GENDER DIFFERENCES IN PAIN-PHYSICAL ACTIVITY LINKAGES AMONG OLDER ADULTS: LESSONS LEARNED FROM DAILY LIFE APPROACHES

by

AMY HO

B.A. (Hons), The University of British Columbia, 2013

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR
THE DEGREE OF
MASTER OF ARTS
in
The Faculty of Graduate and Postdoctoral Studies
(Psychology)

THE UNIVERSITY OF BRITISH COLUMBIA
(Vancouver)

August 2016

Abstract

Many older adults know about the health benefits of an active lifestyle, but frequently, pain prevents them from engaging in physical activity. The majority of older adults experience pain, which is a complex experience that can vary across time and is shaped by sociocultural factors such as gender. The objectives of this study are twofold: first, to describe the time-varying associations between daily pain and physical activity, and second to explore differences in these associations between women and men. One hundred and twenty eight community dwelling older adults aged 65 years and older were asked to report their pain levels three times daily over a 10-day period. For the same period, participants wore an accelerometer to objectively capture their daily physical activity (step counts; minutes of moderate to vigorous physical activity). Findings indicate that increased daily pain was associated with increased daily step counts and minutes of moderate to vigorous physical activity especially among older women. Secondly, confirming past literature and contrasting daily pain reports, overall pain levels across the study period were negatively associated with minutes of moderate to vigorous physical activity. Findings highlight that pain is significantly associated with physical activity in old age. The nature of this association depends on the time-scale that is considered and it differs between women and men. There is a need to pay more attention to those that are particularly vulnerable pain experience, to ensure both older men and women have an equal opportunity to engage in and benefit from physical activity.

Preface

This thesis is based on data from a larger study on physical activity, cognition, and emotions of older adults that was funded through a Canadian Institute of Health Research catalyst grant (F10-00785) awarded to Christiane Hoppmann, Maureen Ashe, Peter Graf, Karim Khan, and Jochen Ziegelmann. This study was ethics approved and conducted at the University of British Columbia, Vancouver, BC (Project Title: "Physical Activity, Cognition, and Emotions (PACE) in Older Adults," BREB # H10-00685). The work presented constitutes a novel approach to the existing data set that I helped collect and organize. Dr. Christiane Hoppmann, my research supervisor, and I jointly identified the new research questions for my thesis and I conducted the appropriate statistical analyses. My master's thesis work was supported by a Canadian Institute of Health Research scholarship and a graduate entrance scholarship from the University of British Columbia .

A shorter version of this manuscript, co-authored by myself, Maureen Ashe, Anita DeLongis, Peter Graf, Karim Khan, and Christiane Hoppmann has been accepted for publication:

Ho, A., Ashe, M., DeLongis, A., Graf, P., Khan, K. & Hoppmann, C. (in press). Gender differences in pain-physical activity linkages among older adults: Lessons learned from daily life approaches. *Pain Research & Management*.

I took the lead on identifying the research questions, conducting data analysis, and composing the manuscript. Dr. Ashe provided guidance on interpreting accelerometry data for analysis and assisted in manuscript revisions. Dr. DeLongis and Dr. Graf both provided invaluable feedback on manuscript revisions. Dr. Khan contributed to the study design of the original larger research project from which this thesis stems. Finally, my supervisor Dr. Hoppmann is the senior author on this project and contributed to study design, concept formation, provided guidance on data analysis, and assisted in manuscript revisions.

Table of Contents

Abstract……ii
Preface……iii
Table of Contents……iv
List of Tables……v
List of Figures……vi
Acknowledgements……vii
Chapter 1: Introduction……1
1.1 Pain Experience and Physical Activity in Older Age……2
1.2 Individual Differences in Pain Experience……2
1.3 Study Objectives and Hypotheses……3
Chapter 2: Method……4
2.1 Participants……4
2.2 Procedure……4
2.3 Measures……5
2.4 Statistical Analyses……6
Chapter 3: Results……8
3.1 Everyday Pain, Gender, and Physical Activity……8
3.2 Exploratory Follow-Up Analyses……9
Chapter 4: Conclusion……10
4.1 Overall Pain Experience and Physical Activity Associations……10
4.2 Gender Differences in Day-to-Day Pain-Physical Activity Associations……11
4.3 Limitations and Future Directions……13
4.4 Closing Remarks……14
References……18

List of Tables

Table 1: Means and Standard Deviations of Central Study Variables and Variable Intercorrelations (N = 128) ……………………………………………..………………………15

Table 2: Hierarchical Linear Models Predicting Everyday Physical Activity (Step Counts; Minutes of Moderate to Vigorous Physical Activity) from Person – Specific and Time-Varying Characteristics Using Restricted Maximum Likelihood Estimation in HLM (N = 128) ……………………………………………………………..……………………………16

List of Figures:

Figure 1: Minutes of moderate to very vigorous as a function of daily pain and gender……………………………………..…………………………...……………………….17

Acknowledgements

I would like to express my deepest gratitude towards my supervisor, Dr. Christiane Hoppmann, for being an endless source of inspiration and unwavering support throughout my graduate studies. I also owe deep thanks to Drs. Anita Delongis, Frances Chen, Maureen Ashe, and Peter Graf for their indispensable insight and investment in my graduate pursuits. Special thanks are owed to my family for their unconditional support. Finally, I am grateful for the funding from the Canadian Institute of Health Research and the University of British Columbia that supported this project.

Chapter 1: Introduction

In Canada, the number of seniors will reach 25% of the population in 2036, more than double the percentage at 2009 (Statistics Canada, 2010). Given the growing population of older adults, concern of public health is becoming more pressing. The risks of developing chronic disease and disabling conditions increases with advancing age, and physical activity is known to reduce these risks (Nelson et al., 2007, Chodzko-Zajko et al., 2009). For example, routine physical activity improves one's general health (Wang et al., 2002); decreases the risk of medical conditions such as artery disease, diabetes, osteoporosis, and hypertension (Netz et al., 2005); and can prevent falls (Barnett et al., 2003). Decreasing the number of physically inactive adults by a mere 10% is estimated to save approximately 150 million Canadian dollars per year in costs for medical care, sick leave, and lost revenue (Katzmarzyk et al. 2000).

Physical activity has been recognized as a prime target for health promotion, but the majority of older Canadians do not engage in sufficient levels of physical activity to maintain or improve their health (Ashe, Miller, Eng, & Noreau, 2009; Pubic Health Agency of Canada, 2009). In fact, older adults make up the most inactive segment of the Canadian population (Public Health Agency of Canada, 2009). Physical activity is defined as any bodily movement produced by skeletal muscles that requires energy expenditure (World Health Organization, 2015). Physical activity does not have to take the form of a structured exercise regimen; it can also occur as part of older adults' activities of daily living, such as housework, gardening, or walking for transportation. Many older adults are aware of the health benefits of physical activity and are motivated to engage in physical activity (Kolt, Driver, & Giles, 2004), but there are many factors that prevent them from being physically active (Booth, Bauman, Owen, & Gore, 1997; Booth, Owen, Bauman, Clavisi, & Leslie, 2000; Crombie et al., 2004; Newson & Kemps, 2007). Previous research indicates that the majority of older adults report at least one barrier to physical activity. Self-perceived poor health (Cohen-Mansfield et al, 2003), neighbourhood environment (Centre for Disease Control, 1996), lack of physician intervention (Calfas et al., 1996), and lack of knowledge and understanding of the relationship between moderate exercise and health (Cohen-Mansfield et al, 2003) can all serve as barriers to exercise in adults. Pain also serves as an obstacle to physical activity and has been documented to be the single most frequently reported barrier (Calfas et al., 1996; Cohen-Mansfield, Marx, & Guralnik, 2003; Schutzer & Graves, 2004). The purpose of this study was to examine daily life fluctuations in pain and to explore its association with objectively measured physical activity [moderate to vigorous physical activity (MVPA), step counts] as older adults engaged in their typical daily life routines and environments. We also examined gender differences as an important factor that may impact pain-physical activity associations in old age.

1.1 Pain Experience and Physical Activity in Older Age

Because of their elevated chronic disease burden, older adults have a high risk of experiencing daily pain (Bernabei et al., 1998; Tracy & Morrison, 2013), and their pain experience may produce a wide spectrum of detrimental consequences including reduced quality of life, reduced engagement in social and recreational activities, and an increased risk of falls (Herr & Garand, 2001; Robinson, 2006). Using population-level data, Ashe and colleagues discovered that the presence of pain reduces the likelihood for older adults meeting physical activity guidelines even when factoring in chronic health conditions (Ashe et al., 2009). Related research has shown that older adults with chronic pain conditions, such as back pain, are significantly less physically active compared with their counterparts who do not experience back pain (Cecchi et al., 2006). Pain, especially its musculoskeletal form, is a ubiquitous complaint in old age (Mobily, Herr, Clark, & Wallace, 1994; Scudds & Robertson, 2000), and thus it is crucial to disentangle the relationship between pain and physical activity engagement.

1.2 Individual Differences in Pain Experience

Pain is a complex experience (Craig, 2009) that varies across time and people (Newth & DeLongis, 2004). To illustrate, research on persons with rheumatoid arthritis has revealed that pain fluctuates significantly both across and within days (Grennan & Jayson, 1989; Holtzman & DeLongis, 2007). This type of finding emphasizes the need to use repeated daily life assessments for capturing meaningful fluctuations in pain and for examining concurrent associations between pain and physical activity. Research focused on the pain and physical activity of older adults in the performance of their daily life routines also maximizes ecological validity (Trull & Ebner-Priemer, 2013). An added benefit of this type of research is that it is likely to reveal potential targets for intervention that are deeply embedded in older adults' lived experiences.

Pain does not only fluctuate across time; there are also significant individual differences in pain perceptions and responses (Craig, 2009). For example, the literature suggests that men and women experience pain differently. Specifically, women have been shown to have a lower pain threshold and pain tolerance, and stronger responses to analgesics than do men (Hellström & Lundberg, 2000; Keogh & Herdenfeldt, 2002). These gender differences are present in community-dwelling and clinical samples (Ciccone & Holdcroft, 1999; Hellström & Lundberg, 2000; Myles, McLeod, Hunt, & Fletcher, 2001; Walker & Carmody, 1998). In view of such findings, the present study examined whether compared to men, women also engage in less physical activity on days with elevated pain.

To provide a meaningful interpretation of the proposed daily life associations between fluctuating pain experiences and physical activity as well as gender differences therein, we also wished to consider a number of other factors. Specifically, we wanted models that also account for the well-known effects of age and an objective measure of functional mobility, the Timed Up and Go Test, on physical activity (Whitney, Lord, & Close, 2005).

1.3 Study Objectives and Hypotheses

To summarize, the present study used data from 128 older adults (*M* age = 71.94 years, *SD* = 4.99; 64% women) who provided three daily pain ratings for up to 10 consecutive days and who concurrently also wore accelerometers, which allowed us to examine time-varying associations between daily pain and physical activity. We first examined the relationship between pain and physical activity, expecting that increased pain would be associated with a concurrent decrease in physical activity in terms of daily step counts and minutes of moderate to vigorous physical activity. Second, we examined associations with gender, anticipating that compared to men, women would show lower daily step counts and minutes of moderate to vigorous physical activity as well as a stronger association between pain and physical activity.

Chapter 2: Method

2.1 Participants

One hundred and forty two community dwelling older adults aged 65 years and above from Metro Vancouver, Canada took part in this study. Participants were recruited through media and local community centers for a study on daily life activities. They received $100 for participating in the study. Participants were eligible for the study if they (a) had no current conditions for which physical activity was contraindicated; (b) were able to read newspaper sized print; (c) could hear the sound of an alarm clock; and (d) had no physician diagnosed neurodegenerative disease or brain dysfunction. Of the 142 participants who signed up for the study, three did not complete it, and 11 had missing data on one of the central study variables. We included only those 128 participants with complete data on all variables of interest. Our final sample had a mean age of 71.94 years (*SD* = 4.99) and their heritage was either European (63.0%) or Asian (35.4%). Heritage data from 2 participants were missing. The sample included mostly women (64.1%), the majority of them retired (90.9%), and most participants had completed at least some college education (62.2%). A large proportion of the sample (63.8%) reported having at least one of the following conditions that are associated with pain: arthritis (rheumatoid or osteroarthiris), osteoporosis, degenerative disc disease (back disease spinal stenosis, or severe chronic back pain), and upper gastronintestinal disease (hernia, ulcer, or reflux). The study was approved by the University of British Columbia's Behavioural Research Ethics Board. All participants provided written consent prior to taking part in the study.

2.2 Procedure

The study involved a three-hour baseline session during which participants completed measures regarding demographics, physical health, and psychosocial variables. Participants were also trained on the time-sampling protocol and on the use of accelerometers (ActiGraph GT3X, ActiGraph, Pensacola, FL) for objective physical activity measurement. The day after the baseline session, participants started a 10-day time sampling phase, during which a vibrating watch prompted them to complete daily questionnaires three times a day - at 11:00am, 4:00pm, and 9:00pm. Participants also received an electronic time-stamp to record the exact time each questionnaire was started and completed before putting it into an envelope, sealing it and stamping it across the seal. The time-stamp data revealed that participants adhered closely to the study protocol and completed the daily questionnaires at 11:13 am (*SD* = 0:54), 4:13 pm (*SD* = 0:55), and at 8:55 pm (*SD* = 1:44). In the daily questionnaires, participants were asked to report on their current pain intensity. In addition, participants wore an accelerometer over their dominant hip during the 10-day time-sampling phase, except for water-based activities, in the shower, and while sleeping at night. After the time-sampling phase, participants were invited back to the lab for a one-hour exit session, during which they provided feedback on the study procedures as well as completing some additional measures. On average, each participant completed 29.61 of the 30 questionnaires and only a small proportion (9.5%) of participants reported that participating in the study resulted in a change of their everyday behaviours. The majority (89.8%) of participants considered the days during which they participated in the study as being typical for their everyday life.

2.3 Measures

Pain. Pain intensity was self-reported during the 10-day time sampling phase, at three daily assessments. At each assessment, participants were asked to rate their current pain intensity on a 5-point Likert scale, with 1 being "not at all [in pain]" and 5 being "very much [in pain]." Pain intensity ratings were aggregated across the day. This aggregation was necessary to match the time units of the objective physical activity data. Overall, participants had a mean pain score of 1.35 (*SD* = .47) with 64.8% of the sample reporting that they had experienced pain (a pain rating greater than 1) at least once during the study period.

Physical Activity. During the time-sampling phase, participants also wore a pre-programmed tri-axial accelerometer (ActiGraph GT3X, ActiGraph, Pensacola, FL) on an elastic waistband above their dominant hip for 10 consecutive days during waking hours. The use of accelerometers allowed us to capture physical activity beyond structured exercise including activities such as gardening, walking to complete errands, and doing household chores that many older adults may not think of as 'physical activity', when in fact guidelines do consider them physical activity (Physiology, 2015). Participants were instructed to remove the accelerometer for water-based activities and to wear it only during waking hours. As a consequence, raw data included zero counts, indicators of non-activity. We excluded data due to non-wear time before analyses based on information from daily wear-time logs. We also considered episodes of more than 90 minutes of continuous zeros as non-wear time. The accelerometer data were aggregated at the level of the day. We only analysed accelerometer days with at least 10 hours of wear time (*M* no of accelerometer days across the sample = 9.20, *SD* = 1.43, *Range* = 2 - 10). Physical activity was operationally defined as minutes of moderate to vigorous physical activity (MVPA) per day (*M*= 30.71, *SD*= 22.85), according to the Freedson cut-off points (Freedson, Melanson, & Sirard, 1998) as well as by the number of steps taken each day (*M* steps= 7704.23, *SD*= 2998.57). These two measures of physical activity were chosen to capture more lifestyle forms of physical activity (e.g. step counts) as well as high-intensity movement as reflected in current physical activity guidelines (e.g. minutes of MVPA). Forty-four percent of the sample did not meet physical activity guidelines as defined by a minimum of 150 MVPA/week (Physiology, 2015)

Functional Mobility. Functional mobility was assessed at Baseline with the Timed Up and Go Task (Podsiadlo & Richardson, 1991; Whitney et al., 2005). For this task, participants were asked to stand up from a chair without using their hands to push themselves up if possible, walk at their usual pace for three meters, turn around, walk back, and sit back down on the chair. Participants were instructed to wear comfortable footwear and to use any walking aids or mobility devices that they normally use. All participants were able to complete the task without assistance and the average time required was 8.61 seconds (*SD* = 2.24).

2.4 Statistical Analyses

Hierarchical linear models were used to account for the nested data structure with measurement occasions nested within participants (HLM; Raudenbush, Bryk, Cheong, & Congdon, 2000). We used models with two levels of nesting: the first level regarded momentary fluctuations in daily ratings of pain and objective physical activity indices and the second level regarded individual characteristics (gender, age, functional mobility, and overall pain aggregated across the 10-day time-sampling phase).

At level 1, we examined within-person associations between pain and the two respective physical activity indices (minutes of MVPA and step counts) separately:

$$\text{MVPA} = \beta_0 + \beta_1 \text{ (daily pain)} + r$$

Level 2 predictors included gender, age, functional mobility, and overall pain aggregated across the 10-day time-sampling phase. We also modeled a cross-level interaction to examine the proposed moderating role of gender on pain-physical activity slopes:

$$\beta_0 = \gamma_{00} + \gamma_{01} \text{ (gender)} + \gamma_{02} \text{ (age)} + \gamma_{03} \text{ (functional mobility)} + \gamma_{04} \text{ (overall pain)} + u_0$$

$$\beta_1 = \gamma_{10} + \gamma_{11} \text{ (gender)} + u_1$$

A similar model was created for the second index of physical activity, step count:

$$\text{Step Count} = \beta_0 + \beta_1 \text{ (daily pain)} + r$$

$$\beta_0 = \gamma_{00} + \gamma_{01} \text{ (gender)} + \gamma_{02} \text{ (age)} + \gamma_{03} \text{ (functional mobility)} + \gamma_{04} \text{ (overall pain)} + u_0$$

$$\beta_1 = \gamma_{10} + \gamma_{11} \text{ (gender)} + u_1$$

For both models, Level 1 predictors were person-centered to reflect deviations from the respective individual's overall mean. Level 2 predictors were grand-mean centered to allow comparisons across study participants.

Chapter 3: Results

Table 1 shows descriptive statistics and the variable inter-correlations for the study variables. There were no zero-order gender differences in physical activity. However, older participants engaged in significantly less physical activity in terms of minutes of MVPA. Functional mobility as measured by the Timed Up and Go test was negatively associated with both minutes of MVPA and step counts. Overall pain was significantly negatively associated with minutes of MVPA, but not with step counts.

3.1 Everyday Pain, Gender, and Physical Activity

We used hierarchical linear modeling to examine our central research questions. In Step 1, we examined how physical activity is associated with age, gender, functional mobility, overall pain and daily fluctuations in pain. The results, in *Table 2* (A models), indicate that the overall average of pain intensity ratings across the study period was negatively associated with MVPA, and that functional mobility was also negatively associated with MVPA as well as with step counts. We did not find significant associations between time-varying pain ratings and MVPA or step counts. There were also no gender main effects on MVPA or step counts. As a next step, we examined gender differences in pain intensity-physical activity associations (see *Table 2,* B models). In line with our expectations, compared to men, women showed steeper pain-physical activity slopes across both physical activity indices. However, while overall pain ratings across the study period continued to be negatively associated with minutes of MVPA across the study period, daily pain ratings were positively associated with daily MPVA in women, only. The findings of the respective gender by daily pain interaction on MVPA are illustrated in *Figure 1*.

Using the Pseudo R^2 approach (Snijders & Bosker, 1999), reductions in variance were calculated comparing unconditional and conditional models including the interaction term for gender (step counts *Pseudo* $\Delta R^2 = .06$; MVPA *Pseudo* $\Delta R^2 = .07$). The respective reductions in deviance were significant: Step Counts ($\chi^2 = 18.56$, $df = 6$, $p < .01$), MVPA ($\chi^2 = 21.98$, $df = 6$, $p < .01$).

3.2 Exploratory Follow-Up Analyses

In order to better understand why daily pain and aggregated pain across the study period were both associated with MVPA albeit in opposite direction, we conducted exploratory analyses to bridge the gap between our findings. These follow up analyses showed that daily minutes of MVPA were associated with increased evening pain as assessed at the 9pm measurement occasion ($b = .001$, $p = .02$) and that evening pain was positively associated with next day 11am pain reports irrespective of gender. Of note, 11am pain reports were not associated with same day MVPA.

Chapter 4: Conclusion

The overall goal of this study was to extend the knowledge base on time-varying pain-physical activity associations in old age and to examine whether they are moderated by gender. Our results show that overall means of self-reported pain over the study period were associated with fewer minutes of MVPA measured objectively using physical activity monitors. In addition, and different from our initial expectation, elevated daily pain was associated with more daily MVPA minutes and daily step counts in women but not in men. We conducted follow up analyses to shed light on possible reasons for these opposing findings that capture processes at different levels of analyses and time frames. As outlined below, we entertain the idea that these seemingly contradictory findings start to make sense when we assume that daily pain could have cumulative effects that are qualitatively distinct from acute effects.

4.1 Overall Pain Experience and Physical Activity Associations

Physical activity is associated with a plethora of health benefits, but barriers like pain deter from physical activity engagement (Calfas et al., 1996; Cohen-Mansfield et al., 2003; Schutzer & Graves, 2004). In line with the extant literature we find that overall pain was negatively associated with MVPA; this is in line with the assumption that pain serves as a significant barrier to physical activity, which was captured objectively by the use of accelerometers. For example, for every one-unit increase in overall pain, older adults participated in 9.91 fewer minutes of MVPA. Ten minutes may not seem like much but they can easily move an older adult below the 150 weekly minutes of MVPA that are recommended by Canadian physical activity (Physiology, 2015). Clearly, barriers like pain have implications for older adults' physical activity engagement when left unaddressed. And yet, a number of studies indicate that health professionals tend to underestimate pain, under-prescribe and under-medicate pain in older adults in particular (Allcock, McGarry, & Elkan, 2002; Blomqvist & Hallberg, 2002; Idvall & Ehrenberg, 2002; Nash et al., 1999; Tait & Chibnall, 2002). Hence, this finding provides a new perspective on the fact that older adults represent the least active segment of the Canadian population (Ashe et al., 2009).

Our study quantified physical activity in two ways - minutes spent in MVPA and step counts. Although overall pain was associated with fewer minutes of MVPA there was no corresponding negative association between overall pain and step counts. Perhaps pain was only negatively associated with MVPA because these minutes reflect high intensity movement, whereas step counts also capture lower intensity movement. In other words, older adults may continue to engage in lighter forms of physical activity like walking independent of their overall pain, whereas more vigorous forms of physical activity are discontinued. This is important because MVPA is the type of activity with the best-documented health benefits (Swain & Franklin, 2006; Teychenne, Ball, & Salmon, 2008). This being said, we should not ignore the potential benefits of light physical activity as several studies have explored and reported that lower intensity movement may also be associated with health benefits (Kushi et al., 1997; Leon, Connett, Jacobs, & Rauramaa, 1987; Paffenbarger Jr et al., 1993).

4.2 Gender Differences in Day-to-Day Pain-Physical Activity Associations

In addition to the findings that emerged across the 10 days, we also examined day-to-day fluctuations in physical activity and pain. Respective findings show that women do indeed show steeper pain-physical activity associations compared to men, but in the opposite direction of what we expected. In other words, increases in pain were associated with increases in physical activity. How do these findings fit with the above reported negative associations between overall pain and MVPA across the study period?

One way to make sense of these seemingly contradictory findings is as follows: more daily minutes of MVPA may go hand in hand with increased evening pain. In fact, past research has shown the same positive association as well, evident in both time-sampling studies and experimental studies (Murphy, Smith, Clauw, & Alexander, 2008; Wilcox et al., 2006). Furthermore, increased pain may turn out to have longer lasting effects, thus ultimately reducing MVPA levels in the long run (e.g., 10 day period). To examine this possibility, we conducted exploratory analyses that showed that the more pain a participant felt in the evening of the previous day, the more pain he or she would report the following morning and this was true irrespective of the gender of the person. Increased morning pain was not associated with reductions in the minutes of MVPA that day though. We suspect this to be the case because our participants, most of whom were not meeting physical activity guidelines, might not be engaging in MVPA on a daily basis, thereby reducing our chances of detecting associations between increased previous evening or morning pain and minutes of MVPA. Nevertheless, acute increases in pain may still have cumulative effects ultimately leading to the reported negative association between overall pain and minutes of MVPA across the study period. Further research should address this possibility by including items that ask participants whether and how their physical activity is shaped by earlier experienced pain.

Findings on daily life associations speak to gender differences in the relationship between pain and physical activity with women showing positive concurrent associations whereas no similar association was observed in men. These findings may have emerged for various reasons. First, values related to gender roles might be coming into play, which often lead people to have different expectations about how men and women should respond to pain (Myers, Robinson, Riley Iii, & Sheffield, 2001; Nayak, Shiflett, Eshun, & Levine, 2000). Socialization differences in pain responses related to gender roles can be traced back to childhood. For example, Unruh and Campbell (Unruh & Campbell, 1999) describe how fathers expect sons to tolerate pain better than their daughters, how girls show more distress in response to pain (even with similar pain ratings), as well as how men are expected to be more stoic in the presence of pain. Another example of gendered pain responses is a study of children in daycare centers (Fearon, McGrath, & Achat, 1996). Irrespective of gender, children reported the same amount and similar severity of everyday pain, but girls displayed more distress responses to pain and received more physical comfort from adult caregivers. Such early socialization effects related to gender roles, which enforce more liberal responses to pain by women may partly explain the results we see in our study, supporting the notion that daily pain reports among women are higher when physical activity levels are increased.

Differences in pain perception between men and women can also contribute to the observed gender-specific associations between daily pain and physical activity. Pain perception differences between men and women manifest in the forms of a lower pain threshold, pain tolerance, as well as analgesic response in women (Bartley & Fillingim, 2013; Hellström & Lundberg, 2000; Keogh & Herdenfeldt, 2002; Paller, Campbell, Edwards, & Dobs, 2009; Richardson & Holdcroft, 2009). These trends can be found in both healthy and clinical samples (Berkley, 1997; Ciccone & Holdcroft, 1999; Hellström & Lundberg, 2000; Myles et al., 2001; Walker & Carmody, 1998). There is debate on whether these differences in perception are any different from socialized pain responses or just another form of it; in other words, do women show lower pain tolerance and threshold due to learned responses and experience? However, Marskey and Spear (Merskey & Spear, 1967) state that "pain threshold is more dependent on physiological factors and pain tolerance on psychological factors." Yet, there is also increasing evidence for physiological explanations for gender differences in pain thresholds and tolerance (Bartley & Fillingim, 2013; Mogil, 2012; Paller et al., 2009). In other words, there are multiple plausible explanations for women's lower pain tolerance and thresholds, which are psychological and physiological, helping us to understand the amplified associations between daily pain and physical activity in the present sample.

Taken together, a multitude of different explanations have been brought up to elucidate the gender differences often found in pain experience. Our study extends the notion of gender differences in pain experience by showing that daily pain is more strongly associated with minutes of MVPA in women as compared to men. These findings have many real life consequences with implications for interventions. For example, hip replacement surgeries are associated with high post-surgery pain, but physical activity immediately after the surgical procedure is crucial for successful patient recovery. With the knowledge that women have a higher likelihood to report higher pain when engaging in physical activity, health care providers can pay closer attention to the administration of medications and provide extra support with physical activity regimens after hip surgery among women to ensure a successful recovery. Furthermore, our findings can also be applied to nonclinical samples. By simply knowing that pain and physical activity are more closely tied in women as compared to men, interventions that target physical inactivity in older age may want to include pain management as old age is predominantly female.

4.3 Limitations and Future Directions

This study uses a daily life approach to capture physical activity and pain experience as they unfold in older adults' everyday environments, thereby maximizing ecological validity. However, there are limitations in our study that should be addressed by future research. Despite having a compliant and demographically diverse sample, daily life approaches entail limited sample sizes ($N = 128$) due to their intensive nature. Second, the accelerometers worn by participants objectively measured physical activity in terms of minutes of physical activity and step counts, but the devices were not able to capture any water-based activities taken up by participants. If a participant's main source of physical activity were swimming or water exercises, then we would have missed it. We asked participants to report any water-based activities they engaged in throughout the day, but this information was self-reported. Third, women might accumulate their physical activity through different types of activities than men that may contribute to pain but are difficult to halt in the presence of pain in daily life. Future research needs to address this possibility by examining if the reported gender-specific findings might be due to the social context in which physical activity occurs (alone versus together with other people) or the purpose of the physical activity (doing heavy household chores versus leisure activities) especially since past research has shown gender differences in indoor versus outdoor/leisure activities (Bennett, 1998). Lastly, our sample was relatively healthy and had low levels of pain across the study period, therefore it is important to examine whether the findings that emerged in our sample are different compared to findings from samples experiencing reoccurring or chronic pain.

4.4 Closing Remarks

Physical activity has been linked to a plethora of health benefits, making it crucial to better understand the linkages with barriers to physical activity. Our study showed that increased daily pain was associated with increased minutes of MVPA especially among older women, yet overall pain experienced over the 10 day period was associated with an overall decrease in MVPA. Given that our findings are based on a relative healthy sample, future research should apply a similar paradigm on a different demographic, perhaps one where pain experience is more pronounced and examine whether the trends hold true or will be amplified. Our study also indicated that women displayed more pronounced pain- physical activity associations than did men. These findings highlight that there is a need to pay more attention to those that are particularly vulnerable to the effects of pain, to ensure both older men and women have an equal opportunity to engage in this key health-promoting behavior.

Table 1

Means and Standard Deviations of the Central Study Variables, and Variable Intercorrelations (N = 128)

		M (SD)	1	2	3	4	5	6
1	Age	71.95 (4.97)		-.06	.08	-.11	-.17*	-.16
2	Gender	64% women			-.10	.03	-.14	-.10
3	Functional mobility	8.61 (2.24)				.17*	-.21*	-.26**
4	Overall Pain	1.35 (.47)					-.20*	-.15
5	Moderate to Vigorous PA	30.71 (22.85)						.88**
6	Step Count	7704.23 (2988.57)						

Note.*$p < .05$, **$p < .01$.

Table 2

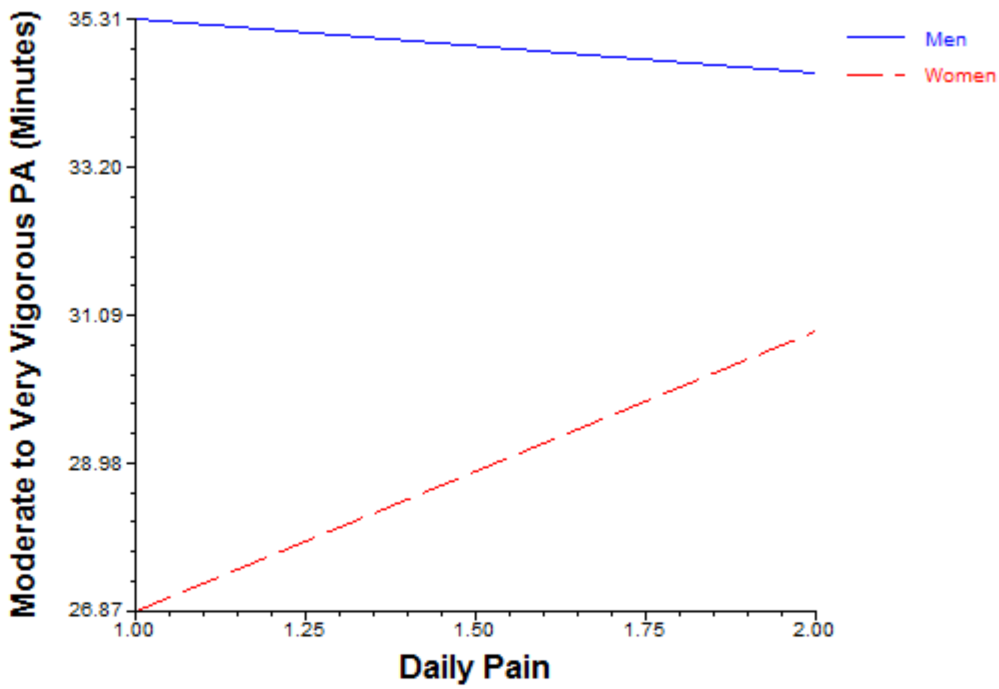
Hierarchical Linear Models Predicting Everyday Physical Activity (Step Counts; Minutes of Moderate to Vigorous Physical Activity) from Person – Specific and Time-Varying Characteristics Using Restricted Maximum Likelihood Estimation in HLM (N = 128)

Note.* p‹.05; ** p‹.01; Unstandardized coefficients

Fixed effects	Daily Step Counts		Daily minutes of moderate to very vigorous physical activity	
	Model A	Model B	Model A	Model B
Intercept	**7713.78****	**8187.04****	**30.70****	**35.38****
Age	-94.07*	**-93.41***	-.80*	**-0.83****
Functional mobility	**-346.12****	**-321.13****	**-2.10****	**-1.89***
Gender	-551.20	-745.00	-6.17	-7.36
Overall pain	-939.53	-699.14	**-9.91****	**-8.02****
Daily pain	46.73	-653.42	2.40	-3.34
Gender X daily pain		**1055.15***		**8.69***

Figure 1

Minutes of moderate to very vigorous as a function of daily pain and gender. Note that 91.5% of all daily pain ratings fell into the 1-2 point range.



References

Allcock, N., McGarry, J., & Elkan, R. (2002). Management of pain in older people within the nursing home: a preliminary study. *Health & Social Care in the Community, 10*(6), 464-471.

Ashe, M. C., Miller, W. C., Eng, J. J., & Noreau, L. (2009). Older adults, chronic disease and leisure-time physical activity. *Gerontology, 55*(1), 64-72.

Barnett, A., Smith, B., Lord, S. R., Williams, M., & Baumand, A. (2003). Community-based group exercise improves balance and reduces falls in at-risk older people: A randomised controlled trial. *Age and ageing*, *32*(4), 407-414.

Bartley, E. J., & Fillingim, R. B. (2013). Sex differences in pain: A brief review of clinical and experimental findings. *British Journal of Anaesthesia, 111*(1), 52-58.

Bennett, K. M. (1998). Gender and longitudinal changes in physical activities in later life. *Age and Ageing, 27*(suppl 3), 24-28.

Berkley, K. J. (1997). Sex differences in pain. *Behavioral and Brain Sciences, 20*(03), 371-380.

Bernabei, R., Gambassi, G., Lapane, K., Landi, F., Gatsonis, C., Dunlop, R., . . . Group, S. S. (1998). Management of pain in elderly patients with cancer. *Jama, 279*(23), 1877-1882.

Blomqvist, K., & Hallberg, I. R. (2002). Managing pain in older persons who receive home-help for their daily living. Perceptions by older persons and care providers. *Scandinavian Journal of Caring Sciences, 16*(3), 319-328.

Booth, M. L., Bauman, A., Owen, N., & Gore, C. J. (1997). Physical activity preferences, preferred sources of assistance, and perceived barriers to increased activity among physically inactive Australians. *Preventive Medicine, 26*(1), 131-137.

Booth, M. L., Owen, N., Bauman, A., Clavisi, O., & Leslie, E. (2000). Social–cognitive and perceived environment influences associated with physical activity in older Australians. *Preventive Medicine, 31*(1), 15-22.

Calfas, K. J., Long, B. J., Sallis, J. F., Wooten, W. J., Pratt, M., & Patrick, K. (1996). A controlled trial of physician counseling to promote the adoption of physical activity. *Preventive Medicine, 25*(3), 225-233.

Canadian Society for Exercise Physiology (2015). Canadian Physical Activity Guidelines. Retrieved 18th October 2015 from http://www.csep.ca/CMFiles/Guidelines/CSEP_PAGuidelines_older-adults_en.pdf

Cecchi, F., Debolini, P., Lova, R. M., Macchi, C., Bandinelli, S., Bartali, B., . . . Ferrucci, L. (2006). Epidemiology of back pain in a representative cohort of Italian persons 65 years of age and older: The InCHIANTI study. *Spine, 31*(10), 1149.

Chodzko-Zajko, W., Proctor, D.N., Fiatarone Singh, M.A., Minson, C.T., Nigg, C.R., Salem, G.J. and Skinner, J.S. (2009) ACSM position stand: Exercise and physical activity for older adults. *Medicine & Science in Sports & Exercise*, 41(7): 1510-1530.

Ciccone, G. K., & Holdcroft, A. (1999). Drugs and sex differences: A review of drugs relating to anaesthesia. *Survey of Anesthesiology, 43*(5), 293-294.

Cohen-Mansfield, J., Marx, M. S., & Guralnik, J. M. (2003). Motivators and barriers to exercise in an older community-dwelling population. *Journal of Aging and Physical Activity, 11*(2), 242-253.

Craig, K. D. (2009). The social communication model of pain. *Canadian Psychology/Psychologie Canadienne, 50*(1), 22.

Crombie, I. K., Irvine, L., Williams, B., McGinnis, A. R., Slane, P. W., Alder, E. M., & McMurdo, M. E. T. (2004). Why older people do not participate in leisure time physical activity: A survey of activity levels, beliefs and deterrents. *Age and Ageing, 33*(3), 287-292.

Fearon, I., McGrath, P. J., & Achat, H. (1996). 'Booboos': The study of everyday pain among young children. *Pain, 68*(1), 55-62.

Freedson, P. S., Melanson, E., & Sirard, J. (1998). Calibration of the computer science and applications, inc. accelerometer. *Medicine and Science in Sports and Exercise, 30*(5), 777-781.

Grennan, D. M., & Jayson, M. I. V. (1989). Rheumatoid arthritis. *Textbook of Pain* (4 ed., pp. 317-326). New York Churchill Livingstone.

Hellström, B., & Lundberg, U. (2000). Pain perception to the cold pressor test during the menstrual cycle in relation to estrogen levels and a comparison with men. *Integrative Physiological and Behavioral Science, 35*(2), 132-141.

Herr, K. A., & Garand, L. (2001). Assessment and measurement of pain in older adults. *Clinics in Geriatric Medicine, 17*(3), 457-478.

Holtzman, S., & DeLongis, A. (2007). One day at a time: The impact of daily satisfaction with spouse responses on pain, negative affect and catastrophizing among individuals with rheumatoid arthritis. *Pain, 131*(1), 202-213.

Idvall, E., & Ehrenberg, A. (2002). Nursing documentation of postoperative pain management. *Journal of Clinical Nursing, 11*(6), 734-742.

Katzmarzyk, P. T., Gledhill, N., & Shephard, R. J. (2000). The economic burden of physical inactivity in Canada. *Canadian Medical Association Journal*, *163*(11), 1435-1440.

Keogh, E., & Herdenfeldt, M. (2002). Gender, coping and the perception of pain. *Pain, 97*(3), 195-201.

Kolt, G. S., Driver, R. P., & Giles, L. C. (2004). Why older Australians participate in exercise and sport. *Journal of Aging and Physical Activity, 12*(2), 185-198.

Kushi, L. H., Fee, R. M., Folsom, A. R., Mink, P. J., Anderson, K. E., & Sellers, T. A. (1997). Physical activity and mortality in postmenopausal women. *Jama, 277*(16), 1287-1292.

Leon, A. S., Connett, J., Jacobs, D. R., & Rauramaa, R. (1987). Leisure-time physical activity levels and risk of coronary heart disease and death: The multiple risk factor intervention trial. *Jama, 258*(17), 2388-2395.

Merskey, H., & Spear, F. G. (1967). *Pain: Psychological and psychiatric aspects*, Baillière, Tindall & Cassell.

Mobily, P. R., Herr, K. A., Clark, M. K., & Wallace, R. B. (1994). An epidemiologic analysis of pain in the elderly the Iowa 65+ rural health study. *Journal of Aging and Health, 6*(2), 139-154.

Mogil, J. S. (2012). Sex differences in pain and pain inhibition: Multiple explanations of a controversial phenomenon. *Nature Reviews Neuroscience, 13*(12), 859-866.

Murphy, S. L., Smith, D. M., Clauw, D. J., & Alexander, N. B. (2008). The impact of momentary pain and fatigue on physical activity in women with osteoarthritis. *Arthritis Care & Research, 59*(6), 849-856.

Myers, C. D., Robinson, M. E., Riley Iii, J. L., & Sheffield, D. (2001). Sex, gender, and blood pressure: Contributions to experimental pain report. *Psychosomatic Medicine, 63*(4), 545-550.

Myles, P. S., McLeod, A. D. M., Hunt, J. O., & Fletcher, H. (2001). Sex differences in speed of emergence and quality of recovery after anaesthesia: Cohort study. *Bmj, 322*(7288), 710-711.

Nash, R., Yates, P., Edwards, H., Fentiman, B., Dewar, A., McDowell, J., & Clark, R. (1999). Pain and the administration of analgesia: What nurses say. *Journal of Clinical Nursing, 8*(2), 180-189.

Nayak, S., Shiflett, S. C., Eshun, S., & Levine, F. M. (2000). Culture and gender effects in pain beliefs and the prediction of pain tolerance. *Cross-cultural Research, 34*(2), 135-151.

Nelson, M.E., Rejeski, W.J., Blair, S.N., Duncan, P.W., Judge, J.O., King, A.C., Macera, C.A., & Castaneda-Sceppa, C. (2007). Physical activity and public health in older adults: Recommendation from the American College of Sports Medicine and the American Heart Association. *Medicine & Science in Sports & Exercise, 116(9):* 1094-1105.

Newson, R. S., & Kemps, E. B. (2007). Factors that promote and prevent exercise engagement in older adults. *Journal of Aging and Health, 19*(3), 470-481.

Netz, Y., Wu, M., Becker, B. J., & Tenenbaum, G. (2005). Physical activity and psychological well-being in advanced age: A meta-analysis of intervention studies. *Psychology and Aging*, *20*(2), 272.

Newth, S., & DeLongis, A. (2004). Individual differences, mood, and coping with chronic pain in rheumatoid arthritis: A daily process analysis. *Psychology & Health, 19*(3), 283-305.

Paffenbarger Jr, R. S., Hyde, R. T., Wing, A. L., Lee, I. M., Jung, D. L., & Kampert, J. B. (1993). The association of changes in physical-activity level and other lifestyle characteristics with mortality among men. *New England Journal of Medicine, 328*(8), 538-545.

Paller, C. J., Campbell, C. M., Edwards, R. R., & Dobs, A. S. (2009). Sex-based differences in pain perception and treatment. *Pain Medicine, 10*(2), 289-299.

Podsiadlo, D., & Richardson, S. (1991). The timed" Up & Go": A test of basic functional mobility for frail elderly persons. *Journal of the American Geriatrics Society, 39*(2), 142-148.

Public Health Agency of Canada (2009). Physical activity and healthy ageing. Retrieved 10th March 2012 from http://www.phac-aspc.gc.ca/seniors-aines/publications/pro/healthy-sante/haging_newvision/vison-rpt/physical-physique-eng.php

Richardson, J., & Holdcroft, A. (2009). Gender differences and pain medication.

Robinson, C. L. (2006). Relieving pain in the elderly. *Health Progress (Saint Louis, Mo.), 88*(1), 48-53, 70.

Schutzer, K. A., & Graves, B. S. (2004). Barriers and motivations to exercise in older adults. *Preventive Medicine, 39*(5), 1056-1061.

Scudds, R. J., & Robertson, J. M. (2000). Pain factors associated with physical disability in a sample of community-dwelling senior citizens. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences, 55*(7), M393-M399.

Snijders, T., & Bosker, R. (1999). Multilevel analysis: An introduction to basic and applied multilevel analysis. London: Sage.

Statistics Canada. (2010). *Population projections: Canada, the provinces and territories.* Retrieved from http://www.statcan.gc.ca/dailyquotidien/100526/dq100526b-eng.htm

Swain, D. P., & Franklin, B. A. (2006). Comparison of cardioprotective benefits of vigorous versus moderate intensity aerobic exercise. *The American Journal of Cardiology, 97*(1), 141-147.

Tait, R. C., & Chibnall, J. T. (2002). Pain in older subacute care patients: Associations with clinical status and treatment. *Pain Medicine, 3*(3), 231-239.

Teychenne, M., Ball, K., & Salmon, J. (2008). Physical activity and likelihood of depression in adults: A review. *Preventive Medicine, 46*(5), 397-411.

Tracy, B., & Morrison, R. S. (2013). Pain management in older adults. *Clinical Therapeutics, 35*(11), 1659-1668.

Trull, T. J., & Ebner-Priemer, U. (2013). Ambulatory assessment. *Annual Review of Clinical Psychology, 9*, 151.

Unruh, A., & Campbell, M. A. (1999). Gender variation in children's pain experiences. *Progress in Pain Research and Management, 13*, 199-242.

Walker, J. S., & Carmody, J. J. (1998). Experimental pain in healthy human subjects: gender differences in nociception and in response to ibuprofen. *Anesthesia & Analgesia, 86*(6), 1257-1262.

Whitney, J. C., Lord, S. R., & Close, J. C. T. (2005). Streamlining assessment and intervention in a falls clinic using the Timed Up and Go Test and Physiological Profile Assessments. *Age and Ageing, 34*(6), 567-571.

Wilcox, S., Der Ananian, C., Abbott, J., Vrazel, J., Ramsey, C., Sharpe, P. A., & Brady, T. (2006). Perceived exercise barriers, enablers, and benefits among exercising and nonexercising adults with arthritis: Results from a qualitative study. *Arthritis Care & Research, 55*(4), 616-627.

World Health Organization (2015). Physical activity. Retrieved 18th October 2015 from http://www.who.int/topics/physical_activity/en/