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Predictors of early postoperative pain interference following orthopaedic surgery

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A R T I C L E I N F O

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A B S T R A C T

Introduction: Despite the increasing incidence of orthopaedic surgeries, there is a lack of data reporting on patient experience and recovery following surgery. As such, there is a need to better characterize the natural history of pain interference (PI) after orthopaedic surgery to better manage patients' expectations and recovery.
Purpose: To identify factors associated with greater pain interference two weeks following orthopaedic surgery.
Methods: All patients undergoing elective outpatient orthopaedic surgery at a single urban academic institution were evaluated preoperatively from August 2016 to March 2018. Patients completed a baseline assessment consisting of demographic information, PROMIS computer adaptive testing in 6 domains including Pain Interference (PI), Physical Function, Social Satisfaction, Fatigue, Anxiety, and Depression. Two weeks following surgery, patients completed the same questionnaires along with assessments of Improvement and Satisfaction. Bivariate and multivariable regression analyses were performed. Categorical data was compared with ANOVA and continuous data was compared with Spearman's correlation coefficient (r_s).
Results: 435 patients (age = 41.1 ± 15.7, 47% female) were studied. Mean PI was 60.1 ± 7.0 prior to surgery and 61.7 ± 7.6 at 2 weeks postoperative. Worse 2 week PROMIS PI was associated with lower extremity surgery, prior surgery on the joint, preoperative opioid use, depression, lower income, lower education, and higher ASA score ($p < 0.05$). Better 2 week PROMIS PI was correlated with better baseline and better 2 week scores on all outcome measures. Multivariable analysis demonstrated that lower extremity surgery, worse preoperative pain scores, and worse preoperative pain interference were independent predictors of worse pain interference after surgery.
Conclusion: Early postoperative pain interference is associated with function, demographic, and psychosocial factors.

1. Introduction

Millions of orthopaedic surgeries are performed annually in the United States.[1–3] Despite the increasing number of orthopaedic surgeries, there is a significant lack of data reporting on patient experience and recovery following surgery. Pain is an especially important patient reported outcome because it is often the predominant complaint of patients seeking orthopaedic surgery consultation. Thus, pain must be assessed and managed postoperatively to optimize care. Persistent pain is an immense personal burden—affecting function, emotional well-being, and longevity—as well as a public health burden.[4–6]

This study used the Patient-Reported Outcomes Measurement Information System (PROMIS) developed by the National Institutes of Health (NIH). PROMIS is comprised of question banks related to domains, including Pain Interference. The system utilizes computerized adaptive testing (CAT), in which subsequent questions are selected from a question bank based on responses to previous questions to create efficient, individualized surveys with fewer questions.[7] The validity of the complete question banks and the shorter CAT versions for individual PROMIS domains was evaluated among a sample of 21,133 people from the general population, and PROMIS scores had strong correlations with results from previously accepted measures of each domain.[8] PROMIS therefore provides an assessment of patient-reported outcomes that is cost-effective, time-effective, and generalizable over a wide variety of

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clinical patients.

The PROMIS Pain Interference (PI) domain has already been applied to procedures involving the knee; however, results focus on later post-operative values.[9,10] Pain Interference is a measure of the degree to which pain impacts relevant aspects of patients' lives, including the impact on social, cognitive, emotional, and recreational activities.[11] Other surgical fields have examined early postoperative pain and have found an association with negative long-term outcomes.[10,12–14] However, more work is needed in quantifying pain interference two weeks postoperatively in orthopaedics specifically. Aside from the ethical and economic implications of reducing pain, early pain can predict the development of chronic postsurgical pain.[13,15–19] Chronic postsurgical pain is defined as pain lasting more than two months following a surgical procedure that cannot be attributed to another cause such as infection or malignancy.[20] Studies of elective orthopaedic procedures have already documented the emerging incidence of chronic postsurgical pain.[21–23] Proper management of early pain may deter the development of chronic pain, and analysis of factors that predict early pain could assist physicians in counseling patients and understanding their respective risks. Furthermore, a better understanding of patients' postsurgical pain could be instrumental in tailoring analgesic regimens.[19]

The objective of this study was to identify factors associated with greater Pain Interference two weeks following orthopaedic surgery. We hypothesized that greater postoperative Pain Interference two weeks following orthopaedic surgery will be associated with worse preoperative pain, function, and general health status.

2. Methods

All patients undergoing elective outpatient orthopaedic surgery at a single urban academic institution were evaluated preoperatively from August 2016 to March 2018. Inclusion criteria were as follows: (1) patient undergoing surgery, (2) age 17 years and older, and (3) English speaking. Patients who were unable to read or write English, and patients who were incarcerated or wards of the state were excluded. Eligible patients were enrolled into an Institutional Review Board (IRB) approved, prospective Web-based registry.[24] Study data was collected and managed using REDCap™ (Research Electronic Data Capture) electronic data capture tools hosted at the University of Maryland School of Medicine.[25] Eligible patients were approached by research staff preoperatively, either when the decision to proceed with surgery was made or on the day of surgery in the preoperative registration area. Patients who provide written, informed consent were enrolled in the Maryland Orthopaedic Registry.

Within one week of surgery, participants completed an electronic baseline assessment. Specifically, questionnaires include the following: PROMIS Computer Adaptive Testing in 6 domains (Physical Function, Pain Interference, Social Satisfaction, Fatigue, Anxiety, Depression), Numeric Pain Scales (NPS) for pain in the whole body and the location of surgery, International Physical Activity Questionnaire (IPAQ), and Tegner Activity Rating Scale. Patients then complete the same questionnaires two weeks after surgery, along with assessments of Improvement and Satisfaction. Demographic data was self-reported by each respondent, and each their medical records were reviewed for relevant medical history, including American Society of Anesthesiologists (ASA) score, smoking status, alcohol use, and current medications.

Data from pre and postoperative questionnaires, as well as clinical data from participants' medical records, were collected and managed through REDCap™. De-identified patient data was extracted and analyzed. Statistical analysis included parametric and/or non-parametric bivariate tests depending on normality of the data as well as multivariable analysis.

2.1. Statistical analyses

Mean PROMIS PI scores for categorical variables were analyzed with ANOVA. PROMIS PI scores and continuous variables were analyzed with Spearman's rank correlation coefficient (r_s). For maximum validation of R,[2] we applied backwards stepwise elimination regression to identify independent preoperative predictors of two-week PROMIS PI. The possible predictors that were included in the regression model were preoperative parameters found to be significant in bivariate analyses. Statistical tests used were two-sided, with $p < 0.05$ indicating statistical significance. The analyses were done using SAS Version 9.4 (SAS Institute Inc., Cary, NC).

3. Results

A total of 435 patients were analyzed. There were of 232 (53%) males and 203 (47%) females (Table 1). The mean age of patients sampled was 41.1 ± 15.7 (Table 2). The mean preoperative PROMIS PI was 60.1 ± 7.0, and mean PROMIS PI at two weeks increased to 61.7 ± 7.6 (Table 2). Worse postoperative PI was significantly associated with no college degree, lower income, preoperative opioid use, higher ASA score, history of depression or anxiety symptoms, previous surgery on the operative joint, and surgery on the lower extremity (Table 1).

Better 2 week PI was correlated with better baseline scores on all outcome measures (Table 2), and was most strongly correlated for NPS in the location of surgery ($r_s = 0.27$, $p < 0.001$). Similarly, better postoperative scores on all outcome measures were associated with better 2 week PI scores and the correlations were stronger than baseline measures with strongest correlation with 2 week PROMIS Fatigue (($r_s = 0.62$, $p < 0.001$) (Table 2).

Table 3 displays the ten most common surgeries performed on upper and lower extremities that were included in this study. There were significant differences between surgeries performed on the lower extremity for both baseline PI and postoperative PI. The lowest levels of baseline and two-week PI were associated with arthroscopic removal of foreign bodies in the knee. Conversely, total hip arthroplasty was associated with the highest levels of pre- and postoperative PI, though pain was on average decreased following surgery. There were no significant differences between surgeries performed on the upper extremities for either baseline or postoperative PI. Analogous to lower extremity patients, total shoulder arthroplasty patients experienced the worst PI preoperatively (Table 3).

Multivariable regression confirmed that better preoperative pain assessment scores were independent predictors of better 2-week PI scores, while lower extremity surgery predicted worse pain (Table 4).

4. Discussion

The findings of our study support our hypothesis as greater postoperative Pain Interference two weeks following orthopaedic surgery was associated with worse preoperative pain, function, and general health status. Furthermore, we found that postoperative pain interference was associated with multiple demographic and surgical factors, and undergoing lower extremity surgery was an independent predictor of greater pain interference. These findings are congruent with assessment of physical function, as patients undergoing lower extremity surgery also experienced the greatest impedance on physical function.[26] Our results provide further evidence that Pain Interference is an important metric that takes into account the impairment due to pain.[11] An understanding of the intertwined nature of the pain and function is important for considering the effects that surgery may have on mental wellbeing and general health, both short-term and long-term.

Mental health was assessed in several ways in this study. A history of depression or anxiety as assessed by the preoperative survey showed significant association with worse postoperative PI. Additionally, PROMIS Depression, Anxiety, and Fatigue were significantly positively correlated with postoperative PI scores both preoperatively and postoperatively. Together, these findings demonstrate the relationship between mental health and pain. While the coincidence of pain and

Table 1
2 Week PROMIS PI for categorical variables.

Categorical Variable	Number of Patients (Percent)	Mean 2 Week PI (±SD)	p
Sex			
Male	232 (53)	62.0 (±7.28)	0.43
Female	203 (47)	62.0 (±7.92)	
Ethnicity			
Not Hispanic or Latino	400 (93)	61.5 (±7.69)	0.22
Hispanic or Latino	28 (7)	63.4 (±7.28)	
Race			
Black	95 (22)	62.6 (±7.34)	0.21
White	298 (69)	61.2 (±7.62)	
Other	38 (9)	62.6 (±8.48)	
Education			
No college degree	206 (48)	62.7 (±7.47)	**0.008**
College degree	224 (52)	60.8 (±7.71)	
Income			
Less than $70,000	174 (42)	62.8 (±7.87)	**0.016**
More than $70,000	241 (58)	60.9 (±7.51)	
Marital Status			
No	232 (54)	62.0 (±7.73)	0.43
Yes	197 (46)	61.4 (±7.53)	
Employment Status			
Currently Employed	277 (64)	61.4 (±7.76)	0.29
Not Currently Employed	91 (21)	62.8 (±7.19)	
Student	67 (15)	61.4 (±7.65)	
Smoking Status			
Never Smoked	307 (72)	61.2 (±7.73)	0.13
Quit Smoking	78 (18)	62.8 (±7.14)	
Current Smoker	43 (10)	62.9 (±7.52)	
Alcohol Consumption			
Never	123 (29)	62.7 (±7.36)	0.27
4 Times Monthly or Fewer	198 (46)	61.3 (±8.20)	
More than 4 Times Monthly	109 (25)	61.6 (±6.83)	
Recreational Drug Use			
No	404 (93)	61.6 (±7.67)	0.49
Yes	31 (7)	62.6 (±7.15)	
Pre-Operative Opioid Use			
No	320 (74)	61.1 (±7.80)	**0.007**
Yes	111 (26)	63.4 (±6.84)	
ASA score			
1	166 (38)	60.7 (±7.66)	**0.048**
2	230 (53)	62.6 (±7.76)	
3	29 (7)	62.3 (±5.74)	
Depression or Anxiety Symptoms			
No	382 (88)	61.3 (±7.53)	**0.005**
Yes	53 (12)	64.5 (±7.94)	
Injury Prior to Surgery			
No	153 (35)	62.1 (±7.34)	0.30
Yes	282 (65)	61.4 (±7.78)	
Prior Surgery on Operative Joint			
No	339 (78)	61.1 (±7.70)	**0.007**
Yes	94 (22)	63.5 (±7.12)	
Operative Extremity			
Lower	226 (52)	62.8 (±7.56)	**0.002**
Upper	209 (48)	60.5 (±7.54)	
Baseline IPAQ Activity			
Inactive	173 (40)	62.9 (±6.45)	**0.031**
Minimally Active	39 (9)	61.2 (±7.58)	
HEPA	223 (51)	60.9 (±8.36)	
2 week IPAQ Activity			
Inactive	295 (68)	62.6 (±7.39)	**0.001**
Minimally active	57 (13)	60.8 (±7.48)	
HEPA	83 (19)	59.1 (±8.00)	

HEPA: Heath Enhancing Physical Activity.

Table 2
Correlations with two weeks postoperative PROMIS pain interference scores.

		Mean (±SD)	r_s	p
Demographics	Age	41.1 (15.7)	0.01	0.79
	BMI	29.4 (6.66)	0.08	0.12
	Charlson Comorbidity Index	2.08 (1.39)	0.08	0.22
Baseline measures	**PROMIS Physical Function**	42.1 (8.83)	**−0.26**	**<.0001**
	PROMIS Social Satisfaction	42.4 (9.29)	**−0.25**	**<.0001**
	PROMIS PI	60.1 (7.04)	**0.33**	**<.0001**
	PROMIS Fatigue	51.5 (10.4)	**0.25**	**<.0001**
	PROMIS Anxiety	54.9 (8.74)	**0.26**	**<.0001**
	PROMIS Depression	48.7 (9.36)	**0.23**	**<.0001**
	NPS Joint	4.86 (2.78)	**0.27**	**<.0001**
	NPS body	1.34 (1.98)	**0.21**	**<.0001**
	Current Tegner activity	2.24 (1.87)	**−0.19**	**0.0001**
2 week measures	**PROMIS Physical Function**	35.5 (8.9)	**−0.51**	**<.0001**
	PROMIS Social Satisfaction	39.0 (8.07)	**−0.51**	**<.0001**
	PROMIS Fatigue	54.4 (10.0)	**0.62**	**<.0001**
	PROMIS Anxiety	53.6 (9.55)	**0.47**	**<.0001**
	PROMIS Depression	49.4 (10.5)	**0.32**	**<.0001**
	NPS Joint	4.09 (2.38)	**0.61**	**<.0001**
	NPS Body	1.68 (2.15)	**0.26**	**<.0001**
	Current Tegner activity	1.14 (1.35)	**−0.41**	**<.0001**
	Met Treatment Expectations	55.0 (27.6)	**−0.26**	**<.0001**
	Surgery Satisfaction	69.1 (16.0)	**−0.37**	**<.0001**
	Improvement	56.0 (24.7)	**−0.29**	**<.0001**

depression is well documented in patients experiencing chronic pain, this study provides evidence that the troublesome relationship is present even in the acute phase of pain.[27–29] Overall, worse pain was correlated with worse scores on all outcome measures, illustrating the broad effects of pain on well-being and health. These results are consistent with results from analysis of preoperative pain in orthopaedic patients that found significant correlations amongst PROMIS domains and legacy outcome measures.[30,31] Furthermore, surgical satisfaction and improvement were both negatively correlated with postoperative PI, indicating more satisfaction and improvement are seen when there is less postoperative PI.

Traditional methods of assessing patient reported pain, such as the numerical pain scale, have failed to encompass the broad effects of pain. These measures are susceptible to their subjective nature and the risk of ceiling effects, inflating pain intensity and therefore escalating pain management.[32] Proper management of acute pain is imperative for function, recovery, wellbeing, and may stave off development of chronic pain.[19] However, the United States is currently in the midst of an opioid epidemic,[33] a crisis which has not spared orthopaedists: over 25% of conditions associated with prescription of opioids leading to sustained use were due to orthopaedic or spine conditions.[34] The use of PROMIS PI in orthopaedics setting may help curb this trend in opioid prescription by providing a more accurate representation of patients' pain. However, it is important to recognize that PROMIS PI may perform differently in different patient populations. We found that greater pain interference after surgery was associated with prior surgery on the joint, preoperative opioid use, lower income, lower education, and higher ASA score. Consequently, these factors should be taken into account when

Table 3
Preoperative and 2-week PI for the top 10 CPT codes for upper and lower extremity procedures.

CPT Code:	Count:	Procedure Description:	Mean Preoperative PI:	Mean 2-Week PI:
Upper Extremity Procedures				
29826	38	Arthroscopy, shoulder, surgical; decompression of subacromial space with partial acromioplasty, with coracoacromial ligament (ie, arch) release, when performed	60.3 ± 7.0	62.6 ± 8.7
23430	23	Arthroscopy, shoulder, surgical; decompression of subacromial space with partial acromioplasty, with coracoacromial ligament (ie, arch) release, when performed	59.4 ± 7.6	63.5 ± 5.5
29806	22	Arthroscopy, shoulder, surgical; capsulorrhaphy	58.1 ± 8.0	60.2 ± 7.8
29825	21	Arthroscopy, shoulder, surgical; with lysis and resection of adhesions, with or without manipulation	59.2 ± 7.0	59.5 ± 8.1
29823	20	Arthroscopy, shoulder, surgical; debridement, extensive	61.5 ± 5.1	61.8 ± 9.9
23472	17	Arthroplasty, glenohumeral joint; total shoulder (glenoid and proximal humeral replacement (eg, total shoulder))	62.1 ± 5.0	62.5 ± 9.1
29827	16	Arthroscopy, shoulder, surgical; with rotator cuff repair	61.8 ± 9.0	63.9 ± 7.9
64721	14	Neuroplasty and/or transposition; median nerve at carpal tunnel	56.6 ± 5.6	56.5 ± 6.2
26055	11	Tendon sheath incision (e.g., for trigger finger)	59.5 ± 5.5	59.1 ± 4.7
29824	10	Arthroscopy, shoulder, surgical; distal claviculectomy including distal articular surface (Mumford procedure)	59.9 ± 7.1	58.1 ± 12.4
Lower Extremity Procedures				
29888	65	Arthroscopically aided anterior cruciate ligament repair/ augmentation or reconstruction	57.4 ± 6.4	63.2 ± 7.6
29881	60	Arthroscopy, knee, surgical; with meniscectomy (medial OR lateral, including any meniscal shaving) including debridement/shaving of articular cartilage (chondroplasty), same or separate compartment(s), when performed	58.1 ± 6.9	61.3 ± 6.3
29876	49	Arthroscopy, knee, surgical; synovectomy, major, 2 or more compartments (eg, medial or lateral)	58.5 ± 7.1	60.2 ± 7.5
29882	30	Arthroscopy, knee, surgical; with meniscus repair (medial OR lateral)	57.0 ± 7.8	61.2 ± 9.2
29879	28	Arthroscopy, knee, surgical; abrasion arthroplasty (includes chondroplasty where necessary) or multiple drilling or microfracture	58.2 ± 7.9	60.3 ± 10.8
29877	22	Arthroscopy, knee, surgical; debridement/shaving of articular cartilage (chondroplasty)	60.3 ± 8.0	62.1 ± 7.0
29914	16	Arthroscopy, hip, surgical; with femoroplasty (ie, treatment of cam lesion)	60.1 ± 7.2	63.7 ± 6.7
29916	15	Arthroscopy, hip, surgical; with labral repair	60.4 ± 7.5	63.3 ± 7.0
29874	13	Arthroscopy, knee, surgical; for removal of loose body or foreign body (eg, osteochondritis dissecans fragmentation, chondral fragmentation)	56.1 ± 7.8	57.2 ± 8.8
27130	12	Arthroplasty, acetabular and proximal femoral prosthetic replacement (total hip arthroplasty), with or without autograft or allograft	68.3 ± 6.5	67.5 ± 5.9

PROMIS Pain Interference was analyzed against Current Procedural Terminology (CPT) code using ANOVA. Upper Extremity Procedures: There were no significant differences in Preoperative PI between CPT codes (F-statistic = 1.02, p = 0.42) or in 2-Week PI (F-statistic = 1.46, p = 0.17). **Lower Extremity Procedures: There were significant differences in Preoperative PI between CPT codes (F-statistic = 3.35, p < 0.001), and 2-Week PI (F-statistic = 2.01, p = 0.038).**

Table 4
Multivariate analysis of two week PROMIS pain interference.

Two Week PROMIS Pain Interference	Estimate	SE	t Ratio	p value	Adjusted R^2
Preoperative PROMIS PI	0.3	0.05	5.85	<0.0001	0.14
Preoperative NPS	0.6	0.18	3.07	0.0023	
Lower Extremity	1.2	0.3	3.45	0.0006	

The following preoperative variables were included in multivariable analysis: PROMIS Physical Function, Social Satisfaction, PI, Fatigue, Anxiety, and Depression, NPS Joint, NPS Body, Current Tegner Activity Level, Lower Extremity Activity Rating Scale, College Degree, Income, Operative Extremity, ASA score, Preoperative Opioid Use, Depression and Anxiety Symptoms, and Baseline IPAQ Level.

considering outcomes. Nevertheless, the significant correlations with all other outcome measures suggest that PROMIS PI may be useful as a single measure of patient status two weeks after orthopaedic surgery.

This study is possibly limited by its observational nature and all the conventional limitations associated with an observational study design. Thus, this study cannot determine causality with the degree of certainty that can be achieved with experimental studies, nor is it possible to determine if all potential confounding factors were known, collected, and controlled. Furthermore, our study is limited to a degree by response bias. Within the Maryland Orthopaedic Registry, there were significant differences between patients who filled out early postoperative questionnaires and those who did not. Specifically, patients with more fatigue and pain preoperatively were less likely to fill out their postoperative questionnaires.[35] Nonetheless, our study is strengthened by its sample size and the diversity of the patient population. To the extent of our knowledge, this is the largest sample on which PROMIS PI CAT has been applied in a prospective manner.

5. Conclusion

Postoperative PROMIS Pain Interference showed significant associations with measures of pain, function, general health, and psychosocial status. PROMIS Pain Interference may be useful as a single measure of patient status two weeks after orthopaedic surgery.

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CRediT authorship contribution statement

Jamie Kator: Writing - original draft, Data curation, Visualization, Investigation. **Ali Aneizi:** Formal analysis, Writing - review & editing, Data curation, Visualization. **Vidushan Nadarajah:** Methodology, Writing - review & editing. **Patrick M.J. Sajak:** Visualization, Writing - review & editing. **Min Zhan:** Formal analysis, Data curation. **Mohit N. Gilotra:** Investigation, Writing - review & editing. **Ngozi M. Akabudike:** Investigation, Writing - review & editing. **Jonathan D. Packer:** Investigation, Writing - review & editing, Supervision. **R. Frank Henn:** Supervision, Funding acquisition, Project administration, Writing - review & editing.

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