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ORIGINAL ARTICLE

Mental health and tobacco use are correlated with PROMIS upper extremity and pain interference scores in patients with shoulder pathology

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Abstract

Purpose To determine whether patient demographics have predictive influence on patient-reported outcomes measurement information system (PROMIS) domains of pain interference (PROMIS-PI), depression (PROMIS-D), and upper extremity (PROMIS-UE) for patients with shoulder pathology treated nonoperatively.

Methods Patients with partial rotator cuff tears, impingement, scapular dyskinesia, osteoarthritis, muscle strains, biceps tendonitis, instability, and acromioclavicular arthritis were retrospectively identified. Patients who underwent surgery were excluded. Demographic characteristics were documented, and PROMIS scores before and after nonoperative intervention were analyzed for correlations between each domain.

Results A total of 638 questionnaires (PROMIS-UE, PROMIS-PI, and PROMIS-D) were analyzed. PROMIS-UE had a strong negative correlation with PROMIS-PI ($R = -0.73$, $P < .001$). PROMIS-PI and PROMIS-D demonstrated a positive correlation of moderate strength ($R = 0.54$, $P < .001$). Patients who never used tobacco, compared to current or former users, had significantly higher PROMIS-UE scores (34.5 vs. 30.6 and 31.9; $P < .001$), lower PROMIS-PI (59.7 vs. 63.1 and 60.9; $P < .001$), and lower PROMIS-D scores (47.3 vs. 52.1 and 49.3; $P < .001$). Patients with body mass index < 24.8 had significantly higher PROMIS-UE scores than those with > 24.8 ($P < .05$).

Conclusion There is an inverse relationship between upper extremity physical function and pain and depression, as measured by PROMIS scores. Smoking and increased BMI are significant contributors to worse outcomes in patients with shoulder pathology, even in nonoperative populations. Counseling patients regarding prognosis and functional outcomes is important in managing their expectations in this patient population.

Keywords PROMIS · Shoulder · Smoking · Depression

Introduction

Patient-reported outcome measures are utilized as tools to evaluate treatment response in patient populations [6, 15]. There are a number of well-studied and validated patient-reported outcome measures collectively known as legacy measures. Historically, these legacy measures have been limited to select patient populations and certain orthopedic conditions, restricting their use in comparisons among studies and communicating between providers. Additionally, legacy measures are often narrow in scope and lengthy to administer and exhibit floor and ceiling effects [25, 28].

The patient-reported outcomes measurement information system (PROMIS) was developed as an initiative to provide a more valid, reliable, and generalizable measure of clinical outcomes [8]. This system was created to evaluate outcomes that are of specific importance to patients under a number of assessable domains spanning physical, mental, and social health. The test is conducted using computer-adaptive testing (CAT), a dynamic algorithm that customizes questions based on answers to previous items [11]. As the patient answers questions, the computer algorithm is able to

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adapt and provide relevant, focused queries. This allows for fewer questions and a higher level of precision, lessening the burden on both patients and providers. Another significant advantage is that scores are reported on a 0–100 normalized scale, allowing for easier comparison [19]. Transitioning to a common system has the potential to standardize outcome reporting and improve the overall quality of the literature.

There have been a number of studies examining the use of PROMIS scores to evaluate outcomes in patients with shoulder pathology [1, 10]. The current orthopedic literature primarily evaluates outcomes using the physical function domain and tends to focus on surgically treated patient populations. A more specific PROMIS domain was developed to focus on the physical function of the upper extremity (PROMIS-UE). This score represents the ability of patients to utilize their upper extremities for a variety of tasks from activities of daily living to athletic movements.

Currently, there is a paucity of investigations examining shoulder pathology as it relates to both physical function and other important health domains, particularly in the patient with diagnosis of partial rotator cuff tears, impingement, scapular dyskinesia, osteoarthritis, muscle strains, biceps tendonitis, instability, and acromioclavicular arthritis treated with nonoperative interventions such as injections, physical therapy, and non-steroidal anti-inflammatories. Additionally, the influence of patient demographic factors and their correlations with pain, depression, and physical function are not well understood.

The purpose of our study was to examine the PROMIS domains of PROMIS-UE, pain interference (PROMIS-PI), defined as the impact of pain on restricting an individual's ability to participate in daily living, and depression (PROMIS-D) for nonoperative patients presenting to our ambulatory sports orthopedic clinic. We also set out to determine whether patient demographics have any predictive influence on reported outcome scores. Our hypothesis is that there will be a strong negative correlation between PROMIS-UE scores and corresponding PROMIS-PI and PROMIS-D scores in our patient population. We also predict that increased age, higher body mass index (BMI), and lower income levels will result in increased pain interference and depression with worse physical function, as measured by PROMIS scores.

Methods

All patients presenting to an orthopedic sports medicine ambulatory clinic of three providers with shoulder complaints were considered eligible for the study. Chart review was performed for all patients aged 18 and older presenting between July 2017 and November 2017. As per the standard clinic workflow, surveys were administered upon check-in for the office visit prior to the evaluation. Patients were identified retrospectively via clinic chart reviews of patients presenting with shoulder pain without subsequent surgical intervention. Patients survey forms were completed on a tablet computer (iPad tablet; Apple, Inc., Cupertino, CA). Those who could not communicate (read and write) in English or refused participation were excluded from the study. Additionally, patients who were planning for future surgical intervention, as indicated in the chart review, were excluded. Patients with a documented diagnosis of shoulder pathology including partial rotator cuff tears, impingement, scapular dyskinesia, osteoarthritis, muscle strains, biceps tendonitis, instability, and acromioclavicular arthritis, who were treated with nonoperative interventions such as injections, physical therapy, and non-steroidal anti-inflammatories, were thereby included in chart review.

Participation in completing intake surveys was voluntary, and the survey was administered on a tablet device. All study data were collected and managed using Research Electronic Data Capture, a secure, web-based application designed to support data capture for research studies hosted at our institution (REDCap, Nashville, TN). These surveys included a questionnaire regarding the general nature of the patient's visit (e.g., location of pain and name of provider), followed by a questionnaire set consisting of PROMIS-PI, PROMIS-UE, and PROMIS-D computer-adaptive tests (CAT).

Patient gender, age, race, ethnicity, BMI, tobacco use, employment status, and the diagnosis of the presenting shoulder of concern were retrospectively collected from electronic medical records. Tobacco use, including any form, was recorded as never, current, or former use. Employment status was recorded as employed or unknown. Patients with documented employment received an employed designation, while those without documented employment received an unknown designation. Median household income (MHI) was recorded as the MHI of the patient's zip code. This information was publically available through the US Census Bureau's American FactFinder Web site (https://factfinder.census.gov/faces/nav/jsf/pages/community_facts.xhtml). Primary diagnosis was determined from a chart review of the clinic visit during which the survey was collected.

Statistical analysis

Continuous data, consisting of PROMIS outcomes, were compared between groups using one-way analyses of variance and independent *t* tests, with $P < .05$ denoted as statistically significant differences. All analyses were performed using Stata, version 14 (StataCorp, LLC, College Station, TX). Pearson correlations were performed to investigate the relationships between PROMIS scores. Correlation coefficients were interpreted based on previously published medical statistics literature, with absolute values of 0.00–0.30

Table 1 Patient demographic characteristics ($n=638$)

Variable		Value
Age (years)*	55.6 ± 17.5	(18–93)
Body mass index*	29.5 ± 6.6	(17.1–54.6)
Median household income (US dollars)*	$63,994 ± $25,640	($14,299–$157,536)
Sex†		
Male	319	50.0%
Female	318	50.0%
Race†		
White	401	62.9%
Black	138	21.6%
Other	99	15.5%
Employment status†		
Employed	260	40.8%
Unknown	378	59.2%
Tobacco use†		
Current	79	12.4%
Former	173	27.1%
Never	371	58.2%
Unknown	15	2.3%

*Values are expressed as mean ± SD (minimum–maximum)

†Values are expressed as number (percentage)

Table 2 Primary diagnosis

Diagnosis	Value
Rotator cuff	314 (49.2%)
Osteoarthritis	59 (9.2%)
Labrum/instability	35 (5.5%)
Proximal bicep	13 (2.0%)
Chronicity	
Acute	401 (62.9%)
Chronic	168 (26.3%)
Unknown	69 (10.8%)

Values are expressed as number (percentage)

Table 3 Questions completed per PROMIS domain

PROMIS domain	Mean ± SD
Upper extremity	4.9 ± 2.1
Pain interference	4.3 ± 1.3
Depression	6.6 ± 3.5

PROMIS patient-reported outcomes measurement information system, *SD* standard deviation

Table 4 Correlations between PROMIS domains

	PROMIS-UE	PROMIS-PI
PROMIS-PI	−0.73*	
PROMIS-D	−0.48*	0.54*

PROMIS patient-reported outcomes measurement information system, *PROMIS-D* PROMIS depression, *PROMIS-PI* PROMIS pain interference, *PROMIS-UE* PROMIS upper extremity physical function

*Indicates statistically significant correlation ($P<.05$)

representing a negligible correlation, 0.31–0.50 a weak correlation, 0.51–0.70 a moderate correlation, 0.71–0.90 a strong correlation, and 0.91–1.00 a very strong correlation [20].

Results

A total of 638 computer-adaptive testing questionnaire sets (PROMIS-UE, PROMIS-PI, and PROMIS-D) were collected and analyzed from 524 unique patients, representing some patients with multiple clinic visits during the study period (Table 1), totaling 1910 PROMIS forms. The average age of the patients surveyed was 56 years (range 18–93 years; standard deviation [SD] ± 17.5) with 50.0% male and female participants. The MHI as determined by zip code was $63,994 (range $14,229–$157,536; SD ± $25,640). The average BMI of our population was 29.5 mg/kg^2 (range 17.1–54.6; SD ± 6.6), and 62.9% of the patients identified as white. Two hundred sixty (40.8%) of the questionnaire sets were completed by patients with documented employment. Patients that were unemployed or did not have employment status documented in their chart were collectively categorized as unknown. The majority of patient surveys (58.2%) stated they have never used tobacco. The most frequent diagnoses were those of the rotator cuff (49.2%), followed by osteoarthritis, labrum/instability, and proximal biceps-related concerns (Table 2).

Each PROMIS questionnaire was administered on a CAT platform; thereby, questionnaires varied in length depending on the responses to each question. Table 3 lists the number of questions completed on average by patients for each PROMIS domain. PROMIS-D required the most questions on average (6.6) followed by PROMIS-UE and PROMIS-PI.

Table 4 summarizes PROMIS correlations as each domain relates to the other domains. PROMIS-UE was found to have a strong negative correlation with PROMIS-PI ($R=-0.73$, $P<.001$) and a weak correlation with PROMIS-D ($R=-0.46$, $P<.001$). Additionally, PROMIS-PI and PROMIS-D were positively correlated with each other with moderate strength ($R=0.54$, $P<.001$).

Age, BMI, and MHI were stratified into quartiles, and the average PROMIS-UE, PROMIS-PI, and PROMIS-D scores are reported in Table 5. Younger patients (first

Table 5 Impact of patient demographics on PROMIS

	PROMIS-UE	PROMIS-PI	PROMIS-D
Mean	33.2 ± 8.9	60.5 ± 7.3	48.6 ± 10.2
Range	(14.7–61.0)	(38.7–83.8)	(34.0–81.1)
Sex			
Male	35.8 ± 9.2*	58.9 ± 7.4*	46.7 ± 10.1*
Female	30.7 ± 7.8*	62.1 ± 6.9*	50.5 ± 9.9*
Race			
White	33.7 ± 9.1	59.8 ± 7.2*	48.2 ± 9.8
Black	32.4 ± 8.5	62.0 ± 7.4*	48.7 ± 11.3
Other	32.7 ± 8.8	61.1 ± 7.2*	50.0 ± 10.2
Tobacco use			
Current	30.6 ± 7.4*	63.1 ± 6.9*	52.1 ± 11.9*
Former	31.9 ± 8.9*	60.9 ± 7.0*	49.3 ± 9.2*
Never	34.5 ± 9.1*	59.7 ± 7.4*	47.3 ± 10.1*
Chronicity			
Acute (≤ 6 weeks)	33.2 ± 8.7	60.7 ± 7.0	49.2 ± 10.2
Chronic (> 6 weeks)	31.9 ± 8.5	61.3 ± 6.9	48.9 ± 10.1
Age quartile			
1st (10–46 years)	36.0 ± 9.4*	60.1 ± 7.6	46.8 ± 9.7*
2nd (47–57 years)	33.2 ± 8.3*	60.7 ± 7.5	49.1 ± 11.2*
3rd (58–67 years)	32.9 ± 9.1*	60.3 ± 7.5	47.6 ± 9.7*
4th (68–93 years)	31.0 ± 8.1*	60.9 ± 6.7	50.8 ± 9.8*
Body mass index quartile			
1st (17.1–24.8)	32.4 ± 9.0*	60.7 ± 8.1	49.9 ± 10.5
2nd (24.8–28.3)	35.0 ± 10.0*	60.0 ± 6.8	47.7 ± 9.5
3rd (28.3–33.3)	32.9 ± 8.0*	60.3 ± 6.7	48.9 ± 10.1
4th (33.3–54.6)	32.7 ± 8.4*	60.9 ± 7.5	48.0 ± 10.5
MHI quartile			
1st ($14,299–$45,795)	32.4 ± 8.6	61.9 ± 7.4*	49.6 ± 12.3
2nd ($46,238–$62,987)	33.2 ± 8.8	60.6 ± 7.2*	48.8 ± 9.5
3rd ($63,073–$78,884)	33.7 ± 9.1	59.5 ± 7.6*	46.8 ± 9.4
4th ($79,245–$157,536)	33.7 ± 9.1	60.1 ± 6.9*	49.1 ± 9.3

MHI median household income, *PROMIS* patient-reported outcomes measurement information system, *PROMIS-D* PROMIS depression, *PROMIS-PI* PROMIS pain interference, *PROMIS-UE* PROMIS upper extremity physical function

*Denotes a statistically significant finding ($P \leq .05$)

quartile: 10–27 years) had significantly higher PROMIS-UE, lower PROMIS-PI, and lower PROMIS-D scores than patients older than 27 years ($P < .05$ for all). Patients with lower BMI (first quartile: 15.8–24.8) had significantly higher PROMIS-UE scores than patients with a BMI larger than 24.8 ($P < .05$).

When stratified by patient demographics, male patients had significantly higher average PROMIS-UE scores compared to female patients (35.8 vs. 30.7, respectively; $P < .001$), while having lower pain interference (58.9 vs. 62.1, respectively; $P < .001$) and depression scores (46.7 vs. 50.5, respectively; $P < .001$). Black patients had significantly higher PROMIS-PI scores (62.0) compared to white patients (59.8, $P < .05$) and those of all other races (61.1; $P < .05$). Patients who have never used tobacco had statistically significantly higher PROMIS-UE scores (34.5 vs. 30.6 and 31.9, respectively; $P < .001$) and lower PROMIS-PI (59.7 vs. 63.1 and 60.9, respectively; $P < .001$) and PROMIS-D scores (47.3 vs. 52.1 and 49.3, respectively; $P < .001$) than those who were current or former tobacco users. There was also no statistically significant difference in PROMIS-PI, PROMIS-D, and PROMIS-UE between acute and chronic conditions. These relationships are presented in Table 5.

Discussion

The most important finding of this study is the strong influence that pain and depression confer upon reduced upper extremity function. Additionally, smoking is a further risk factor for poor outcomes in this patient population. As such, providers should be aware of patients with these risk factors and counsel them appropriately as they initiate the nonoperative treatment pathway for a multitude of shoulder pathologies. These results confirmed our primary hypothesis, and lower physical function scores in the upper extremity are correlated with increased PROMIS-PI and PROMIS-D scores. PROMIS-UE had a strong negative correlation with PROMIS-PI and a near moderate negative correlation with PROMIS-D. This demonstrates the close relationship between pain, function, and mental health in our population of shoulder patients being treated nonoperatively.

Higher PROMIS-D score was correlated with worse PROMIS-UE and PROMIS-PI scores. Using legacy measures, Wylie et al. previously demonstrated that a patient's mental health has the strongest association with shoulder function and shoulder pain scores. Interestingly, rotator cuff tear severity was not as strongly correlated with function and pain as mental health [31]. This study demonstrates the negative association of depression with pain and function using PROMIS scores. As the trend to evaluate orthopedic care shifts from purely objective outcome measures to patient-reported measures, understanding the patient specific factors that influence patient-reported outcome measures is increasingly important [9, 18, 23, 24]. The patients included in this study completed PROMIS-D computer-adaptive testing forms in roughly seven questions. PROMIS-D is a relatively low burden and effective method to evaluate a patient's mental health.

Previous studies have examined surgical outcomes in smokers undergoing shoulder procedures. Smoking has consistently demonstrated a negative effect on healing, failure of surgery, and overall postoperative outcomes [13, 17, 27]. Smoking also has been shown to predispose patients to rotator cuff pathology [4]. Larger rotator cuff tears and increased tear severity are correlated with the daily number

of cigarettes [7]. Smoking leads to an increased duration of inflammation secondary to the proinflammatory cytokines [3, 26] it promotes, which have been associated with rotator cuff tendinopathy and subacromial bursitis [5, 12, 29]. This investigation demonstrated the significant negative impact of smoking on physical function, pain, and depression. With regard to the minimal clinically important differences (MCID) for PROMIS scores, previous standards have been established which can be applied to our results. Norman et al., in a series of papers, validated that a difference of at least one-half of the SD of the mean consistently represents a MCID in patient outcome [21, 22]. Orthopedic literature has applied these principles with regard to PROMIS-PI and PROMIS-D [14]. We found that for current smokers, the PROMIS-UE score (30.6) plus one-half the SD (3.7) equaled 34.3, which was less than the PROMIS-UE improvements of non-smokers (34.5). Likewise, the PROMIS-PI of non-smokers (59.7) was nearly the same as that of current smokers (63.1) minus one-half the SD (59.65). The PROMIS-D of smokers (52.1) and non-smokers (47.3) was within one-half SD (5.95) of one another. These findings demonstrate that treating smokers with shoulder pathology has the potential to change patient outcomes in a clinically significant manner. Further studies are needed to delineate whether smoking cessation in a previous smoker improves these outcomes or whether focusing on smoking cessation on this population improves their outcomes irrespective of treatment for their shoulder pathology.

BMI is also a well-known contributor to poorer health outcomes. There have been conflicting reports on the influence of BMI on functional outcomes following shoulder surgery. Specifically, after rotator cuff repair, a study investigating the effect of BMI on outcomes following rotator cuff repair found higher rates of failure and worse outcomes scores when stratifying patients by BMI [2]. Contrary to this investigation, a 2018 investigation found no difference in functional outcomes and pain scores at 3-year follow-up; however, there was a higher likelihood of patient admission in the obese group [16]. This was reiterated in other studies that found longer operative time and increased lengths of stay in the hospital for rotator cuff repairs on obese individuals [30]. Our study showed that even in nonoperative patients, increasing BMI was a risk factor for poorer functional outcomes. This demonstrates the importance of managing patients' expectations when counseling them on their treatment and prognosis.

Limitations

This investigation was not without limitations. This study was conducted in a single healthcare system; thus, it may not be generalizable to all populations. However, our institution has multiple clinical sites across a diverse metropolitan area, demonstrated by the wide range in MHI. This is a cross-sectional study, and surveys were not tracked over time. Finally, the patient demographics were gathered from the electronic health record; however, this information is updated during each clinic visit for patients throughout the medical system (a large regional healthcare system with a captured patient population across many sites and specialties).

Conclusion

In conclusion, our study demonstrated that in patients with shoulder pathology initiated on nonoperative treatment interventions, there is an inverse relationship between upper extremity physical function and pain and depression, as measured by PROMIS scores. Smoking and increased BMI are significant contributors to worse outcomes in patients with shoulder pathology, even in nonoperative populations. Counseling patients regarding prognosis and functional outcomes is important in managing their expectations in this patient population.

Smoking cessation and weight loss should be considered as initial steps to treating shoulder pathology. The findings in this study help identify patients at high risk for poor outcomes in order to help guide future treatment.

Authors' contributions MF, JT, LK, SM, VM, and EM contributed to the concept and design of the work. JM and GS carried out the chart review and questionnaire documentation. JM and GS created the format of the database, which MF, JT, and LK supervised along with the chart review. SM, VM, and EM reviewed the database for errors. MF, JT, LK, SM, VM, and EM carried out literature review. MF, JT, LK, JM, GS, SM, VM, and EM participated in detailing the statistical analysis request, analyzing the results, and synthesizing tables and figures as well as drafting the manuscript. SM, EM, and VM cross-referenced that statistical results and tables to confirm accuracy. SM, EM, and VM provided feedback and edits to statistical requests, as well as analysis of results. SM, EM, and VM revised drafts of the work. All authors contributed to multiple revisions of the manuscript. SM, VM, and EM are attending physicians who included patients in the study, reviewed the literature cited and statistical analysis requested, revised each draft of the manuscript, and provided mentorship throughout the course of the study. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest Educational and material support from Stryker, Arthrex, and Pinnacle is disclosed by V.M. Consultation and royalty/material support from Smith & Nephew and Springer are disclosed by E.M. There are no disclosures directly relevant to this work. No other authors report any conflicts of interest.

Ethical approval This project was reviewed and approved by the Institutional Review Board at Henry Ford Hospital, the main institution of the attending physician conducting the research.

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