The CES-D is a 20-item scale that identifies depressive symptoms, mood, and affect over the past week. Participants were provided statements, which included but were not limited to the following: "During the past week, I was bothered by things that usually don't bother me," or "During the past week my sleep was restless." Possible responses include the following: "Rarely or none of the time (Less than 1 day)", "Some or a Little of the Time (1-2 days)", "Occasionally or a Moderate Amount of Time (3-4 days)", and "Most or All of the Time (5-7 days)." Possible scores range from 0 - 60. Higher total scores are indicative of greater depressive symptomology. Scores on the CES-D remained continuous and analyzed independent of health conditions as it is representative of psychological health and has been found to be prevalent in individuals who experience pain (Patel et al., 2013). In addition to the CES-D, an individual history of depressive symptoms was included. History of depressive symptoms was obtained via self-reported medical history, and comprised a "yes" (1) or "no" (0) response to the following question: "In the past 12 months have you experienced depression?" (Evans et al., 2010).

Psychosocial Variables. Psychosocial variables were obtained during the in-home interviews. Neighborhood rating was provided as a component of the in-home questionnaire, and asked participants, "How would you rate your neighborhood?" Possible responses included the following: "excellent" (5), "very good" (4), "good" (3), "fair" (2), or "poor" (1). For this study, this variable was categorized as "excellent", "very good", and "good", (0); and "fair" and "poor" (1). "Fair" and "Poor" responses were collapsed due to unequal distribution; which is consistent with research that has previously explored similar neighborhood ratings (Schootman et al., 2006). Previous findings concluded that poorer neighborhood ratings, particularly as it pertains to neighborhood SES, are associated with chronic pain across older Blacks and Whites (Fuentes et al., 2007). This indicator represented perceived neighborhood quality.

Effortful coping was measured by the "John Henryism" Scale for Active Coping (James, 1994). This 12-item scale included statements such as: "I've always felt that I could make of my life pretty much what I wanted to make of it, "and "When things don't go the way I want them to, that just makes me work even harder." Responses to each question ranged from "completely true" (1) to "completely false" (5). All items are reverse coded, and summed to arrive at a total score, which ranges from "low John Henryism" (12) to "high John Henryism" (60). Individuals that are "high" in "John Henryism" demonstrate more active or high-effort, coping responses, which are implemented to manage psychological stress associated with psychosocial factors (e.g., discrimination based on SES and/or race; Bennett et al., 2004; James, 1994). Because of the racially and socioeconomically diverse nature of the sample, "John Henryism" may reflect differential coping strategies between racial and socioeconomic groups. As a result, individuals high in "John Henryism" may be less likely to indicate pain due to effortful coping and cultural adaptation to current situations and are likely to display more confrontational approaches to pain.

Statistical Analyses

Only participants with valid data across all measures were included within the analyses (n = 887). Chi square tests of independence and independent samples t-tests were used to identify the differences between those excluded and included from analyses. Descriptive statistics of participants' sociodemographic, health, psychosocial characteristics, as well as subjective and objective pain reports within the final sample are reported.

Aim 1 Analyses. Spearman correlations were used to examine the relationship between subjective and objective musculoskeletal pain across the hands, neck, and low back. Particularly, these analyses examined the relationship between subjective and objective hand pain, the relationship between subjective and objective neck pain, and the relationship between subjective and objective low back pain.

Aim 2 Analyses. To explore which individual characteristics (e.g., sociodemographic, health, and psychosocial factors) are unique correlates of consistent and inconsistent subjective and objective pain, participants were grouped as reporting consistent or inconsistent pain measurements for each pain site (i.e., hands, neck, and low back). For example, participants who responded "no" to subjective or objective pain across each site or those who responded "yes" to both subjective and objective pain across each site were categorized as consistent pain measurements (0). Those who indicated "yes" to subjective pain, and "no" to objective pain; or individuals who indicated "yes" to objective pain, and "no" to subjective pain for each pain site were categorized as inconsistent pain measurements (1). Descriptive information for consistent and inconsistent pain measurements are provided for each pain site. Chi-square tests of independence and independent samples t-tests were used to identify differences between consistent and inconsistent pain groups for each pain site.

To examine the relationship between sociodemographic, health, and psychosocial characteristics and consistent and inconsistent pain measurements for each pain site, four binary logistic regression models were conducted. In the first model, all sociodemographic variables were entered (i.e., age, sex, race, years of education, WRAT-III scores, and poverty status). The second model incorporated sociodemographic and health-related variables (i.e., comorbidities, CES-D, a history of depressive symptoms, and BMI). The third model integrated perceived neighborhood rating (neighborhood quality) as a psychosocial characteristic. Although conventional approach to examining two-way interactions is to consider independent variables and moderators that are both related to the outcome (Aiken & West, 1991), in this exploratory study, any significant predictors identified in model 3 were explored further through two-way interactions between sociodemographic, health, and psychosocial characteristics (Model 4). Furthermore, a subsample of 595 participants had valid data on the "John Henryism" variable. Therefore, analyses using this variable were restricted to this subsample and incorporated similar analytic procedures across the three models.

Binary logistic regression results were reported using odds ratios and confidence intervals. Statistical significance was set at two-tailed, $p < .05$. All statistical analyses were conducted using SAS statistical software package 9.2 (SAS Institute, Cary, NC).

Power Analyses

Power analyses were estimated a priori for appropriate effect size in binary logistic regression analyses using the G*Power 3.1.1 statistical software package (Faul, Erdfelder, Lang, & Buchner, 2007). For binary logistic regressions, considering a two-tailed test at 80% power, with a medium effect size (0.2; Cohen, 1992), *p*-value set at <.05, the recommended sample size

is 721. The current study incorporated an overall sample size of 887 participants, which satisfied the amount of participants to detect significant findings for the primary analyses.

Results of Study 1

As identified in Figure 3, out of the 3,202 participants in the HANDLS study, 887 reported valid subjective and objective pain, sociodemographic, health, and psychosocial data. Due to missing data, "John Henryism" was conducted on a subsample of participants (n = 595), and was analyzed separately in follow-up analyses to maximize sample size throughout this study. Participants with complete data were compared to those with missing data (n = 2,315) to identify any differences between the two groups in sociodemographic, health, and psychosocial characteristics.

Chi square tests of independence for categorical variables and independent samples t-tests for continuous variables were conducted to examine differences in sociodemographic characteristics (i.e., age, sex, race, years of education, WRAT-III, and poverty status) between individuals who were included in analyses and those who were excluded from analyses. Individuals who were missing data were significantly different in age, $t(1697.1) = -2.36$, $p = .019$ after Satterthwaite correction due to unequal variances. This finding suggested that participants who were excluded from analyses were significantly younger (M = 47.4, SD = 9.5) than participants who were included (M = 48.2, SD = 8.9). Moreover, the participants who were excluded differed by race, $\chi2\ (1) = 40.57$, $p < .001$, sex, $\chi2\ (1) = 3.94$, $p = .047$, and poverty status $\chi2\ (1) = 14.06$, $p < .001$. These findings indicated that excluded participants were more likely to be Black (60.0%, n = 1,390), male (46.2%, n = 1,069), and were below poverty status (43.7%, n = 1,012). Excluded participants did not differ in years of education $t(3104) = -1.02$, p

= 0.309, but differed significantly in quality of education as measured by scores on the WRAT-III, $t(2353) = -2.56$, $p = 0.012$. These findings indicated that individuals who were excluded from this study performed significantly more poorly on the WRAT-III ($M = 41.5$, $SD = 8.2$) than participants who were included in the analyses ($M = 42.4$, $SD = 7.9$).

Chi square tests of independence and independent samples *t*-tests were conducted to examine differences in health characteristics (i.e., health conditions, CES-D, history of depressive symptoms, and BMI) between individuals who were included in analyses and those who were excluded from analyses. There was no significant difference between those excluded and included from analyses on CES-D scores, $t(2386) = -1.02$, $p = 0.307$; and excluded participants did not significantly differ from included participants on history of depressive symptoms, $\chi 2\ (1) = 0.27$, $p = .601$. Participants who were excluded from the sample did not reach the cut-off for depressive symptoms on the CES-D ($M = 15.3$, $SD = 11.5$), and approximately 29% of those who were excluded experienced a history of depressive symptoms ($n = 399$). There were no significant differences between participants who were excluded and included on BMI, $t(2473) = 0.86$, $p = .401$. Participants who were excluded demonstrated BMI consistent with obesity ($M = 30.33$, $SD = 8.27$), as defined by the World Health Organization ($\geq 30 – 39.99$; 2000).

Lastly, chi square tests of independence and independent samples *t*-tests examined differences between individuals in psychosocial characteristics (i.e., perceived neighborhood quality and "John Henryism") between individuals who were excluded from vs. included in the analyses. There were no significant differences observed between excluded and included participants in perceived neighborhood quality, $\chi 2\ (1) = 0.87$, $p = .352$, or "John Henryism",

$t(2327) = -1.02$, $p = .310$. These findings indicate that those excluded and included did not significantly differ from each other in psychosocial characteristics.

Participant Characteristics of the Final Sample

Sociodemographic, Health, and Psychosocial Characteristics of the Final Sample.

The final overall sample included in the analyses comprised 887 adults aged 30-64 with valid subjective and objective pain, sociodemographic, health, and psychosocial data. Participants in the final sample were predominately White (52.4%, *n* = 465), female, reported an average of high school education, achieved an approximate WRAT-III score of 42, and were above poverty status (63.6%, *n* = 564; see Table 1 for sociodemographic, health, and psychosocial characteristics of the final sample). Over half of the sample reported at least one medical condition, which included the following: hypertension (39.4%, *n* = 349), history of a fracture (25.0%, *n* = 222), hypothyroidism (5.0%, *n* = 44), and hyperthyroidism (2.8%, *n* = 25). On average, participants did not reach the clinical cut-off scores for depressive symptoms on the CES-D (≥ 16; Long Foley, Reed, Mutran, & DeVellis, 2002; Smarr & Keefer, 2011). Specifically, 43% (*n* = 381) of the final sample indicated CES-D scores ≥16. Approximately 72% of the final sample reported no history of depressive symptoms. The overall BMI of the sample reached the cut-off for obesity (BMI of ≥ 30; World Health Organization, 2000). For psychosocial characteristics, a majority of the participants rated their neighborhood as "good" to "excellent" (52.4%, *n* = 465), and overall "John Henryism" scores of 42.2 were below the average scores of 50-54 points that were identified as "high John Henryism" within other studies (Bennett et al., 2004).

Subjective and Objective Pain Characteristics of the Final Sample. Approximately 55% of the sample identified at least one area of subjective or objective pain (n = 491). Pearson and spearman correlations indicated that individuals who demonstrated musculoskeletal pain were more likely to be female (r = 0.10, p = .003), identified a higher number of comorbidities (r = 0.11, p = .001), and indicated a history of depressive symptoms (r = 0.16, p <. 001). Fifty-two percent of the total sample (n = 464) experienced subjective pain in at least one location with a majority of subjective pain complaints identified in the lower back (38.6%; n = 342), followed by subjective neck pain (15.5%; n = 137) and subjective hand pain (14.4% n = 128). In contrast, 7.7% (n = 68) of the overall sample experienced objective pain upon passive range of motion in at least one area. Objective pain of the low back was the most prevalent pain location amongst the final sample (5.9%, n = 52), followed by objective pain in the neck (3.0%, n = 27) and objective hand pain (0.8%, n = 5; See Tables 2-4 for frequencies of subjective and objective pain measurements across the hands, neck, and low back, as well as consistent and inconsistent measurement of pain across self-reports vs objective assessment).

Relationships between all Characteristics on Subjective and Objective Hand Pain. Pearson and spearman correlations were conducted to examine the relationships between sociodemographic, health, and psychosocial characteristics on subjective and objective pain across each pain site. Results indicated that there were no significant associations between subjective hand pain and sociodemographic (age group, p = .999; sex, p = .323; race, p = .131; years of education, p = .301; WRAT-III scores, p = .678; and poverty status, p = .131), health (comorbidities, p = .960; CES-D scores, p = .508; history of depressive symptoms, p = .797; and BMI, p = .678), or psychosocial characteristics (perceived neighborhood quality, p = .718; or “John Henryism”, n = 595, p = .809).

Similarly, there were no significant associations between objective hand pain and sociodemographic (age group, $p = .747$; sex, $p = .313$; race, $p = .734$; years of education, $p = .462$; WRAT-III scores, $p = .101$; and poverty status, $p = .868$), health (comorbidities, $p = .708$; CES-D scores, $p = .969$; subjective history of depressive symptoms, $p = .163$; and BMI, $p = .250$), or psychosocial characteristics (perceived neighborhood quality, $p = .734$, and "John Henryism", $n = 595$, $p = .327$).

Relationships between all Characteristics on Subjective and Objective Neck Pain. A significant positive association was observed between subjective neck pain and history of depressive symptoms ($p < .001$), which suggests that individuals who reported subjective neck pain also tended to report a history of depressive symptoms (Table 5). There were no significant associations observed between subjective neck pain and the following characteristics: age group ($p = .272$), sex ($p = .094$), race ($p = .182$), years of education ($p = .795$), WRAT-III scores ($p = .805$), poverty status ($p = .549$), comorbidities ($p = .083$), CES-D scores ($p = .737$), BMI ($p = .731$), perceived neighborhood quality ($p = .279$), or "John Henryism" scores ($n = 595$, $p = .659$).

Furthermore, a significant positive association was identified between objective neck pain and race ($p = .044$), which indicates that individuals who experienced objective neck pain tended to be Black. There were no significant associations observed between objective neck pain and the following characteristics: age group ($p = .224$), sex ($p = .177$), years of education ($p = .311$), WRAT-III scores ($p = .133$), poverty status ($p = .736$), comorbidities ($p = .347$), CES-D scores ($p = .430$), history of depressive symptoms ($p = .268$), BMI ($p = .410$), perceived neighborhood quality ($p = .652$), or "John Henryism" scores ($n = 595$, $p = .329$).

Relationships between all Characteristics on Subjective and Objective Low Back Pain. There were significant positive associations identified between subjective low back pain and sex

(p = .006), comorbidities (p < .001), and history of depressive symptoms (p < .001; Table 5). These findings suggest that females, individuals with higher numbers of comorbidities, and those with a history of depressive symptoms tended to report subjective low back pain. There were no significant relationships observed between subjective low back pain and the following characteristics: age group (p = .065), race (p = .139), years of education (p = .375), WRAT-III scores (p = .986), poverty status (p = .175), CES-D scores (p = .903), BMI (p = .308), perceived neighborhood quality (p = .752), or "John Henryism" scores (n = 595, p = .162).

Furthermore, a significant relationship was identified between objective low back pain and comorbidities (p = .026), which indicates that individuals who experienced objective low back pain also reported a higher number of comorbidities. There were no significant associations observed between objective low back pain and the following characteristics: age group (p = .160), sex (p = .389), race (p = .619), years of education (p = .743), WRAT-III scores (p = .756), poverty status (p = .384), CES-D scores (p = .940), a history of depressive symptoms (p = .156), BMI (p = .915), perceived neighborhood quality (p = .054), or "John Henryism" (n = 595, p = .322).

Study 1 - Aim 1 Results

Spearman correlations were conducted to explore the relationships between subjective and objective pain for each pain site. A weak but significant relationship was observed between subjective and objective hand pain (p < .001; see Table 5 for correlation coefficients), which suggests that individuals who reported subjective hand pain also tended to experience objective hand pain. However, there were no significant relationships identified between subjective and objective neck pain (p = .926) as well as subjective and objective low back pain (p = .548).

Study 1 - Aim 2 Results

The unique sociodemographic, health, and psychosocial characteristics of those who indicated consistent and inconsistent pain measurement were identified for the hands, neck, and low back (Table 1).

Characteristics of those with Consistent/Inconsistent Measurements of Hand Pain

Consistent Measurements of Hand Pain. Participants with subjective and objective hand pain (n = 762) were predominately middle-aged (M = 48.2, SD = 8.9), White (51.3%, n = 391), female, with an average of high school education, achieved an approximate WRAT-III score of 42, and were considered above poverty status (62.5%, n = 476). A majority of the participants in this pain group reported one or more medical conditions, which included the following: hypertension (39.0%, n = 297), fracture (25.5%, n = 194), hypothyroidism (4.6%, n = 35), and hyperthyroidism (2.8%, n = 21). The average score on the CES-D neared the cut-off for depressive symptoms (≥16), and approximately 72% indicated no history of depressive symptoms (n = 551). The average BMI was approximately 30, which is consistent with ranges suggestive of obesity. Furthermore, 52.2% of the participants in the consistent pain group rated the quality of their neighborhood from "good" to "excellent" (52.1%, n = 397).

Inconsistent Measurements of Hand Pain. Nearly 14% of the sample demonstrated inconsistent hand pain reports. Participants who demonstrated inconsistent hand pain measurements (n = 125) were predominately middle-aged (M = 48.9, SD = 9.0), White (59.2%, n = 74), female, possessed an average of high school education, achieved an approximate WRAT-III score of 43, and were above poverty status (70.4%, n = 88). Participants indicated one or more medical conditions, which included the following: hypertension (41.6%, n = 52), fracture (22.4%, n = 28), hypothyroidism (7.2%, n = 9), and hyperthyroidism (3.2%, n = 4). On average,

participants who reported inconsistent pain did not reach clinical cutoff scores for depressive symptoms (< 16), and approximately 70% of the sample indicated no depressive symptoms. The average BMI measurement for those with inconsistent hand pain were considered obese (≥30). Additionally, the majority of these participants rated the quality of their neighborhoods as "good" to "excellent" (54.4%, n = 68).

Differences between Consistent/Inconsistent Measurements of Hand Pain. Chi square tests of independence examined differences between those with consistent and inconsistent measurement of hand pain across categorical sociodemographic, health, and psychosocial variables. There were no significant differences between consistent and inconsistent measurement of hand pain for age group, $\chi 2$ (2) = 0.22, p = .898; sex, $\chi 2$ (1) = 2.68, p = .102, race, $\chi 2$ (1) = 0.90, p = .344; poverty status, $\chi 2$ (1) = 2.92, p = .088; medical conditions, $\chi 2$ (2) = 2.36, p = .307; history of depressive symptoms, $\chi 2$ (1) = 0.19, p = .659; or neighborhood quality, $\chi 2$ (1) = 0.23, p = .633.

Additionally, independent sample t-tests were performed to investigate differences between consistent and inconsistent hand pain across non-categorical sociodemographic, health, and psychosocial variables. There were no significant differences between consistent and inconsistent hand pain measurements in years of education, t(885) = -1.19, p = .232; WRAT-III scores, t(885) = -0.52, p = .603; CES-D scores, t(885) = 0.86, p = .393; BMI, t(885) = -0.58, p = .565; or "John Henryism" scores, t(593) = -0.42, p = .931.

Characteristics of those with Consistent/Inconsistent Measurements of Neck Pain

Consistent Measurements of Neck Pain. Participants with consistent measurements of neck pain were middle-aged (M = 48.0, SD = 9.0), White (51.6%, n = 377), female, possessed on average a high school education, achieved an approximate score of 42.5 on the WRAT-III, and

were above poverty status (64.0%, *n* = 468). This group predominately indicated one or more medical conditions, which included a history of the following: hypertension (37.9%, *n* = 277), fracture (25.3%, *n* = 185), hypothyroidism (4.8%, *n* = 35), and hyperthyroidism (2.7%, *n* = 20). The average CES-D score across this sample neared the cut-off for depressive symptoms (≥16), but approximately 74% indicated no history of depressive symptoms in the 12 months prior to data collection. Individuals that demonstrated consistent neck pain reports averaged a BMI of 30, which suggests that individuals in this group were within the range consistent with obesity.

Inconsistent Measurements of Neck Pain. Approximately 18% of the sample demonstrated inconsistent neck pain measurements. Participants who demonstrated inconsistent neck pain measurements were predominately middle-aged (*M* = 49.2, *SD* = 8.3), White (56.4%, *n* = 88), female, reported an average of high school education, averaged an approximate score of 42 on the WRAT-III, and were predominately above poverty status (61.5%, *n* = 96). These participants identified one or more medical conditions, which included the following: hypertension (46.1%, *n* = 72), fracture (23.7%, *n* = 37), hypothyroidism (5.8%, *n* = 9), and hyperthyroidism (3.2%, *n* = 5). Average scores on the CES-D neared the cut-off scores for depressive symptoms (≥16), but approximately 61% of the sample reported no history of depressive symptoms in the 12 months prior to data collection. Participants in this group had an average BMI that was classified as overweight (≥25 – 29.99; World Health Organization, 2000).

Differences between those with Consistent/Inconsistent Measurements of Neck Pain. Chi square tests of independence examined differences between consistent and inconsistent measurements of neck pain across categorical sociodemographic, health, and psychosocial variables. A significant relationship was identified between consistent and inconsistent neck pain on history of depressive symptoms, $\chi 2\ (1) = 11.67$, $p < .001$. These findings indicate that

individuals who demonstrated inconsistent neck pain measurements were more likely to indicate a history of depressive symptoms (39.1%) than individuals who demonstrated consistent neck pain measurements (25.6%). There were no significant associations between participants with consistent and inconsistent neck pain measurements on age group, $\chi 2$ (2) = 3.77, p = .152; sex, $\chi 2$ (1) = 2.55, p = .110; race, $\chi 2$ (1) = 1.21, p = .272; poverty status, $\chi 2$ (1) = 0.34, p = .558; comorbidities, $\chi 2$ (2) = 2.35, p = .308; or perceived neighborhood quality, $\chi 2$ (1) = 0.71, p = .399.

Independent samples *t*-tests were conducted to examine the differences between consistent and inconsistent neck pain measurements across non-categorical sociodemographic, health, and psychosocial measures. Results indicated that there were no significant differences between those with consistent and inconsistent neck pain measurements on years of education, $t(885) = 1.04$, p = .300; WRAT-III scores, $t(885) = 1.01$, p = .313; CES-D scores, $t(885) = 0.22$, p = .830; BMI, $t(885) = 0.63$, p = .531; or "John Henryism" scores, $t(593) = 0.39$, p = .697.

Characteristics of those with Consistent/Inconsistent Measurements of Low Back Pain

Consistent Measurements of Low Back Pain. Participants who demonstrated consistent low back pain measurements were middle-aged (M = 48.0, SD = 8.8), Black, female, reported on average a high school education, indicated an approximate score of 42 on the WRAT-III, and were predominately above poverty status (65.0%, n = 344). Participants in this group reported one or more medical conditions, which included the following: hypertension (35.5%, n = 188), fracture (23.3%, n = 123), hypothyroidism (4.0%, n = 21), and hyperthyroidism (1.9%, n = 10). The average BMI was suggestive of obesity (≥30). Furthermore, this group demonstrated an average CES-D score that was trending toward the clinical cut-off for depressive symptoms

(≥16). However, 79% of the consistent pain group reported no history of depressive symptoms over the 12 months (*n* = 417). Nearly 52% rated the quality of the neighborhood as "good" to "excellent" (*n* = 274).

Inconsistent Measurements of Low Back Pain. Approximately 40% of the sample reported inconsistent low back pain measurements. Participants who demonstrated inconsistent low back pain measurements were middle-aged (*M* = 48.5, *SD* = 9.0), White (56.2%, *n* = 201), female, had an average of high school education, indicated average WRAT-III scores of approximately 42, and were above poverty status (61.5%, *n* = 220). This group reported one or more medical conditions, which included the following: hypertension (45.0%, *n* = 220), fracture (27.7%, *n* = 99), hypothyroidism (6.4%, *n* = 23), and hyperthyroidism (4.2%, *n* = 15). The average BMI for individuals with inconsistent low back pain measurements was in the obese range (≥30). The average scores for the CES-D were trending toward clinical levels of depressive symptoms; however, were shy of the clinical cut-off (≥16). Approximately 62% of those with inconsistent low back pain measurements indicated no history of depressive symptoms. This group primarily rated the quality of their neighborhood as "good" to "excellent" (53.4%, *n* = 191).

Differences between those with Consistent/Inconsistent Measurements of Low Back Pain. Chi square tests of independence examined differences between those who demonstrated consistent and inconsistent low back pain measurements across categorical sociodemographic, health, and psychosocial characteristics. Findings indicated significant relationships between sex, $\chi 2$ (1) = 8.75, p = .003; comorbidities, $\chi 2$ (2) = 14.86, p <.001; and history of depressive symptoms, $\chi 2$ (1) = 29.98, p <.001. These findings suggested that individuals who reported inconsistent low back pain measurements were predominately female, reported one or more

medical conditions, and experienced a history of depressive symptoms in the past 12 months. There were no significant differences between those with consistent and inconsistent low back pain measurements on the following characteristics: age group, $\chi 2$ (2) = 1.99, p = .370; race, $\chi 2$ (1) = 3.33, p = .068; poverty status, $\chi 2$ (2) = 3.77, p = .152; or perceived neighborhood quality, $\chi 2$ (2) = 3.77, p = .152.

Independent samples *t*-tests were conducted to investigate the differences between those with consistent and inconsistent low back pain measurements across non-categorical sociodemographic, health, and psychosocial characteristics. There were no significant differences identified between those with consistent and inconsistent low back pain measurements in years of education, $t(885) = 0.58$, p = .562; WRAT-III scores, $t(885) = 0.06$, p = .955; , $t(885) = -0.22$, p = .825; BMI, $t(885) = -1.11$, p = .267; or "John Henryism", $t(593) = 1.57$, p = .118.

Sociodemographic, Health, and Psychosocial Characteristics in Relation to Consistent vs. Inconsistent Measurements of Pain

Pearson and spearman correlations were conducted to explore the associations between those with consistent and inconsistent pain and sociodemographic, health, and psychosocial characteristics across each pain site. Additionally, binary logistic regressions were conducted to explore the relationships between sociodemographic, health, and psychosocial characteristics across each pain site. In efforts to understand the complex relationships between independent variables and consistent and inconsistent pain groups, two-way interactions between the significant independent variable and sociodemographic, health, and psychosocial variables were explored for any significant predictors identified in the final model.

Consistent and Inconsistent Hand Pain. There were no significant associations between consistent and inconsistent hand pain measurements and sociodemographic (age group, $p = .923$; sex, $p = .344$; race, $p = .102$; years of education, $p = .232$; WRAT-III scores, $p = .603$; poverty status, $p = .088$), health (comorbidities, $p = .625$; CES-D scores, $p = .393$; history of depressive symptoms, $p = .660$; BMI, $p = .565$), or psychosocial characteristics (perceived neighborhood quality, $p = .399$, and "John Henryism", $n = 595$, $p = .673$; see Table 6 for correlation coefficients across all pain sites).

Results from the binary logistic regression indicated no significant relationships between consistent and inconsistent hand pain measurements and sociodemographic, health, and psychosocial characteristics across all three models (ps > .05; see Tables 7-9 for odds ratios and confidence intervals across models 1-3 for each pain site).

Additionally, among the subsample of individuals who completed the "John Henryism" scale ($n = 595$), there was no significant relationship observed between the consistent and inconsistent hand pain measurements and "John Henryism" scores (Model 3).

Consistent and Inconsistent Neck Pain. Pearson and spearman correlations were conducted to examine the relationship between consistent and inconsistent neck pain measurements and sociodemographic, health, and psychosocial characteristics. Results indicated a significant relationship between consistent and inconsistent neck pain and history of depressive symptoms ($p < .001$). These findings suggest that individuals who reported a history of depressive symptoms tended to demonstrate inconsistent neck pain measurements. However, there were no other significant associations identified between consistent and inconsistent neck pain groups and the following characteristics: age group ($p = .237$), sex ($p = .110$), race ($p = .273$), years of education ($p = .300$), WRAT-III scores ($p = .313$), poverty status ($p = .559$),

comorbidities (p = .625), CES-D scores (p = .830), BMI (p = .531), perceived neighborhood quality (p = .399), and "John Henryism" (n = 595, p = .697).

Three binary logistic regressions were conducted to examine the relationships between sociodemographic, health, and psychosocial characteristics and neck pain groups. A significant relationship was observed between consistent and inconsistent neck pain measurements and history of depressive symptoms (model 2), which remained significant after accounting for psychosocial characteristics (β = 0.14, p = .003; Model 3). Results from model 3 indicated that individuals who have experienced a history of depressive symptoms over the past 12 months were nearly 1.8 times more likely to demonstrate inconsistent neck pain (95% CI = 1.22, 2.56).

There were no other significant relationships identified between consistent and inconsistent neck pain measurements and the following characteristics: age group, sex, race, education, WRAT-III scores, comorbidities, CES-D scores, BMI, or perceived neighborhood quality (ps >.05).

To further explore this significant finding between history of depressive symptoms and consistent and inconsistent pain measurements, a fully adjusted binary logistic regression was conducted to examine two-way interactions between history of depressive symptoms and all sociodemographic, health, and psychosocial characteristics on consistent and inconsistent neck pain measurements. A significant two-way interaction was observed between history of depressive symptoms and poverty status for consistent and inconsistent neck pain measurements (β = -0.10, p = .049; model 4), after accounting for all sociodemographic, health, and psychosocial variables. Follow-up binary logistic regressions were conducted to explore the direction of this relationship. Results indicated that individuals who reported a history of depressive symptoms and were below poverty status were nearly 3 times more likely to

demonstrate inconsistent neck pain measurements (β = -0.28, $p < .001$, OR 3.0, CI = 1.66, 5.43; see Figure 4).

Additionally, in the subsample analyses, there were no significant associations between consistent and inconsistent neck pain groups and "John Henryism" scores (β = -0.04, $p = .561$; Model 3). Due to non-significant relationships between "John Henryism" and consistent and inconsistent pain measurements, two-way interactions were not explored.

Consistent and Inconsistent Low Back Pain. Pearson and spearman correlations were conducted to examine the relationships between consistent and inconsistent low back pain measurements and sociodemographic, health, and psychosocial characteristics. Significant positive relationships were identified between consistent and inconsistent low back pain and sex ($p = .003$), comorbidities ($p < .001$), and history of depressive symptoms ($p < .001$). These findings indicated that individuals who demonstrated inconsistent low back pain measurements tended to be female, with greater number of comorbidities, and reported a history of depressive symptoms in the 12 months prior to data collection. There were no significant correlations identified between consistent and inconsistent low back pain for the following characteristics: age group ($p = .205$), race ($p = .068$), years of education ($p = .561$), WRAT-III ($p = .955$), poverty status ($p = .278$), CES-D scores ($p = .825$), BMI ($p = .269$), perceived neighborhood quality ($p = .649$), and "John Henryism" ($n = 595$, $p = .118$).

Binary logistic regressions were conducted across the three models to explore the relationships between consistent and inconsistent low back pain and sociodemographic, health, and psychosocial characteristics. After accounting for sociodemographic (model 1), health (model 2), and psychosocial variables (model 3), significant relationships were identified between consistent and inconsistent low back pain and sex (β = 0.10, $p = .008$; model 3),

comorbidities (β = 0.13, p = .002; model 3), and history of depressive symptoms (β = 0.18, p < .001; model 3). Females were 1.5 times more likely to demonstrate inconsistent measurements of low back pain (95% CI = 1.10, 1.95; model 3). Individuals who reported a greater number of comorbidities were 1.4 times more likely to demonstrate inconsistent measurements of low back pain (95% CI = 1.13, 1.72; model 3). Additionally, individuals who experienced a history of depressive symptoms in the 12 months prior to data collection were approximately two times more likely to demonstrate inconsistent low back pain reports (95% CI = 1.50, 2.77; model 3). Across all three models, there were no significant relationships between consistent and inconsistent low back pain measurements and the following: age group (p = .630), race (p = .198), years of education (p = .835), WRAT-III scores (p = .934), poverty status (p = .487), CES-D scores (p = .692), BMI (p = .357), and perceived neighborhood quality (p = .638) across all 3 models.

To further explore these significant findings, fully adjusted binary logistic regressions were conducted to examine two-way interactions between sex, comorbidities, and history of depressive symptoms with other sociodemographic, health, and psychosocial characteristics on consistent and inconsistent low back pain measurements. A significant two-way interaction was observed between history of depressive symptoms and perceived neighborhood quality for consistent and inconsistent low back pain measurement (β = 0.10, p = .010; model 4). Binary logistic regressions were conducted as follow-up analyses to identify the direction of this relationship. Results indicated that individuals who experienced a history of depressive symptoms, and reported the quality of their neighborhood as “poor” to “fair”, were 3.3 times more likely to demonstrate inconsistent low back pain reports (β = 0.30, p < .001, OR = 3.32, 95% CI = 2.10, 5.24; see Figure 5).

There were no significant two-way interactions observed between sex or comorbidities and other sociodemographic, health, and psychosocial characteristics on consistent and inconsistent low back pain measurements (*p*s > .05)

In the subsample analyses that examined "John Henryism", there was no significant association identified between consistent and inconsistent low back pain and "John Henryism" scores (n = 595, p = .054; Model 3). Due to non-significant relationships between "John Henryism" and consistent and inconsistent pain measurements, two-way interactions were not explored.

Discussion – Study 1

The purpose of study 1 was to examine the relationships between subjective and objective pain within the hands, neck, and low back (aim 1); and to explore which individual sociodemographic, health, and psychosocial characteristics may serve as unique correlates of consistent and inconsistent subjective and objective pain measurements (aim 2). It was hypothesized that subjective musculoskeletal pain of the hands, neck, and low back would demonstrate weak or non-significant correlations with objective measures, as obtained through in-person assessment of the same bodily locations (aim 1). Additionally, it was hypothesized that those with consistent subjective and objective reports (i.e., "yes/yes" or "no/no" to subjective and objective pain measures) would be older, indicate more years of education, be above poverty status, and identify a greater number of comorbidities (aim 2). In contrast, it was hypothesized that those with inconsistent subjective and objective measurements would indicate less years of education, more effortful coping (e.g., higher "John Henryism"), higher levels of depressive symptoms, a history of depressive symptoms, and poorer neighborhood ratings. The findings

within study 1 partially support these hypotheses. The specific discussion of results for each aim follows.

Aim 1

In study 1, over half of the sample (55%) indicated subjective or objective pain in at least one bodily location, which is consistent with other epidemiological studies that have reported pain prevalence rates between 14-64% (Hardt, Jacobsen, Goldberg, Nickel, & Buchwald, 2008; Johannes et al., 2010; Portenoy et al., 2004). Among those who identified pain, 52% of the sample indicated subjective reports of pain, which was considerably greater than the 8% who exhibited pain upon passive range of motion. Follow-up analyses examined the correlation between subjective and objective measures of pain across each pain site. The results indicated that subjective hand pain was weakly correlated with objective hand pain; and there were no significant correlations observed between subjective and objective neck pain and subjective and objective back pain. This disparity between subjective and objective pain measurements, as well as the lack of correlation between the two, suggests that these measurements may tap into unique constructs of the pain experience not typically considered under the medical model.

According to the medical model, symptomatic pain should correspond with pathophysiology, which suggests that degenerative processes or disease states are the source of pain complaints (Engel, 1989; Haldeman, 1990). Under this assumption, the subjective and objective pain measurements analyzed in this study should be highly correlated, which suggests there is a pathological cause for the pain. However, the medical model does not account for sociodemographic and psychosocial influences that may exacerbate the pain experience (Engel, 1989). For example, pain is deemed a highly subjective experience that varies from person-to-

person and has been previously associated with sociodemographic factors (Fuentes et al., 2007; Johannes et al., 2010), psychological distress and depression (Arnow et al., 2006; Currie & Wang, 2004), and psychosocial experiences (Green & Hart-Johnson, 2012). As a result, pain identified by subjective indicators that is not substantiated by objective measures of pain may signal pain that is psychosomatic and independent of underlying pathology, which warrants alternative treatment approaches (e.g., cognitive behavioral therapy or mindfulness). While this study lends further support to a biopsychosocial approach to pain, more research is needed that strives to understand these relationships.

The findings from the first aim of this study are consistent with earlier research that investigated the relationships between similar subjective and objective pain measurements (McGregor et al., 1998; Michel, Kohlmann, & Raspe, 1997). Specifically, McGregor and colleagues (1998) examined the associations between subjective and objective pain measures of the back, which included a traditional clinical assessment (e.g., passive range of motion) and a thorough physical assessment (e.g., spinal motion and stability) that tested range of motion across various planes of movements. While significant relationships between subjective and objective pain measurements were observed, the strength of these relationships were weaker than initially expected. In another study, Michel and colleagues (1997) examined the relationships between subjective indicators of back pain and objective physical examinations (e.g., flexion and extension). Results indicated that there was little agreement between subjective and objective indicators of back pain severity. Furthermore, Teske and colleagues (1983) explored the validity between subjective pain reports and an objective measure of observed pain behaviors (e.g., general restlessness or increased muscular tension). The researchers concluded that although the subjective reports of pain correlated with clinical observations of pain behaviors (as identified

through objective measures of pain), the magnitude of the relationships were small, and discrepancies between subjective and objective reports were evidenced. While our findings are consistent with previous research, cross-study comparisons are difficult due to the differences across objective measures utilized within the research (Michel et al., 1997).

The lack of correlation between subjective and objective measurements may be explained by the measurement properties of the clinical examination. Despite the objective nature of the clinical examination to assess pain upon passive range of motion, these measures may still be subject to individual characteristics, which might compromise the validity of the testing. For example, factors such as pain severity, duration, location, and tolerance (Pope, Rosen, Wilder, & Frymoyer, 1980; Teske et al., 1983), differences in physical abilities and function across individuals (e.g., flexibility; Deyo, 1988), as well as presence of psychological distress (McGregor et al., 1998) may impact the findings of the clinical examination and make diagnosis of painful conditions more challenging. Particularly, McGregor and colleagues (1998) hypothesized that inconsistencies observed across subjective and objective pain measures may be the product of unique sociodemographic, health, and psychosocial characteristics; however, these relationships had not been thoroughly explored to date.

Aim 2

In efforts to understand the individual factors that may be associated with inconsistent pain measurements, this study further explored sociodemographic, health, and psychosocial characteristics that increased the likelihood of observed discrepancies. Of primary interest in this study are those who demonstrated inconsistent reports across subjective and objective pain measures (i.e., pain reported subjectively but not observed objectively and vice versa).

Characteristics Associated with Consistent and Inconsistent Hand Pain. We did not observe any significant relationships between sociodemographic, health, and psychosocial factors and consistent or inconsistent hand pain measurements. Additionally, there were no significant associations identified amongst the subsample with "John Henryism" data on consistent or inconsistent hand pain measurements. Overall, consistent measurements of hand pain occurred in approximately 86% of the sample and a majority of those who were consistent demonstrated no subjective or objective hand pain (85%). Conversely, among the 14% with hand pain measured objectively or subjectively, less than 1% had a record of hand pain in both. As compared to other pain sites, hand pain comprised the smallest group of those who reported inconsistency between subjective and objective pain measurements.

Previous research has identified that osteoarthritis and rheumatoid arthritis were significant predictors for hand pain, however, most of these studies were conducted on participants who were older in age (Dahaghin et al., 2005). Within this study, osteoarthritis and rheumatoid arthritis were not significantly associated with subjective or objective pain (as described in methodology) and therefore, were not incorporated as an aspect of health within this study. However, the research to date regarding predictors of hand pain is largely inconclusive. Of the research that has been conducted amongst younger age groups, hand pain has been previously associated with occupation (e.g., manual labor) as well as occupational stressors (e.g., work-related dissatisfaction; Behrens, Seligman, Cameron, Mathias, & Fine, 1994; Feuerstein, Carosella, Burrell, Marshall, & Decaro, 1997). While we did not consider occupation or occupation-related stressors within the current study, these may be significant predictors for inconsistent hand pain measurements. However, more research is needed to understand sociodemographic, health, and psychosocial characteristics associated with hand pain, as well as

factors that may contribute to inconsistency between subjective and objective hand pain measurements amongst those who are younger in age.

Characteristics Associated with Consistent and Inconsistent Neck Pain. Results from the binary logistic regressions that examined the relationships between sociodemographic, health, and psychosocial characteristics and inconsistent neck pain measurements identified that individuals who reported a history of depressive symptoms were 1.8 times more likely to indicate inconsistent neck pain measurements. A history of depressive symptoms was the only significant characteristic identified within the fully adjusted model. Interestingly, two-way interactions to better understand the complex relationships across sociodemographic, health, and psychosocial characteristics indicated that individuals who reported a history of depressive symptoms, and were below poverty status, were approximately three times more likely to demonstrate inconsistent neck pain measurements.

Previous research has identified relationships between depressive symptomology and pain. Bair and colleagues (2003) concluded that approximately 65% of individuals who experience depression tended to report chronic pain in at least one bodily location. Inversely, the rates of depressive symptoms in chronic pain samples vary from 5-85% across primary care and community samples (Bair et al., 2003), with levels of pain severity predicting greater risk of developing depressive symptoms despite age (Currie & Wang, 2004; Lépine & Briley, 2004). As a result, the presence of either one can increase the likelihood of developing, or exacerbating, the other. The causal pathways underlying the pain and depression relationship are largely undetermined as there is still debate as to whether depression is an antecedent to, or consequence of pain (Fishbain, Cutler, Rosomoff, & Rosomoff, 1997). While this study is unable to clarify the causal pathway of these findings due to the correlational and cross-sectional nature of the

research, it does add to the body of literature, which has previously concluded that depressive symptoms are associated with neck pain (Blozik et al., 2009).

Additionally, despite the plethora of literature pertaining to the relationship between depression and pain, this study expands upon existing findings by highlighting relationships among individuals who are demonstrating inconsistent neck pain measurements. The research to date that has investigated the relationships between subjective and objective pain measures has not thoroughly explored sociodemographic, health, and psychosocial factors that may be related to inconsistency across these measurements (McGregor et al., 1998). Furthermore, research has not thoroughly explored these complex relationships across specific pain sites. This study's findings related to inconsistency between subjective and objective measurements highlight a unique interaction between psychological and sociodemographic factors, which to our knowledge, has not been observed as it pertains to consistency in pain measurements. These interactions may be further explained by the biopsychosocial model of pain.

The biopsychosocial model of pain model considers the dynamic interactions that occur between the biological, psychological, cognitive, and social processes; and ultimately shapes individual perception of the pain experience (Gatchel, 2004; Turk & Flor, 1999). Pain is a highly individualized and subjective experience that is not limited to a single stressor, rather it is contingent on numerous stressors that include the following: distress related to chronic pain; worry regarding the cause of pain; and impact of pain on health, overall function (e.g., cognitive and physical), and social roles (e.g., unemployment; Valente, Ribeiro, & Jensen, 2009). Gatchel (2004) suggests that these interacting factors can produce maladaptive cognitive appraisals of pain (e.g., catastrophizing, learned helplessness, and passive coping skills), which may lead to or

exacerbate pain behaviors and behavioral disturbances (e.g., physical disability and sleep disturbance; Campbell, Clauw, & Keefe, 2003; Goesling, Clauw, & Hassett, 2013).

In this study, it was observed that poverty status significantly moderated the relationship between history of depressive symptoms and inconsistent neck pain measurements. Earlier research has identified relationships between depressive symptoms and lower socioeconomic status (Kosidou et al., 2011), particularly among those classified as low income (Andersen, Thielen, Nygaard, & Diderichsen, 2009). Additionally, Palmlöf and colleagues (2012) concluded that individuals with lower levels of income were at greater risk of developing ongoing chronic neck pain, which may be attributable to increased levels of stress, financial strain, or occupational factors (e.g., manual labor). Particularly, physically demanding work or work that is considered high stress may contribute to psychological distress, as well as the development and persistence of chronic neck pain among working age individuals (Palmer et al., 2001; Palmlöf et al., 2012). Findings across these studies support the unique interaction between depressive symptoms and poverty status as it pertains to pain. However, more research is needed that incorporates additional measures of SES (e.g., occupation) in efforts to identify related factors that may contribute to inconsistent neck pain reports.

Characteristics Associated with Consistent and Inconsistent Low Back Pain. Additionally, we observed similar findings between history of depressive symptomology and consistency of subjective and objective low back pain measurements. Results revealed that individuals who reported a history of depressive symptoms during the year prior to data collection were nearly two times more likely to demonstrate inconsistent low back pain measurements. While findings also indicated that females and individuals with greater number of comorbidities were significantly more likely to indicate inconsistent low back pain

measurements, the odds of those experiencing inconsistent low back pain measurements were greater among those with a history of depressive symptomology. Two-way interactions were conducted to explore dynamic interactions between significant characteristics (i.e., sex, comorbidities, and history of depressive symptoms) and other sociodemographic, health, and psychosocial characteristics, to which no significant two-way interactions were identified for sex and comorbidities.

Interestingly, this study identified a significant two-way interaction between history of depressive symptoms and neighborhood quality, which indicated that the quality of the neighborhood significantly moderated the relationship between history of depressive symptomology and consistency in subjective and objective pain measurements. Particularly, individuals who reported a history of depressive symptoms and rated their neighborhood as "poor" to "fair" were over three times more likely to indicate inconsistent low back pain measurements. These findings align closely with past research that has examined the relationships between depressive symptoms and neighborhood quality (Aneshensel & Sucoff, 1996) and satisfaction (Gory, Ward, & Sherman, 1985). However, to our knowledge, this is the first study to date that has identified these unique interactions as they pertain to inconsistent low back pain measurements.

Furthermore, the neighborhood has been most commonly incorporated into the literature as a macro-level indicator of social disadvantage and SES (Green & Hart-Johnson, 2012; Schieman & Pearlin, 2006). However, Nicotera (2007) indicated that perceived neighborhood satisfaction, as measured subjectively, is an important indicator of the overall quality of the neighborhood as individual perception of the neighborhood is a direct reflection of the lived experience within that environment. Particularly, neighborhood-rating scales may provide

researchers with surface-level information pertaining to the resident's overall perception of the physical conditions, social supports, and resources available within the neighborhood (Nicotera, 2007). This subjective view of the neighborhood is typically the product of cognitive and perceptual differences that are typically a reflection of social status, cultural values, as well as unique life experiences (Gory et al., 1985). Specifically, research has shown that individuals who reside in lower income neighborhoods were more likely to report worse perceived neighborhood conditions (Steptoe & Feldman, 2001) and poor psychological health (Gary, Stark, & LaVeist, 2007), which may be a result of social and physical neighborhood characteristics (e.g., the built environment; Franzini, Caughy, Spears, & Esquer, 2005). Thus, the individual perception of the neighborhood may reflect the demand that these social and physical environments place upon each individual (Lawton & Nahemow, 1973), which is directly related to psychological well-being (Lawton, Nahemow, & Tsong-M.Y., 1980). Specifically, it is hypothesized that individual competencies (e.g., functional and cognitive abilities), particularly reduced competencies, may intensify the sensitivity to the conditions of the neighborhood (Gory et al., 1985) and may ultimately lead to poor health outcomes (Gary et al., 2008), depressive symptomology (Curry, Latkin, & Davey-Rothwell, 2008; Gary et al., 2007), and pain (Green & Hart-Johnson, 2012).

Specifically, Rudy and colleagues (1988) indicated that individuals who experience pain and concomitant depressive symptomology may appraise their situation negatively. Negative appraisal and cognitive distortions evidenced in comorbid pain and depression may decrease occupational involvement, reduce participation in social and recreational activities, and increase withdrawal from in-home family activities (Geerlings, Twisk, Beekman, Deeg, & van Tilburg, 2002). While directionality of findings from this study cannot be determined due to the cross-sectional nature of the data, two possible explanations can be inferred. First, it is possible that

poor perceived neighborhood conditions reinforce or exacerbate psychological distress, which may lead to greater likelihood of developing psychosomatic pain, or pain that is not associated with underlying pathological conditions (Delgado, 2004). Secondly, it is possible that perceived lack of supports, low access to physical or mental health care services, or poor physical conditions of the neighborhood reinforce the cyclic relationship observed between pain and depression.

Regardless, subjective pain complaints that do not correspond with objective pain measurements may still have physiological implications. Specifically, it is hypothesized that the complex interactions between sociodemographic and psychosocial factors are producing physiological reactions to pain that are independent of pathological conditions (Flor, Turk, & Birbaumer, 1985). These physiological reactions may be prevalent earlier in the life course, as identified in the Motor Adaptation to Pain theory (Hodges & Tucker, 2011) and the proposed Adapted Conceptual Model of the Motor Adaptation to Pain Theory. Specifically, Flor and colleagues (1985) examined whether individuals with chronic low back pain exhibited physiological reactions (e.g., muscular tension and reduced spinal motion) after exposure to personally-relevant stressful situations. The exposure to stressful situations were implemented to elicit greater levels of psychological distress within the participants in efforts to understand the role of stress on physiological responses. The researchers investigated whether these physiological reactions to stressful situations served as stronger predictors of pain than pathological predictors (e.g., degenerative conditions). Findings from their study indicated that individuals with chronic low back pain demonstrated hyper-reactivity to stressors of personal significance and experienced prolonged delay in return to normal physiological function following exposure to these stressors. These findings also confirmed that physiological responses

associated with psychological distress may contribute to the development and persistence of low back pain earlier in the life course (Flor et al., 1985).

These findings across the literature may explain some of the inconsistencies between subjective and objective pain measures incorporated within the current study. It is also possible that complex and dynamic interactions are translating into psychosomatic pain reports, which are independent of pathological conditions, yet they may still have implications on physical function and performance. More research is needed that examines the influences of sociodemographic, health, and psychosocial characteristics that may lead to discrepant pain measurements, and should consider whether or not pain that does not correlate with pathological findings leads to deficits in physical function and performance.

Relationships between the History of Depressive Symptoms and the CES-D. It is also important to note that while we observed significant relationships between a history of depressive symptoms and the inconsistent pain measurements of the neck and low back, we did not identify any unique relationships with the CES-D, a clinical screening tool used to identify individuals who may be at risk for depressive symptomology (Radloff, 1977). The history of depressive symptoms considers a longer timeframe in which symptoms may have been evidenced, as compared to the CES-D, which focuses on symptoms experienced over the past week. Individuals with a history of depressive symptoms may not be actively experiencing these symptoms, thereby explaining the potential lack of correlation between the two, as well as the lack of associations between the CES-D and inconsistency in pain measurements. Additionally, despite reports of high prevalence of depression across minority populations (Dunlop, Song, Lyons, Manheim, & Chang, 2003), there is some discourse as to whether existing screening measures for depressive symptoms (e.g., CES-D) are appropriate and/or sensitive enough to

detect depressive symptomology (Borowsky et al., 2000; Callahan & Wolinsky, 1994; Das, Olfson, McCurtis, & Weissman, 2006; Long Foley et al., 2002). In fact, Long-Foley and colleagues (2002) examined the adequacy of the CES-D among a group of older African Americans. The authors concluded that the total scores on the CES-D were positively skewed toward less depressive symptomology, which suggests that this screening measure may underestimate depressive symptoms within this group (Callahan & Wolinsky, 1994).

Some researchers have posited that the underestimated level of depressive symptoms may be explained by racially/culturally-derived concerns pertaining to racism and discrimination, stigmatization (Williams, Neighbors, & Jackson, 2003), mistrust (Whaley, 2001), and/or health beliefs (Diamant et al., 2004). As a result, African Americans may not report traditional depressive symptoms (e.g., feeling sad or blue), rather their symptoms may manifest as somatic or physiological complaints (F. M. Baker, Okwumabua, Philipose, & Wong, 1996; Brown, Schulberg, & Madonia, 1996; Nguyen, Kitner-Triolo, Evans, & Zonderman, 2004). Specifically, Brown and colleagues (1996) indicated that African Americans may be more likely to demonstrate depressive symptomology through adoption of negative health behaviors (e.g., drinking or smoking), experience poor health outcomes (e.g., higher risk for high blood pressure or other cardiovascular diseases, sleep disturbances, and pain), and display functional limitations and disability (Brown et al., 1996). Consequently, somatization has been hypothesized as an individual coping mechanism that may protect the individual from more traditional affective symptoms of depression (Jenkins, Kleinman, & Good, 1991), and may serve as a stronger indicator of depressive symptoms in screening measures (Nguyen et al., 2004). Thus, future research should consider incorporating the somatization section from the CES-D, as opposed to the overall scores, in efforts to enhance identification of depressive symptomology across

minority groups. Especially as increased somatic complaints are associated with pain severity across sociodemographic groups. Because the overall CES-D score was identified apriori for this study, it was incorporated as such within the analyses, but may explain the lack of association identified with CES-D and consistency in pain measurements.

Strengths of the Study

The current study has many strengths, which should be further highlighted. This is one of the first studies to examine the relationships between subjective and objective pain measurements across a variety of pain sites. Particularly, while past studies have also identified weak to non-existent relationships, this is one of the first to explore the unique individual characteristics that may contribute to our understanding of inconsistencies in pain measurements. It is also important to note that the overall prevalence of pain identified through subjective and objective pain reports supported the first pathway of the conceptual model that indicates high levels of pain are experienced earlier in the life course. Much of the literature to date has explored pain among older populations, despite studies indicating that individuals who are younger in age are demonstrating prevalence rates of pain that are consistent with older population groups (Rustøen et al., 2005). The unique findings of this study suggest that the pain experienced earlier in the life course may be related to pathological findings; however, there are unique sociodemographic and psychosocial correlates that may further contribute to the pain experienced earlier in adulthood.

Additionally, while this study contributed to the literature related to consistency and inconsistency of subjective and objective pain measurements, we incorporated numerous indicators of SES in efforts to disentangle the complex relationships between demographic and

socioeconomic factors and pain. While we did not observe interactions between race and socioeconomic status in two-way interactions across pain measures, we did observe the unique relationship between history of depressive symptoms and poverty status on inconsistent neck pain reports.

Furthermore, while neighborhood quality has previously been studied as a determinant of health, this is one of the first studies to incorporate a general neighborhood rating as a measure of neighborhood quality in the context of pain across pain sites. Most of the literature to date has incorporated neighborhood ratings pertaining to levels of crime or violence (Curry et al., 2008), community supports and/or resources, social cohesion, and/or the built environment among other factors (Aneshensel & Sucoff, 1996; Franzini et al., 2005; Gary et al., 2007; Saarloos, Alfonso, Giles-Corti, Middleton, & Almeida, 2011). However, this is one of first studies to incorporate a general indicator of neighborhood quality to enhance our understanding of inconsistencies in pain measurement. While overall neighborhood rating is a broad measure that may comprise numerous components, more research is needed to understand whether this single question may be an appropriate follow-up question for those who indicate inconsistent pain reports.

Limitations of the Study

The primary limitations of the study pertain to the measurement of subjective and objective pain measurement. Specifically, the subjective pain measurement incorporated pain experienced in the 12 months prior to data collection. As a result, it is possible that recall bias is a factor in subjective reports of pain. Furthermore, this subjective measure does not give an indication of intensity, severity, frequency, or duration of the pain within the respective areas.

There are also several limitations pertaining to the objective measure of pain. While the same physicians and nurses within the study conducted the objective pain measurements, it is possible that the protocol for physical manipulation was subject to measurement error. This may have biased the actual representation of those who experienced objective pain in the hands, neck, and low back. Additionally, this procedure and subsequent observations are subject to the physician's interpretation of these pain behaviors during the clinical examination. It is possible that while facilitating the clinical examination, the physician missed non-verbal gestures (e.g., wincing) exhibited by the study's participants. However, it is important to note that these procedures, as undertaken in the study, are generally consistent with clinical examinations conducted in primary care settings. As a result, it is imperative that standardized and evidence-based methods for physical examination translate to clinical practices, in efforts to enhance validity of objective pain measurements. Regardless, the limitations that exist between subjective and objective pain measures may have over- or under-estimated the association or lack thereof between the two.

Missing data and incorporation of only those with valid data may have biased the sample. However, using multiple imputation for over 60% of the data may have produced greater biases within the results. This study should be replicated using multiple imputation approaches to identify consistencies and differences. Additionally, within this study we did not observe any significant relationships between "John Henryism" and consistency in pain measures. This lack of association may have been a factor of insufficient power due to the low number of respondents with valid data across all measures, including "John Henryism". Future studies should incorporate "John Henryism" to understand how effortful coping may moderate or mediate the relationships between sociodemographic, health, and other psychosocial

characteristics and inconsistent pain measurements. Finally, this study is cross-sectional in nature, which means that causality could not be established.

Conclusion

In conclusion, subjective and objective indicators of hand pain were weakly correlated, and there were no significant relationships identified between subjective and objective neck pain and subjective and objective low back pain measurements. History of depressive symptoms and indicators of socioeconomic status (i.e., poverty status and neighborhood quality) were identified as moderators of inconsistent pain measurements across this racially and socioeconomically diverse sample. These findings suggest that musculoskeletal pain may be a product of sociodemographic characteristics, psychological distress, and psychosocial factors, which may be independent of underlying pathology. As a result, treatment approaches to musculoskeletal complaints should not only be based upon findings from clinical examination; rather, clinicians should also consider unique sociodemographic and psychosocial characteristics that may contribute to the development or exacerbation of musculoskeletal pain complaints. The implications of this research are discussed in greater detail in the general conclusions section of this dissertation.

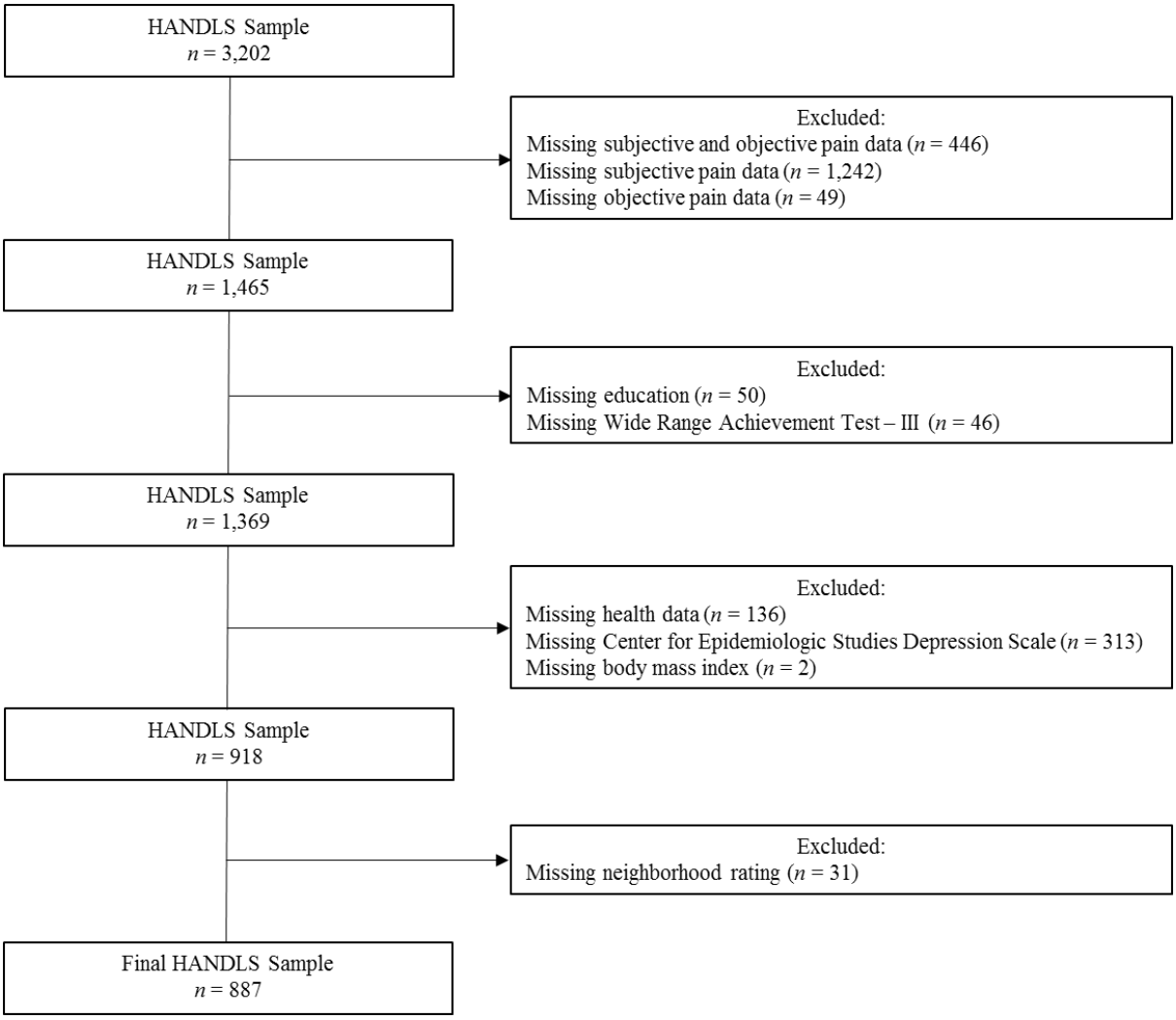

Figure 3. Flow chart of participants with missing data for Study 1. *Note:* Subjective pain is a composite variable of anyone who responded to low back pain, hand pain, and neck pain. Objective pain is based upon physical examination (i.e., pain upon passive range of motion) of the left- and right hand, neck, and low back.

Table 1: Demographic Characteristics of the Overall Sample and Consistent and Inconsistent Measurements across Pain Sites

Characteristics	Hand				Neck			Low Back		
	Total (*n* = 887) n (%) / *M* (*SD*)	Consistent Pain[a] (*n* = 762) n (%) / *M* (*SD*)	Inconsistent Pain[b] (*n* = 125) n (%) / *M* (*SD*)	*p* - value	Consistent Pain[a] (*n* = 731) n (%) / *M* (*SD*)	Inconsistent Pain[b] (*n* = 156) n (%) / *M* (*SD*)	*p* - value	Consistent Pain[a] (*n* = 529) n (%) / *M* (*SD*)	Inconsistent Pain[a] (*n* = 358) n (%) / *M* (*SD*)	*p* - value
Sociodemographic										
Age Groups										
Ages 30-39	167 (18.83)	142 (18.64)	25 (20.00)		146 (19.97)	21 (13.46)		103 (19.47)	64 (17.88)	
Ages 40-54	463 (52.20)	400 (52.49)	63 (50.40)	.898	374 (51.16)	89 (57.05)	.152	282 (53.31)	181 (50.56)	.370
Ages 55-64	257 (28.97)	220 (28.87)	37 (29.60)		211 (28.86)	46 (29.49)		144 (27.22)	113 (31.56)	
Sex (female)	512 (57.72)	435 (57.09)	77 (61.60)	.344	413 (56.60)	99 (64.46)	.110	284 (53.69)	228 (63.69)	.003
Race (Black)	422 (47.58)	371 (48.69)	51 (40.80)	.102	354 (48.43)	68 (43.59)	.272	265 (50.05)	157 (43.85)	.068
Education (years)	*12.15* (*2.88*)	*12.10* (*2.87*)	*12.43* (*2.98*)	.232	*12.19* (*2.82*)	*11.93* (*3.14*)	.300	*12.19* (*2.84*)	*12.09* (*2.94*)	.562
WRAT- III (score)	*42.41* (*7.94*)	*42.35* (*7.97*)	*42.75* (*7.78*)	.603	*42.53* (*8.00*)	*41.83* (*7.67*)	.313	*42.42* (*7.97*)	*42.39* (*7.91*)	.955
Poverty Status (below)	323 (36.41)	286 (37.53)	37 (29.60)	.088	263 (35.98)	60 (38.46)	.558	185 (34.97)	138 (36.31)	.278
Health										
Medical Conditions (1+)	513 (57.83)	435 (57.08)	78 (62.40)	.307	417 (57.05)	96 (61.54)	.308	283 (53.50)	230 (64.25)	<.001
CES-D (score)	*15.80* (11.69)	*15.94* (*11.61*)	*14.48* (*12.18*)	.393	15.84 (11.83)	*15.62* (*11.05*)	.830	*15.73* (*11.70*)	15.91 (11.69)	.825
History of Depressive Symptoms (yes)	248 (27.96)	211 (27.69)	37 (29.60)	.659	187 (25.58)	61 (39.10)	<.001	112 (21.17)	136 (37.99)	<.001
Body Mass Index (total)	*30.05* (*7.74*)	*29.99* (*7.88*)	*30.42* (*6.86*)	.565	*30.12* (*7.83*)	*29.69* (*7.31*)	.531	*29.80* (*7.71*)	30.40 (7.79)	.269
Psychosocial										
Neighborhood Quality	422 (47.58)	397 (52.10)	57 (45.60)	.633	343 (46.92)	70 (50.64)	.399	255 (48.20)	167 (46.65)	.649
"John Henryism"[c] (score)	*42.24* (*5.39*)	*42.20* (*5.40*)	*42.49* (*5.33*)	.673	42.27 (5.45)	*42.05* (*5.13*)	.697	*42.52* (*5.35*)	*41.81* (*5.43*)	.119

Note: WRAT-III = Wide Range Achievement Test – III; CES-D = Center for Epidemiological Studies Depression Scale; Body Mass Index = kg/m^2. Chi square tests of independence were used to identify differences between those with consistent and inconsistent pain across pain sites. Independent samples *t*-test were used to estimate differences between those with consistent and inconsistent pain across pain sites for continuous variables.

[a]Consistent Pain = Subjective pain and objective pain reported ("yes", "yes") or no subjective or objective pain reported ("no", "no").

[b]Inconsistent Pain = Only one measure of pain reported (e.g., "yes" to subjective pain but "no" to objective pain or "yes" to objective pain but "no" to subjective pain).

[c]Due to missing data "John Henryism" was explored in a subsample of participants with complete pain, sociodemographic, health, and psychosocial data (n = 595). The counts of the 595 participants with consistent and inconsistent pain measurement groups across sites are as follows: consistent (n = 526) and inconsistent (n = 69) hand pain, consistent (n = 491) and inconsistent (n = 104) neck pain, and consistent (n = 358) and inconsistent (n = 237) low back pain measurements.

Table 2: Frequencies of Subjective and Objective Pain across Consistent and Inconsistent Hand Pain Measurements

		Objective Hand Pain[a]	
		No	Yes
Subjective Hand Pain	No	*n* = 758 (Consistent)	*n* = 1 (Inconsistent)
	Yes	*n* = 124 (Inconsistent)	*n* = 4 (Consistent)

Note. Consistent and inconsistent hand reporting responses for the final sample (*n* = 887). Participants who demonstrated consistent hand pain reports (*n* = 762; "no" for both subjective and objective hand pain or "yes" for both subjective and objective hand pain) and participants who demonstrated inconsistent hand pain reports (*n* = 125; "yes" to subjective hand pain and "no" to objective hand pain; or vice versa) comprise the consistent and inconsistent hand pain measurement groups.

[a]Objective hand pain is based upon physical examination (i.e., pain upon passive range of motion) of the hands.

Table 3. Frequencies of Subjective and Objective Pain across Consistent and Inconsistent Neck Pain Measurements

		Objective Neck Pain[a]	
		No	Yes
Subjective Neck Pain	No	*n* = 727 (Consistent)	*n* = 23 (Inconsistent)
	Yes	*n* = 133 (Inconsistent)	*n* = 4 (Consistent)

Note. Consistent and inconsistent neck pain measurement responses for the final sample (*n* = 887). Participants who demonstrated consistent neck pain measurements (*n* = 731; "no" for both subjective and objective neck pain or "yes" for both subjective and objective neck pain) and participants who demonstrated inconsistent neck pain measurements (*n* = 156; "yes" to subjective neck pain and "no" to objective neck pain; or vice versa) comprise the neck pain measurement groups.

[a]Objective neck pain is based upon physical examination (i.e., pain upon passive range of motion) of the neck.

Table 4. Frequencies of Subjective and Objective Pain across Consistent and Inconsistent Low Back Pain Measurements

		Objective Low Back Pain[a]	
		No	Yes
Subjective Low Back Pain	No	*n* = 511 (Consistent)	*n* = 34 (Inconsistent)
	Yes	*n* = 324 (Inconsistent)	*n* = 18 (Consistent)

Note. Consistent and inconsistent low back pain measurements for the final sample (*n* = 887). Participants who demonstrated consistent low back pain measurements (*n* = 529; "no" for both subjective and objective low back pain or "yes" for both subjective and objective low back pain); and participants who demonstrated inconsistent low pain reports (*n* = 358; "yes" to subjective low back pain and "no" to objective low back pain; or vice versa) comprise the low back pain measurement groups.

[a]Objective low back pain is based upon physical examination (i.e., pain upon passive range of motion) of the low back.

Table 5. Relationships between Sociodemographic, Health, and Psychosocial Characteristics and Subjective and Objective Pain

Measure	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Age Group	-																	
2. Sex	-0.01	-																
3. Race	0.02	0.01	-															
4. Education	-0.01	-0.00	0.04	-														
5. WRAT-III	-0.08*	0.03	-0.17***	0.44***	-													
6. Poverty Status	0.07*	-0.01	-0.08*	0.24***	0.21***	-												
7. Comorbidites	0.28***	-0.03	-0.04	-0.02	0.00	-0.04	-											
8. CES-D	-0.01	-0.01	0.01	-0.03	0.00	-0.06	-0.07*	-										
9. History of Depressive Symptoms	0.00	0.11***	-0.10**	-0.00	0.01	-0.06	0.09**	0.02	-									
10. Body Mass Index	-0.06	-0.05	-0.04	-0.02	-0.03	-0.01	0.04	-0.00	0.03	-								
11. "John Henryism"	-0.04	0.04	-0.01	0.05	0.01	0.09*	0.02	-0.27***	0.03	-0.02	-							
12. Neighborhood Quality	0.00	-0.02	0.03	-0.05	-0.05	-0.04	0.00	0.12***	0.00	-0.01	-0.15***	-						
13. Subjective Hand Pain	0.00	0.03	-0.05	0.03	0.01	0.05	0.00	-0.02	0.01	0.03	0.01	-0.01	-					
14. Objective Hand Pain	0.01	0.03	-0.01	-0.02	-0.06	-0.01	-0.01	-0.00	-0.05	-0.04	-0.06	-0.01	0.14***	-				
15. Subjective Low Back Pain	0.06	0.09**	-0.05	-0.03	0.00	-0.05	0.13***	0.00	0.20***	0.03	-0.05	0.01	-0.06	-0.03	-			
16. Objective Low Back Pain	0.05	0.03	-0.02	-0.01	-0.01	0.03	0.07*	0.00	0.05	0.00	-0.04	-0.06	0.16***	0.10**	-0.02	-		
17. Subjective Neck Pain	0.03	0.06	-0.04	-0.01	-0.01	-0.02	0.06	-0.01	0.16***	-0.01	0.02	0.04	-0.02	0.01	0.29***	-0.01	-	
18. Objective Neck Pain	0.04	0.05	0.07*	-0.03	-0.05	0.01	-0.03	0.03	-0.04	-0.03	-0.05	0.02	0.10**	0.34***	-0.02	0.26***	-0.00	-

Note: WRAT-III = Wide Range Achievement Test - 3rd Edition; CES-D = Centers for the Epidemiological Studies Depression Scale.

Overall sample size = 887. "John Henryism" is based on a subsample of participants (n = 595). *p<.05, **p<.01, ***p<.001

Table 6. Correlations between Consistent and Inconsistent Pain Groups and Sociodemographic, Health, and Psychosocial Characteristics

Characteristics	Correlation Coefficients		
	Hand Pain Groups	Neck Pain Groups	Low Back Pain Groups
Sociodemographics			
Age Group[a]	-0.00	0.04	0.04
Sex[a]	0.03	0.05	0.10**
Race[a]	-0.05	-0.04	-0.06
Education[b]	0.04	-0.03	-0.02
WRAT-III[b]	0.02	-0.03	-0.00
Poverty Status[a]	0.06	-0.02	-0.04
Health			
Comorbidities[a]	0.02	0.05	0.13***
CES-D[b]	-0.03	-0.01	-0.03
History of Depressive Symptoms[b]	0.01	0.11***	0.18***
BMI[b]	0.05	-0.02	0.02
Psychosocial			
Neighborhood Rating[a]	-0.02	0.03	-0.02
"John Henryism"[b]	0.02	-0.02	0.02

Note: WRAT-III = Wide Range Achievement Test (3rd Edition); CES-D = Center For Epidemiological Studies Depression Scale; BMI = Body mass index. *p <.05, **p <.01, ***p <001.

[a]Spearman correlations were used to examine the relationships between consistent and inconsistent pain measurements and categorical sociodemographic, health, and psychosocial characteristics across each pain site.

[b]Pearson correlations were used to examine the relationships between consistent and inconsistent pain measurements and non-categorical sociodemographic, health, and psychosocial characteristics across each pain site.

Table 7. Binary Logistic Regressions for Sociodemographic, Health, Psychosocial, and Pain Variables and Consistent and Inconsistent Hand Pain Measurements

Characteristics	Hand Pain Groups					
	Model 1		Model 2		Model 3	
	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
Model 1						
Sociodemographic						
Age Group	0.97 (0.74, 1.29)	.841	0.96 (0.71, 1.28)	.759	0.96 (0.71, 1.28)	.759
Sex	1.22 (0.83, 1.80)	.315	1.23 (0.83, 1.82)	.311	1.22 (0.83, 1.82)	.314
Race	0.72 (0.48, 1.07)	.099	0.73 (0.49, 1.08)	.117	0.73 (0.49, 1.09)	.119
Education	1.04 (0.97, 1.12)	.299	1.04 (0.97, 1.12)	.302	1.04 (0.97, 1.12)	.307
WRAT-III	0.99 (0.97, 1.02)	.581	0.99 (0.97, 1.02)	.562	0.99 (0.96, 1.02)	.557
Poverty Status[a]	1.36 (0.89, 2.09)	.159	1.37 (0.89, 2.10)	.157	1.36 (0.89, 2.10)	.158
Model 2						
Health						
Comorbidities			1.08 (0.81, 1.46)	.616	1.08 (0.81, 1.44)	.613
CES-D			0.99 (0.98, 1.01)	.478	1.01 (0.98, 1.03)	.496
History of Depressive Symptoms			1.04 (0.68, 1.60)	.847	1.04 (0.68, 1.60)	.847
BMI			1.01 (0.98, 1.03)	.610	1.01 (0.98, 1.03)	.609
Model 3						
Psychosocial						
Neighborhood Quality					0.95 (0.71, 1.28)	.811
"John Henryism"[b]					1.00 (0.95, 1.05)	.848

Note: WRAT-III = Wide Range Achievement Test – 3rd Edition; CES-D = Centers for the Epidemiological Studies Depression Scale. Binary Logistic Regressions reflect the odds for inconsistent (1) vs. consistent (0) measurement of hand pain as those with inconsistent measurement of pain was the group of interest.

[a]Poverty Status = "Below" (income level at or below 125% poverty level) or "Above" (income over 125% of poverty level).

[b]"John Henryism" is based on a subsample of participants (n = 595). Overall sample size is 887.*p < .05, **p < .01, ***p < .001.

Table 8. Binary Logistic Regressions for Sociodemographic, Health, Psychosocial, and Pain Variables and Consistent and Inconsistent Neck Pain Measurements

Characteristics	Neck Pain Groups					
	Model 1		Model 2		Model 3	
	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
Model 1						
Sociodemographic						
Age Group	1.17 (0.90, 1.51)	.239	1.12 (0.85, 1.47)	.421	1.12 (0.85, 1.47)	.423
Sex	1.35 (0.94, 1.93)	.101	1.27 (0.89, 1.83)	.193	1.28 (0.89, 1.84)	.187
Race	0.80 (0.56, 1.14)	.212	0.84 (0.58, 1.21)	.349	0.84 (0.58, 1.21)	.343
Education	0.99 (0.92, 1.06)	.676	0.99 (0.92, 1.06)	.663	0.99 (0.92, 1.06)	.686
WRAT-III	0.99 (0.97, 1.02)	.444	0.99 (0.97, 1.01)	.396	0.99 (0.97, 1.02)	.411
Poverty Status[a]	0.92 (0.63, 1.34)	.665	0.96 (0.66, 1.40)	.844	0.97 (0.66, 1.41)	.853
Model 2						
Health						
Comorbidities			1.12 (0.86, 1.45)	.402	1.12 (0.86, 1.45)	.401
CES-D			1.00 (0.98, 1.01)	.780	1.00 (0.98, 1.01)	.714
History of Depressive Symptoms			1.77 (1.22, 2.56)	**.003**	1.77 (1.22, 2.56)	**.003**
BMI			0.99 (0.97, 1.02)	.471	0.99 (0.97, 1.02)	.470
Model 3						
Psychosocial						
Neighborhood Quality					1.17 (0.82, 1.66)	.396
"John Henryism"[b]					0.99 (0.95, 1.03)	.561

Note: WRAT-III = Wide Range Achievement Test – 3rd Edition; CES-D = Centers for the Epidemiological Studies Depression Scale. Binary Logistic Regressions reflect the odds for inconsistent (1) vs. consistent (0) measurement of neck pain as those with inconsistent measurement of pain was the group of interest.

[a]Poverty Status = "Below" (income level at or below 125% poverty level) or "Above" (income over 125% of poverty level).

[b]"John Henryism" is based on a subsample of participants (n = 595). Overall sample size is 887.*p < .05, **p < .01, ***p < .001.

Table 9. Binary Logistic Regressions for Sociodemographic, Health, Psychosocial, and Pain Variables and Consistent and Inconsistent Low Back Pain Measurements

Characteristics	Low Back Pain Groups					
	Model 1		Model 2		Model 3	
	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
Model 1						
Sociodemographic						
Age Group	1.16 (0.95, 1.41)	.157	1.05 (0.85, 1.31)	.632	1.05 (0.85, 1.31)	.630
Sex	1.52 (1.15, 2.00)	**.003**	1.47 (1.11, 1.95)	**.008**	1.47 (1.10, 1.95)	**.008**
Race	0.76 (0.58, 1.01)	.055	0.83 (0.62, 1.10)	.194	0.83 (0.62, 1.10)	.198
Education	1.00 (0.94, 1.05)	.882	1.00 (0.94, 1.05)	.848	0.99 (0.94, 1.05)	.835
WRAT-III	1.00 (0.98, 1.02)	.984	1.00 (0.98, 1.02)	.941	1.00 (0.98, 1.02)	.934
Poverty Status[a]	0.84 (0.62, 1.12)	.228	0.90 (0.67, 1.22)	.493	0.90 (0.67, 1.21)	.487
Model 2						
Health						
Comorbidities			1.39 (1.13, 1.72)	**.002**	1.39 (1.13, 1.72)	**.002**
CES-D			1.00 (0.99, 1.01)	.730	1.00 (0.99, 1.03)	.692
History of Depressive Symptoms			2.04 (1.50, 2.77)	**<.001**	2.04 (1.50, 2.77)	**<.001**
BMI			1.01 (0.99, 1.03)	.355	1.01 (0.99, 1.03)	.357
Model 3						
Psychosocial						
Neighborhood Quality					0.94 (0.71, 1.24)	.638
"John Henryism"[b]					0.97 (0.94, 1.00)	.054

Note: WRAT-III = Wide Range Achievement Test – 3rd Edition; CES-D = Centers for the Epidemiological Studies Depression Scale. Binary Logistic Regressions reflect the odds for inconsistent (1) vs. consistent (0) measurement of low back pain as those with inconsistent measurement of pain was the group of interest.

[a]Poverty Status = "Below" (income level at or below 125% poverty level) or "Above" (income over 125% of poverty level).

[b]"John Henryism" is based on a subsample of participants (n = 595). Overall sample size is 887.*p < .05, **p < .01, ***p < .001.

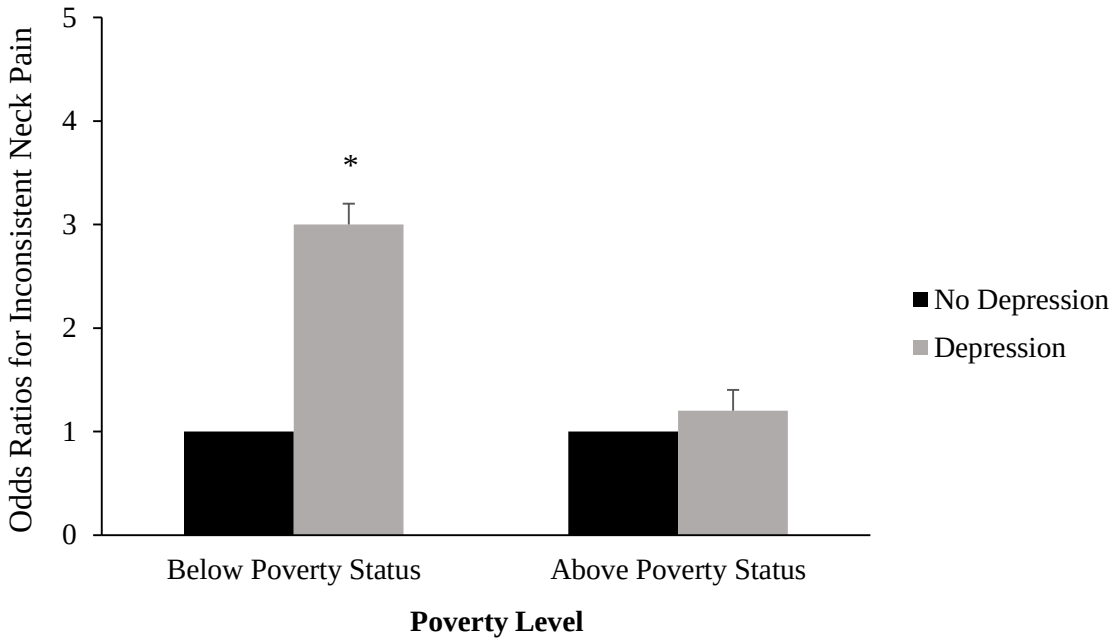

Figure 4. Two-way interaction between history of depressive symptoms and poverty status on inconsistent neck pain measurements. *p <.05. *Note*: These findings signify that individuals who have experienced depressive symptoms and were below the poverty line were nearly 3 times more likely to demonstrate inconsistent neck pain measurements.

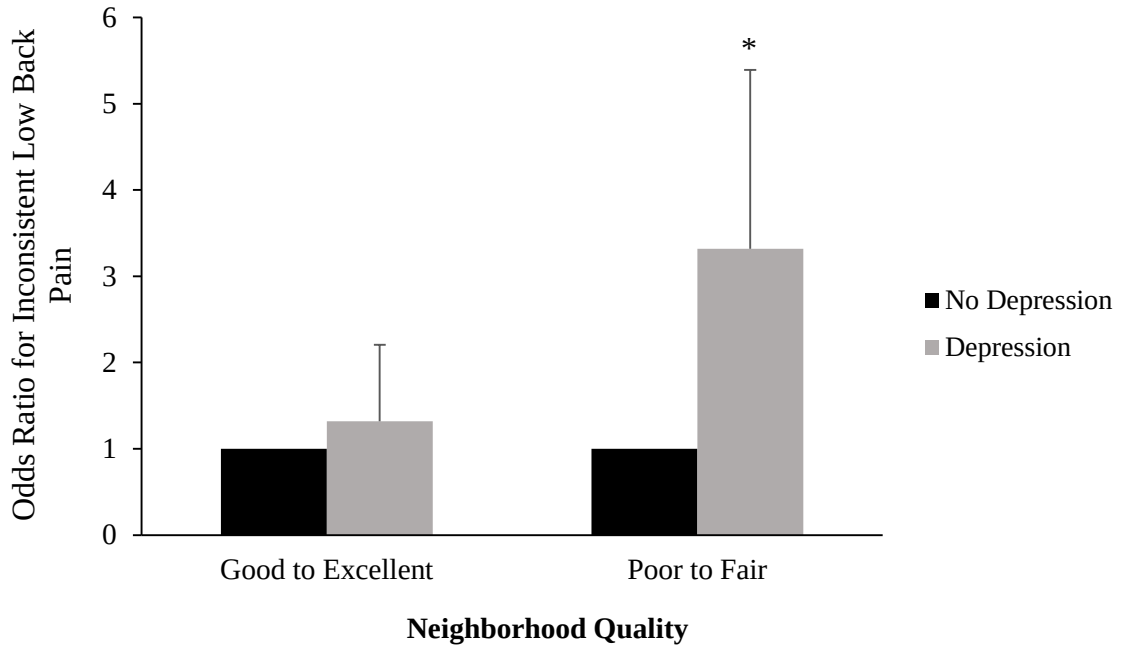

Figure 5. Two-way interaction between history of depressive symptoms and neighborhood quality on inconsistent low back pain reports. *$p < .05$. These findings signify that individuals who have experienced a history of depressive symptoms and report "poor" to "fair" neighborhood quality are 3.3 times more likely to demonstrate inconsistent neck pain measurements.

CHAPTER FOUR: STUDY 2: CROSS-SECTIONAL EXAMINATION OF PAIN AND PHYSICAL FUNCTION IN A SOCIOECONOMICALLY DIVERSE SAMPLE OF BLACK AND WHITE ADULTS

Introduction

Musculoskeletal pain is associated with greater levels of disability (Patel et al., 2013; Peat et al., 2006) and threatens functional independence across numerous age groups. Existing literature is largely focused on pain and poorer physical function in older adult populations, despite some evidence of mid-life pain and similar reports in physical limitations (Covinsky et al., 2009; Rustøen et al., 2005). Older individuals tend to express more pain (Blyth et al., 2001) of greater intensity (Elliott, Smith, Penny, Cairns Smith, & Alastair Chambers, 1999); whereas, middle-aged individuals tend to express more pain locations of unidentifiable causes, and are considered a high-risk group for chronic pain (Rustøen et al., 2005; Yagci et al., 2007). Rustøen and colleagues (2005) identified pain as a chronic and persistent problem plaguing the middle-age group; and Covinsky and colleagues (2009) concluded that middle-aged individuals in pain are demonstrating functional limitations similar to those typically observed in studies including older adult samples. However, much of the existing literature that examined pain and physical function earlier in the life course has included only subjective reports of functional limitations and disability, and has not thoroughly examined how race and socioeconomic status might moderate this relationship.

Given the findings by Covinsky and colleagues (2009), studies that strive to expand upon the relationships between pain and physical function earlier in the life course, and across sensitive performance measures, are essential. Existing studies that have examined these relationships between pain and physical function commonly include measures of subjective reports of functional limitations and disability (Covinsky et al., 2009; Peat et al., 2006), rather than objective measures of physical performance. Self-reported limitations in physical function may not often correlate well with more objective measures (Reuben, Valle, Hays, & Siu, 1995), suggesting that these measures may be tapping into different constructs of functional abilities (Gitlin, 2006). Moreover, objective performance measures provide information that may not be attainable through self-reported evaluation of physical function (e.g., more accurate assessment of specific functional capabilities of strength, balance, and mobility), as the individual may often be unaware that specific deficits exist (Gitlin, 2006; Guralnik, Simonsick, et al., 1994). Because middle-aged individuals have greater compensatory strategies, changes in physical function earlier in the life course may be subtle and go unnoticed, as losses are fully compensated (Ferrucci et al., 2016). This may be especially true amongst younger- to middle-aged adults who are compensating when in greater pain. Incorporating objective measures of upper- and lower-body strength, balance, and gait that are sensitive enough to detect losses or deficits promotes a more comprehensive understanding of musculoskeletal pain and its relationship with various measures of physical function.

Sociodemographic Disparities in Pain and Physical Function

Additionally, previous literature that has examined pain and physical function earlier in the life course has typically incorporated individuals who were predominately White, or of

higher socioeconomic status (SES). This is despite the fact that a high percentage of minority populations (e.g., Blacks) report musculoskeletal pain (Berkman et al., 1993; Leveille et al., 2002). Prior studies also concluded that females (Smith et al., 2001), ethnically diverse groups (Green & Hart-Johnson, 2012; Portenoy et al., 2004), and those of lower SES (Johannes et al., 2010; Portenoy et al., 2004; Smith et al., 2001) are at greatest risk of experiencing pain. Particularly, Johannes et al. (2010) identified that individuals with lower household incomes demonstrated greater odds of musculoskeletal pain than individuals with higher levels of income (i.e., ≥$100,000; Johannes et al., 2010). Similar studies indicated that SES-related characteristics (e.g., education) were also significantly related to musculoskeletal pain, particularly pain that was considered disabling (Portenoy et al., 2004).

Furthermore, SES may explain racial and gender disparities in physical function. Specifically, lower levels of SES are significantly associated with worse physical performance related to grip strength, lower-body strength, and balance for men and women (Kuh et al., 2005). When accounting for measures of SES (e.g., education), racial disparities are often reduced or eliminated (Clay et al., 2015; LaVeist et al., 2011). These complex interactions are particularly evident among individuals who report musculoskeletal pain, but have not been thoroughly explored amongst a racially and socioeconomically diverse group of younger- to middle-aged adults (Portenoy et al., 2004).

The aims of this study were to: 1) Examine the relationship between musculoskeletal pain and global physical function (i.e., a global measure of performance, based on upper- and lower-body strength, balance, gait abnormalities); and, 2) Investigate whether sociodemographic characteristics (e.g., age, race, and measures of SES) moderate the relationship between pain and physical function, in a sample of community-dwelling, Black and White adults. It was

hypothesized that both musculoskeletal pain and pain interference would be significantly associated with poorer physical function. Additionally, adults who self-identify as Black, have lower levels of education, poorer reading literacy, or fall below poverty status would demonstrate worse physical functioning, particularly if they experienced musculoskeletal pain and pain interference.

Methodology

Participants

Participants in this study came from the Healthy Aging in Neighborhoods of Diversity across the Life Span (HANDLS; Evans et al., 2010) a 20-year longitudinal study designed to examine the influences of sociodemographic factors, specifically race and SES over time on health outcomes. Community dwelling, socioeconomically diverse, Blacks and Whites aged 30-64 (n = 875), were included in the current study if they had valid data across all measures (e.g., pain, sociodemographic, health, and physical function data; see Figure 6 for study flowchart). HANDLS recruited participants from 13 pre-determined groups of contiguous census tracts located within Baltimore, Maryland. HANDLS visits consisted of an in-home interview in which various subjective information were collected (e.g., health status, psychosocial information, and cognitive evaluation). Additionally, Medical Research Vehicles parked within each neighborhood were used to collect objective measures (e.g., physical examination and physical function measures). Participants were compensated for their time. To test the study aims, the current study utilized cross-sectional data from HANDLS Wave 1, which was collected over approximately 4½ years (2004-2009). HANDLS was approved by the Institutional Review Board at the National Institute of Environmental Sciences at National Institutes of Health. All

participants provided written informed consent. Additionally, this study was approved by the Institutional Review Board at the University of South Florida.

Musculoskeletal Pain and Pain Interference as Independent Variables

Pain. Information on pain was obtained during examination of participant's medical history. A physician or nurse practitioner collected participants' medical history in a structured interview, in which participants indicated whether they have/had experienced pain in the neck, low back, muscle/s and/or joint/s in the 12 months prior to data collection ("No" = 0, "Yes" = 1). Hand pain was derived from the following question: "Is pain or arthritis in the hands worse recently?" ("No" = 0, "Yes" = 1). Responses were summed and categorized into three groups: (1) no pain sites, (2) single pain site, or (3) >1 pain site and reflected musculoskeletal pain as done in previous research (Eggermont, Bean, Guralnik, & Leveille, 2009; Leveille et al., 2009).

Pain Interference. Pain interference has been utilized as an indicator of pain that is considered disabling, and is associated with sociodemographic, health, and psychosocial factors (Jordan et al., 2008). For example, previous research has concluded that older adults (Thomas, Peat, Harris, Wilkie, & Croft, 2004), individuals with depression, those with a prior history of pain, and of poorer SES (Jordan et al., 2008) are more likely to report pain interference. Specifically, pain interference is associated with greater physical limitations among females, older adults, as well as individuals who report chronic health conditions (e.g., arthritis and cardiovascular conditions; Scudds & Østbye, 2001). For this study, pain interference was examined using item number eight from the SF-12 ("During the past 4 weeks, how much did pain interfere with your normal work, including work outside the home and housework"), with five response options ranging from "extremely" (1) to "not at all" (5; Ware, Kosinski, & Keller,

1996). For this study, the responses based on the extent of pain interference were dichotomized as “Extremely”, “Quite a bit”, and “Moderately” (1), and “A little bit” and “Not at all” (0), due to unequal distribution of responses, which is consistent with past research (Jordan et al., 2008; Scudds & Østbye, 2001; Thomas et al., 2004; Ware, Kosinski, Dewey, & Gandek, 2000). Because pain interference has been identified as a measure of the impact of pain, and is associated with physical limitations, it was considered an independent variable within the analyses.

Physical Function Variables as Dependent Variables

Physical performance was examined using items from the short physical performance battery (SPPB; Guralnik, Simonsick, et al., 1994). The SPPB included measures of upper- and lower-body strength (e.g., time to complete repeated chair stands), and balance, as originally incorporated within the Established Populations for Epidemiologic Studies of the Elderly (Taylor, Wallace, Ostfeld, & Blazer, 2006) and Women’s Health and Aging Study (Guralnik, Fried, Simonsick, Kasper, & Lafferty, 1995). Participants completed the performance tasks in the following order: right- and left-grip strength, side-by-side stand, semi-tandem stand, tandem stand, and 5- and 10-chair stands.

Upper-Body Strength. Grip strength is a common measure used as an indicator of upper- (Cesari et al., 2006) and lower-body strength (Pijnappels, Reeves, & van Dieën, 2008), and frailty (Fried et al., 2001). Among participants in the HANDLS sample, previous research has reported that grip strength is particularly sensitive to race and socioeconomic status, as performance varied across Blacks and Whites, as well as males below and above poverty status (Thorpe et al., 2016). Right- and left-handed grip strength were measured using a Jamar

Hydraulic Hand Dynamometer (Model No. 5030J 1 Sammons Preston Rolyan, Bolingbrook, IL), in which the maximum kilograms of force across two trials for each hand were recorded. For this measure, each hand was tested in a resting position on a table, with flexion at approximately 160^{o} (Evans et al., 2010). Two trials were conducted across each hand in which the average of the two hands were calculated for this study, which is consistent with previous research (Woo, Leung, & Lau, 2009).

Lower-Body Strength. Time to complete 5- and 10-chair stands (seconds) was used as an indicator of lower-body strength. Chair stands are a commonly-used tool to examine lower-body strength in middle-aged and older populations (Bohannon, 1995). With this measure, participants are asked to stand up from a straight-backed chair repeatedly, in which time to complete both 5- and 10-chair stands were reported. In order to address higher functionality existing across younger participants, HANDLS researchers modified the SPPB to identify meaningful differences earlier in the life course (Evans et al., 2010). Because the SPPB is commonly used with older adults, particularly those with functional limitations, chair stand measures were modified for proposed higher functional capacity by increasing the completion number from 5- to 10. The split time for 5-chair stands and total time to complete 10-chair stands were collected separately during testing (Curb et al., 2006; Evans et al., 2010). As a result, this study examined 5- and 10-chair stands separately. Because higher time is representative of poorer performance on the chair stand time, the continuous score was reverse coded for analyses to ensure those unable to complete the task (i.e., received a score of 0) did not skew the means toward better performance.

Balance. Balance, as part of the SPPB, was measured using the side-by-side, semi-tandem, full-tandem stand test (Guralnik, Simonsick, et al., 1994). Participants were required to

maintain their balance without the use of any aid for a given period. If loss of balance occurred, the time that balance was lost was noted. See Table 10 for procedure, timing, and scoring of the balance task (Eggermont et al., 2009; Guralnik, Simonsick, et al., 1994; Lang, Guralnik, & Melzer, 2007). Scores across each balance test were summed to derive a component measure of balance, in which higher score (i.e., score = 9) and was representative of better balance.

Gait. Any observed abnormalities in gait (i.e., "senile", "Parkinsonian", "spastic", and/or "other" types of gait disturbances) were coded as "abnormal" (1). Participants who did not display any of the aforementioned gait disturbances were coded as "normal" (0), based on clinical examination by a trained physician (Evans et al., 2010). The gait abnormalities sum was used as a proxy for impaired mobility (e.g., higher number of observed gait abnormalities may be representative of more impaired mobility; Evans et al., 2010) as gait speed is unavailable within the HANDLS dataset.

Covariates

Sociodemographic Variables. Demographic data were collected via self-report during the in-home visits. Age was grouped to distinguish "younger age" (0; age 30-39), "middle-aged" (1; age 40-54), and "older age" (2; age 55+). Sex represented "males" (0) and "females" (1). Race was coded as "White" (0) or "Black" (1). The education variable was continuous and reflected total years of education attained (range 0 – 21 years). Poverty status was determined by poverty guidelines published by the U.S. Department of Health and Human Services (2004). Poverty status was based on poverty guidelines set forth in 2004, and was defined by HANDLS as, "below poverty status" (0), which included those who subjectively reported income at or below 125% of the poverty level, and "above poverty status" (1), which included those who

reported income over 125% of the poverty level (Evans et al., 2010). The Wide Range Achievement Test - III (WRAT-III; Wilkinson, 1993), was used as an objective measure of reading literacy and education quality. Scores are continuous and determined by a participant's ability to recognize and correctly pronounce letters and words. The total WRAT-III score was analyzed as a continuous variable, in which scores ranged from "low reading literacy" (0) to "high reading literacy" (57).

Health Variables. Health-related factors were obtained during medical history interview, in which participants indicated "yes" (1) or "no" (0) to being asked if they have/had the following health conditions: 1) fracture, 2) hypertension, 3) hyperthyroidism and 4) hypothyroidism, 5) stroke, 6) asthma, 7) diabetes, 8) sleep apnea, 9) osteoarthritis, 10) rheumatoid arthritis, and/or 11) gout. These conditions have been previously incorporated in the pain and/or physical function literature (Covinsky et al., 2009; Jordan et al., 2008; Rustøen et al., 2005); therefore, they were considered in this study. Health conditions incorporated within study 2 differed from health conditions incorporated within study 1 due to the change in pain measurement, which excludes objective pain, and incorporates pain interference and measures of physical function. Health conditions consisted of two composite variables. First, a sum score was calculated for musculoskeletal-related conditions (i.e., fracture, osteoarthritis, rheumatoid arthritis, and gout; total range 0 – 4), based upon the number of "yes" responses indicated. Due to uneven distribution, musculoskeletal-related conditions were collapsed to the following: none (0), 1 (1), or ≥ 2 (2). Second, a sum score was calculated for all other medical conditions (i.e., hypertension, stroke, asthma, diabetes, sleep apnea, and hyper- and hypothyroidism; total range 0 – 7), based upon the number of "yes" responses indicated. Due to unequal distribution this variable, other medical conditions was collapsed to the following: none (0), 1 (1), or ≥ 2 (2)

medical conditions. Incorporating two composite variables of health conditions aimed to differentiate musculoskeletal conditions from other medical conditions, as each may have unique implications on musculoskeletal pain, pain interference, and/or physical function. Height and weight of each participant were measured by HANDLS researchers. Body mass index (BMI) was calculated as weight (kg) divided by height (m^2), and has been incorporated in similar studies (Covinsky et al., 2009; Eggermont et al., 2009). BMI remained continuous within the analyses.

The Center for Epidemiologic Studies Depression Scale (CES-D; Radloff, 1977) was used to examine depressive symptomology of the sample. The CES-D is a 20-item scale that examined depressive symptoms, mood, and affect over the past week. Participants were provided statements, which included but were not limited to the following: "During the past week, I was bothered by things that usually don't bother me," or "During the past week my sleep was restless." Possible responses included the following: "Rarely or none of the time (Less than 1 day)", "Some or a Little of the Time (1-2 days)", "Occasionally or a Moderate Amount of Time (3-4 days)", and "Most or All of the Time (5-7 days)." Possible scores range from 0 - 60. Higher total scores are indicative of greater depressive symptomology. Scores on the CES-D remained continuous and independent of health conditions. Depressive symptoms were analyzed separately from health as it is representative of psychological health, and has been found to be prevalent in individuals who experience pain (Patel et al., 2013).

Statistical Analyses

Only participants with valid data across all measures were included in the analyses (n = 875). Chi square tests of independence and independent samples t-tests were conducted to explore differences in sociodemographic characteristics between those excluded (due to missing

data) and those included within the analyses. Descriptive analyses reported sociodemographic, health, and musculoskeletal pain and pain interference characteristics of the final sample.

Aim 1 Analyses. To examine the relationship between musculoskeletal pain, pain interference, and global physical function in a sample of community-dwelling adults, six physical function tasks (i.e., right-grip strength, left grip strength, times to complete 5- and 10-chair stands, balance, and gait) were converted into z-scores and averaged to comprise a measure of global physical function (see Figure 6 for the distribution of scores for global physical function; Buchman, Boyle, Wilson, Bienias, & Bennett, 2007). Higher scores on the global physical function variable indicated better performance across measures. Pearson correlations were used to examine the relationship between musculoskeletal pain, pain interference, and global physical function.

Multivariable regression analyses were utilized across four models to examine the relationship between musculoskeletal pain and the global physical function outcome as identified in aim 1. Model 1 adjusted for sociodemographic variables (e.g., age group, sex, race, years of education, WRAT-III scores, and poverty status), and model 2 controlled for sociodemographic characteristics and health-related factors (e.g., musculoskeletal conditions, other medical conditions, BMI, and CES-D). All independent variables and covariates were centered around the mean. Similarly, to investigate the relationship between pain interference and physical function, these multivariable regression analyses were conducted across models 1 and 2.

Aim 2 Analyses. To examine whether the relationship between pain and physical function is moderated by sociodemographic characteristics (e.g., age, race, sex, and measures of SES), multivariable regression analyses were used to investigate 2- and 3-way interactions between musculoskeletal pain and sociodemographic variables. These analyses were

incorporated to further explore whether the relationship between musculoskeletal pain and global physical function, and pain interference and physical function, varied by sociodemographic characteristics. Analytical models 3 and 4 addressed aim 2. Model 3 included tests of 2-way interactions between musculoskeletal pain and any significant sociodemographic predictors that were identified in model 2 (e.g., musculoskeletal pain × age group, musculoskeletal pain × race, musculoskeletal pain × sex, musculoskeletal pain × years of education, musculoskeletal pain × WRAT-III, and/or musculoskeletal pain × poverty status) in relation to global physical function. Additionally, model 4 examined 3-way interactions between musculoskeletal pain and sociodemographic characteristics, based on any significant moderating effects identified in model 3 (e.g., musculoskeletal pain × age group × race, musculoskeletal pain × race × education, or musculoskeletal pain × sex × poverty status).

For significant 2- and 3-way interactions, simple slopes analyses were estimated to examine the association between musculoskeletal pain and global physical function across the levels of the sociodemographic characteristics. These procedures were replicated to examine 2- and 3-way interactions between pain interference and sociodemographic factors on global physical function, across models 3 and 4.

Multivariable regression results are reported using standardized coefficients to facilitate comparisons among tests with different metrics. Statistical significance was set at two-tailed, $p < .05$. All statistical analyses were conducted using SAS statistical software package 9.2 (Cary, NC).

Power Analyses

Power analyses were estimated apriori for appropriate effect size in multivariable regression analyses using the G*Power 3.1.1 statistical software package (Faul et al., 2007). For

multivariable regression, considering a two-tailed test at 80% power, with a medium effect size (0.2; Cohen, 1992), *p*-value set at < .05, with 10 predictors, the recommended sample size is 42. The current study incorporated a sample size of 875 participants, which satisfied the amount of participants necessary to detect significant findings.

Results of Study Two

As indicated in Figure 6, of the 2,361 participants, 875 possessed valid data across all sociodemographic, health, pain, and physical function measures. Participants who were excluded from the study's analyses (n = 1,468) were compared to those who were included to identify any significant differences between the two groups in sociodemographic characteristics.

Chi square tests of independence for categorical variables and independent samples *t*-tests for non-categorical variables were conducted to examine differences in sociodemographic characteristics (i.e., age group, sex, race, years of education, WRAT-III scores, and poverty status) between those excluded and those included from analyses. Significant differences were identified between excluded and included participants in age group, $\chi 2$ (2) = 13.33, p = .001, sex, $\chi 2$ (1) = 7.74, p = .005, poverty status, $\chi 2$ (1) = 4.23, p = .039, and years of education t(2263) = -3.03, p = .003. Specifically, excluded individuals were more likely to be younger (age group = 30-39; 25.2%), male (47.0%), below poverty status (47.2%), and reported significantly less years of education (M = 11.82, SD = 2.78) than those who were included. There were no significant differences observed between those excluded and included on race, $\chi 2$ (1) = 2.89, p = .089 or WRAT-III scores, t(1731) = -0.61, p = .544.

Participant Characteristics of the Final Sample

Sociodemographic and Health Characteristics of the Final Sample. The final sample (n = 875) was predominately middle-aged (M = 48.50, SD = 8.90), female, Black, indicated an average of high school education, obtained an approximate WRAT-III score of 42, and were considered above poverty status (57.1%; see Table 11 for sociodemographic, health, and pain characteristics of the final sample). Participants reported the following musculoskeletal-related conditions: fracture (26.2%, n = 229), osteoarthritis (19.7%, n = 172), rheumatoid arthritis (4.6%, n = 40), and gout (3.1%, n = 27). Approximately 37.3% of the sample reported at least one musculoskeletal-related condition (n = 326), whereas 8.0% reported two or more musculoskeletal-related conditions (n = 70). Additionally, other medical conditions were identified within the sample: hypertension (40.5%, n = 354), diabetes (15.7%, n = 137), heart murmur (10.5%, n = 92), hypothyroidism (5.5%, n = 48), sleep apnea (3.5%, n = 31), hyperthyroidism (2.3%, n = 20), and stroke (2.1%, n = 18). Approximately 32.2% reported at least one medical condition (n = 282), whereas 16.8% of the sample (n = 147) experienced at least two or more types of other medical conditions The average scores on the CES-D for this sample were consistent with depressive symptoms (≥ 16; Long Foley et al., 2002; Smarr & Keefer, 2011). The overall BMI of the current sample was approximately 30, which is consistent with the cut-off for obesity (BMI of ≥ 30; World Health Organization, 2000).

Musculoskeletal Pain and Pain Interference Characteristics in the Final Sample. Approximately 35.7% of the sample reported one musculoskeletal pain site (n = 312) and nearly 23.5% indicated two or more musculoskeletal pain sites (n = 206). Pearson and spearman correlations were conducted to identify significant relationships between sociodemographic and health characteristics and musculoskeletal pain. Musculoskeletal pain was significantly

associated with the following characteristics: age group (p <.001), sex (p = .010), and other medical conditions (p <.001; Table 12). These findings suggest that participants who were older in age, female, and reported a greater number of medical conditions indicated more musculoskeletal pain. There were no significant relationships identified between musculoskeletal pain and the following characteristics: race (p =.406), years of education (p =.535), WRAT-III scores (p =.446), poverty status (p =.473), musculoskeletal-related conditions (p =.786), CES-D scores (p =.962), or BMI (p =.662).

Furthermore, results indicated that nearly 30% of the final sample reported moderate – extreme pain interference. Pearson and spearman correlations were conducted to examine the relationships between sociodemographic and health characteristics and pain interference. Pain interference was significantly correlated with the following characteristics: age group, years of education, poverty status, and other medical conditions (ps <.001; see Table 12). These findings suggest that participants, who were older in age, reported lower levels of education, were below poverty status, and indicated a higher number of medical conditions tended to report moderate-severe pain interference. There were no significant findings observed between pain interference and the following: race (p = .382), sex (p = .151), WRAT-III scores (p = .154), musculoskeletal-related conditions (p = .558), CES-D scores (p = .762), and BMI (p = .961).

Spearman correlations also indicated that musculoskeletal pain was weakly-moderately correlated with pain interference (p <.001; Table 12). These results indicate that individuals with more musculoskeletal pain tended to report moderate-extreme pain interference.

Global Physical Function Characteristics of the Final Sample. Overall global physical function was evenly distributed across the sample with higher scores indicative of better overall physical function (Figure 7). Pearson correlations were conducted to examine the relationships

between sociodemographic and health characteristics and global physical function (see Table 12). Significant relationships were identified between age group (p = .009) and other medical conditions (p = .026), which indicated that those who were older in age and those who reported comorbid medical conditions tended to demonstrate poorer global physical function. There were no significant relationships between global physical function and the following sociodemographic and health characteristics: sex (p = .142), race (p = .641), years of education (p = .600), WRAT-III scores (p = .190), musculoskeletal-related conditions (p = .122), CES-D scores (p = .714), or BMI (p = .688).

Study 2 - Aims 1 and 2 Results

Relationships between Musculoskeletal Pain and Physical Function (Aim 1). Pearson correlations were conducted to explore the bivariate relationships between musculoskeletal pain and global physical function. Findings indicated that musculoskeletal pain was significantly correlated with global physical function (p = .003; see Table 12 for correlation coefficients), which suggests that individuals who reported more musculoskeletal pain demonstrated poorer global physical function.

Multivariable regression analyses were conducted to examine the relationship between musculoskeletal pain and global physical function. Significant main effects were identified for musculoskeletal pain and global physical function after adjusting for all sociodemographic (p = .021; Model 1) and health characteristics (p = .031; Model 2; see Table 13 for standardized coefficients for all models). These findings indicated that musculoskeletal pain was significantly associated with poorer physical function, even after accounting for all sociodemographic and health factors.

Interactions between Musculoskeletal Pain and Sociodemographic Characteristics on Global Physical Function (Aim 2). Two-way interactions were conducted as follow-up analyses between musculoskeletal pain and significant predictors (i.e., age group and poverty status) after adjusting for all sociodemographic and health characteristics in model 2. Because the model fit did not improve between models 1 and 2, model 1 was utilized to explore 2-way interactions between musculoskeletal pain and significant sociodemographic predictors. A significant two-way interaction was observed between musculoskeletal pain and age group (p = .040). Estimated simple slopes suggested that more musculoskeletal pain was significantly associated with worse physical functioning for middle-aged (β = -0.04, p = .041) and older adults (β = -0.05, p = .027; Model 3; Figure 8). Simple slopes did not reach statistical significance for younger adults within these analyses (β = -0.04, p = .064). There were no significant two-way interactions observed between musculoskeletal pain and poverty status on physical function (p = .983).

Because of the significant interaction between musculoskeletal pain and age group, follow-up analyses were conducted to explore any 3-way interactions between musculoskeletal pain, age group, and other sociodemographic characteristics. Findings indicated that there were no significant 3-way interactions observed between the following: musculoskeletal pain × age group × race (β = 0.04, p = .343), musculoskeletal pain × age group × sex (β = -0.03, p = .409), musculoskeletal pain × age group × education (β = -0.04, p = .280), musculoskeletal pain × age group × WRAT-III (β = 0.06, p = .151), musculoskeletal pain × age group × poverty status (β = 0.00, p = .935; Model 4).

Relationships between Pain Interference and Physical Function (Aim 1). Pearson correlations were conducted to investigate the relationship between pain interference and global physical function. Results indicated that pain interference was significantly associated with global physical function (p = .014; see Table 12 for correlation coefficients), which suggests that individuals who indicated moderate-extreme pain interference also demonstrated poorer global physical function.

Multivariable regression analyses were conducted to examine the relationship between pain interference and global physical function. Significant main effects were identified for pain interference and global physical function after adjusting for sociodemographic characteristics (p = .024; Model 1; See Table 14). This relationship remained significant after accounting for all sociodemographic and health characteristics (p = .042; Model 2). These findings suggested that moderate-severe pain interference was significantly associated with poorer global physical function.

Interactions between Pain Interference and Sociodemographic Characteristics on Physical Function (Aim 2). Two-way interactions were conducted as follow-up analyses between pain interference and significant predictors (i.e., age group and poverty status) after adjusting for all sociodemographic and health characteristics in model 2. Because the model fit did not improve between models 1 and 2, model 1 was utilized to explore 2- and 3-way interactions across pain interference and sociodemographic characteristics. A significant 2-way interaction was observed between pain interference and age group on global physical function (p = .024; Model 3; see Table 14). The estimated simple slopes indicated that moderate-extreme pain interference was significantly associated with poorer global physical function, particularly for older adults (β = -0.08, p = .043; see Figure 9). Simple slopes were not significant for

younger- (β = -0.06, *p* = .112) or middle-aged adults within these analyses (β = -0.07, *p* = .069). There was no significant association identified between pain interference and poverty status on global physical function (*p* = .811).

Because of the significant interaction between musculoskeletal pain and age group, 3-way interactions were conducted between pain interference, age group and other sociodemographic characteristics. Findings indicated that there were no significant 3-way interactions observed between the following: pain interference × age group × race (β = 0.03, *p* = .432), pain interference × age group × sex (β = -0.03, *p* = .329), pain interference × age group × education (β = 0.01, *p* = .879), pain interference × age group × WRAT-III (β = 0.01, *p* = .762), pain interference × age group × poverty status (β = 0.20, *p* = .583; Model 4).

Discussion - Study 2

The purpose of this study was to examine the relationship between musculoskeletal pain and pain interference, and physical function across an urban population of community dwelling, middle-aged Whites and Blacks. Furthermore, we strived to identify whether the relationships between musculoskeletal pain, pain interference, and physical function were moderated by sociodemographic characteristics (e.g., age, race, sex, and across measures of SES). We hypothesized that musculoskeletal pain and pain interference would be significantly associated with poorer physical function. Additionally, we hypothesized that those who are Black or of lower SES (e.g., lower levels of education, poor reading literacy, or below poverty status) would demonstrate worse physical functioning, particularly if they identified musculoskeletal pain or pain interference. Primary findings indicated that individuals who reported more musculoskeletal pain as well as pain interference demonstrated significantly worse physical function, which

varied by age of the participants. These findings partially supported the hypotheses across both aims.

Relationships between Musculoskeletal Pain and Physical Function

Approximately 59% of individuals with valid data indicated one or more pain sites, which is consistent with large epidemiological studies that have identified pain prevalence rates ranging from 14-64% across the United States (Hardt et al., 2008; Johannes et al., 2010; Portenoy et al., 2004; Watkins, Wollan, Melton, & Yawn, 2008). Musculoskeletal pain was particularly evident amongst individuals who were older in age, female, as well as those who reported non-musculoskeletal health conditions, which is also consistent with the existing literature (Johannes et al., 2010). Surprisingly though, musculoskeletal pain within this study was not significantly associated with musculoskeletal-related conditions (i.e., osteoarthritis or rheumatoid arthritis, gout, or fracture), which may be explained by a predominately younger- and middle-aged sample who have not yet developed musculoskeletal-related conditions (e.g., osteoarthritis or gout). As a result, this lack of relationship suggests that musculoskeletal pain may be a product of sociodemographic and/or psychosocial factors that are independent of musculoskeletal pathology (Haldeman, 1990). Another possible explanation for the lack of relationship between musculoskeletal-related conditions and musculoskeletal pain may be the result of racial and socioeconomic disparities in health. Specifically, African Americans/Blacks as well as individuals of lower socioeconomic status may experience poorer access to quality care (Nelson, Stith, & Smedley, 2002), and experience lack of insurance coverage and/or expensive diagnostic testing (e.g., magnetic resonance imaging; Gusmano, Fairbrother, & Park, 2002), which could inhibit potential for diagnoses of these conditions. However, more research is

needed to further our understanding of potential factors associated with musculoskeletal pain earlier in the life course.

Within the current study, we identified that musculoskeletal pain was significantly associated with physical function, after accounting for sociodemographic and health characteristics. Particularly, we identified that these relationships were observable as early as middle age. Much of the literature to date that has explored the relationships between pain and physical function have done so within older populations (Eggermont et al., 2009; Hicks et al., 2005; Patel et al., 2013; Weiner et al., 2003). Among older adults, musculoskeletal pain was previously associated with greater self-reported difficulties with physical function (e.g., difficulty walking a quarter of a mile; Eggermont et al., 2009; Lichtenstein, Dhanda, Cornell, Escalante, & Hazuda, 1998). Furthermore, older adults who reported chronic pain were also more likely than their younger counterparts to perform more poorly on objective measures of strength (Eggermont et al., 2009; Patel et al., 2013), balance (Lihavainen et al., 2010), and gait (Eggermont et al., 2009; Leveille et al., 2007). These findings suggest that pain is a significant indicator of poorer physical outcomes than age alone.

Although the research is less prevalent in younger and middle-aged groups, some studies have concluded that these individuals are considered a high-risk group for chronic pain (Rustøen et al., 2005), and are reporting similar levels of functional limitations that are typically identified among older age groups (Covinsky et al., 2009). However, much of the research that has examined these relationships earlier in the life course have done so using self-reported measures of functional limitations and/or disability (Iezzoni, McCarthy, Davis, & Siebens, 2001; Melzer et al., 2005; Mottram et al., 2008; Peat et al., 2006), which may not correlate well with objective measures of physical function (Gitlin, 2006). Subsequently, many objective measures currently

used to assess physical function are designed for older populations, in which functional deficits may be more easily detectable. However, when these objective physical function measures are applied to examine physical performance among younger, and/or potentially higher functioning samples, ceiling effects may be observed (Guralnik, Seeman, Tinetti, Nevitt, & Berkman, 1994; Simonsick et al., 2001). As a result, existing measures may not be sensitive enough to detect early deficits in physical function (Gitlin, 2006). The findings of the current study expand upon the existing literature by incorporating sensitive measures of physical function in efforts to comprise a global physical function score. Additionally, this study was successful in identifying that greater levels of musculoskeletal pain are significantly associated with poorer performance on objective measures of physical function, particularly amongst middle-aged and older individuals within the sample.

The findings from this study may best be explained by The Motor Adaptation to Pain Theory (MAP Theory; Hodges & Tucker, 2011). The underlying premise of the MAP theory posits that pain alters physiological function. Specifically, the MAP theory describes micro- (neural mechanisms) and macro-level (muscle behavior) physiological modifications that are initiated to reduce levels of pain, thereby providing short-term relief from pain (e.g., reduced muscular activation, weight distribution, or changes in load; Hodges & Smeets, 2015). However, these physiological modifications have immediate and potentially continuous implications on the nervous system that can influence the quality of movement if pain is not alleviated and proper movement not restored. Particularly, the theory hypothesizes that failure to remediate pain and restore appropriate physiological function may have long-term implications for individuals as they advance into older age (e.g., poor mobility; Hodges, 2011; Hodges, Ervilha, & Graven-Nielsen, 2008). If pain remains untreated, it is possible that these physiological modifications

(e.g., reduced muscular activation or redistributed loading patterns) can translate to deficits in physical function and performance. For those who are younger in age, these deficits associated with pain may be fully compensated, and therefore may be more difficult to detect using objective performance measures; however, if unresolved the deficits may become more pronounced over time as the individual's ability to compensate is significantly reduced with age (Ferrucci et al., 2016). Thereby, interventions (e.g., physical therapy, exercise-based programming, and/or cognitive behavioral therapies) implemented to reduce pain and restore proper posture and movement may be critical earlier in the life course, in efforts to preserve physical function over time. Because of the cross-sectional nature of this study, we were unable to identify whether individuals who report musculoskeletal pain earlier in the life course demonstrate greater declines in physical function over time, above and beyond the effects of age-related changes. As a result, more longitudinal research is needed to further our understanding of these relationships.

Moreover, this study is unique due to the inclusion of a racially and socioeconomically diverse sample who are typically under-represented in the current literature, in efforts to understand the relationships between musculoskeletal pain and physical function. Previous research has identified that minority groups (e.g., African Americans/Blacks) tend to present with more predictors for pain (e.g., lower SES; Portenoy et al., 2004; Smith et al., 2001). Additionally, females, non-Whites, those below poverty level, as well as those with lower levels of education have demonstrated poorer physical function (Berkman et al., 1993), particularly if pain was present (Hicks et al., 2005; Leveille et al., 2002; Leveille et al., 2007). Based on the previous findings in the literature, we aimed to not only incorporate a racially and socioeconomically diverse sample of adults, but we also strived to disentangle the complex

relationships previously observed between race and SES in relation to the experience of pain and its association with physical function.

Particularly, this study examined whether sociodemographic characteristics moderate the relationship between musculoskeletal pain and physical functions. Within the fully adjusted model (Model 2) of the multivariable regression analyses, both age group and poverty status were also identified as unique predictors of physical function. However, only age group significantly moderated the relationship between musculoskeletal pain and physical function. While we hypothesized that there would be unique and complex interactions between race and SES, these were not evidenced within this study. The lack of interactions between race and SES may be attributed to the inclusion of individuals with complete and valid data. As noted previously, individuals who were excluded from the final sample were more likely to be below poverty status and indicate significantly less years of education. Thus, the final sample may be biased towards individuals of higher SES. While it has been suggested that multiple imputation for missing data within diverse populations or individuals of lower SES may also be subject to bias (Shavers, 2007), future research should explore opportunities for multiple imputation to better understand whether these complex relationships between race and SES exist within this sample.

Relationships between Pain Interference and Physical Function

In addition to our findings with musculoskeletal pain and physical function, we also investigated the relationship between pain interference and physical function. We observed that 29% of the participants reported pain interference, which is also consistent with prevalence rates ranging from approximately 27-39% in other studies (Blyth et al., 2001; Scudds & Østbye, 2001;

Thomas et al., 2004). Furthermore, moderate-extreme pain interference was predominately identified among those of older age, lower levels of education, individuals below poverty status, those who reported non-musculoskeletal-related conditions, as well as individuals who indicated greater levels of musculoskeletal pain.

Previous research that has incorporated pain interference from the SF-12, has observed similar findings pertaining to older age (Thomas et al., 2004), comorbidities, and lower levels of income demonstrating greater levels of pain interference (Scudds & Østbye, 2001). Additionally, higher number of pain sites have also been previously identified as a correlate of pain interference (Blyth et al., 2001). However, it is important to note that existing prevalence rates of pain interference using the SF-12 are primarily identified using middle-aged to older samples (50 years of age and older). Findings from these studies vary with regard to the influence of age on pain interference. While some research has indicated that pain interference increases linearly with age, particularly affecting older age groups (Scudds & Østbye, 2001; Thomas et al., 2004), others have demonstrated high prevalence of pain interference in younger age groups (aged 20-24) who reported chronic pain (Blyth et al., 2001). While the discrepancies between the findings across studies may lie in differences between pain interference measures, further investigation is needed to understand whether pain interference is largely a function of age, whether it may be a function of pain severity, or both.

Moreover, this is one of the first studies, to our knowledge, that has examined pain interference using the SF-12 in relation to physical function amongst a racially and socioeconomically diverse group of adults ranging in age from 30-64. The findings indicated that after accounting for sociodemographic and health characteristics of the sample, moderate-extreme pain interference was associated with poorer physical function. This relationship was

particularly evident amongst older individuals and supports earlier research that suggested that pain interference increases with age.

Specifically, Ferrucci and colleagues (2016) indicated that individuals in younger- to middle-adulthood who experience pain may be capable of fully compensating for changes in physical function. As a result, this compensation may mask physiological deficits (e.g., reduced strength) experienced earlier in the life course. However, with greater age comes a reduced ability to compensate, which makes physical deficits more obvious and thereby easier to detect using objective measures of physical function. These hypotheses by Ferrucci and colleagues (2016) may explain why the relationships between pain interference and physical function are observed in older adulthood and not earlier in the life course. It is possible that individuals who are younger in age do not experience pain that interferes with normal work as they have an increased ability to compensate. However, over time as the ability to compensate decreases, individuals may become more cognizant of the impact of pain and the extent to which pain interferes with their daily lives. This may explain why the relationships between musculoskeletal pain and physical function encompassed those in middle age, whereas the associations between pain interference and physical function were primarily evidenced among older age groups. While this dissertation was only able to identify cross-sectional relationships, more research is needed that examines at what point in the life course pain begins to interfere with normal work and activity, and how pain interference may translate to, or be associated with, physical declines with age. As a result, further research that examines these relationships longitudinally is warranted.

Additionally, while poverty status was also identified as a unique predictor of physical function within the multivariable regression analyses, there was no significant interactions observed between pain interference and poverty status on physical function. These findings were

particularly surprising as past literature has described social disadvantage as a unique predictor of both pain interference (Blyth et al., 2001) and poorer physical function (Kuh et al., 2005). Hence, it was hypothesized that poverty status might moderate this relationship. However, similar to the explanations posed for musculoskeletal pain, the lack of findings may be a result of incorporating only those with complete data. However, more research is needed to understand these relationships.

Strengths of the Study

The uniqueness of this study lies in the performance measures that comprise a global physical function score. This study is one of the first to examine the relationships between musculoskeletal pain and pain interference across objective measures of physical function using a sample with a high proportion of adults often under-represented in the literature (e.g., Blacks and/or lower SES adults; Evans et al., 2010). The objective measures included also account for potentially higher functionality across a younger sample who possess greater compensatory abilities, thereby increasing sensitivity and reducing the potential for ceiling effects (Ferrucci et al., 2016; Tomey & Sowers, 2009).

Additionally, this study expands the body of knowledge regarding the relationships between pain and physical function evidenced earlier in the life course. As previously mentioned, much of the literature to date examined older populations, despite evidence that individuals are experiencing pain and deficits in physical function earlier in the life course. While we were not able to explore the longitudinal relationships due to the cross-sectional nature of the data, we were able to demonstrate that physical deficits may be evidenced in sensitive physical performance measures, particularly amongst individuals who report musculoskeletal

pain and pain interference. Moreover, of the studies that have examined these relationships earlier in the life course, many have not thoroughly explored the potential interactions between sociodemographic characteristics and pain across a racially and socioeconomically diverse group of adults.

Limitations of the Study

The current study is not without limitations. While HANDLS is a longitudinal study, the data analyzed is cross-sectional. To continue to understand the extent of these relationships between pain and physical function, longitudinal evaluation is necessary. Longitudinal evaluation would not only further or our understanding, but it may also highlight possible functional declines exhibited amongst those who demonstrate pain.

Missing data was also a limitation identified within the study. While those with only complete data were incorporated in efforts to minimize bias from imputation (Shavers, 2007), it is possible that incorporating only those with complete data produced similar biases. More research is needed to further explore acceptable approaches to missing data among racially and socioeconomically diverse samples, such as HANDLS.

Furthermore, another significant limitation within this study is the physical function measure. There was minimal variation in the balance and gait variables, which may have led to ceiling effects, thereby positively skewing standard scores to represent higher levels of physical function within the sample. Despite the greater attempts to increase the sensitivity of the measure (i.e., longer time to hold semi-tandem and tandem stands), individuals may not be experiencing significant deficits in balance and gait due to younger age and greater ability to compensate. Particularly, Ferrucci and colleagues (2016), proposed a hierarchical structure of physical

function, with mobility being the "hallmark" or apex of physical performance. Because strength is essential for the maintenance of balance (Fukagawa, Wolfson, Judge, Whipple, & King, 1995), and strength and balance are essential for fluid mobility (Bean et al., 2003), it is possible that deficits in strength may be evidenced earlier in the life course and eventually proceed to deficits in balance as individual compensation declines over time. These declines over time may be greater amongst individuals who report pain. Depending upon individual functional reserve and compensation, deficits in balance may be preserved, or compensated for, earlier in the life course and become progressively worse with age. Future studies should explore these hypotheses through longitudinal investigations. Moreover, these future studies should consider using more sensitive measures of balance (e.g., the single leg stand), as well as an objective measure of gait (e.g., timed walk). This study did not include a timed walk-test, which is commonly used as an indicator of gait, due to limited testing space. As a result, observed gait abnormalities were used as a proxy for mobility impairments, which may not provide a full understanding of the extent to which deficits in gait may be evidenced.

Lastly, the measure of musculoskeletal pain does not provide an indication of the level of frequency, intensity, or duration of the pain. Future studies should incorporate the frequency of pain as well as the intensity to understand differences in levels of pain and the impact on physical function. Additionally, duration is also important in efforts to distinguish acute from chronic pain in relation to deficits in physical function.

Conclusion

In conclusion, musculoskeletal pain, and pain interference, were significantly associated with physical function. These relationships varied by age group of the sample. Greater

consideration should be given to understanding musculoskeletal pain and its relationship to physical function earlier in the life course. Acknowledging the unique circumstances of the individual, in addition to their functional abilities within the clinical setting, will enhance existing treatments and may elicit the development of new interventional approaches. Implications of this research are discussed in detail within the general conclusions section.

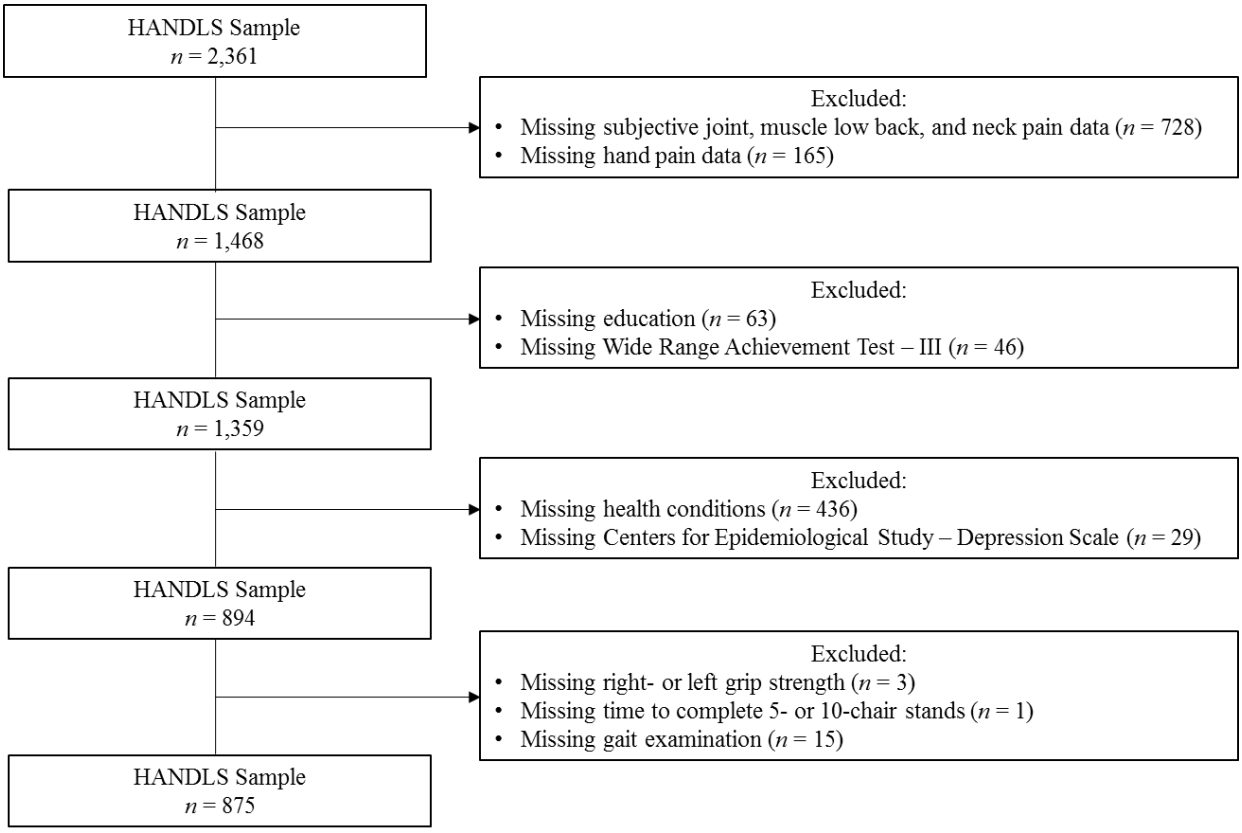

Figure 6. Flow chart of participants with missing data for Study 2. The final sample included 875 participants with valid data across musculoskeletal pain, sociodemographic, health, and physical function data. *Note*: Musculoskeletal pain data included responses to self-reported pain questions related to experience of pain in the hand/s, neck, low back, joint/s, and/or muscle/s.

Table 10. Balance Measures and Scoring

Measure	Task	Time	Scoring
Side-by-Side Stand	Stand with feet together	10 seconds	0 = < 9.9 seconds or unable 1 = 10 seconds
Semi-Tandem Stand	Stand with the side of the heel of one foot touching large toe of the other foot	30 seconds	0 = unable 1 = 1-9.9 seconds 2 = 10-19.9 seconds 3 = 20-29.9 seconds 4 = 30 seconds
Tandem Stand	Stand heel-to-toe with feet together	30 seconds	0 = unable 1 = 1-9.9 seconds 2 = 10-19.9 seconds 3 = 20-29.9 seconds 4 = 30 seconds

Note: Participants were coded based on the length of time in which they were able to maintain their balance. A sum score was calculated for the side-by-side (1=pass/0=fail), semi-tandem, and tandem stands (possible range=0-9; higher score = better; Eggermont et al., 2009; Guralnik, Simonsick, et al., 1994; Lang et al., 2007).

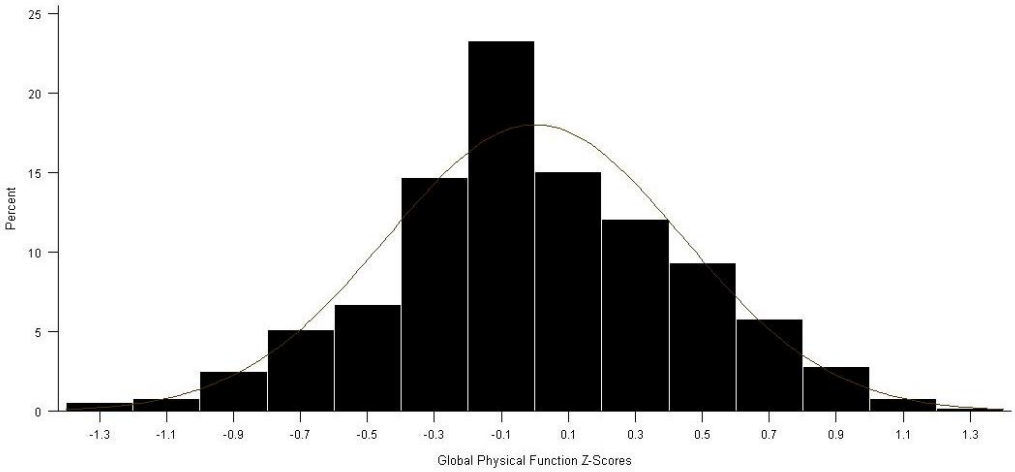

Figure 7. Distribution of standardized global physical function. This figure incorporates the distribution for all participants (n = 875) on a composite measure of global physical function, which includes the following physical function measures: right- and left grip strength, time to complete 5- and 10-chair stands, balance, and gait abnormalities.

Table 11. Sociodemographic, Health, and Pain Characteristics of the Final Sample

Measures	***n* (%)**	**Range**	**Mean**	***SD***
Sociodemographic Characteristics				
Age Groups (years)				
30 – 39	166 (18.97)	-	-	-
40 – 54	447 (51.09)			
55+	262 (29.94)			
Sex (female)	515 (58.86)	-	-	-
Race (Black)	453 (51.77)	-	-	-
Education	-	1 - 21	12.19	2.91
Poverty Status (below poverty status)	375 (42.86)	-	-	-
WRAT-III (score)	-	11 - 57	41.88	8.05
Health Characteristics				
Musculoskeletal-related Health Conditions (≥1)	396 (45.21)	-	-	-
Other Health Conditions (≥1)	486 (55.48)	-	-	-
CES-D (score)	-	0 - 59	16.55	11.89
Body Mass Index (kg/m^2)	-	15.82 - 57.94	29.95	7.72
Musculoskeletal Pain (1+ pain sites)	518 (59.20)	-	-	-
Pain Interference (moderate-extreme)	259 (29.60)	-	-	-

Note: WRAT-III = Wide-Range Achievement Test (3rd Edition); CES-D = Centers for Epidemiological Studies Depression Scale; *SD* = Standard Deviation.

Table 12. Correlation Coefficients between Sociodemographic, Health, Pain Variables, and Physical Function

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Age Group	-												
2. Sex	-0.01	-											
3. Race	0.03	0.01	-										
4. Education	-0.02	0.04	-0.00	-									
5. WRAT-III	-0.09*	0.05	-0.22***	0.44***	-								
6. Poverty Status	0.04	-0.01	-0.21***	0.25***	0.25***	-							
7. Musculoskeletal Conditions	0.02	-0.14***	-0.07*	-0.05	-0.04	-0.08*	-						
8. Other Health Conditions	0.36***	0.06	0.08*	-0.04	-0.02	-0.04	0.01	-					
9. CES-D	-0.04	-0.03	0.03	-0.02	-0.07*	-0.06	0.04	-0.04	-				
10. BMI	-0.03	-0.05	-0.04	-0.02	-0.03	0.07*	0.12***	-0.00	-0.03	-			
11. Musculoskeletal Pain	0.15***	0.09**	-0.03	0.02	0.03	-0.03	0.01	0.16***	-0.00	0.02	-		
12. Pain Interference	0.17***	0.05	0.03	-0.11***	-0.05	-0.12***	0.02	0.25***	0.01	0.00	0.28***	-	
13. Global Physical Function[a]	-0.09**	-0.05	0.02	-0.02	-0.04	0.06	0.01	-0.08*	-0.01	-0.01	-0.10**	-0.10**	-

Notes: WRAT-III = Wide Range Achievement Test (Third Edition); CES-D = Centers for Epidemiological Studies Depression Scale; BMI = Body Mass Index. *p < .05; **p < .01; ***p < .001.

[a]Global Physical Function comprised the average of the z-scores of the six physical function tasks (i.e., right-grip strength, left-grip strength, times to complete 5- and 10-chair stands, balance, and gait).

Table 13. Multivariable Regression Models to Examine the Relationship between Musculoskeletal Pain and Physical Function

Covariates	Global Physical Function					
	Model 1		**Model 2**		**Model 3**	
	Unstandardized Beta (*SE*)	β	Unstandardized Beta (*SE*)	β	Unstandardized Beta (*SE*)	β
Musculoskeletal Pain	-0.04 (0.02)*	-0.08	-0.04 (0.02)*	-0.07	-0.04 (0.02)*	-0.07
Age Group	-0.05 (0.02)*	-0.09	-0.05 (0.02)*	-0.08	-0.06 (0.02)*	-0.09
Poverty Status	0.07 (0.03)*	0.08	0.08 (0.03)*	0.09	0.07 (0.03)*	0.08
Musculoskeletal Pain × Age Group					-0.00 (0.00)*	-0.07
Musculoskeletal Pain × Poverty Status					0.00 (0.04)	0.00
Total Adjusted R^2		0.02		0.02		0.02
Adjusted R^2 Change				0.00		0.00

Note: SE = Standard Error. β = Standardized beta. *p<.05, **p<.01, ***p<.001.

[a]Model 1 adjusts for sociodemographic characteristics (i.e., age, sex, race, years of education, WRAT-III total score, and poverty status).

[b]Model 2 adjusts for sociodemographic characteristics and health characteristics (i.e., musculoskeletal-related medical conditions, other medical conditions, depressive symptoms, and body mass index).

[c]Model 3 adjusts for all sociodemographic characteristics and includes 2-way interactions between musculoskeletal pain and significant covariates from Model 2 (i.e., age group and poverty status).

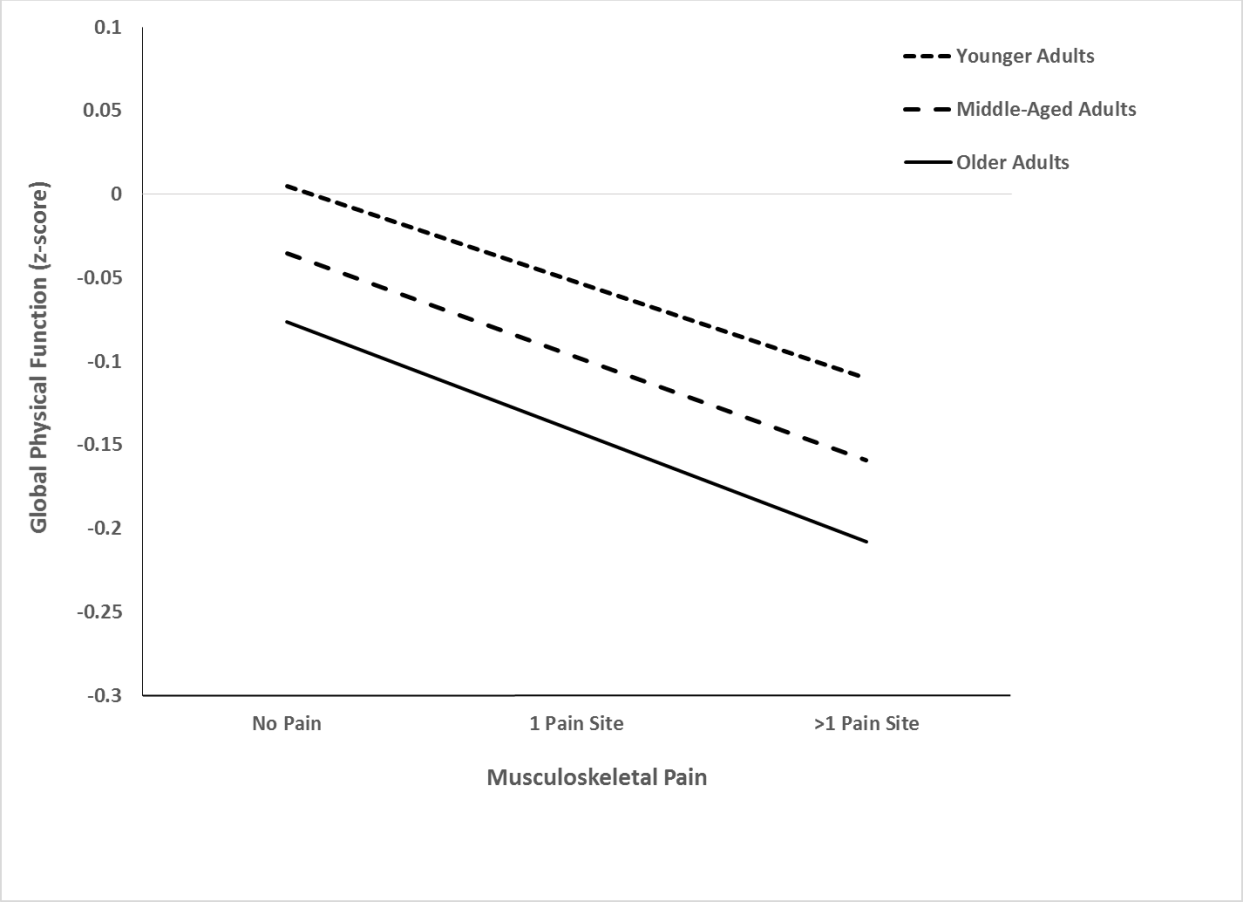

Figure 8. Two-way interaction between musculoskeletal pain and age group in relation to global physical function. *Note*: Simple slopes estimated that musculoskeletal pain was significantly associated with poorer physical function across middle-aged adults (40-54 years of age) and older adults (aged 55+).

Table 14. Multivariable Regression Models to Examine the Relationship between Pain Interference and Physical Function

Covariates	Global Physical Function					
	Model 1		**Model 2**		**Model 3**	
	Unstandardized Beta (*SE*)	β	Unstandardized Beta (*SE*)	β	Unstandardized Beta (*SE*)	β
Pain Interference	-0.08 (0.03)*	-0.08	-0.07 (0.03)*	-0.07	-0.06 (0.03)	-0.06
Age Group	-0.05 (0.02)*	-0.08	-0.05 (0.02)*	-0.08	-0.06 (0.02)**	-0.09
Poverty Status	0.07 (0.03)*	0.08	0.08 (0.03)*	0.08	0.07 (0.03)*	0.07
Pain Interference × Age Group					-0.01 (0.00)*	-0.08
Pain Interference × Poverty Status					0.02 (0.07)	0.01
Total Adjusted R^2		0.02		0.02		0.02
Adjusted R^2 Change				0.00		0.00

Note: β = Standardized beta. SE = Standard Error. *p<.05, **p<.01, ***p<.001.

[a]Model 1 adjusts for sociodemographic characteristics (i.e., age, sex, race, years of education, WRAT-III total score, and poverty status).

[b]Model 2 adjusts for sociodemographic characteristics and health characteristics (i.e., musculoskeletal-related medical conditions, other medical conditions, depressive symptoms, and body mass index).

[c]Model 3 adjusts for sociodemographic characteristics and includes 2-way interactions between pain interference and significant covariates from Model 2 (i.e., age group and poverty status).

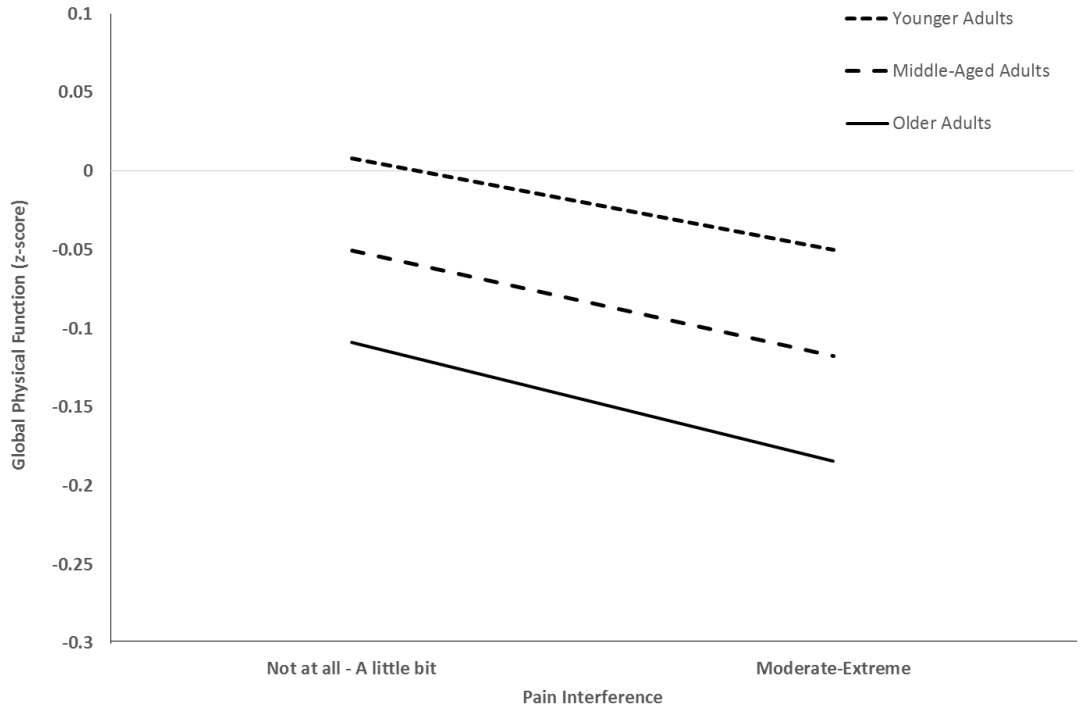

Figure 9. Two-way interaction between pain interference and age group in relation to global physical function. *Note*: Simple slopes estimated that pain interference was significantly associated with poorer physical function, particularly amongst older adults (aged 55+) within the sample.

CHAPTER FIVE:

GENERAL DISCUSSION AND IMPLICATIONS

Nearly 100 million people in the United States are reporting chronic pain (Institute of Medicine, 2011), and approximately $560-635 billion is spent on direct (e.g., medical bills and diagnostic testing) and indirect costs (e.g., missed work time) associated with pain (Interagency Pain Research Coordinating Committee, 2015). While we continue to expand upon our understanding of the pain experience, as well as the short- and long-term implications of pain, we are just beginning to scratch the surface. The overarching goal of the studies conducted in this dissertation were to further our understanding of the sociodemographic, health, and psychosocial factors that may be unique predictors of musculoskeletal pain and to expand the body of knowledge regarding the associations between musculoskeletal pain, pain interference, and physical function earlier in the life course. Much of research that examined these relationships have done so among older populations; however, this dissertation aimed to highlight the pain experience amongst a racially and socioeconomically diverse group of adults earlier in the life course.

Preliminary Support for the Proposed Conceptual Model

Particularly, the research conducted offered preliminary support to the proposed conceptual model based upon the MAP Theory (Figures 1 and 2; Hodges & Tucker, 2011). The conceptual model developed for this dissertation proposed that musculoskeletal pain, whether it

is psychosomatic or pathological in nature, may have neuromuscular implications that alter physical function, with deficits evidenced as early as younger- to middle-age. These deficits are greater than what is typically observed with normal age-related changes and declines. With time, the individual continues to compensate for these deficits resulting from pain through physiological modifications until functional reserves are exhausted and compensation is no longer possible (Ferrucci et al., 2016). As a result, the long-term consequences, as originally identified by the MAP theory, may encompass losses pertaining to physical performance (e.g., strength and balance), poor mobility, and falls with advancing age. The conceptual model aimed to expand upon the MAP theory in efforts to highlight these long-term consequences, to which the individual may be particularly susceptible if pain remains untreated and physical deficits uncorrected. While we were unable to examine these relationships longitudinally within this dissertation, the two cross-sectional studies conducted offered preliminary support to specific pathways within the proposed conceptual model.

Specifically, the two cross-sectional studies identified pain prevalence rates ranging from 55-59%, which lent support to the first pathway of the conceptual model that states pain is observed earlier in the life course. In the first study we were not only able to identify the pain prevalence across a racially and socioeconomically diverse group of adults ranging in age from 30-64, but also strived to enhance our understanding of pain reporting and inconsistencies between findings of routine subjective (self-reported pain) and objective pain measurements (passive range of motion during a clinical examination). While further research is needed to understand differences in pain expression between age groups, we identified that inconsistency between subjective and objective pain measurements may be particularly evident in the neck and low back amongst those who report a history of depressive symptoms. These relationships were

further moderated by sociodemographic and psychosocial characteristics lending additional support to this biopsychosocial approach. Hodges and Smeets (2015) posit that unique sociodemographic, health, and psychosocial factors influence the development or exacerbation of pain, and further interact with biological processes to affect neuromuscular and overall physiological functions.

While we were unable to identify or prove the extent to which the pain experienced within this sample led to neuromuscular changes, we did observe significant relationships between greater pain, and pain interference and deficits in physical function. Previous studies that have explored these relationships have primarily done so within older populations (Eggermont et al., 2009; Hicks et al., 2005; Patel et al., 2013); however, this study indicated that these relationships are evidenced as early as middle age. Specifically, individuals with greater number of pain sites were more likely to perform more poorly on a global measure of physical function. This relationship was particularly evident among individuals in middle- and older age; however, was trending toward significance for younger age groups as well. This unique finding suggests that sensitive performance measures may be used to detect subtle changes in physical capabilities amongst those who report pain earlier in the life course. Specifically, this sensitive performance measure may be implemented in clinical settings to detect the presence and extent of pain and the possible implications of pain on physical function, despite age.

Furthermore, we observed that moderate to extreme pain interference was significantly associated with global physical function, particularly for older adults within the sample. This finding supports the conceptual model that pain may not interfere with normal work and social activities until older adulthood, and is consistent with other studies who have indicated that pain interference is particularly prevalent in older age and increases linearly with age (Scudds &

Østbye, 2001; Thomas et al., 2004). Specifically, the point at which pain interferes with normal work may also depend on individual compensation and functional reserve and is unique to each individual. While we were able to identify these unique relationships between pain interference and physical function, longitudinal research is needed to understand at what point an individual begins to experience pain interference, and to what extent pain interference might reflect in, or potentially lead to, physical deficits. Furthermore, while these studies considered age within younger, middle-aged, and older groups for comparison, incorporating age within groupings across both studies may have resulted in a loss of power and impeded the ability to detect significant relationships between musculoskeletal pain, pain interference and physical function (Royston, Altman, & Sauerbrei, 2006). As a result, further research should analyze these relationships with age as a continuous variable, in efforts to better understand the onset of musculoskeletal pain and pain interference across the life course.

Implications of this Research

The significance of this research lies in the ability to identify unique individual characteristics that may explain differences in the pain experience, and to enhance our understanding of the relationship between musculoskeletal pain and physical function amongst a racially and socioeconomically diverse group of younger-, middle-aged, and older adults. Pain is often associated with individuals of older age groups; however, this dissertation highlights the prevalence to which pain may be exhibited earlier in the life course amongst a group who are often under-represented in the current literature (Evans et al., 2010).

Specifically, research that has examined the associations between sociodemographic, health, and psychosocial factors (e.g., age, race, medical conditions, and neighborhoods), on both subjective and objective musculoskeletal pain, was limited to date. However, this research

highlights that if subjective pain reports are inconsistent with objective pain measurements, it may be an indication of underlying psychological distress and/or exaggerated pain behaviors. As a result, pain that may be caused or exacerbated by sociodemographic and/or psychosocial circumstances (e.g., lower SES, history of psychological distress, or poor neighborhood quality) may require different approaches to treatment than what is typically prescribed for pain that is secondary to health conditions (e.g., opioids). Continuing to view pain strictly as a process of pathophysiology is undermining the importance of sociodemographic, psychological, and psychosocial processes that cause or exacerbate pain.

Furthermore, failure to recognize the presence of pain attributed to unique individual factors may limit the types of treatments available, subject the person to unnecessary diagnostic procedures that prolong the treatment process, and/or may render pharmacological approaches to pain treatment ineffective (Interagency Pain Research Coordinating Committee, 2015). Greater awareness of the unique individual characteristics that may contribute to individualized pain experiences will stimulate the need for more effective measurements that not only incorporate objective measurements of pain, but also gauge the micro- and macro-level factors that may lend to the pain experience. Enhancing diagnostic and assessment efforts and improving our understanding of the complex interactions between biological, social, emotional, and cognitive processes that may cause or worsen pain, may lead to the development of more appropriate interventions tailored to the needs across diverse groups. Such interventions may be non-pharmacologically-based and include the following approaches: cognitive behavioral therapy (Jensen et al., 2012), psychoeducation (LeFort, Gray-Donald, Rowat, & Jeans, 1998), and/or biofeedback (Flor & Birbaumer, 1993), which have been rendered effective for pain and may offer appropriate alternatives to pharmacological treatments (e.g., opioids).

However, musculoskeletal pain that is improperly diagnosed or untreated, or unresolved musculoskeletal pain that interferes with normal work may have implications on physical function and contribute to disability with age. While we were unable to examine the relationships between pain and physical declines, we did identify that pain was significantly associated with physical deficits earlier in the life course. Specifically, we utilized sensitive objective performance measures to reduce the possibility of ceiling effects due to potentially better compensatory ability, amongst a younger group of individuals, in efforts to identify these deficits.

Additionally, because this study identified these functional deficits earlier in the life course, this dissertation highlights the need for research that continues to explore health-related and psychosocial factors in order to implement appropriate interventions for pain and physical function earlier in the life course. As a result, this research strived to enhance the ability to identify those who are at greatest risk for musculoskeletal pain (e.g., females, those of lower SES, greater number of health conditions, history of depressive symptoms, and poor perceived neighborhood quality) and reduced physical function (e.g., middle-aged and older individuals). Moreover, this research has significant clinical implications related to the timing of therapeutic interventions (e.g., non-pharmacologically-based interventions for pain as well as physical or recreational therapy to restore proper physical function) tailored to the unique needs of the individual experiencing pain.

Future Directions

Future research is needed that continues to not only explore the pathophysiology of pain, but also strives to explain the unique contribution of individual characteristics to the pain

experience as well as what factors may explain the transition from acute to chronic pain. Furthermore, diagnostic examinations associated with pain complaints also warrant further attention. For example, subjective complaints of pain that are not corroborated by objective measurements of pain (e.g., passive range of motion), may require additional probing of individual circumstances to detect other factors that contribute to the chronicity of the pain experience (e.g., lower SES and poor access to care and treatment, history of depressive symptomology, or poor neighborhood conditions).

Additionally, due to the weak relationships between subjective and objective measures of pain (e.g., passive range of motion), alternative or complementary measurements (e.g., a sensitive physical performance battery) should be implemented as a component of the clinical examination as these performance measures may provide additional information pertaining to the presence, extent, and implications of pain earlier in the life course. These sensitive performance measures are quick and may be easily administered within clinical care settings in conjunction with other diagnostic procedures (e.g., passive range of motion) following subjective complaints of pain. While similar performance measures have been implemented amongst older populations (Studenski et al., 2003), the findings of this dissertation suggest that similar measures that are sensitive enough to detect performance deficits, may also be suitable for individuals who are younger in age, particularly if they are reporting pain. Future research should continue to explore the feasibility and validity of such testing within clinical settings.

Moreover, while accounting for numerous sociodemographic and health characteristics within study 2, these variables did not explain much of the variance in physical function. It is possible that other factors that were not included may account for a greater proportion of the variance. Particularly, inclusion of sleep disturbances (e.g., insomnia; Goldman et al., 2007),

self-efficacy beliefs (de Leon, Seeman, Baker, Richardson, & Tinetti, 1996), sociocultural factors (e.g., discrimination, medical mistrust, and access to quality healthcare services; de Leon, Barnes, Bienias, Skarupski, & Evans, 2005; Williams, Yu, Jackson, & Anderson, 1997), perceived health status, and levels of physical activity (Stuck et al., 1999) within similar models may account for a greater proportion of the variance as it pertains to physical function, and should be considered in future research. Additionally, based on the findings of study 1, it is imperative that future studies that incorporate racially and socioeconomically diverse adults further consider the role of the psychosocial characteristics such as environment, (e.g., poor neighborhood conditions) and "John Henryism", as they may serve as unique predictors of poorer physical function.

Lastly, more research is needed to further our understanding of how psychosomatic pain, as well as pathophysiology, contribute to deficits in physical function across the life course. Specifically, longitudinal studies should explore whether individuals with musculoskeletal pain demonstrate greater physical declines than what is typically observed with normal age-related losses.

Conclusion

In summary, pain is defined as an unpleasant sensory and emotionally-based experience that is typically associated with pathology or chronic conditions as well as perceived tissue damage (Merskey, 1986). Interactions across physiological/biological, cognitive, psychological, and emotional processes comprises the perception of pain as well as the transition from acute pain to chronic pain over time. However, pain is most commonly viewed as a symptom that is secondary to pathology and typically warrants pharmacological approaches to treatment. This

dissertation demonstrates that musculoskeletal pain may be independent from pathological findings and is associated with unique sociodemographic, psychological, and psychosocial characteristics. Moreover, this musculoskeletal pain is significantly associated with deficits in physical function that may be observed as early as middle age when using sensitive performance measures.

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APPENDICES

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2/16/2017

Angela Sardina, M.S.
School of Aging Studies
4202 East Fowler Avenue
MHC 1305
Tampa, FL 33620

RE: **Not Human Subjects Research Determination**
IRB#: Pro00029831
Title: Pain and Physical Function in a Socioeconomically Diverse Sample of Black and White Adults

Dear Ms. Sardina:

The Institutional Review Board (IRB) has reviewed your application and determined the activities do not meet the definition of human subjects research. Therefore, this project is not under the purview of the USF IRB and approval is not required. If the scope of your project changes in the future, please contact the IRB for further guidance.

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We appreciate your dedication to the ethical conduct of research at the University of South Florida. If you have any questions regarding this matter, please call 813-974-5638.

Sincerely,

V Jorgensen MD

E. Verena Jorgensen, M.D., Chairperson
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