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Relationship of Knee Pain to Time in Moderate and Light Physical Activities: Data from Osteoarthritis Initiative

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Abstract

Introduction—While OA literature indicates greater pain is related to less time being physically active, it is not known if time curtailment occurs primarily for moderate intensity activities or for light activities or in both. We examine the cross-sectional association of knee pain with physical activity using data from 1874 Osteoarthritis Initiative participants.

Methods—Knee pain characteristics of constant and intermittent pain were each scored by the Intermittent and Constant Osteoarthritis Pain instrument and categorized into four pain levels (no pain, intermittent pain below and above median level, and constant pain). The relationships between knee pain levels and objectively measured physical activity (average weekly moderate or light intensity minutes) were assessed by quantile regression adjusted for socio-demographics and health factors.

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Results—Knee pain levels had a strong negative relationship with moderate intensity physical activities (p-value for trend=0.029). Compared to the no pain group, persons with more severe knee pain, particularly those reporting higher intermittent or constant pain spent less time in moderate activity. In contrast, there was no notable trend related to pain with time spent in light intensity activity. These patterns remained when restricted to persons with clinical evidence (symptoms and/or radiographic) of knee OA and among persons not using medications for knee symptoms.

Conclusion—Greater knee pain levels were strongly related to less moderate intensity activity time, but not time spent in light intensity physical activity. This relationship suggests that light activity may be a more acceptable way to increase physical activity than moderate activity for people with symptomatic knee pain.

Keywords

osteoarthritis; physical activity; intermittent knee pain; constant knee pain

Introduction

Osteoarthritis (OA) affects nearly 27 million adults in the United States.[1] OA causes more limitations in activities of daily living than any other medical condition [2, 3] and directly affects the quality of life of persons with the disease. Currently the main strategy to manage this non-curable disease is to reduce symptoms and preserve function.[4]

Regular physical activity is widely accepted and recommended as a strategy to control pain and improve function for people with OA [5–8]. Paradoxically, some people with OA tend to curtail physical activity to avoid pain aggravation. Pain was a recognized perceived barrier to uptake and maintenance of therapeutic exercise in OA.[9, 10] OA literature indicates greater pain is related to less time being physically active.[11–14] However it is not known if time curtailment is primarily for moderate intensity activities like brisk walking or if it also occurs for light activities like pushing a grocery cart. Understanding relationships between different pain profiles and physical activity intensity may help inform the development of interventional strategies that promote physical activity without exacerbating pain, and ultimately improve function and quality of life.

Arthritis-related pain is a complex experience with multi-dimensional attributes and may not be similar across individuals with OA. Two distinct types of pain are noted by patients with OA: 1) a dull, aching pain, which becomes more constant over time, and 2) intermittent pain that comes and goes and varies in intensity.[11] In focus groups, patients described the early stage of OA pain progression as activity-induced intermittent pain, which triggers avoidance of high impact activities. A middle stage is characterized by frequent intermittent pain which progresses to constant pain and interferes with activities of daily living. Advanced OA pain stage is characterized by constant dull/aching pain accompanied with intense intermittent pain, leading to reduced social and recreational activities. To our knowledge there is no quantitative study investigating how these different pain characteristics relate to physical activity.

In this study, we examine the cross-sectional relationship between knee pain levels and physical activity in a large, multi-site cohort of people with or at high risk for knee OA. Based on the OA pain stages observed by Hawker et al.[11], we characterize knee pain levels no pain (the least severe), intermittent pain only (subdivided into lower and higher intermittent), and any constant pain with or without intermittent pain (most severe). We hypothesize that adults with greater knee pain level are not only more likely to have less moderate-intensity physical activity but also less light intensity physical activity.

Materials and Methods

Study design and participants

The study sample was a subcohort of the Osteoarthritis Initiative (OAI) accelerometer ancillary study. The parent OAI is a prospective natural history study investigating risk factors and biomarkers for the progression and/or onset of knee OA. At enrollment (2004–2006), the OAI recruited 4796 men and women aged 45–79 years from four study sites: Baltimore, MD; Columbus, OH; Pittsburgh, PA; and Pawtucket, RI. Adults eligible for enrollment were either required to have symptomatic osteoarthritis in at least one knee (i.e. definite tibiofemoral osteophytes[15] and pain, aching, or stiffness on most days for at least one month during the past 12 months) or were required to have at least one factor from a set of established knee osteoarthritis risk factors (knee symptoms, being overweight or obese, prior knee injury, prior knee surgery, family history of total knee replacement, Heberden's nodes, repetitive knee bending, and age ≥ 70).[16] Complete inclusion and exclusion criteria and study rationale were described in detail and can be found at http://www.oai.ucsf.edu/datarelease/About.asp. Each participant provided written informed consent. Institutional Review Board approval was obtained from each OAI site and Northwestern University.

We tested our hypotheses using an analytical sample of 1894 from the 2127 participants in the accelerometer ancillary study conducted at the OAI 48-month follow-up (2008–2010).[17] Excluded were 200 persons without knee pain measures by the Intermittent and Constant Osteoarthritis Pain (ICOAP) instruments, 32 persons with less than 4 days of valid physical activity monitoring, and 21 with incomplete data in other covariates. All data were from the OAI 48-month follow-up unless noted elsewhere.

Physical Activity Measures

Physical activity was monitored using the ActiGraph GT1M uniaxial accelerometer (ActiGraph; Pensacola, FL). The monitor was attached to a belt that strapped around the waist. At the OAI 48-month clinic visit, participants were given the accelerometer and were instructed to wear the monitor arising in the morning until retiring at night for seven consecutive days over their right hip, except during showers, bathing, swimming, or other water activities. Participants maintained a daily log to record time spent in water and cycling activities, which may not be fully captured by accelerometers. Uniaxial accelerometer validation studies against whole-body indirect calorimetry showed high correlation with metabolic equivalent (r=0.93) and total energy expenditure (r=0.93).[18] The accuracy[19] and test-retest reliability[20] of ActiGraph accelerometers under field conditions have been established in many populations including persons with OA.[21]

The uniaxial accelerometer output is an activity count, which is the weighted sum of the number of accelerations measured over a minute, where the weights are proportional to the magnitude of measured acceleration. Accelerometer data were analytically filtered using validated methodology.[22, 23] Nonwear periods were defined as ≥ 90 minutes with zero activity counts per minute (allowing for up to 2 consecutive minutes with counts between 1 and 100 per minute).[24] To get reliable physical activity measurements, we restricted analysis to participants with 4–7 valid monitoring days (i.e., 10 or more wear hours per day).[24] National Cancer Institute thresholds were applied to identify light (100–2019 counts/minute) and moderate or vigorous intensity (counts/minute ≥ 2020) activity on a minute-by-minute basis.[24] Since vigorous intensity activity was rarely achieved by this cohort, we used “moderate” to label activity intensity with counts/minute ≥ 2020. Daily minutes spent in light or moderate intensity were accumulated over the wearing hours. To account for variability in daily monitoring time, we standardized these physical activity measures to 16 hours of wear time per day. Weekly activity minutes spent at each intensity level were summed from the standardized daily totals; for individuals with 4, 5, or 6 valid days of monitoring, weekly activity minutes were estimated as 7 times the average daily activity minutes.

Intermittent and Constant Knee Pain

Knee pain intensity and characteristics were measured by using Intermittent and Constant Osteoarthritis Pain (ICOAP) questionnaire. ICOAP instrument was developed to evaluate the constant and intermittent pain experience among people with hip and knee OA.[11] At the OAI 48-month clinic visit, participants were asked to assess their knee pain experience “in the past 7 days”, one week prior to the week physical activity was measured. The questionnaire included 5 questions for constant pain and 6 questions for intermittent pain. Questions for each pain type assessed pain intensity, how much pain affected sleep, quality of life, and how the participants have been “frustrated or annoyed”, and “upset or worried” by pain. An additional question assessed the frequency of intermittent pain. Each question was scored from 0 to 4 with 4 indicating the worst situation (extremely or very often) and summed to provide a separate intermittent and a constant pain score. Each pain score was normalized from 0 (no pain) to 100 (extreme pain) from raw scores (constant range 0–20, intermittent range 0–24).

Based on the OA pain stages observed by Hawker et al[11], we categorized people into four mutually exclusive intermittent and constant knee pain levels: 1) no pain (both intermittent and constant pain score=0), 2) lower intermittent pain (no constant pain, intermittent ICOAP pain score below median), 3) higher intermittent pain (no constant pain, intermittent ICOAP pain score above median), and 4) any constant pain with or without intermittent pain. Median intermittent pain was calculated among 1087 people with intermittent pain (median = 20.8).

Covariates

Covariates included socio-demographic factors (age, sex, race, education) and health factors (knee OA presence, body mass index (BMI), high depressive symptoms, comorbidity). Race/ethnicity (African American, White, or other race) was ascertained from self-report.

Education was dichotomized as post high school versus less education or not reported. Knee OA severity was evaluated using Kellgren-Lawrence grade from “fixed-flexion” knee radiography protocol.[25] Presence of radiographic knee OA was identified by a Kellgren-Lawrence grade[26] of two or higher in one or both knees at the OAI 48 month or an earlier visit. BMI was calculated from measured height and weight [weight (kg)/height^2 (m^2)]. We used 36-month BMI as a proxy for missing in 48-month BMI (n=6, 0.3%). Obesity was defined as BMI ≥ 30. High depressive symptoms were identified by Center for Epidemiological Studies Depression (CESD) scale ≥ 16.[27] Presence of comorbidity was ascertained by modified Charlson Comorbidity Index > 0.[28]

Statistical Analysis

Descriptive statistics summarize participant characteristics and knee pain for the overall sample and by knee pain levels. We examined the cross-sectional association between pain levels and time spent in weekly physical activity using quantile regression models controlling for socio-demographics and health covariates. Quantile regression is robust to outliers and does not require assumptions regarding the underlining distribution of the outcome to obtain valid inference tests.

Sensitivity analyses were conducted testing for interactions between pain levels and age, sex, obesity, and presence of radiographic knee OA. To address the possibility pain medication influence the relationship between knee pain and physical activity we conducted stratified analyses on people reporting and not reporting taking medications for knee pain. Further analysis were restricted to persons with clinical evidence of knee OA, which included adults with radiographic evidence of knee OA and/or chronic knee symptoms based on reported pain, aching, or stiffness on most days of a month during the previous year in at least one knee.

All statistical analyses were conducted using Stata/SE 13.1 (StataCorp LP, College Station, TX) and SAS software version 9.4 (SAS Institute, Cary, NC).

Results

This cohort with or at high risk for knee OA had a mean age of 65 years; 55% were female; 61% had radiographic knee OA in at least one knee; and 35% were obese (Table 1). About 40% of these participants in the past week reported no pain, 22% reported lower intermittent knee pain but no constant pain, 27% reported higher intermittent pain but no constant pain, and 11% reported constant knee pain. Most people who reported constant pain concurrently reported intermittent pain (78%). Participants reporting knee pain were more likely to have radiographic knee OA, high depressive symptoms, comorbidities, and be obese compared to those reporting no pain; these relationships became stronger as intermittent pain intensity increased and were the strongest among people who reported constant pain.

The cohort did little moderate intensity activities (median 95 minutes/week) and spent most of their activity time in light intensity activities (median 2093 minutes/week). Figure 1 showed participants with constant knee pain did the least amount of moderate intensity

physical activity, followed by people with higher intermittent pain, no pain, and lower intermittent pain. No particular pattern was observed for light intensity physical activity.

Table 2 summarizes the medians of weekly physical activity time by knee pain levels adjusting for socio-demographics and health factors among the overall cohort with or at high risk for knee OA. There was a statistically significant trend for decreased moderate activity time with increasing pain levels (p-value for trend = 0.029; adjusted medians 72, 76, 58, and 52 minutes per week for no pain, lower intermittent pain, higher intermittent pain, constant pain, respectively). Participants with constant pain spent 26% less time in moderate physical activity than adults reporting no knee pain, representing a difference of 19 minutes/week (95% CI: −39, 1; p-value=0.06). Those with higher intermittent pain spent 19% less time (14 minutes/week, 95% CI: −28, 0; p-value=0.06) in moderate activity than adults with no pain. On the other hand, people with lower intermittent pain spent similar amount of time in moderate activity as those without pain. In contrast, time spent in light activity did not differ statistically among the four knee pain groups. The difference in median time spent in light physical activity by adults with pain compared to those without pain was negligible (percent of difference ranged from −0.2% to 1.4%).

Further analyses were restricted to people with knee symptoms and/or radiographic knee OA. As shown in Table 3, the findings were similar to the overall sample (Table 2). A statistically significant trend of less moderate activity according to knee pain levels were found (p-value for trend=0.039). Higher intermittent pain and constant pain were associated with 20% and 30% less moderate physical activity than no pain; although these differences did not reach statistical significance. There were no clear patterns in associations of ICOAP knee pain level and light intensity physical activity.

Sensitivity analyses tested for the interactions between ICOAP pain levels with sex, obesity, and the radiographic knee OA; none were statistically significant. To address the possibility pain medication influence could the relationship between knee pain and physical activity stratified analyses were done on people reporting and not reporting taking medications for knee pain (not shown). Among the 1522 participants not taking pain medication their findings were similar to Table 2; moderate intensity activity significantly decreased with greater pain levels (p-for for trend=0.037) but there was no relationship between light intensity activity and pain levels. Among the 355 people who reported taking knee pain medications, no significant relationships were found between knee pain levels with either moderate intensity activity or light intensity activity, but it is recognized this small subgroup had less power to detect relationships.

Discussion

This study examined the relationship between physical activity and knee pain levels among people with or at high risk for knee OA. We hypothesized that more severe knee pain is associated with less physical activity regardless of light or moderate-to-vigorous intensity physical activity. However our findings rejected this hypothesis and showed that the strength of the relationship between knee pain level and objectively measured physical activity depended on the intensity of physical activity and the type of pain reported. Greater knee

pain levels were strongly related to less moderate intensity activity time, but not time spent in light intensity physical activity. These patterns remained when restricted to persons with clinical evidence (symptoms and/or radiographic) of knee OA as well as when restricted to persons who did not use medications for knee symptoms.

Adults with OA-related pain may increase or decrease physical activity in response to their pain. There is a spectrum of literature on knee pain and physical activity. One body of evidence finds a negative relationship supporting the benefits of physical activity to reduce OA pain.[5, 29] The effect of exercise on OA pain is comparable to simple analgesics and oral non-steroid anti-inflammatory drugs.[30] For these reasons, evidence-based guidelines for OA management specify regular physical activity as a core non-pharmacologic, non-surgical recommendation. [5, 31] Another body of literature found no relationship between knee pain and physical activity.[32, 33] A third body of literature found a positive relationship. It is believed that people with OA frequently adopt a pain control strategy through reducing or avoiding activities. Qualitative studies identify pain as a barrier to exercise among adults with OA.[9, 10] Patients with OA pain report limitations that first occur in high impact activities, and eventually in recreational and social activities.[11] Evidence based on objectively measured physical activity showed that among people with knee OA, those with worse knee pain were more likely to be physical inactive [12] and accumulating fewer daily steps[13]. OA-related knee or hip symptoms that “reflects patients’ pain”, was reported as a strong predictor for less self-reported physical activity.[14] Our findings gives insight to these different relationships by showing worse knee pain has a significant negative relationship with moderate but no relationship with light intensity physical activity.

The literature evaluating types of knee pain in relation to health outcomes is recent but growing. OA related pain could be chronic or fluctuate over time. In a qualitative study among patients with knee or hip OA, Hawker and colleagues noted that constant and intermittent pain could have different relationships to health outcomes; intense intermittent knee pain, particularly unpredictable pain, was more likely to affect quality of life than constant knee pain.[11] A recent study in an OA-population by Davidson and colleagues found that constant and intermittent ICOAP knee pain were each associated with worse self-reported knee function measured by WOMAC and KOOS; but the relationships with other function outcomes were mixed.[34] Another cohort study showed that individuals with symptomatic knee OA were most likely to find their symptoms unacceptable if they experienced higher pain severity (constant or intermittent) or a greater degree of unpredictable intermittent pain.[35] Our study indicated the presence of constant pain and higher level of intermittent pain were related to less time spent in moderate physical activity compared to no pain.

Our findings support the importance of pain management when promoting physical activity among people with knee OA, especially for individuals who reported constant pain. Pain levels appeared to have less influence on light intensity physical activity than moderate intensity activity. This finding suggests light intensity physical activity could be an alternative initial pathway to better physical function and quality of life without provoking pain.[36] Future studies to examine the effect of light intensity physical activity on pain and

function would elucidate the potential benefits of light intensity physical activity for people with pain and more advanced disease.

The strength of this study includes its large sample size, a diverse distribution of age and sex, and objective accelerometer measured physical activity. There are several limitations to this study. The study is cross-sectional and causation cannot be inferred from these observational data. It is possible types of knee pain are surrogates of knee OA disease severity.[11, 37] Therefore, a sensitivity analysis controlling for K/L grade was conducted to address the potential confounding effect of disease stage on physical activity. The results remained consistent with our reported findings. Finally, while accelerometer monitoring provides objective information of the frequency and intensity of activities, it does not distinguish the context of the physical activity, for example walking or climbing stairs.

Conclusion

Greater knee pain levels had a greater impact on moderate intensity than on light intensity physical activity. This relationship suggests that light activity may be a more acceptable way to increase physical activity than moderate activity for people with symptomatic knee pain. Advising more light activities for persons dealing with knee pain may be easier for a clinician to recommend and more attractive for a patient to hear than moderate activity advice.

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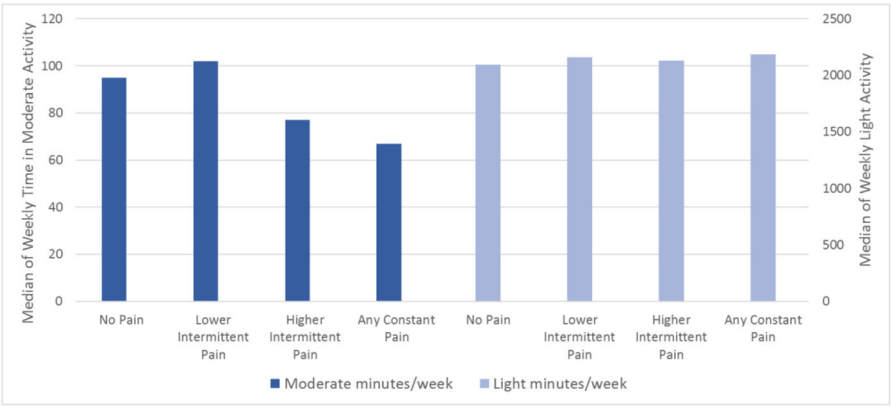

Figure 1.

Time Spent in Moderate and Light Intensity Physical Activity (minutes/week) by Intermittent and Constant Knee Pain Levels among Adults with or at High Risk for Knee OA (n=1874)

Table 1

Characteristics by Intermittent/Constant Knee Groups among Adults with or at High Risk for Knee OA (n=1874)

	Overall (n=1874)	Intermittent/Constant Knee Pain Groups [a]			
		No Pain (n=754)	Lower Intermittent Pain (n=406)	Higher Intermittent Pain(n=511)	Any Constant Pain (n=203)
Age (yrs), mean (Standard Deviation [SD]); median	65 (9); 65	66 (9); 67	64 (9); 63	65 (9); 64	63 (9); 61
Women, %	55%	56%	55%	55%	54%
White, %	83%	87%	89%	83%	61%
Education years 12+, %	87%	86%	90%	88%	81%
Symptomatic/Radiographic Knee OA, %	72%	56%	71%	87%	96%
Radiographic Knee OA, %	61%	52%	60%	69%	73%
Symptomatic Knee OA, %	39%	13%	29%	67%	91%
Obesity, %	35%	28%	34%	43%	45%
High depressive symptoms, %	12%	9%	7%	16%	21%
Presence of comorbidity, %	30%	26%	21%	36%	42%
ICOAP Knee Pain Scores, mean (SD); median					
Constant Pain	4 (14); 0	0	0	0	36 (23); 35
Intermittent Pain	15 (17); 13	0	12 (3); 13	33 (13); 29	29 (24); 29

[a] Intermittent and Constant Osteoarthritis Pain (ICOAP) knee pain groups was defined as: no pain, lower intermittent pain (< median of intermittent pain), higher intermittent pain (>median of intermittent pain), and any constant pain. Median of intermittent pain among 1087 participants with intermittent pain =20.8.

Table 2

Adjusted[a] Medians and Differences (95% CI) of Average Weekly Physical Activity by Intermittent/Constant Knee Pain Groups among Adults with or at High Risk for Knee OA (n=1874)

	Adjusted[a] Physical Activity Median Time		Adjusted[a] Difference (95% CI) in Physical Activity Medians Compared to No Pain	
	Moderate Intensity Activity (minutes/ week)	Light Intensity Activity (minutes/ week)	Moderate Intensity Activity (minutes/week)	Light Intensity Activity (minutes/week)
No Pain (n=425)	72	2111	Reference	Reference
Lower Intermittent Pain (n=290)	76	2122	4 (−11, 19)	11 (−62, 84)
Higher Intermittent Pain (n=449)	58	2141	−14 (−28, 0)	30 (−39, 99)
Any Constant Pain (n=199)	52	2106	−19 (−39, 1)	−5 (−101, 92)
***P* for trend**	**0.029**	0.814	-	-

[a]Adjusted for age, sex, race, education, obesity, high depressive symptoms, comorbidity, knee OA presence

Table 3

Adjusted[a] Medians and Differences (95% CI) of Average Weekly Physical Activity by Intermittent/Constant Knee Pain Groups among Adults with Knee OA (n=1348)

	Adjusted[a] Physical Activity Median Time		Adjusted[a] Difference (95% CI) in Physical Activity Medians Compared to No Pain	
	Moderate Intensity Activity (minutes/ week)	**Light Intensity Activity (minutes/ week)**	**Moderate Intensity Activity (minutes/week)**	**Light Intensity Activity (minutes/week)**
No Pain (n=425)	66	2089	Reference	Reference
Lower Intermittent Pain (n=290)	70	2071	4 (−15, 23)	−19 (−114, 77)
Higher Intermittent Pain (n=449)	53	2111	−13 (−30, 4)	28 (−58, 114)
Any Constant Pain (n=199)	46	2024	−20 (−42, 3)	−59 (−171, 54)
***P* for trend**	**0.039**	0.833	-	-

[a]Adjusted for age, sex, race, education, obesity, high depressive symptoms, comorbidity, knee OA presence