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ORIGINAL ARTICLE

Disease-specific pain and function predict future pain impact in hip and knee osteoarthritis

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Abstract The objective of this study is to determine if osteoarthritis (OA) pain and function, persistent low back pain (LBP) and psychosocial factors predict future pain impact (PI) in people with hip and knee OA. In a population-based cohort with hip/knee OA, a standardized telephone questionnaire was used to assess baseline sociodemographics, baseline PI, patient-reported OA severity (Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) summary score), psychosocial factors (fatigue, pain catastrophizing (PC), anxiety, social network, and depression), and self-reported persistent LBP. Two years post-baseline, PI was assessed using the Pain Impact Questionnaire. The association of key independent variables with PI was evaluated through multivariable linear regression, adjusting for covariates (e.g., age, sex, baseline PI, etc.) In 462 participants, the mean age was 76 years (range 58 to 96), 78 % were female and 35 % reported LBP at baseline. Mean scores for PC (9.4), and anxiety (3.7) were low and social network (20.1) high. In multivariable regression analyses, only the WOMAC summary score (unstandardized ß 0.181 95% CI (0.12, 0.24) $p < 0.001$) was independently associated with greater PI at follow-up. In a population-based cohort with hip/knee OA, only the baseline WOMAC summary score was an independent predictor of future PI. This suggests that treatment needs to be focused on limiting pain severity and functional limitations in individuals with hip and knee OA. However, scores for the psychosocial factors are indicative of a healthy cohort and therefore results may not be generalizable to those with poorer psychosocial health.

Keywords Knee osteoarthritis · Low back pain · Psychosocial · WOMAC

Introduction

Osteoarthritis (OA) is one of the most prevalent musculoskeletal diseases and has a significant impact on disability worldwide [1, 2]. OA most commonly affects the hip or knee joints [3]. The effect of hip and knee OA on function and pain with daily activities is typically assessed with patient-reported disease-specific measures such as the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) [4], the Knee Osteoarthritis Outcomes Scale [5] or the Hip

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Osteoarthritis Outcomes Scale [6]. However, the biopsychosocial model views disease as a complex interaction of biological, psychological, and social factors and is the most widely accepted perspective to the understanding and treatment of chronic pain [7]. Recently, the American Pain Society highlighted the need to measure pain impact by calling for the assessment of biopsychosocial processes and risk determinants that contribute to chronic pain conditions [8].

With its agenda for future pain research, the American Pain Society has drawn attention to the importance of measuring pain impact [8]. Evidence demonstrates that pain is a complex construct that is associated with poor quality of life, depression, disturbed sleep, functional disability, as well as reduced capacity to work [9, 10]. Therefore, assessing the impact of pain on patients' lives is advantageous as it may represent a broader concept than OA-related pain and function, one that is more representative of the biopsychosocial model.

Both psychological factors (e.g., depression, anxiety, pain catastrophizing) and low back pain (LBP) have been shown to contribute to the reported severity of pain and limitation of function in people with OA [11–15]. However, less is known about the effect of these factors on future pain impact, which considers pain severity, and the impact of chronic pain on work and leisure activities, as well as on emotional well-being [16]. This differs from the commonly used disease-specific measures such as the WOMAC that focus on the effect of pain on function [4]. Wolfe [12] reported that in people with hip/knee OA, pain severity and functional limitations, measured by the WOMAC, were worse by about 65 % in those with LBP as compared to those without LBP. Additionally, studies have found LBP to be a significant predictor of pain severity and functional limitations as measured by the WOMAC for both hip and knee OA [11, 12]. Further, Bollegala et al. [17] showed that having LBP *and* arthritis (defined broadly as arthritis or rheumatism) had a greater impact on health status (self-rated health, self-rated mental health, and visits to the family doctor) than either condition alone.

Psychological factors such as depression, anxiety, and pain catastrophizing have been reported to be associated with greater pain and disability in people with hip and knee OA [14, 15], and they are also predictors of pain and function after hip or knee total arthroplasty [18]. Cruz-Almeida et al. [19] reported that distinct psychological profiles exist in people with knee OA, and that aspects such as depression and negative affect are directly related to OA pain and function, whereas optimism has an inverse relationship. In a review by Keefe and Somer of arthritis populations, the authors highlight the impact that emotional, cognitive, and social factors have on pain and function and the need to adequately address them [20]. However, what is unknown is what effect psychosocial factors have on the broader concept of pain impact, one that encompasses self-reported health, psychological and social elements, in people with hip and knee OA.

Therefore, the purpose of this study was to determine the effects of patient-reported OA pain and function, persistent LBP and psychosocial factors on future pain impact in a population cohort of people with hip and/or knee OA. We hypothesized that (1) those with higher OA-related pain and disability, (2) those with persistent LBP, and (3) those with greater psychosocial distress would have higher pain impact.

Materials and methods

Study design and participants

This study is a secondary analysis of longitudinal data from a prospective population-based cohort study conducted in two regions of Ontario, Canada, one rural and one urban. The details of recruitment have been previously published [21]. In short, the participants were recruited between 1996 and 1998 after screening 100 % of the population 55 years of age and older in these two regions. Participants were included if they (1) reported difficulty in the last 3 months with each of the following: stair climbing, rising from a chair, standing, and walking; (2) had swelling, pain, or stiffness in any joint lasting at least 6 weeks; and (3) indicated on a diagram that a hip or knee had been "troublesome" resulting in an initial cohort of $n = 2411$. A validation study found that 96 % of those who met these screening criteria had clinical signs of hip and/or knee arthritis on examination; 86.4 % had stress pain on range of motion and a Kellgren and Lawrence radiographic grade of ≥2 in one or more hips or knees indicating OA. Follow-up has been conducted by standardized telephone interview at least annually since inception. The current study utilized data collected in 2006 ($n = 834$) (hereafter "baseline") and 2008 (follow-up). We excluded participants who were identified as having inflammatory arthritis ($n = 1$), who had undergone a total joint replacement at baseline ($n = 357$), or who had no current complaints of hip or knee pain on questionnaires completed in 2006 ($n = 14$), resulting in an analyzable sample of 462 individuals. Ethical approval for the original study was obtained from the Women's College Hospital Research Ethics Board, Toronto, Canada, performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. All subjects gave informed consent to participate in the study.

Measures

Outcome

The primary outcome was pain impact measured by the Pain Impact Questionnaire 6™ [16] (PIQ6™) at follow-up assessment (2 years). The PIQ6™ is a six-item patient-reported measure which asks subjects about the impact of pain during

the past 4 weeks. Items inquire about (1) the severity of bodily pain, (2) the degree of pain interference on work and (3) frequency of pain interference on enjoyment of life, (4) the frequency with which pain made simple tasks hard or (5) affected leisure activities, and lastly (6) the frequency that the pain elicited feelings of frustration. Items are scored on a 5-point scale with higher scores representing greater severity, or frequency. Scores are calibrated and presented as T-scores (mean = 50, 1 standard deviation = 10 above or below). Higher scores indicate greater pain impact. The measure is internally consistent (Cronbach's alpha = 0.94) and has demonstrated construct validity [16]. Convergent validity has been shown through association with the visual analog and numeric pain rating scales (r = 0.81–0.84) [16]. Discriminant validity has been demonstrated with the Shortform-8 Health Survey Physical and Mental summary scores (r = −0.77; r = −0.32, respectively) as well as statistically significant mean score differences between people in the general population, those with chronic pain, and in those with self-reported health conditions [16].

Independent variables of interest

Psychosocial measures All other variables were evaluated at the baseline assessment. The participants' catastrophizing thoughts and behaviors were assessed using the patient-reported Pain Catastrophizing Scale [22], a valid and reliable unidimensional scale comprised of 13 items in 3 domains: rumination, magnification, and helplessness [23, 24]. Items are scored on a scale from 1 to 4 indicative of the degree to which the subject experiences the behavior when he/she is in pain [23]. The score ranges from 0 to 52 with higher scores indicating greater pain catastrophizing. Depression was evaluated with The Center for Epidemiologic Studies Depression Scale (CES-D), a 20-item patient-reported measure rating the frequency of depressive symptoms during the past week [25]. Responses range from 0 (rarely or none of the time; less than 1 day) to 3 (most or all of the time; 5–7 days). The maximal total score is 60 with a score of 16 or more indicative of depressive symptoms [25]. The CES-D has been used in community settings to identify depression in the elderly as well as in individuals with significant comorbid medical illnesses [26]. The Profile of Mood States fatigue scale is patient-reported and evaluates the degree to which one has felt worn out, fatigued, exhausted, sluggish, and weary in the past week (0 = not at all; 4 = extremely) [27]. Total possible score is 20 with higher scores indicating higher levels of fatigue. Fatigue has been associated with psychosocial factors such as depression and stressful life events [12, 28, 29]. The scale has shown good internal consistency and single-factor structure [30]. Anxiety was measured by the reliable and valid Hospital Anxiety and Depression anxiety subscale [31], which includes seven self-report items designed for populations with medical illness. Responses are scored on a scale of 0–3 with three indicating higher frequency of symptoms experienced in the past week. The maximum total score is 21 with higher scores indicating higher levels of anxiety [31]. Social support was assessed with the patient-reported Lubben Social Network Scale 6 item version [32], which assesses the strength of family and friendship networks by inquiring about the number of people in each category, family or friends, that one communicates with regularly, feels at ease with, and can ask for help. Items are scored from 0 (none) to 5 (nine or more) with higher numbers indicating greater social network support. Scores range from 0 to 30 with lower scores indicating greater social isolation [32]. Developed specifically for older populations, it has shown reliability and validity across national samples [32].

Self-reported health history variables Persistent LBP was measured based on self-reported physician diagnosis and treatment for LBP in the past year. Severity of pain and disability of hip and knee OA was measured by the reliable and valid Western Ontario and McMaster osteoarthritis index (WOMAC) [4]. The index is comprised of 24 items in 3 domains: pain (5 items), functional limitations (17 items), and stiffness (2 items). Higher scores indicate greater symptoms and disability with scores ranging from 0 to 96 [4].

Covariates Demographic variables collected included age in years, sex, marital status, and level of education. Body mass index (BMI) was calculated from self-reported height and weight. Pain impact was also measured at baseline using the PIQ6™ [16]. Participants were asked to report if in the past year they had ever received a physician diagnosis and had received treatment for the following conditions: persistent LBP, lung problems, high blood pressure, heart problems (angina, heart attack, heart failure), atherosclerosis, stomach ulcer, kidney disease/failure, cancer, major paralysis, or neurologic problems, such as stroke, multiple sclerosis, muscular dystrophy, diabetes, osteoporosis, depression or other major mental illnesses, liver disease, or other trauma. The number of comorbidities was calculated [33] excluding persistent LBP. Participants were asked to indicate which joints were troublesome (painful, aching, swollen, or stiff) in the past week and the number summed to indicate multijoint pain. The location of OA, (i.e., hip, knee, or both) was self-reported based on identification on a joint homunculus.

Analyses Descriptive statistics were examined for each variable. Validated measures for the key independent variables were assessed for collinearity with Pearson's correlation coefficient. Multivariable linear regression was performed for each of the independent variables of interest—total WOMAC score, persistent LBP, and psychosocial variables (anxiety, depression, fatigue, pain catastrophizing, social network)—and the dependent variable of future pain impact with

adjustment for covariates. Missing data averaged 15 % across the independent variables. We conducted analyses with multiple imputation and report these results. Models of multiple regression make several assumptions regarding the normality of the data being used. Diagnostics of the regression models, including those for collinearity, were conducted to assess for severe violations of these assumptions. All analyses were conducted using the Statistical Package for the Social Sciences (v.22 IBM, Chicago Ill.)

Results

The mean age of the 462 participants was 76 years (range 58 to 96) and most were female (77 %). Approximately one third (35 %) reported persistent LBP and 53 % reported both hip and knee OA (see Table 1). The mean BMI was 27.8 kg/m^2 and the mean WOMAC score was 45.6. Means for the psychosocial variables were pain catastrophizing 9.4, depression 11.5, anxiety 3.7, fatigue 11.7, and social network 20.1.

Collinearity of validated measures

Table 2 presents Pearson's correlations for the key independent variables. Since the CES-D was moderately and significantly correlated with anxiety, fatigue, and pain catastrophizing, we chose to remove it from the multivariable linear regression analysis.

Table 1 Baseline characteristics $n = 462$

	N (%)
Married ($n = 462$)	196 (42.4)
Female ($n = 462$)	358 (77.5)
Education (*$n = 356$) high school or less	271 (58.7)
Hip pain only (*$n = 398$)	27 (5.8)
Knee pain only (*$n = 398$)	125 (27.1)
Hip and knee pain (*$n = 398$)	246 (53.2)
Low back pain (*$n = 414$)	166 (34.9)
	Mean (SD)
Pain catastrophizing scale score 0–52 (*$n = 401$)	9.4 (10.7)
CES-D score 0–60 (*$n = 401$)	11.5 (8.5)
HADS anxiety score 0–21 (*$n = 401$)	3.7 (2.7)
POMS fatigue, score 0–20 (*$n = 401$)	11.7 (5.6)
†Lubben Social Network Scale score 0–30 (*$n = 401$)	20.1 (7.5)
Age in years (*$n = 401$)	76.3 (7.1)
BMI (*$n = 391$)	27.8 (5.1)
Total WOMAC score 0–96 (*$n = 398$)	45.6 (19.0)
Comorbidity total score 0–14 (*$n = 401$)	1.9 (1.3)
Multijoint pain count score 1–21 (*$n = 401$)	8.4 (4.4)
Pain impact (*$n = 375$)	59.3 (8.3)

*where n is less than total sample of 462, missing data were present

†Lower social score indicates smaller social network

Multivariable linear regression

In the fully adjusted model assessing for the effects of OA pain and function (WOMAC summary score), persistent LBP, and psychosocial factors, only the WOMAC summary score (unstandardized ß 0.181 (0.12, 0.24) $p < 0.001$) was significant, explaining ~31 % of the variance (partial r) in follow-up pain impact (see Table 3). This means that for every one-point increase in total WOMAC score, a person's pain impact score would increase by approximately 0.18 controlling for all other variables. Diagnostic tests of the assumptions of normality were negative, including those for collinearity (variance inflation factor <3 and tolerance >0.40), indicating that the results are trustworthy.

Discussion

In this cohort with hip/knee OA, people with higher WOMAC summary scores experienced greater pain impact at 2-year follow-up. Neither persistent LBP nor any of the psychosocial factors were predictive of future pain impact. To our knowledge, this is the first time that pain impact, as measured by the PIQ6™, has been used in this population making comparison with the literature difficult. Its use as a primary outcome is in line with the recent agenda for future pain research as outlined by the American Pain Society [8].

The value of measuring pain impact lies in the ability to better represent how pain affects individuals living with chronic pain conditions such as hip/knee OA. A concept representative of the biospychosocial model, pain impact allows for the capture of a different and broader construct than commonly used disease-specific measures such as the WOMAC that largely focus on functional limitations and to a lesser degree, pain intensity on specified activities. According to the IMMPACT consensus group recommendations of core domains to be measured in chronic pain clinical trials [34], it would appear that the PIQ6™ addresses several of the criteria (pain intensity, temporality, emotional, and physical function). Measuring the association of other known risk factors with pain impact in future studies may provide deeper understanding of why pain becomes recalcitrant and interferes in the lives of some, but not for all people with hip and knee OA [35].

The pain experience of people with hip/knee OA has been well documented in qualitative studies, which highlight among other things, the impact of pain on function [36–38]. A recent systematic review of the lived experience of people with OA reported the severity of symptoms and the impact of the symptoms on functional capability as two of the most important effects [39]. Based on these experiential reports, it

Table 2 Pearson's correlations of key independent measures (n = 462)

	WOMAC total	CES-D depression	HADS anxiety	POMS fatigue	Lubben Social Network	Pain catastrophizing
WOMAC total	—	—	—	—	—	—
CES-D depression	.545**	—	—	—	—	—
HADS anxiety	.267**	.711**	—	—	—	—
POMS fatigue	.544**	.613**	.374**	—	—	—
Lubben Social Network	−.339**	−.360**	−.216**	−.237	—	—
Pain catastrophizing	.641**	.647**	.380**	.496**	−.382**	—

**$p \leq 0.01$

is not surprising that our first hypothesis was supported given that the WOMAC summary score is largely representative of function and pain-related activity. The WOMAC and the PIQ6™ account for pain severity and activity-related pain. It is known that current pain often predicts future pain status [40–42]. However, qualitative studies provide several factors beyond pain intensity and activity-related pain to consider when determining pain impact [36–38]. Previous reports have demonstrated that complex relationships exist between fatigue, depression, disability, and future pain [33]. We cannot rule out that such complexity may exist in determining pain impact. Given this was an initial analysis using the PIQ6™, we did not investigate mediating or moderating relationships. However, analyses of causal relationships could be a line of questioning for future studies.

Additionally, this cohort was older (mean age 76 years (range 58 to 96)) and there are specific guidelines regarding pain assessment and management for older persons [43–45]. The impact of pain on older persons includes decreases in muscle strength and balance, increases in physical frailty, emotional distress, and activity avoidance [45]. Interestingly, it has been studies of older adults with OA that have been the most informative regarding the pain-function relationship in this population, indicating that there is a high prevalence of OA-related pain, decreased function associated with pain, which in turn predicts disability, and that psychological factors have an important mediating role on both pain and function [45]. Our results appear to concur with the points regarding pain and function, but we found no effect of the psychological factors. This may be due to low prevalence of the constructs we investigated indicating a relatively healthy cohort or limited validity of the PIQ-6™ to detect these constructs. Recommended management of pain in older adults includes pharmacologic, psychological interventions, as well exercise and use of assistive devices [44]. These are principles shared by current guidelines for the management of hip and knee OA [46, 47].

Table 3 Multivariable regression results predicting future pain impact

Variable	Adjusted unstandardized beta	P value	Partial r
WOMAC total	0.181 (0.12, 0.24)	<0.001	0.309
Anxiety	0.106 (−0.21, 0.42)	0.508	0.037
Fatigue	0.056 (−0.12, 0.23)	0.524	0.035
Social network	−0.036 (−0.15, 0.07)	0.526	-0.035
Pain catastrophizing	0.073 (−0.03, 0.18)	0.163	0.076
Persistent LBP	0.602 (−0.99, 2.20)	0.461	0.041

Adjusted for multijoint pain, comorbidities, baseline pain impact, BMI, education, marital status, age, gender, and symptomatic joints (hip, knee, hip/knee)

The lack of support for our second hypothesis regarding the effect of LBP on pain impact may broadly be related to aspects of measurement. Muraki et al. [48] reported similar findings using the outcome of quality of life. The authors examined the association of LBP only, knee pain only, having both conditions or neither condition with quality of life in Japanese men and reported no significant differences in any domains between subjects with both LBP and knee pain compared to those with LBP or knee pain only [48]. While quality of life may not capture the same construct as pain impact, our results in combination with Muraki's may infer that the effect of LBP may be limited to the experience of pain and disability as an outcome. Alternatively, another reason may be related to the fact that the items in the WOMAC are very similar to those found in scales for LBP, e.g., Oswestry Disability Index or the Roland Morris Disability Questionnaire [49]. If the WOMAC cannot measure LBP as a separate concept from hip or knee pain, adding an indicator variable for LBP would therefore not add any additional explained variance to the outcome of pain impact. The potential exists for future studies of people with LBP or hip and knee pain to explore the validity of these separate measures in these populations to determine if they can discriminate among those with LBP, hip or knee pain.

Similarly, measurement issues may also account for why we found no significant relationship between psychosocial factors and future pain impact. To our knowledge this is the first study to use the generic PIQ6™ for the measurement of pain impact in people with hip and knee OA, and its validity in

this population is unknown. The body of existing qualitative work in people with OA describes OA as negatively affecting mood, mental health (anxiety and depression), sleep, and participation in social and recreational activities [39]. Loss of identity, social stigma, and isolation have also been highlighted [39]. The scores for pain catastrophizing and anxiety were low and those for social networks high, perhaps indicative of a relatively healthier cohort that may limit the ability to detect an effect of these variables. Associations of these variables to pain intensity/pain experience in people with chronic pain conditions have been widely reported. In the absence of other studies for comparison, it is difficult to know if the lack of association of these variables with pain impact is due to their low prevalence in this cohort or if the PIQ6™ is limited in its validity to detect these constructs. In a validation study of the PIQ-6™ [16], correlation with the mental component summary score of the SF-8™ Health Survey indicated discriminant validity ($r = -0.32$). However, this may also indicate a lack of sensitivity to detect these measures and suggest that our results may not be generalizable to those in poorer health. While the PIQ6™ addresses pain interference of enjoyment of life and feeling fed up and frustrated, in terms of face validity, it does not appear to account for several other concepts highlighted in the qualitative studies (sleep, social stigma, isolation, or loss of identity). Validation of the PIQ6™ in this population in future studies is therefore warranted.

The strengths of our study include its use of a population-based cohort of people with symptomatic hip and knee OA making the results more generalizable than clinical cohorts. Limitations include that our sample was of people with chronic symptomatic hip/knee OA; thus, our results may not be generalizable to those in earlier stages of the disease. We were also unable to measure other potentially important psychosocial constructs such as pain-related fear, which has explained significant variability in function in this population [15]. The measurement of LBP was based on self-report and may have resulted in misclassification, as a small percentage of people may have had radicular pain and been unable to correctly attribute it to the back. Additionally, we did not measure the intensity/severity of LBP, and this may matter when considering pain impact. The effects of other forms of arthritis and widespread pain were part of the list of comorbidities and therefore were not adjusted for separately.

In conclusion, this study examined the use of a novel outcome measure in hip and knee OA, which is that of pain impact. Pain impact was chosen to study as it may capture more broadly the effects of the condition not only on disability, but also on psychosocial aspects, and is therefore more representative of the biopsychosocial model than measures of only pain or disability. In this cohort of older adults with hip and knee OA, the PIQ6™ scores (mean = 59 range 40–78/100) suggest that the impact of pain were similar to values found in the PIQ6™ validation study in adults with OA in the USA [16]. Our results indicate that OA-related pain and functional limitations as measured by the WOMAC summary score, but not persistent, LBP and psychosocial factors in people with hip/knee OA are associated with future pain impact. However, scores for the psychosocial factors indicate that this was a healthy cohort, and we therefore cannot rule out that these results may not be generalizable to those with poorer psychosocial health. These results suggest that in older adults with hip and knee OA that treatment be focused on limiting pain severity and functional limitations. The use of the PIQ6™ to measure pain impact may provide an opportunity for future studies to broaden the lens of how OA affects individuals beyond pain and function. However, a generic pain impact measure may not adequately reflect the challenges expressed by people living with OA.

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Compliance with ethical standards

Disclosures None.

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