Journal of Clinical Orthopaedics and Trauma 11 (2020) S539–S545

Contents lists available at ScienceDirect

Journal of Clinical Orthopaedics and Trauma

journal homepage: www.elsevier.com/locate/jcot

Evaluation of preoperative pain in patients undergoing shoulder surgery using the PROMIS pain interference computer-adaptive test

Vidushan Nadarajah [b], Anshum Sood [a], Jamie L. Kator [a], Michael J. Foster [a], Julio J. Jauregui [a], Mohit N. Gilotra [a], S. Ashfaq Hasan [a], R. Frank Henn III [a,**]

[a] Department of Orthopaedics, University of Maryland School of Medicine, Baltimore, MD, USA
[b] Department of Orthopaedic Surgery and Rehabilitation Medicine, SUNY Downstate Medical Center, Brooklyn, NY, USA

ARTICLE INFO

Article history:
Received 7 January 2020
Received in revised form
12 April 2020
Accepted 24 April 2020
Available online 30 April 2020

Keywords:
Shoulder
Pain interference
Pain intensity
PROMIS
Cross-sectional
Patient-reported outcomes

ABSTRACT

Objective: The purpose of this study was to evaluate the Patient Reported Outcomes Measurement Information System (PROMIS) computerized adaptive testing Pain Interference (PROMIS PI) item bank in patients undergoing shoulder surgery. We hypothesized that PROMIS PI would exhibit a strong positive correlation with the numerical pain scale for the operative shoulder (shoulder NPS) with less floor and ceiling effects. Secondary study aims included assessing the relationships between patient characteristics and PROMIS PI.
Design: Analytical cross-sectional study.
Setting: Urban academic medical center.
Patients: One-hundred and ninety-five patients undergoing shoulder surgery between June 2015 to June 2017.
Main outcome measures: All patients completed a series of patient-reported outcomes measures, including PROMIS PI and NPS. Non-parametric tests were used for bivariate analysis. Multivariable regression models were used to determine independent associations.
Results: There was a moderate correlation between the PROMIS PI and shoulder NPS scores ($r_s = 0.53$; $p < 0.001$). PROMIS PI had no ceiling or floor effects while shoulder NPS had 26 patients (13.3%) at either the floor or the ceiling. PROMIS PI demonstrated a strong correlation with PROMIS Physical Function ($r_s = -0.65$; $p < 0.001$), ASES total score ($r_s = -0.67$; $p < 0.001$), and PROMIS Fatigue ($r_s = 0.64$; $p < 0.001$).
Conclusions: The strong association noted between PROMIS PI and psychosocial and behavioral factors, versus that of NPS, demonstrates that PROMIS Pain Interference may be a more appropriate choice as an outcome measure where the surgeon is concerned about a patient's improvement of functioning and decrease in the impact of pain in other aspects of wellbeing following shoulder surgery.
Level of evidence: IV.

1. Introduction

Pain is often the chief complaint of patients presenting to orthopaedic surgeons, accounting for nearly 70 million outpatient visits in the U.S. each year.[1–3] The prevalence, disability, cost, multiple clinical trials,[3–5] and pressure of physicians to monitor pain as the "fifth vital sign"[6] all underscore the need for quality patient-reported outcome (PRO) measurement of pain.

Patient-reported pain severity often represents the prime outcome in most orthopaedic studies. Various permutations of pain-reporting tools, including the visual analog scale, ordinal Numeric Pain Scale (NPS), and Box Score-11 Scale have been applied in clinical trials.[7,8] Studies in orthopaedic populations have demonstrated markedly different pain-severity responses based on different qualifiers used for pain questions, yielding mean preoperative pain severities as high as 8/10 and as low as 2/10 in the same patient population at the same interview session. Furthermore, pain-severity responses may be impacted by psychosocial and behavioral factors.[9] These "legacy" measures are limited by the static nature of classical test theory. They require the patient to complete all items, even items that provide no additional

** Corresponding author. University of Maryland Rehabilitation and Orthopaedic Institute, 2200 Kernan Drive, Baltimore, MD, 21207, USA.
E-mail address: Frank_Henn@yahoo.com (R.F. Henn).

https://doi.org/10.1016/j.jcot.2020.04.025
0976-5662/

information, and have limited usefulness in evaluating how precisely items measure across the continuum of pain.[10,11]

While the NPS is familiar to most patients, a single-item such as an NPS measuring a complex construct like pain will likely have more measurement error than multi-item scales like the recently developed Patient Reported Outcomes Measurement Information System (PROMIS) measures. PROMIS is a National Institutes of Health (NIH) developed project charged with using item-response theory (IRT) to develop measures of patient-reported outcomes that are brief and maximally reliable and valid in several health domains, including pain.[11–14]

Pain, a multifaceted experience consisting of sensory, neural, emotional, and social components,[15,16] has been shown to decrease a person's quality of life, negatively affect their well-being, and decrease their physical function and longevity.[17–20] Pain interference (i.e. pain impact) is defined as the magnitude to which pain disrupts a person's physical, intellectual, spiritual, and leisurely endeavors.[6–8]

The purpose of this study was to evaluate PROMIS PI in patients undergoing shoulder surgery. We hypothesized that PROMIS PI would exhibit a strong positive correlation with the numerical pain scale for the operative shoulder (shoulder NPS) with less of a floor and ceiling effect. Secondary study aims included comparing the associations between patient characteristics and PROMIS PI.

2. Materials and methods

From June 2015 to June 2017, patients undergoing shoulder surgery at a single academic institution were evaluated preoperatively. Inclusion criterion was patients undergoing shoulder surgery. Patients who were unable to read or write English, who were incarcerated, and/or who were wards of the state were excluded. Eligible patients were enrolled into an institutional review board-approved, prospective registry.[21] Study data was collected and managed using REDCap (Research Electronic Data Capture) electronic data capture tools.[22] Demographic data was self-reported by each respondent, and each patient's medical record was reviewed for relevant medical history, including their American Society of Anesthesiologists (ASA) score, smoking status, alcohol use, and current medications. Preoperative expectations were evaluated with the Musculoskeletal Outcomes Data Evaluation and Management System (MODEMS) expectations questionnaire.[23]

All enrolled patients were preoperatively administered the PROMIS Computer Adaptive Test (v1.2) in six domains (Pain Interference, Physical Function, Social Satisfaction, Fatigue, Anxiety, and Depression). Patients were also administered the American Shoulder and Elbow Surgeons (ASES) score to assess shoulder function.[24] Pain Intensity in the operative shoulder (shoulder NPS) and the rest of the body (body NPS) were each measured using a 0–10 ordinal scale with higher scores corresponding to more pain. Physical activity levels were measured using the Tegner Activity Scale (Tegner),[25] the International Physical Activity Questionnaire (IPAQ),[26] and Marx Shoulder Activity Rating Scales (Marx).[27]

2.1. Statistical analysis

A power analysis was conducted with respect to the primary null hypothesis. This found that a minimum sample size of 85 patients was needed to detect a 0.3 (weak) correlation between PROMIS PI and the other PRO measures, with 80% power (alpha 0.05). Thus, our sample size of 195 patients was more than adequate for the main objective of this study and should also allow for the additional objectives of controlling for possible mediators/moderators.

The distribution of multiple variables was non-normally distributed. Therefore, we used non-parametric tests for hypothesis testing, with statistical significance set at $p < 0.05$. The variables of employment status, income, and smoking were recoded to combine similar groups with small sample sizes, thus reducing the risk of false associations. Spearman correlation coefficients (r_s) were used to analyze the relationships between continuous variables. We regarded an r_s value greater than 0.6 as a strong correlation, $0.3 < r_s < 0.6$ representing a moderate correlation, $0.1 < r_s < 0.3$ representing a weak correlation, and any value less than 0.1 representing a negligible relationship.[28] Wilcoxon rank sum tests and Kruskal-Wallis nonparametric tests were used to determine relationships between non-continuous variables.

A bootstrapped forest-partitioning model was used to rank the possible predictors of PROMIS PI and Pain Intensity. The 10 highest ranked predictors, and additional variables found to be significant in bivariate analysis were entered into a backward, stepwise elimination model as explanatory variables. The least significant explanatory variable at each step was removed until all the variables had been added. By scrutinizing the overall fit of the model, variables were automatically removed until the optimum model was found. Our model was validated using a maximum validation R-Square method, where a stopping rule was imposed to avoid overfitting the model, and an adjusted R-squared was calculated to assess the collective influence of the factors in the regression model on the variability of PROMIS Pain Interference and Pain Intensity. In order to determine if multicollinearity was influencing our regression model, we calculated the variance inflation factor (VIF) of each predictor in the final model. A VIF > 10 was used as a cutoff to indicate influence of multicollinearity and removed from the final model. We used a one-way repeated measures MANOVA (Multivariate Analysis of Variance) model to assess whether there was a difference between the PROMIS PI score and shoulder NPS score based on the type of procedure performed (i.e. unique CPT code). Possible confounding factors included in the model were: age, BMI, employment status, preoperative narcotic use, and PROMIS Physical Function score. Statistical software JMP Pro, Version 13 software (JMP®, Version 13. SAS Institute Inc., Cary, North Carolina) was used for all analyses.

3. Results

We sampled and reviewed preoperative data for 195 patients undergoing shoulder surgery from a single orthopaedic sports medicine database. The average age of the patient population was 48.1 ± 16.9 years. There were 106 (54%) males and 89 (46%) females. The demographics of the study participants are listed in Tables 1A and 1B. Patients reported an average PROMIS PI of 61.6 (±7.7), and shoulder NPS of 5.3 (±2.9) (Table 2). There were neither floor nor ceiling effects observed in PROMIS PI and Shoulder NPS. None of the patients (0%) scored the minimum and maximum score for the PROMIS PI measure, whereas 13 patients (6.7%) of patients reports the maximum of 10 on the Shoulder NPS and 13 patients (6.7%) reported the minimum score of 0 (Table 2).

There was a moderate correlation between the PROMIS PI and shoulder NPS scores ($r_s = 0.53$; $p < 0.0001$) (Table 3). PROMIS PI demonstrated a strong negative correlation with PROMIS Physical Function ($r_s = -0.65$; $p < 0.001$), and the ASES total score ($r_s = -0.67$; $p < 0.001$); and a strong positive correlation with PROMIS Fatigue ($r_s = 0.64$; $p < 0.001$). Additionally, PROMIS PI demonstrated a moderate negative correlation with PROMIS Social Satisfaction ($r_s = -0.57$; $p < 0.0001$), ASES Function Subscore ($r_s = -0.58$; $p < 0.0001$), IPAQ ($r_s = -0.40$; $p < 0.0001$), and Tegner Current/Pre-surgery ($r_s = -0.55$; $p < 0.0001$); and a moderate positive correlation with PROMIS Anxiety ($r_s = 0.50$; $p < 0.0001$), PROMIS Depression ($r_s = 0.42$; $p < 0.0001$) and body NPS ($r_s = 0.43$;

Table 1A
Categorical patient demographics.

Demographic	Number (%)
Sex	
Male	106 (54)
Female	89 (46)
Ethnicity	
Not Hispanic or Latino	176 (90)
Hispanic or Latino	9 (5)
Race	
Black	69 (35)
White	109 (56)
Other	17 (9)
Education	
Some high school or below	14 (8)
High school graduate or above	166 (89)
Employment status	
Employed for wages	74 (38)
Self-employed	17 (9)
Out of work, looking for work	2 (1)
Out of work, not currently looking for work	1 (0.5)
Homemaker	4 (2)
Student	22 (11)
Military	1 (0.5)
Retired	27 (14)
Unable to work	27 (14)
Other	5 (3)
Income	
Less than $10,000	16 (8)
$10,000 - $19,999	9 (5)
$20,000 - $29,999	10 (5)
$30,000 - $39,999	9 (5)
$40,000 - $49,999	6 (3)
$50,000 - $59,999	9 (5)
$60,000 - $69,999	8 (4)
More than $70,000	48 (25)
Marital status	
Single – never married	54 (28)
Married or domestic partnership	83 (43)
Divorced, separated, or widowed	15 (8)
Smoking status	
Daily	15 (8)
Less than daily	10 (5)
Quit smoking	111 (57)
Never smoked	45 (23)
Alcohol consumption	
Never	69 (35)
Monthly or less	38 (19)
2 to 4 times a month	31 (16)
2 to 3 times a week	30 (15)
4 or more times a week	12 (6)
Recreational drug use	
No	170 (87)
Yes	5 (3)
Pre-Operative Opioid Use	
Yes	53 (20)
No	122 (73)
ASA score	
1	55 (28)
2	108 (55)
3	12 (6)
4	2 (1)
Depression or anxiety	
No	137 (70)
Yes	38 (19)
Injury prior to surgery	
No	68 (35)
Yes	113 (58)
Worker's Compensation*	
No	4 (2)
Yes	13 (7)
Prior surgery on operative shoulder	
No	146 (75)
Yes	47 (24)

Workers compensation was determined only for those patients who reported an injury prior to surgery; **ASA:** American Society of Anesthesiologists.
* Total N will not equal 195 for each category due to missing values.

Table 1B
Continuous patient demographics.

Demographic	Mean (±SD)
Age (years)	48.1 (16.9)
BMI (kg/m^2)	30.1 (5.8)
Charlson Comorbidity Index	1.32 (1.46)
MODEMS – Expectations Overall	4.4 (0.8)
1) Relief from symptoms	4.4 (0.9)
2) Activities	4.5 (0.9)
3) Sleep	4.4 (1.0)
4) Usual work	4.4 (1.1)
5) Exercise	4.3 (1.0)
6) Disability	4.3 (0.9)
Number of Surgeries (ANY)	4.2 (4.4)
Number of Orthopaedic Surgeries	1.9 (2.7)
Number of surgeries on operative shoulder	1.6 (1.2)
PRO Measures	**Mean (± SD)**
PROMIS – Pain Interference	61.6 (±7.65)
PROMIS – Physical Function	42.7 (±8.90)
PROMIS – Fatigue	53.4(±10.83)
PROMIS – Social Satisfaction	41.0 (±9.68)
PROMIS – Anxiety	55.4 (±9.10)
PROMIS – Depression	49.4 (±10.20)
ASES Total	42.08 (±21.64)
ASES Function Subscore	*37.0 (±24.29)*
IPAQ – MET *(minutes/week)*	3624.4 (±4160.19)
Tegner (Pre-Shoulder problem)	6.0 (±2.89)
Tegner (Current/pre-surgery)	2.4 (±2.10)
Marx	10.8 (±6.50)
Shoulder Pain Intensity (NPS)	5.3 (±2.86)
Body Pain Intensity (NPS)	1.8 (±2.58)

PROMIS: Patient Reported Outcomes Measurement Information System; **ASES**: American Shoulder & Elbow Surgeons; **IPAQ**: International Physical Activity Questionnaire.

Table 2
Performance of PROMIS pain interference and the shoulder numeric pain scale (NPS) in patients undergoing shoulder surgery.

	PROMIS PI*	Shoulder NPS†
Mean	61.6	5.3
Min	38.7	0
Max	77.8	10
Standard Deviation	7.7	2.9
Median	61.5	6
N (%) at minimum	0 (0%)	13 (6.7%)
N (%) at maximum	0 (0%)	13 (6.7%)

PROMIS PI: Patient Reported Outcome Measurement Instrument Systems Pain Interference; **NPS**: Numeric Pain Scale.

$p < 0.0001$). Weak correlations were observed between PROMIS PI and Tegner Pre-shoulder problem ($r_s = -0.25$; $p = 0.0008$), Marx Shoulder Activity Rating Scale ($r_s = -0.22$; $p = 0.0040$), BMI ($r_s = 0.22$; $p = 0.0017$), MODEMS Expectations Overall ($r_s = -0.19$; $p = 0.015$), and Number of Surgeries ($r_s = 0.23$; $p = 0.0010$), respectively (Table 3). Categorical clinical associations of patients' PROMIS PI included gender ($p = 0.0181$), employment status ($p < 0.0001$), income ($p = 0.0003$), smoking status ($p = 0.0205$), and pre-operative opioid use ($p < 0.0001$) (Table 4).

Comparatively, the shoulder NPS demonstrated a strong negative correlation with the ASES total score ($r_s = -0.84$; $p < 0.0001$). Shoulder NPS demonstrated moderate correlations with PROMIS Physical Function ($r_s = -0.34$; $p < 0.0001$), PROMIS Fatigue ($r_s = 0.40$; $p < 0.0001$), PROMIS Social Satisfaction ($r_s = -0.31$; $p < 0.0001$), PROMIS Anxiety ($r_s = 0.32$; $p < 0.0001$), ASES Function Subscore ($r_s = -0.33$; $p < 0.0001$), Tegner Current/Pre-surgery ($r_s = -0.33$; $p < 0.0001$), body NPS ($r_s = 0.43$; $p < 0.0001$), and Number of Surgeries $r_s = 0.31$; $p < 0.0001$), respectively (Table 3). Additionally, shoulder NPS demonstrated weak correlations with

Table 3
Bivariate analysis of continuous variables.

Health-related Outcome Measures	PROMIS Pain Interference		Numeric Pain Intensity (NPS)	
	ρ (rho)*	p-value	ρ (rho)*	p-value
Shoulder Pain Intensity (NPS)	0.53	< **0.0001**	———	———
PROMIS – Pain Interference	–	———	0.53	< **0.0001**
PROMIS – Physical Function	−0.65	< **0.0001**	−0.34	< **0.0001**
PROMIS – Fatigue	0.64	< **0.0001**	0.40	< **0.0001**
PROMIS – Social Satisfaction	−0.57	< **0.0001**	−0.31	< **0.0001**
PROMIS – Anxiety	0.50	< **0.0001**	0.32	< **0.0001**
PROMIS – Depression	0.42	< **0.0001**	0.24	**0.0009**
ASES Total	−0.67	< **0.0001**	−0.84	< **0.0001**
ASES Function Subscore	−0.58	< **0.0001**	−0.33	< **0.0001**
IPAQ – MET *(minutes/week)*	−0.40	< **0.0001**	−0.16	0.051
Tegner (Pre-Shoulder problem)	−0.25	**0.0008**	−0.26	**0.0008**
Tegner (Current/pre-surgery)	−0.55	< **0.0001**	−0.33	< **0.0001**
Marx	−0.22	**0.0040**	−0.26	**0.0006**
Body Pain Intensity	0.43	< **0.0001**	0.43	< **0.0001**
Age	0.12	0.10	0.26	**0.0002**
BMI	0.22	**0.0017**	0.14	0.061
Charlson Comorbidity Index (CCI)	0.13	0.074	0.30	< **0.0001**
MODEMS Expectations (Overall)	−0.19	**0.0115**	−0.18	**0.0148**
Number of Surgeries	0.23	**0.0010**	0.31	< **0.0001**

$r_s > 0.6$ – strong correlation; $0.3 < r_s < 0.6$ – moderate correlation; $0.1 < r_s < 0.3$ – weak correlation; $0.1 < r_s$ – negligible relationship.
PROMIS: Patient Reported Outcomes Measurement Information System; **ASES**: American Shoulder & Elbow Surgeons.
IPAQ: International Physical Activity Questionnaire.

PROMIS Depression ($r_s = 0.24$; $p = 0.0009$), Tegner Pre-shoulder problem ($r_s = -0.26$; $p = 0.0008$), Marx Shoulder Activity Rating Scale ($r_s = -0.26$; $p = 0.0006$), Age ($r_s = 0.26$; $p = 0.0002$), Charlson Comorbidity Index ($r_s = 0.30$; $p < 0.0001$), and MODEMS Expectations ($r_s = -0.18$; $p = 0.0148$) (Table 3). Categorical clinical associations of numerical pain intensity included employment status ($p = 0.0002$), pre-operative opioid use ($p = 0.0048$), marital status ($p = 0.0030$), ASA score ($p = 0.0016$), and depression or anxiety ($p = 0.0196$) (Table 4).

After controlling for likely confounding variables in multivariable analysis, PROMIS Physical Function had the strongest influence on PROMIS PI ($\beta = -0.57$; t-ratio $= -6.44$; $p < 0.0001$). PROMIS Physical Function together with age, BMI, employment status, accounted for 58% of the variance in the PROMIS PI scores (Table 5). Again, after controlling for likely confounding variables, employment status of student had the strongest influence on the shoulder NPS ($\beta = -0.23$; t-ratio $= -2.45$; $p < 0.0158$). Being a student, together with no preoperative narcotics use, higher number of previous surgeries, and an ASA score of 3, accounted for 26% of the variance in the shoulder NPS (Table 5). The most commonly performed procedure in our study population was arthroscopic rotator cuff repair (Table 6). Overall, we found no statistically significant difference between the PROMIS PI score and shoulder NPS score based on the type of procedure performed (F-test p-value = 0.89).

4. Discussion

The findings of our study support our hypothesis that there exists a significant positive correlation between PROMIS PI and traditional shoulder NPS, although, we report a moderate correlation as opposed to strong correlation as stated in our hypothesis. In the clinical setting, and in previous studies, pain is often measured on an ordinal scale employing some variation of the NPS scoring system. However, a patient's perceived pain is more than a number, and often is a complex interplay of an individual's physical, mental, and social status.[15,16] In comparison to NPS, pain interference is a more inclusive metric that helps depict the amount to which pain limits or interferes with an individuals' physical, mental, and social functions.[9] Furthermore, while PROMIS PI did not exhibit any floor or ceiling effects, 26 patients were either at the floor (0/10) or ceiling (10/10) for the shoulder NPS. Thus, it is reasonable to conclude that PROMIS PI can provide a more comprehensive and holistic representation of patients' pain than traditional methods of pain intensity measurement.

As a part of our secondary study aim, we report significant correlation of PROMIS PI with other PROMIS measures of health outcomes and legacy PRO measures. The strong correlation PROMIS PI has with PROMIS Physical Function, PROMIS Fatigue, and ASES total score shows that worse pain interference coincides with poor function and more fatigue. Additionally, PROMIS PI had a moderate correlation with other physical domains, and psychosocial factors including satisfaction, anxiety, and depression. Conversely, the shoulder NPS only demonstrated a strong correlation with ASES total score, a legacy measure of physical function. Shoulder NPS's moderate correlations were with the PROMIS domains aside from Depression, other legacy measures of function, Body Pain Intensity, and number of surgeries. Through these correlations, it is again shown that patients with worse PROMIS PI scores, and to a lesser extent worse shoulder NPS scores, are more likely to experience decreased physical, mental, and social function, more fatigue, and inferior patient reported outcomes. Additionally, the multivariable analysis analyses further illustrate the impact of socioeconomic factors on the phenomena of pain perception, wherein factors such as gender, pre-operative opioid use, smoking, and preexisting comorbidities were identified as significant independent predictors of worse preoperative pain.

Utilization of a better metric for patient-reported outcomes can directly improve patient care. Previous studies in patients undergoing shoulder arthroplasty have identified several clinical factors, such as gender, BMI, and ASA score, associated with outcomes.[29–32] Early identification of patients who are more likely to achieve poor outcomes is critical, as treatments can be personalized to achieve more favorable results. PROs represent a unique way to identify those patients at risk. Wong et al.[33] recently demonstrated that preoperative ASES pain and function scores, as well as Short Form Health Survey (SF-12) Mental Component Summary scores, were predictive of postoperative outcomes after shoulder arthroplasty. However, these traditional PRO measures rely on the NPS, which we have demonstrated to be fallible, prone to over- or underestimating the effect of pain in a patient presenting for shoulder surgery. PROMIS Pain Interference not only has no floor or ceiling effect, but also offers the advantages of speed of administration, as well as capturing function, pain, and social impact in 1 platform. Preoperative PROMIS Pain Interference scores have shown the ability to predict postoperative outcomes in the orthopedic foot and ankle population.[34,35] While PROMIS has been validated in shoulder arthroplasty patients, there is a lack of data in patients undergoing other major shoulder procedures. Given its potential to become a standard-of-care PRO measure in orthopedics, this study offers a baseline assessment of a broad-spectrum of shoulder surgery.

Responses to traditional methods like the NPS are extremely subjective and often exhibiting significant ceiling effects. Such intense pain often is often responded to with the administration of prescription narcotics.[17,18] In 2017 the U.S. Department of Health and Human Services declared a national health emergency to address the national opioid crisis,[36] with an estimated 1.9 million people abusing or dependent on prescription opioid medication in one year alone.[37] In the short- and long-term, PROMIS PI may have the potential to help curb prescription of opioids by providing a more accurate assessment of patients' pain, and help in the

Table 4
Bivariate analysis of categorical variables.

	PROMIS Pain Interference		*p-value*	Shoulder Numeric Pain Intensity		*p-value*
	Mean	*SD*		*Mean*	*SD*	
Sex			**0.0181**			0.15
Male	60.65	*7.33*		60.65	7.33	
Female	62.79	*7.90*		62.80	7.90	
Employment status			< **0.0001**			**0.0002**
Employed for wages	61.69	*8.16*		61.69	8.16	
Self-employed	58.77	*6.28*		58.77	6.28	
Out of work and looking for work	64.65	*0.64*		64.65	0.64	
Out of work but not currently looking for work	61.60			61.60		
Homemaker	65.03	*5.87*		65.03	5.87	
Student	55.16	*6.88*		55.16	6.88	
Military	66.90	.		66.90		
Retired	60.96	*6.68*		60.96	6.68	
Unable to work	66.34	*5.88*		66.34	5.88	
Other	69.12	*4.43*		69.12	4.43	
Income*			**0.0003**			0.14
Less than $10,000	64.56	*7.38*		64.56	7.38	
$10,000 - $19,999	64.81	*5.98*		64.81	5.98	
$20,000 - $29,999	66.18	*5.26*		66.18	5.26	
$30,000 - $39,999	69.48	*5.37*		69.48	5.37	
$40,000 - $49,999	56.68	*8.96*		56.68	8.96	
$50,000 - $59,999	59.50	*9.35*		59.50	9.35	
$60,000 - $69,999	62.90	*7.35*		62.90	7.35	
More than $70,000	58.61	*8.17*		58.61	8.17	
Smoking status*			**0.0205**			0.093
Daily	64.55	*6.57*		64.55	6.57	
Less than daily	60.84	*10.30*		60.84	10.30	
Quit smoking	63.7**2**	*7.63*		63.72	7.63	
Never smoked	60.39	*7.51*		60.39	7.51	
Pre-Operative Opioid Use			< **0.0001**			**0.0048**
Yes	65.58	*6.56*		65.58	6.56	
No	59.81	*7.15*		59.81	7.15	
Marital status			0.12			**0.0030**
Single – never married	59.32	*8.50*		59.32	8.50	
Married or domestic partnership	62.65	*6.60*		62.65	6.60	
Divorced, separated, or widowed	61.17	*6.44*		62.71	8.38	
ASA score			0.20			**0.0016**
1	59.33	*7.99*		59.33	7.99	
2	62.44	*7.15*		62.44	7.15	
3	63.47	*5.44*		63.47	5.44	
4	61.75	*0.49*		61.75	0.49	
Depression or anxiety			0.64			**0.0196**
No	61.41	*7.65*		61.41	7.65	
Yes	61.87	*6.73*		61.87	6.73	

*For each category, the mean (±SD) PROMIS PI and mean (±SD) NPS score is reported.
**Reported p-values represent the significance of the difference between categories respective to each pain measure.

Table 5
Multivariable linear regression model for PROMIS pain interference and numeric pain (intensity) score.

PROMIS PI									
Term	Estimate	Std Error	t Ratio	P value	Lower 95%	Upper 95%	Std Beta	VIF	Adjusted R^2
PROMIS Physical Function	−0.44	0.07	−6.44	<.0001*	−0.57	−0.30	−0.56	2.11	0.58
Employment status_Student	−7.90	2.41	−3.28	0.0014*	−12.67	−3.12	−0.34	3.10	
Age	−0.11	0.04	−3.02	0.0031*	−0.19	−0.04	−0.26	2.05	
BMI	0.22	0.09	2.31	0.0227*	0.03	0.40	0.15	1.15	
Employment status_Employed	−3.49	1.56	−2.23	0.0277*	−6.59	−0.39	−0.23	3.11	
NPS									
Term	**Estimate**	**Std Error**	**t Ratio**	**P value**	**Lower 95%**	**Upper 95%**	**Std Beta**	**VIF**	**Adjusted R^2**
Employment status_Student	−2.02	0.82	−2.45	0.0158*	−3.65	−0.39	−0.23	1.37	0.26
Preop Narcotics (Y/N)_No	−1.95	0.83	−2.36	0.0201*	−3.58	−0.31	−0.33	3.00	
Number of Surgeries	0.15	0.07	2.16	0.0330*	0.01	0.28	0.20	1.40	
ASA Score_3	1.88	0.93	2.03	0.0449*	0.04	3.73	0.17	1.05	

PROMIS: Patient Reported Outcomes Measurement Information System; **ASA**: American Society of Anesthesiologists.

appropriate use of pain management modalities for those patients at greater risk of severe pain interference.[19–23]

Limitations of the present study include all the typical limitations associated with cross-sectional study designs. As a result, it is

Table 6
Ten most performed shoulder procedures versus pain score.

CPT	Description	Count	NPS	PROMIS PI
29827	Arthroscopy, shoulder, surgical; with rotator cuff repair	39	5.34	61.95
23472	Arthroplasty, glenohumeral joint; total shoulder (glenoid and proximal humeral replacement (eg, total shoulder))	32	6.72	62.08
29806	Arthroscopy, shoulder, surgical; capsulorrhaphy	22	3.27	57.86
29825	Arthroscopy, shoulder, surgical; with lysis and resection of adhesions, with or without manipulation	20	6.47	62.55
29826	Arthroscopy, shoulder, surgical; decompression of subacromial space with partial acromioplasty, with coracoacromial ligament (ie, arch) release, when performed (List separately in addition to code for primary procedure)	17	5.53	61.89
23462	Capsulorrhaphy, anterior, any type; with coracoid process transfer	13	4.00	59.09
23395	Muscle transfer, any type, shoulder or upper arm; single	4	4.00	57.35
23515	Open treatment of clavicular fracture, includes internal fixation, when performed	4	2.75	67.25
29823	Arthroscopy, shoulder, surgical; debridement, extensive	4	6.75	59.68
23120	Claviculectomy; partial	3	6.67	65.50

NPS: Numeric Pain Scale; **PROMIS PI**: Patient-Reported Outcomes Information Systems Pain Interference; no procedures were significantly associated with a greater difference between their NPS vs. PROMIS PI scores.

impossible to determine causality with the degree of certainty that is attainable with an experimental study, or if all the potential confounding factors were known, collected and controlled for. Specific strengths of our study include our large sample size and heterogenous group of shoulder procedures. To the best of our knowledge, this is the largest group of patient's undergoing shoulder surgery in which PROMIS Pain Interference was studied. Furthermore, our study population is a racially diverse group from an urban academic medical center, enhancing the generalizability of our data.

5. Conclusion

Multiple measures are available for the measurement of pain in the orthopaedic patient population. The legacy NPS measure is a well-recognized and simple measure of pain intensity, though it is limited by its inability to take into account psychosocial and behavioral factors. The newly developed PROMIS Pain Interference measure may be a more appropriate choice as an outcome measure where the surgeon is concerned about a patient's improvement of functioning and decrease in the impact of pain in other aspects of wellbeing following shoulder surgery.

Funding

This work was supported by a grant from The James Lawrence Kernan Hospital Endowment Fund, Incorporated.

Approval

This study was approved by the Institutional Review Board (IRB) Committee at the University of Maryland, Baltimore (HP-00062261).

Declaration of competing interest

Dr. Henn reports non-financial research support from Arthrex, Inc., outside the submitted work.

Acknowledgements

The authors thank J. Kathleen Tracy, PhD and Michael Smuda, MSAT for their assistance with data collection.

References

1. Simon LS. Relieving pain in America: A blueprint for transforming prevention, care, education, and research. *Journal of pain & palliative care pharmacotherapy*. 2012;26:197–198.
2. Schappert SM. National ambulatory medical care survey: 1992 summary. *Adv Data*. 1994:1–20.
3. Magni G, Marchetti M, Moreschi C, Merskey H, Luchini SR. Chronic musculoskeletal pain and depressive symptoms in the National Health and Nutrition Examination. I. Epidemiologic follow-up study. *Pain*. 1993;53:163–168.
4. Washington (DC). *Musculoskeletal Disorders and the Workplace: Low Back and Upper Extremities*. 2001.
5. Turk DC, Dworkin RH, Revicki D, et al. Identifying important outcome domains for chronic pain clinical trials: an IMMPACT survey of people with pain. *Pain*. 2008;137:276–285.
6. Lorenz KA, Sherbourne CD, Shugarman LR, et al. How reliable is pain as the fifth vital sign? *J Am Board Fam Med*. 2009;22:291–298.
7. Faber E, Kuiper JI, Burdorf A, Miedema HS, Verhaar JA. Treatment of impingement syndrome: a systematic review of the effects on functional limitations and return to work. *J Occup Rehabil*. 2006;16:7–25.
8. Di Fabio RP, Boissonnault W. Physical therapy and health-related outcomes for patients with common orthopaedic diagnoses. *J Orthop Sports Phys Ther*. 1998;27:219–230.
9. Shahgholi L, Yost KJ, Kallmes DF. Correlation of the National Institutes of Health patient reported outcomes measurement information system scales and standard pain and functional outcomes in spine augmentation. *AJNR Am J Neuroradiol*. 2012;33:2186–2190.
10. Hays RD, Bjorner JB, Revicki DA, Spritzer KL, Cella D. Development of physical and mental health summary scores from the patient-reported outcomes measurement information system (PROMIS) global items. *Qual Life Res*. 2009;18:873–880.
11. Amtmann D, Cook KF, Jensen MP, et al. Development of a PROMIS item bank to measure pain interference. *Pain*. 2010;150:173–182.
12. Pilkonis PA, Choi SW, Reise SP, et al. Item banks for measuring emotional distress from the Patient-Reported Outcomes Measurement Information System (PROMIS(R)): depression, anxiety, and anger. *Assessment*. 2011;18:263–283.
13. Cook KF, O'Malley KJ, Roddey TS. Dynamic assessment of health outcomes: time to let the CAT out of the bag? *Health Serv Res*. 2005;40:1694–1711.
14. Kim J, Chung H, Amtmann D, Revicki DA, Cook KF. Measurement invariance of the PROMIS pain interference item bank across community and clinical samples. *Qual Life Res*. 2013;22:501–507.
15. Knorring L. The exerience of pain in depressed patients. A clinical and experimental study. *Neuropsychobiology*. 1975;1:155–165.
16. Magni G, Schifano F, De Leo D. Pain as a symptom in elderly depressed patients. Relationship to diagnostic subgroups. *Eur Arch Psychiatry Neurol Sci*. 1985;235:143–145.
17. Relieving pain in America: a blueprint for transforming prevention, care, education, and research. *Mil Med*. 2016;181:397–399.
18. Burkart BC, Bourne RB, Rorabeck CH, Kirk PG. Thigh pain in cementless total hip arthroplasty. A comparison of two systems at 2 years' follow-up. *Orthop Clin N Am*. 1993;24:645–653.
19. Johnsson R, Thorngren KG. Function after total hip replacement for primary osteoarthritis. *Int Orthop*. 1989;13:221–225.
20. Swanson AJ. The incidence of prepatellar neuropathy following medial meniscectomy. *Clin Orthop Relat Res*. 1983:151–153.
21. Henn 3rd RF, Dubina AG, Jauregui JJ, Smuda MP, Tracy JK. The Maryland Orthopaedic Registry (MOR): design and baseline characteristics of a prospective registry. *J Clin Orthop Trauma*. 2017;8:301–307.
22. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)–a metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inf*. 2009;42:377–381.
23. Henn 3rd RF, Kang L, Tashjian RZ, Green A. Patients' preoperative expectations predict the outcome of rotator cuff repair. *J Bone Joint Surg Am*. 2007;89:1913–1919.

24. Richards RR, An KN, Lu Bigliani, et al. A standardized method for the assessment of shoulder function. *J Shoulder Elbow Surg*. 1994;3:347–352.
25. Tegner Y, Lysholm J. Rating systems in the evaluation of knee ligament injuries. *Clin Orthop Relat Res*. 1985:43–49.
26. Craig CL, Marshall AL, Sjostrom M, et al. International physical activity questionnaire: 12-country reliability and validity. *Med Sci Sports Exerc*. 2003;35:1381–1395.
27. Brophy RH, Beauvais RL, Jones EC, Cordasco FA, Marx RG. Measurement of shoulder activity level. *Clin Orthop Relat Res*. 2005;439:101–108.
28. Levin J. *Elementary Statistics in Social Research*. Pearson Education India; 2006.
29. Wong SE, Pitcher AA, Ding DY, et al. The effect of patient gender on outcomes after reverse total shoulder arthroplasty. *J Shoulder Elbow Surg*. 2017;26:1889–1896.
30. Wells DB, Holt AM, Smith RA, Brolin TJ, Azar FM, Throckmorton TW. Tobacco use predicts a more difficult episode of care after anatomic total shoulder arthroplasty. *J Shoulder Elbow Surg*. 2018;27:23–28.
31. Wagner ER, Houdek MT, Schleck C, et al. Increasing body mass Index is associated with worse outcomes after shoulder arthroplasty. *J Bone Joint Surg Am*. 2017;99:929–937.
32. Johnson CC, Sodha S, Garzon-Muvdi J, Petersen SA, McFarland EG. Does preoperative American Society of Anesthesiologists score relate to complications after total shoulder arthroplasty? *Clin Orthop Relat Res*. 2014;472:1589–1596.
33. Wong SE, Zhang AL, Berliner JL, Ma CB, Feeley BT. Preoperative patient-reported scores can predict postoperative outcomes after shoulder arthroplasty. *J Shoulder Elbow Surg*. 2016;25:913–919.
34. Anderson MR, Houck JR, Saltzman CL, et al. Validation and generalizability of preoperative PROMIS scores to predict postoperative success in foot and ankle patients. *Foot Ankle Int*. 2018;39:763–770.
35. Ho B, Houck JR, Flemister AS, et al. Preoperative PROMIS scores predict postoperative success in foot and ankle patients. *Foot Ankle Int*. 2016;37:911–918.
36. Hargan ED. *Determination that a Public Health Emergency Exists*. Department of Health and Human Services: Office of the Secretary; 2017.
37. Administration SAaMHS. *Results from the 2013 National Survey on Drug Use and Health: Summary of National Findings*. NSDUH Series H-48, HHS Publication No. (SMA) 14-4863. Rockville, MD: Substance Abuse and Mental Health Services Administration; 2014.