



## Factors associated with pain intensity and magnitude of limitations among people with hip and knee arthritis<sup>☆</sup>

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### ABSTRACT

**Background:** The pain and limitations associated with osteoarthritis of the hip and knee have a notable variation that does not correspond directly with pathophysiology. The purpose of this study is to assess the influence of location of the arthritis on pain intensity and magnitude of limitations accounting for personal and psychological factors.

**Methods:** One hundred and fifty four patients with osteoarthritis of the hip (41 patients) or the knee (113 patients) were enrolled in this prospective cross sectional cohort study. Patients answered questionnaires which included demographics, site of arthritis (hip or knee), laterality (unilateral or bilateral), pain intensity, Patient-Reported Outcomes Measurement Information System Physical Function Computer Adaptive Test (PROMIS PF CAT), and psychologic questionnaires including the Tampa Scale of Kinesiophobia (TSK-4), Pain Catastrophizing Scale (PCS-4), Generalized Anxiety Disorder (GAD-2) and Patient-Reported Outcomes Measurement Information System Depression Computer Adaptive Test (PROMIS Dep CAT). Kellgren-Lawrence classification was classified by the treating surgeon. Associations of these factors with pain and function were assessed using bivariate and multivariable regression models.

**Results:** In a multivariable model accounting for potential confounding, magnitude of limitations was independently associated with years of education, work status, time spent exercising, catastrophic thinking (PCS-4), and symptoms of depression. They accounted for 50% of variability in physical function, with the major contributor being catastrophic thinking. The model for pain intensity included time spent exercising and fear of painful movement (TSK-4). Anatomic site and radiographic severity of arthritis were not associated with either physical function or pain in our patient sample.

**Conclusions:** This study confirms that limitations and pain from osteoarthritis of the hip and knee are more closely related to personal and psychological factors, less effective cognitive coping strategies such as catastrophic thinking and kinesiophobia in particular, than to pathological and anatomical factors such as location and severity of arthritis. Care that incorporates incremental correction of common misconceptions that accompany the nociception from osteoarthritis have the potential to improve function and comfort in people with osteoarthritis.

**Level of Evidence:** Prognostic Level II.

### 1. Introduction

Osteoarthritis of the hip and knee is associated with variable symptom intensity and magnitude of limitations. Many patients mention it to their primary doctor, some seek specialty care, and a subset choose arthroplasty. Over 1 million hip and knee arthroplasty procedures are

performed in the United States annually, a number that is projected to continue to grow as the population ages.<sup>1</sup> While these procedures can improve function and quality of life in a manner that seems cost effective,<sup>2</sup> they are associated with notable persistent symptoms and limitations that lead as many as 1 in 5 people to categorize themselves as dissatisfied after total knee arthroplasty.<sup>3</sup>

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It is increasingly noted that the variation in symptoms and limitations related to arthritis are not well accounted for by measures of pathophysiology such as radiographic severity, alignment, and motion.<sup>4</sup> After arthroplasty, the variation in symptoms, limitations, and satisfaction are not well accounted for by technical factors such as implant alignment.<sup>5</sup> Mounting evidence documents that mental and social health account for much of the variation in symptoms and limitations. Less effective cognitive coping strategies such as fear of movement (kinesiophobia) and worst-case (or catastrophic) thinking are important.<sup>6–8</sup> Symptoms of anxiety and depression (psychological distress) also contribute.<sup>8</sup> Mindset and circumstances can contribute to a cycle of disuse and further avoidance of movement, leading to greater limitations and more intense pain.<sup>9</sup> A greater magnitude of kinesiophobia was associated with greater physical limitations in the immediate post-operative period after total knee arthroplasty.<sup>10</sup> Less is known about how these factors affect pain intensity and magnitude of physical limitations in patients with osteoarthritis of the hip and knee.

Studies that directly compared physical function of the hip and knee prior to surgery suggest that patients with hip arthritis have more limitations in physical function than those with knee arthritis.<sup>11,12</sup> These studies do not account for psychological distress (e.g. symptoms of depression) and less effective cognitive coping strategies (e.g. kinesiophobia, and catastrophic thinking) that are known to affect pain intensity and magnitude of physical limitations.

This study tested the primary null hypothesis that there are no factors associated with magnitude of limitations and pain intensity accounting for anatomic site of arthritis: knee or hip.

## 2. Materials and methods

After institutional review board approval for this prospective, cross-sectional, observational cohort study, we prospectively enrolled 155 adult patients between February 18 and September 27, 2019. Patients were seen by five different surgeons with subspecialty focus in arthroplasty at three orthopaedic surgery offices in a large urban area. We included both new and return patients aged 18–89 presenting with hip or knee pain. Patients with prior arthroplasty, combined hip and knee arthritis, or diagnosis other than arthritis as source of hip or knee pain were excluded. Research assistants who were not involved with patient care met with patients after their visit and described the nature of the study to participants. Completion of the surveys represented informed consent.

At the end of the visit patients completed a series of seven questionnaires<sup>1</sup>: demographics including sex, race, 9-digit zip code, marital status, level of education, work status, time spent exercising weekly, insurance status, weight, and height<sup>2</sup>; disease specific information including anatomic location (hip or knee), duration of symptoms, and whether pain is unilateral or bilateral<sup>3</sup>; Tampa Scale of Kinesiophobia Short Form (TSK-4)<sup>4</sup>; Pain Catastrophizing Scale (PCS-4)<sup>5</sup>; Generalized Anxiety Disorder 2-Item (GAD-2)<sup>6</sup>; Pain intensity on numeric rating scale from 0–10<sup>6</sup> the Patient- Reported Outcomes Measurement Information System (PROMIS) Physical Function (PF) Computer Adaptive Test (CAT)<sup>7</sup>; the Patient- Reported Outcomes Measurement Information System (PROMIS) Depression (Dep) Computer Adaptive Test (CAT).

After patients completed the surveys, the research assistant then recorded the diagnosis with the help of the surgeon and asked surgeon to assess Kellgren-Lawrence (KL) grade of arthritis from the patient's most recent x-ray.

The 9-digit zip code was used to determine the national percentile deprivation index using an online neighborhood atlas. MAP (medical assistance program) is a county-provided health insurance which provides coverage to low income individuals who do not qualify for other public healthcare programs. Higher values correspond with higher levels of socioeconomic deprivation.<sup>13</sup> The TSK-4 is a short form of the validated Tampa Scale of Kinesiophobia which uses 4 items each scored from 0 to 4 for a total score of 0–16 where higher score indicate more

fear of movement and reinjury.<sup>14</sup> The PCS-4 is a four-item measure with item scores from 0 “not at all” to 4 “all the time” and total scores ranging from 0 to 16 with higher scores representing more catastrophic thinking which is defined mis- or overinterpretation of nociception.<sup>15</sup> The GAD-2 is a two-item screening questionnaire scored from 0 to 6 which has been shown to accurately identify the condition in various patient cohorts.<sup>16</sup> Pain intensity was measured with an ordinal scale from 0 to 10 with anchor statements at 0 “No pain at all” and 10 “Worst pain possible”.<sup>17,18</sup> The PROMIS PF-CAT v2.0 is a validated instrument for measuring physical limitations. It is a computer adaptive test which uses item response theory to decrease question burden. It provides scores which are comparable to instruments based on classical test theory such as the HOOS, KOOS, and WOMAC and can be completed in as few as four questions.<sup>19–22</sup> It is scored as a continuous t-score with mean of 50 and standard deviation of 10 with higher scores indicating higher levels of physical function.<sup>18</sup> PROMIS Dep-CAT is a computer adaptive test which has been shown to correlate with other validated measurements of depression. It is scored on a continuous t-score which aims to have a mean of 50 and standard deviation of 50, although there have been floor effects associated with this instrument in orthopedic patients.<sup>23</sup>

All questionnaires were administered on an encrypted tablet through a secure, HIPAA-compliant electronic platform REDCap (Research Electronic Data Capture: a secure web-based application for building and managing online surveys and databases; Nashville, TN, USA).<sup>24</sup>

### 2.1. Statistical analysis

A priori power analysis analyses indicated that a sample of 135 subjects would provide 80% statistical power, with alpha set at 0.05, for a regression with seven predictors if one of the explanatory variables would account for 5% or more of the variability in magnitude of limitations, and our complete model would account for 15% of the overall variability. In order to account for 5% incomplete data, we aimed for a combined sample size of 142 patients.

A total of 154 patients were enrolled in the study. Four patients were excluded because they did not indicate whether their disease was unilateral or bilateral. Mean imputation was used to complete missing values for deprivation index ( $n = 16$ ) and K-L grade ( $n = 7$ ). Due to low numbers of patients in initial subgroups ( $n < 5$ ) for race, level of education, insurance status, and K-L grade, small subgroups were consolidated (Table 1).

More women presented for specialty care of knee pain (Table 1). Patients with knee arthritis had a higher average BMI, were more likely to be single, less likely to be non-Hispanic white, had less education, were less likely to have private insurance, and were more likely to live in areas with higher levels of socioeconomic deprivation. There was no significant difference in psychologic surveys, or K-L grade among people presenting with hip or knee arthritis.

We used the Student's t-test to compare continuous and dichotomous variables, Pearson correlation to compare two continuous variables, ANOVA (analysis of variance) to compare continuous and ordinal variables, and Chi square test for tow dichotomous variables.

We analyzed demographic information and PROM scores to compare patients with hip arthritis to those with knee arthritis.

We created two backward stepwise regression models to identify independent factors associated with associated with<sup>1</sup> physical function measured with PROMIS PF-CAT and<sup>2</sup> pain intensity on numeric rating scale. All factors with  $p < 0.10$  on bivariate analysis were included in the regression models (Table 3). We considered  $p < 0.05$  to be significant. Regression coefficient ( $\beta$ ) is the degree of change in an outcome variable for every SD of change in predictor variable with higher absolute value indicating stronger effect. Adjusted  $R^2$  indicates how much variability of the outcome variable is accounted for by the model. Semipartial  $R^2$  is a measure of the variability in the model which is accounted for by a specific independent variable.

**Table 1**  
Patient and clinical characteristics in Hip vs. Knee groups.

| Variables                                    | Hip (N = 40)              | Knee (N = 110)             | p value          |
|--|---------------------------|----------------------------|------------------|
| <b>Sex</b>                                   |                           |                            | <b>&lt;0.001</b> |
| Females                                      | 17 (42)                   | 83 (75)                    |                  |
| Males  | 23 (58)                   | 27 (25)                    |                  |
| <b>BMI</b>                                   | 30.7 ± 9.2<br>(18.5–61.1) | 36.8 ± 10.6<br>(21.8–74.2) | <b>&lt;0.001</b> |
| <b>Duration of Symptoms (Weeks)</b>          | 299.0 ± 716<br>(2–4000)   | 272.1 ± 351.2<br>(1–2000)  | 0.760            |
| <b>Unilateral vs. Bilateral</b>              |                           |                            | <b>&lt;0.001</b> |
| Unilateral                                   | 29 (73)                   | 48 (44)                    |                  |
| Bilateral                                    | 11 (27)                   | 62 (56)                    |                  |
| <b>Marital Status</b>                        |                           |                            | <b>0.015</b>     |
| Divorced                                     | 9 (22)                    | 18 (16)                    |                  |
| Married                                      | 23 (58)                   | 38 (35)                    |                  |
| Single                                       | 6 (15)                    | 43 (39)                    |                  |
| Widowed                                      | 2 (5)                     | 11 (10)                    |                  |
| <b>Race/Ethnicity</b>                        |                           |                            | <b>&lt;0.001</b> |
| White/Non-Hispanic                           | 28 (70)                   | 46 (42)                    |                  |
| Hispanic                                     | 5 (13)                    | 31 (28)                    |                  |
| Other  | 7 (17)                    | 33 (30)                    |                  |
| <b>Level of Education</b>                    |                           |                            | <b>0.023</b>     |
| High School Diploma or Less                  | 15 (38)                   | 59 (54)                    |                  |
| 2-year College                               | 5 (12)                    | 23 (20)                    |                  |
| 4-year College                               | 13 (32)                   | 14 (13)                    |                  |
| Post-College Graduate Degree                 | 7 (18)                    | 14 (13)                    |                  |
| <b>Work Status</b>                           |                           |                            | 0.143            |
| Employed                                     | 18 (44)                   | 29 (26)                    |                  |
| Out of Work                                  | 5 (13)                    | 12 (11)                    |                  |
| Unable to Work                               | 10 (25)                   | 39 (36)                    |                  |
| Other (Homemaker, student, retired)          | 7 (18)                    | 30 (27)                    |                  |
| <b>Time Spent Exercising Weekly</b>          |                           |                            | 0.428            |
| <2 Hours                                     | 20 (50)                   | 63 (57)                    |                  |
| >2 Hours                                     | 20 (50)                   | 47 (43)                    |                  |
| <b>Insurance Status</b>                      |                           |                            | <b>&lt;0.001</b> |
| Public                                       | 15 (38)                   | 40 (36)                    |                  |
| Private                                      | 14 (35)                   | 16 (15)                    |                  |
| MAP CCC                                      | 11 (27)                   | 54 (49)                    |                  |
| <b>Deprivation Index National Percentile</b> | 36.8 ± 23.1<br>(1–87)     | 46.6 ± 23.0<br>(1–97)      | <b>0.022</b>     |
| <b>TSK-4</b>                                 | 6.4 ± 2.5 (2–12)          | 6.8 ± 3.0 (0–12)           | 0.499            |
| <b>PCS-4</b>                                 | 8.6 ± 4.6 (0–16)          | 9.7 ± 4.9 (0–16)           | 0.209            |
| <b>GAD-2</b>                                 | 1.8 ± 2.3 (0–6)           | 2.2 ± 2.3 (0–6)            | 0.303            |
| <b>Pain Intensity</b>                        | 6.0 ± 2.9 (1–10)          | 6.6 ± 2.5 (0–10)           | 0.182            |
| <b>PROMIS PF-CAT</b>                         | 37.2 ± 7.6<br>(19–48)     | 36.7 ± 7.8<br>(19–67)      | 0.694            |
| <b>PROMIS Dep-CAT</b>                        | 51.3 ± 11.4<br>(34–77)    | 51.4 ± 11.3<br>(34–77)     | 0.968            |
| <b>Kellgren-Lawrence Grade</b>               |                           |                            | 0.595            |
| 0–2  | 11 (28)                   | 38 (35)                    |                  |
| 3  | 11 (28)                   | 32 (29)                    |                  |
| 4  | 18 (44)                   | 40 (36)                    |                  |

**Table 1:** Continuous variables as mean ± standard deviation (range); Discrete variables as number (percentage); Bold = p value significant at < 0.05; TSK-4 = Tampa Scale of Kinesiophobia; PCS-4 = Pain Catastrophizing scale; GAD-2 = Generalized Anxiety Disorder; Pain Intensity = Pain on Numerical Rating Scale Pain 0–10; MAP CCC = Medical Access Program Community Care Clinic, county-provided insurance for low income individuals; PROMIS PF-CAT = Patient-Reported Outcomes Measurement Information System Physical Function - Computer Adaptive Test; PROMIS Dep-CAT = Patient-Reported Outcomes Measurement Information System Depression - Computer Adaptive Test.

### 3. Results

In bivariate analysis, higher levels of physical function measured on the PROMIS PF-CAT were associated with lower BMI, unilateral symptoms, being married or widowed, more years of education, being employed or other work status such as homemaker, student, or retired, exercising over 2 h per week, and private insurance. All psychologic assessments including TSK-4, PCS-4, GAD-2, and PROMIS Dep-CAT were

**Table 2**  
Bivariate analyses of factors associated with PROMIS PF-CAT and Pain intensity.

| Variables  | PROMIS PF-CAT | P value          | Pain intensity | P value          |
|--|---------------|------------------|----------------|------------------|
| <b>Sex</b>                                       |               | 0.708            |                | 0.081            |
| Females  | 36.6 ± 7.0    |                  | 6.7 ± 2.4      |                  |
| Males  | 37.1 ± 9.2    |                  | 5.9 ± 3.1      |                  |
| <b>Location</b>                                  |               | 0.694            |                | 0.182            |
| Hip  | 37.2 ± 7.6    |                  | 6.0 ± 2.9      |                  |
| Knee   | 36.7 ± 7.8    |                  | 6.6 ± 2.5      |                  |
| <b>BMI (r)</b>                                   | −0.309        | <b>&lt;0.001</b> | 0.293          | <b>&lt;0.001</b> |
| <b>Duration of Symptoms (Weeks) (r)</b>          | −0.005        | 0.956            | 0.109          | 0.183            |
| <b>Unilateral vs. Bilateral</b>                  |               | <b>&lt;0.001</b> |                | <b>0.048</b>     |
| Unilateral                                       | 38.5 ± 8.3    |                  | 6.9 ± 2.2      |                  |
| Bilateral  | 35.0 ± 6.7    |                  | 6.0 ± 2.9      |                  |
| <b>Marital Status</b>                            |               | <b>&lt;0.001</b> |                | <b>&lt;0.001</b> |
| Divorced   | 35.0 ± 6.9    |                  | 6.4 ± 2.7      |                  |
| Married  | 38.9 ± 7.9    |                  | 5.4 ± 2.9      |                  |
| Single   | 34.3 ± 7.2    |                  | 7.7 ± 1.5      |                  |
| Widowed  | 40.2 ± 7.2    |                  | 6.7 ± 3.0      |                  |
| <b>Race/Ethnicity</b>                            |               | 0.300            |                | <b>&lt;0.001</b> |
| White/Non-Hispanic                               | 37.8 ± 7.4    |                  | 5.5 ± 2.6      |                  |
| Hispanic   | 36.3 ± 9.5    |                  | 7.3 ± 2.3      |                  |
| Other  | 35.5 ± 6.8    |                  | 7.6 ± 2.3      |                  |
| <b>Level of Education</b>                        |               | <b>&lt;0.001</b> |                | <b>&lt;0.001</b> |
| High School Diploma or Less                      | 35.2 ± 7.1    |                  | 7.6 ± 2.0      |                  |
| 2-year College                                   | 35.4 ± 6.4    |                  | 5.9 ± 2.4      |                  |
| 4-year College                                   | 38.1 ± 7.8    |                  | 6.1 ± 2.5      |                  |
| Post-College Graduate Degree                     | 42.6 ± 8.8    |                  | 3.8 ± 2.9      |                  |
| <b>Work Status</b>                               |               | <b>&lt;0.001</b> |                | <b>&lt;0.001</b> |
| Employed   | 39.9 ± 7.4    |                  | 5.3 ± 2.7      |                  |
| Out of Work                                      | 34.2 ± 6.1    |                  | 7.4 ± 1.5      |                  |
| Unable to Work                                   | 32.7 ± 5.8    |                  | 7.7 ± 1.8      |                  |
| Other (Homemaker, student, retired)              | 39.5 ± 8.4    |                  | 5.9 ± 3.1      |                  |
| <b>Time Spent Exercising Weekly</b>              |               | <b>&lt;0.001</b> |                | <b>&lt;0.001</b> |
| <2 Hours   | 34.3 ± 7.0    |                  | 7.4 ± 2.0      |                  |
| >2 Hours   | 39.9 ± 7.6    |                  | 5.3 ± 2.9      |                  |
| <b>Insurance Status</b>                          |               | <b>&lt;0.001</b> |                | <b>&lt;0.001</b> |
| Public   | 37.3 ± 7.4    |                  | 6.4 ± 2.9      |                  |
| Private  | 40.7 ± 8.9    |                  | 4.6 ± 2.9      |                  |
| MAP  | 34.6 ± 6.7    |                  | 7.4 ± 1.6      |                  |
| <b>Deprivation Index National Percentile (r)</b> | −0.116        | 0.157            | 0.27           | <b>&lt;0.001</b> |
| <b>TSK-4 (r)</b>                                 | −0.390        | <b>&lt;0.001</b> | 0.375          | <b>&lt;0.001</b> |
| <b>PCS-4 (r)</b>                                 | −0.639        | <b>&lt;0.001</b> | 0.572          | <b>&lt;0.001</b> |
| <b>GAD-2 (r)</b>                                 | −0.488        | <b>&lt;0.001</b> | 0.472          | <b>&lt;0.001</b> |
| <b>PROMIS Dep-CAT (r)</b>                        | −0.475        | <b>&lt;0.001</b> | 0.349          | <b>&lt;0.001</b> |
| <b>Kellgren-Lawrence Grade</b>                   |               | 0.205            |                | 0.529            |
| 0–2  | 38.2 ± 7.5    |                  | 6.1 ± 2.8      |                  |
| 3  | 37.0 ± 6.7    |                  | 6.4 ± 2.8      |                  |
| 4  | 35.5 ± 8.5    |                  | 6.7 ± 2.3      |                  |

**Table 2:** Continuous variables as mean ± standard deviation (range); Pearson correlation indicated by r; Bold = p value significant at < 0.05; TSK-4 = Tampa Scale of Kinesiophobia; PCS-4 = Pain Catastrophizing scale; GAD-2 = Generalized Anxiety Disorder; Pain Intensity = Pain on Numerical Rating Scale Pain 0–10; MAP CCC = Medical Access Program Community Care Clinic, county-provided insurance for low income individuals; PROMIS PF-CAT = Patient-Reported Outcomes Measurement Information System Physical Function - Computer Adaptive Test; PROMIS Dep-CAT = Patient-Reported Outcomes Measurement Information System Depression - Computer Adaptive Test.

significantly correlated with magnitude of physical function in bivariate analysis, but not correlated with location of arthritis, hip or knee or radiographic severity (Table 2). In multivariable analysis accounting for BMI, bilateral symptoms, marital status, insurance status, magnitude of catastrophic thinking, magnitude of kinesiophobia, and symptoms of depression and anxiety we found that lower physical function was independently associated with fewer years of education, not working, exercising less than 2 h per week, greater catastrophic thinking, and greater symptoms of depression (Table 3).

**Table 3**  
Multivariable linear regression analysis of factors independently associated with PROMIS PF, Pain intensity.

| Dependent variables                 | Independent variables               | Regression coefficient [ $\beta$ ] (95% CI) | Standard Error (SE)   | P value | VIF   | Semipartial R <sup>2</sup> | Adjusted R <sup>2</sup> |       |
|-------------------------------------|-------------------------------------|---|-----------------------|---------|-------|----------------------------|-------------------------|-------|
| PROMIS PF-CAT                       | <b>BMI (r)</b>                      | -0.06 (-0.16 to 0.03)                       | 0.05                  | 0.196   | 1.34  |                            | 0.50                    |       |
|                                     | <b>Unilateral vs. Bilateral</b>     |   |                       |         |       |                            |                         |       |
|                                     | Unilateral                          | Reference Value                             |                       |         |       |                            |                         |       |
|                                     | Bilateral                           | -1.44 (-3.32 to 0.44)                       | 0.95                  | 0.133   | 1.13  |                            |                         |       |
|                                     | <b>Marital Status</b>               |   |                       |         |       |                            |                         |       |
|                                     | Divorced                            | Reference Value                             |                       |         |       |                            |                         |       |
|                                     | Married                             | 0.58 (-2.12 to 3.27)                        | 1.36                  | 0.670   | 2.23  |                            |                         |       |
|                                     | Single                              | 0.24 (-2.50 to 2.98)                        | 1.38                  | 0.865   | 2.14  |                            |                         |       |
|                                     | Widowed                             | 1.58 (-2.49 to 5.65)                        | 2.06                  | 0.443   | 1.57  |                            |                         |       |
|                                     | <b>Level of Education</b>           |   |                       |         |       |                            |                         |       |
|                                     | High School Diploma or Less         | Reference Value                             |                       |         |       |                            |                         |       |
|                                     | 2-year College                      | -4.41 (-7.05 to -1.77)                      | 1.33                  | <0.001  | 1.35  | 0.04                       |                         |       |
|                                     | 4-year College                      | -4.55 (-7.57 to -1.53)                      | 1.53                  | <0.001  | 1.72  | 0.03                       |                         |       |
|                                     | Post-College Graduate Degree        | -1.83 (-5.24 to 1.57)                       | 1.72                  | 0.289   | 1.79  |                            |                         |       |
|                                     | <b>Work Status</b>                  |   |                       |         |       |                            |                         |       |
|                                     | Employed                            | Reference Value                             |                       |         |       |                            |                         |       |
|                                     | Out of Work                         | -1.46 (-5.00 to 2.08)                       | 1.79                  | 0.417   | 1.61  |                            |                         |       |
|                                     | Unable to Work                      | -2.92 (-5.71 to -0.13)                      | 1.41                  | 0.040   | 2.19  | 0.00                       |                         |       |
|                                     | Other (Homemaker, student, retired) | -0.97 (-3.66 to 1.72)                       | 1.36                  | 0.476   | 1.72  |                            |                         |       |
|                                     | <b>Time Spent Exercising Weekly</b> |   |                       |         |       |                            |                         |       |
|                                     | <2 Hours                            | Reference Value                             |                       |         |       |                            |                         |       |
|                                     | >2 Hours                            | 2.35 (-0.19 to 4.52)                        | 1.09                  | 0.033   | 1.48  | 0.01                       |                         |       |
|                                     | <b>Insurance Status</b>             |   |                       |         |       |                            |                         |       |
|                                     | Public                              | Reference Value                             |                       |         |       |                            |                         |       |
|                                     | Private                             | -0.20 (-3.16 to 2.77)                       | 1.49                  | 0.895   | 1.80  |                            |                         |       |
|                                     | MAP                                 | 0.09 (-2.44 to 2.25)                        | 1.18                  | 0.938   | 1.73  |                            |                         |       |
|                                     | <b>TSK-4 (r)</b>                    | -0.23 (-0.61 to 0.15)                       | 0.19                  | 0.239   | 1.53  |                            |                         |       |
|                                     | <b>PCS-4 (r)</b>                    | -0.68 (-0.98 to -0.38)                      | 0.15                  | <0.001  | 2.73  | 0.14                       |                         |       |
|                                     | <b>GAD-2 (r)</b>                    | 0.12 (-0.53 to 0.76)                        | 0.33                  | 0.716   | 2.82  |                            |                         |       |
|                                     | <b>PROMIS Dep-CAT (r)</b>           | -0.16 (-0.29 to -0.03)                      | 0.06                  | 0.017   | 2.69  | 0.04                       |                         |       |
|                                     | Pain Intensity                      | <b>Sex</b>                                  |                       |         |       |                            |                         | 0.520 |
|                                     |                                     | Females                                     | Reference Value       |         |       |                            |                         |       |
|                                     |                                     | Males                                       | -0.19 (-0.98 to 0.59) | 0.40    | 0.630 | 1.37                       |                         |       |
| <b>BMI (r)</b>                      |                                     | 0.013 (-0.02 to 0.05)                       | 0.02                  | 0.481   | 1.44  |                            |                         |       |
| <b>Unilateral vs. Bilateral</b>     |                                     |   |                       |         |       |                            |                         |       |
| Unilateral                          |                                     | Reference Value                             |                       |         |       |                            |                         |       |
| Bilateral                           |                                     | 0.07 (-0.63 to 0.76)                        | 0.35                  | 0.843   | 1.19  |                            |                         |       |
| <b>Marital Status</b>               |                                     |   |                       |         |       |                            |                         |       |
| Divorced                            |                                     | Reference Value                             |                       |         |       |                            |                         |       |
| Married                             |                                     | -0.07 (-1.05 to 0.91)                       | 0.49                  | 0.886   | 2.30  |                            |                         |       |
| Single                              |                                     | 0.64 (-0.38 to 1.65)                        | 0.51                  | 0.216   | 2.27  |                            |                         |       |
| Widowed                             |                                     | 0.38 (-1.11 to 1.87)                        | 0.75                  | 0.611   | 1.62  |                            |                         |       |
| <b>Race/Ethnicity</b>               |                                     |   |                       |         |       |                            |                         |       |
| White/Non-Hispanic                  |                                     | Reference Value                             |                       |         |       |                            |                         |       |
| Hispanic                            |                                     | 0.26 (-0.72 to 1.24)                        | 0.50                  | 0.603   | 1.73  |                            |                         |       |
| Other                               |                                     | 0.64 (-0.26 to 1.54)                        | 0.45                  | 0.160   | 1.55  |                            |                         |       |
| <b>Level of Education</b>           |                                     |   |                       |         |       |                            |                         |       |
| High School Diploma or Less         |                                     | Reference Value                             |                       |         |       |                            |                         |       |
| 2-year College                      |                                     | -0.46 (-1.48 to 0.55)                       | 0.51                  | 0.370   | 1.55  |                            |                         |       |
| 4-year College                      |                                     | 0.59 (-0.54 to 1.72)                        | 0.57                  | 0.306   | 1.88  |                            |                         |       |
| Post-College Graduate Degree        |                                     | -1.01 (-2.30 to 0.28)                       | 0.65                  | 0.123   | 1.97  |                            |                         |       |
| <b>Work Status</b>                  |                                     |   |                       |         |       |                            |                         |       |
| Employed                            |                                     | Reference Value                             |                       |         |       |                            |                         |       |
| Out of Work                         |                                     | 0.02 (-1.28 to 1.31)                        | 0.65                  | 0.978   | 1.66  |                            |                         |       |
| Unable to Work                      |                                     | 0.38 (-0.65 to 1.42)                        | 0.52                  | 0.466   | 2.34  |                            |                         |       |
| Other (Homemaker, student, retired) |                                     | 0.62 (-0.36 to 1.59)                        | 0.49                  | 0.213   | 1.75  |                            |                         |       |
| <b>Time Spent Exercising Weekly</b> |                                     |   |                       |         |       |                            |                         |       |
| <2 Hours                            |                                     | Reference Value                             |                       |         |       |                            |                         |       |
| >2 Hours                            |                                     | -0.87 (-1.66 to -0.08)                      | 0.39                  | 0.030   | 1.52  | 0.13                       |                         |       |
| <b>Insurance Status</b>             |                                     |   |                       |         |       |                            |                         |       |
| Public                              |                                     | Reference Value                             |                       |         |       |                            |                         |       |
| Private                             |                                     | -0.22 (-1.31 to 0.87)                       | 0.55                  | 0.689   | 1.87  |                            |                         |       |
| MAP                                 |                                     | 0.29 (-0.56 to 1.15)                        | 0.43                  | 0.496   | 1.78  |                            |                         |       |
| <b>Deprivation Index (r)</b>        | 0.01 (-0.01 to 0.02)                | 0.01  | 0.399                 | 1.59    |       |                            |                         |       |
| <b>TSK-4 (r)</b>                    | 0.19 (0.05-0.33)                    | 0.07  | <0.001                | 1.57    | 0.15  |                            |                         |       |
| <b>PCS-4 (r)</b>                    | 0.10 (-0.01 to 0.21)                | 0.06  | 0.070                 | 2.78    |       |                            |                         |       |
| <b>GAD-2 (r)</b>                    | 0.10 (-0.13 to 0.33)                | 0.12  | 0.391                 | 2.93    |       |                            |                         |       |
| <b>PROMIS Dep-CAT (r)</b>           | 0.01 (-0.04 to 0.06)                | 0.02  | 0.632                 | 2.91    |       |                            |                         |       |

**Table 3.** Bold indicates significant difference; \* Only the semipartial R<sup>2</sup> of significant variables is reported; VIF = Variance inflation factor; TSK-4 = Tampa Scale of Kinesiophobia; PCS-4 = Pain Catastrophizing scale; GAD-2 = Generalized Anxiety Disorder; Pain Intensity = Pain on Numerical Rating Scale Pain 0-10; PROMIS PF-CAT = Patient-Reported Outcomes Measurement Information System Physical Function - Computer Adaptive Test; PROMIS Dep-CAT = Patient-Reported Outcomes Measurement Information System Depression - Computer Adaptive Test.

In bivariate analysis, greater pain intensity was associated with higher BMI, unilateral symptoms, being single, non-white race, fewer years of education, being unable to work, having public insurance or MAP, higher levels of socioeconomic deprivation, and all psychologic assessments including TSK-4, PCS-4, GAD-2, and PROMIS Dep-CAT, but not with location (hip or knee) or radiographic severity of the arthritis (Table 2). In multivariable analysis accounting for sex, BMI, bilateral disease, marital status, race, years of education, work status, insurance status, socioeconomic deprivation, magnitude of catastrophic thinking, magnitude of kinesiophobia, and symptoms of depression and symptoms of anxiety, we found that lower pain intensity was independently associated with exercising more than 2 h per week and lower levels of kinesiophobia (Table 3).

#### 4. Discussion

Patient reported outcomes seem to correlate less with pathophysiology than with psychosocial factors. Prior studies suggested that hip arthritis is more limiting than knee arthritis. This study addressed the influence of hip or knee location of arthritis on magnitude of limitations or pain intensity accounting for demographic, personal, and psychological factors.

This study was not without limitations. Due to an oversight, we did not measure and account for age, and due to the deidentified nature of the survey we were unable to retrospectively collect it. Physical function tends to decline with age. It's possible that the association of patient reported outcomes with personal and psychological factors observed in our study would be strengthened by the inclusion of age. We also did not collect other measures of pathophysiology such as alignment, stability, and motion. We speculate, based on the notable influence of personal and psychological factors, that a similar study using all available measures of pathophysiology would have similar findings and this can be tested in a future study. The baseline demographic differences including higher BMI and higher prevalence of bilateral disease in the knee group may have affected the influence of anatomic location of arthritis, although these factors were accounted for in our multivariable regression model. Furthermore, factors such as time spent exercising and unilateral or bilateral symptoms were self-reported and not based on objective measurement.

Our findings that psychologic and personal factors best account for magnitude of physical limitations, while hip/knee location or radiographic grade of arthritis have little or no influence, is consistent with the findings in similar studies.<sup>6,8,25–27</sup> For example, among people presenting for their first specialist visit for osteoarthritis of the knee, there was a large correlation between catastrophic thinking and physical function measured using the Oxford Knee Score (OKS) ( $r = -0.60$ ,  $p < 0.001$ ).<sup>6</sup> Another study of 106 patients with knee osteoarthritis found that catastrophic thinking accounted for 11% of the variation in physical function on the Arthritis Impact Measurement Scale (AIMS), a notable percentage in multivariable analysis.<sup>26</sup> A third study of 111 patients with knee arthritis found an association between limitations and both catastrophic thinking and kinesiophobia.<sup>8</sup> The association between physical function and kinesiophobia which was present in our bivariate analysis but was not retained in the multivariable model, likely due to confounding with other psychological factors. There are few studies of the impact of catastrophic thinking in patients with hip arthritis.<sup>28</sup> We did not observe the greater limitations associated with hip arthritis compared to knee arthritis that was documented in prior studies.<sup>11,12</sup> The prior studies addressed patients preparing for arthroplasty (presumably worse pathophysiology) and did not account for psychological factors. The association between fewer physical limitations and greater amount of daily exercise is also consistent with multiple studies as outlined in the systematic review of 44 studies.<sup>29</sup>

The independent association of kinesiophobia and pain intensity is consistent with prior studies in people with knee arthritis.<sup>8</sup> Also consistent with prior studies in people with knee arthritis, catastrophic

thinking correlated with pain intensity in bivariate analysis.<sup>6,8,25</sup> Catastrophic thinking was not retained in the multivariable model, likely due to confounding with kinesiophobia and regular exercise.

In addition to effects on preoperative pain and function, there is also evidence that psychological factors can affect patient reported outcomes after hip and knee arthroplasty.<sup>10,28,30</sup> Psychological factors are modifiable. They can be diagnosed and treated prior to discretionary surgery.<sup>31,32</sup> A systematic review examined 47 studies which utilized various interventions including physical therapy, education, cognitive behavioral therapy, or medications in an attempt to reduce catastrophic thinking prior to undergoing surgical procedures. They found that clinically significant changes were accredited to interventions in 15% of the studies, but there was no single intervention which appeared to more reliably lessen catastrophic thinking compared to the others.<sup>31</sup> A randomized controlled trial of 100 patients undergoing total knee arthroplasty showed a significant decrease in catastrophic thinking after cognitive behavioral therapy.<sup>33(34)</sup> After four half-hour long pre-operative sessions, a 15% decrease in PCS and 17% reduction in TSK were observed. These improvements were maintained even 6 months after surgery.

This study contributes to a growing body of evidence documenting the influence of mental and social health on pain intensity and magnitude of limitations among people with musculoskeletal illness. Future investigations can determine the best method for helping people attend to stress, distress, and less effective coping strategies. The current system that carves out specific pathophysiologies such as hip and knee arthritis and encourages care that is technical and highly specialized may undermine the ability to care for the whole person, which can contribute to unsatisfying speciality care and unsatisfactory results. The impact of integrated practice units where a team of experts collaborates to address health more holistically with improved coordination of care merits additional study.

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