

Interpretation of PROMIS Depression and Anxiety Measures Compared with DSM-5 Diagnostic Criteria in Musculoskeletal Patients

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Background: There is growing awareness among orthopaedic clinicians that mental health directly impacts clinical musculoskeletal outcomes. The Patient-Reported Outcomes Measurement Information System (PROMIS) is increasingly used for mental health screening in this context, but proper interpretation of patient scores remains unclear. The purpose of the present study was to compare musculoskeletal patients' PROMIS Depression and Anxiety scores with a board-certified clinical psychologist's assessment of their depression and/or anxiety diagnoses, as defined by Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) criteria.

Methods: In this cross-sectional analysis, existing medical records were reviewed for 50 patients who presented to an interdisciplinary program within a tertiary care orthopaedic department for the treatment of ≥ 1 musculoskeletal condition. All patients completed PROMIS Depression and Anxiety measures and were evaluated by a board-certified clinical psychologist. Receiver operating characteristic (ROC) curve analyses were performed to assess the diagnostic accuracy of PROMIS Depression and Anxiety scores as compared with the psychologist's diagnosis of a DSM-5 depressive or anxiety disorder.

Results: Twenty-eight patients (56%) were diagnosed by the psychologist with a DSM-5 depressive disorder, and 15 (30%) were diagnosed with a DSM-5 anxiety disorder. The ROC analysis for PROMIS Depression had an area under the curve (AUC) of 0.82. The optimal score cutoff to predict a diagnosis of a DSM-5 depressive disorder was ≥ 53 (sensitivity, 79% [95% CI, 63% to 94%]; specificity, 86% [72% to 100%]; positive predictive value [PPV], 88% [75% to 100%]; negative predictive value [NPV], 76% [59% to 93%]). The ROC analysis for PROMIS Anxiety had an AUC of 0.67. The optimal score cutoff to predict a diagnosis of a DSM-5 anxiety disorder was ≥ 59 (sensitivity, 60% [95% CI, 35% to 85%]; specificity, 74% [60% to 89%]; PPV, 50% [27% to 73%]; and NPV, 81% [68% to 95%]).

Conclusions: Modestly elevated PROMIS Depression scores were suggestive of the presence of a DSM-5 depressive disorder, whereas elevations in PROMIS Anxiety scores seemed to have less association with DSM-5 anxiety disorders. Nevertheless, neither PROMIS measure demonstrated adequate discriminant ability to definitively identify patients who met DSM-5 criteria.

Level of Evidence: Prognostic Level III. See Instructions for Authors for a complete description of levels of evidence.

The detrimental effects of depression and anxiety on orthopaedic outcomes have been established across orthopaedic subspecialties. Compared with the absence of these comorbidities, preexisting depression and anxiety have been associated with worse pain and function, increased post-operative opioid use, worse satisfaction, and increased hospitalization costs and complication rates after procedures such as hip arthroscopy, knee arthroplasty, shoulder arthroplasty, and spine

surgery¹⁻¹¹. There is growing awareness among orthopaedic clinicians that mental health directly impacts physical health¹²⁻¹⁴, and mental health screening in the context of musculoskeletal care is becoming more commonplace. However, it is not yet the standard of care¹².

Orthopaedic surgeons have cited a lack of time as a primary barrier to screening for, and addressing, mental health impairment as part of standard musculoskeletal care¹². For orthopaedic

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clinicians who do incorporate mental health screening into their practices, the Patient-Reported Outcomes Measurement Information System (PROMIS) Depression and Anxiety measures have become popular tools because they are short questionnaires that can harness computer adaptive testing (CAT) technology to efficiently provide precise scores¹⁵⁻²⁴. Yet, appropriate use of PROMIS measures requires that clinicians understand how to interpret patient scores clinically. The PROMIS Depression and Anxiety measures have been compared with well-established legacy depression and anxiety screening measures, and scoring crosswalks have been developed between PROMIS measures and the Patient Health Questionnaire-9 (PHQ-9) depression instrument and Generalized Anxiety Disorder-7 (GAD-7) instrument, among others²⁵⁻²⁸. However, to our knowledge, comparison of PROMIS Depression and Anxiety scores with the gold-standard Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) depression and anxiety criteria has only been done at a cursory level and has never previously been performed for patients with musculoskeletal conditions²⁹.

The purpose of the present study was to compare the PROMIS Depression and Anxiety scores for a group of patients with musculoskeletal conditions against the clinical diagnoses of depression and/or anxiety as determined by a clinical psychologist according to DSM-5 criteria. We hypothesized that, compared with DSM-5 criteria as the gold standard, the diagnostic accuracy of PROMIS Depression and Anxiety would be insufficient to generate useful score cutoffs that could be used as stand-alone, diagnostic mental health assessments in this patient population.

Materials and Methods

This cross-sectional analysis of existing medical records was performed at a single tertiary care academic medical center. University institutional review board approval was obtained prior to data collection via a waiver of informed consent. Medical record data were recorded between September 7, 2017, and January 27, 2021. Data extraction and analysis were performed in 2021 and 2022.

Participants

All patients included in the study were receiving care for ≥ 1 musculoskeletal condition from an interdisciplinary program within the orthopaedic department of our institution. The purpose of the program is to address patient comorbidities that contribute to chronic pain and functional impairment due to musculoskeletal conditions. Patients often enroll in the program to reduce their perioperative risk prior to proceeding with elective orthopaedic surgery. The program is led by a board-certified sports medicine physical medicine and rehabilitation physician (physiatrist), and, as indicated, patients in the program participate in behavioral health counseling, nutrition counseling, smoking cessation counseling, physical therapy, acupuncture, and medical massage³⁰. They complete the Adult PROMIS CAT Depression v1.0 and Anxiety v1.0 assessments on a tablet computer (iPad mini; Apple) prior to clinician encounters¹⁵. Patients are advised to have a consultation with the program's board-certified clinical psychologist if they

report, or if the clinician is concerned, that their mental health could be interfering with the management of their musculoskeletal pain. To be eligible for this study, patients had to have been evaluated by the program psychologist (B.A.H.), who has >40 years of clinical experience and assesses each patient for psychiatric disorders as defined by DSM-5 criteria. Patients who were <18 years old or who had not completed PROMIS Depression and Anxiety measures within 1 month before or after the psychological evaluation were excluded from analysis.

Outcome Measures

PROMIS is a set of patient-reported measures that assesses a variety of health domains. Scores for each PROMIS measure are normalized to a mean of 50 and a standard deviation of 10, and the reference population for the measures used in the present study was a representative sample of generally healthy people who mirror the demographic distribution of the 2000 U.S. General Census¹⁵. A higher PROMIS score represents "more" of the domain, such that a score of 60 on the PROMIS Depression or Anxiety measure is unfavorable. All PROMIS measures used in this study inquire about symptoms over the previous 7 days. The PROMIS Depression domain assesses "self-reported negative mood (sadness, guilt), views of self (self-criticism, worthlessness), and social cognition (loneliness, interpersonal alienation), as well as decreased positive affect and engagement (loss of interest, meaning, and purpose)." Somatic symptoms such as changes in appetite and/or sleeping patterns are intentionally omitted from this domain because these symptoms can also be due to physical conditions. Thoughts of death or suicide are not specifically addressed in this PROMIS domain either¹⁶. The PROMIS Anxiety domain assesses "self-reported fear (fearfulness, panic), anxious misery (worry, dread), hyperarousal (tension, nervousness, restlessness), and somatic symptoms related to arousal (racing heart, dizziness)." Behavioral fear avoidance is not fully evaluated by the PROMIS Anxiety domain^{17,18}.

The clinical psychologist followed the usual structure of a psychiatric interview (i.e., present and past history of psychiatric disorders and psychological stress, including psychiatric symptoms

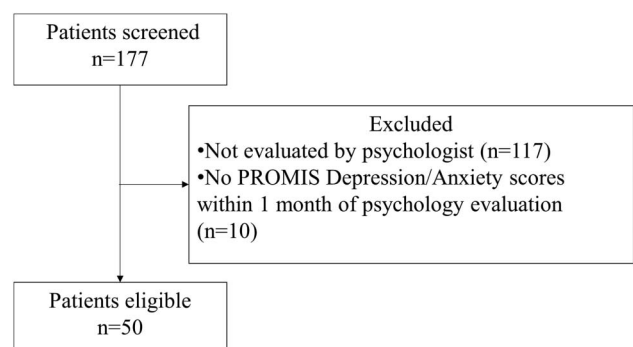


Fig. 1

Flowsheet illustrating how the study group was derived from the overall cohort of patients who were receiving care from an interdisciplinary program for ≥ 1 musculoskeletal condition. PROMIS = Patient-Reported Outcomes Measurement Information System.

TABLE I Demographic and Musculoskeletal Characteristics of 50 Patients Who Were Evaluated by a Clinical Psychologist as Part of an Interdisciplinary Program for Musculoskeletal Conditions*†

Age‡ (yr)	58 ± 14 (22-76)
Sex (no. of patients)	
Female	38 (76%)
Male	12 (24%)
Race (no. of patients)	
White/Caucasian	40 (80%)
African American	8 (16%)
Asian	1 (2%)
Other	1 (2%)
Ethnicity (no. of patients)	
Hispanic	1 (2%)
Non-Hispanic	48 (98%)
National ADI quartile (no. of patients)	
1 (least disadvantaged)	16 (32%)
2	20 (40%)
3	10 (20%)
4 (most disadvantaged)	4 (8%)
Pain location(s) (no. of patients)	
Low back	32 (64%)
Hip/pelvis	14 (28%)
Knee	12 (24%)
Foot/ankle	4 (8%)
Diffuse leg	6 (12%)
Neck	3 (6%)
Shoulder	4 (8%)
Generalized	6 (12%)
Other	3 (6%)
Primary musculoskeletal diagnosis (no. of patients)	
Degenerative disc/spine disease	10 (20%)
Lumbosacral radiculopathy	16 (32%)
Hip osteoarthritis	11 (22%)
Knee osteoarthritis	9 (18%)
Other	4 (8%)
Pain duration for musculoskeletal condition (no. of patients)	
<6 mo	1 (2%)
6 to <12 mo	2 (4%)
1 to <5 yr	16 (35%)
5 to <10 yr	9 (20%)
≥10 yr	18 (39%)

*continued***TABLE I** (continued)

PROMIS CAT Physical Health scores‡	
Physical function	36.0 ± 6.7 (23.2-56.1)
Pain interference	62.3 ± 7.8 (33.6-73.7)

*N = 49 for ethnicity, n = 46 for pain duration. †ADI = Area Deprivation Index, PROMIS = Patient-Reported Outcomes Measurement Information System, CAT = Computer Adaptive Test. ‡The values are given as the mean and the standard deviation, with the range in parentheses.

and behaviors, medications, and psychological interventions) to assess each patient for diagnostic criteria relevant to any type of depressive and/or anxiety diagnosis, as defined by DSM-5 criteria³¹. The DSM-5 criteria are the universally accepted standard for the psychiatric diagnosis of depressive and anxiety disorders. Previous orthopaedic research has not routinely considered depression or anxiety subtypes when evaluating the effect of mental health on physical health; therefore, for the purposes of this study, all DSM-5 depressive disorders were categorized together (e.g., major depressive disorder, persistent depressive disorder [referred to as “dysthymia” in DSM-4 criteria], unspecified depressive disorder, etc.) and all DSM-5 anxiety disorders were categorized together (e.g., generalized anxiety disorder, social anxiety disorder, unspecified anxiety disorder, etc.). The psychologist’s note was used to determine the DSM-5 mental health disorders (if any) for which the patient met diagnostic criteria. Data extraction from the psychologist’s note was performed by a masters’-level clinical social worker with decades of clinical research experience.

Other data that were collected included demographic characteristics (age, sex, race, ethnicity, Area Deprivation Index [a measure of social disadvantage])^{32,33}, musculoskeletal characteristics (pain location[s], primary musculoskeletal diagnosis, pain duration, Adult PROMIS Physical Function CAT v2.0, and Adult PROMIS Pain Interference CAT v1.1), and mental health history (history of diagnosed depression and/or anxiety, and timing of when psychological symptoms started relative to musculoskeletal symptoms). All variables were extracted from the psychologist’s structured clinical notes or from the patient’s history in the electronic medical record, which is reconciled at every clinical visit.

Statistical Analysis

Univariate descriptive statistics were calculated for the study population as a whole. The primary analysis in this study was designed to determine the discriminant ability of PROMIS Depression and Anxiety measures to identify the presence or absence of a clinical diagnosis of depression or anxiety, respectively, as determined by a board-certified clinical psychologist on the basis of DSM-5 criteria, in patients with musculoskeletal conditions. A receiver operating characteristic (ROC) curve was generated for each PROMIS measure. The area under the curve (AUC) was calculated for each ROC curve, and the sensitivity, specificity, positive predictive value (PPV), and negative

predictive value (NPV) for the optimal cutoff score on each measure were calculated. Consistent with a previous study that compared PROMIS Depression scores with DSM-4 criteria in young adult cancer survivors, thresholds of sensitivity ($\geq 85\%$) and specificity ($\geq 75\%$) were a priori set as the minimum requirements to consider a PROMIS measure as having adequate discriminant ability³⁴. All analyses were performed on the sample of all eligible patients. Study data were collected and managed with use of Research Electronic Data Capture (REDCap)³⁵. All statistical analyses were performed in SAS (v9.4; SAS Institute).

Source of Funding

This study was supported by the National Institutes of Health (K23AR074520, P5MH122351), the Doris Duke Charitable Foundation, the Barnes-Jewish Hospital Foundation, and the Jacqueline N. Baker Washington University Living Well Center Fund. The funding sources played no role in the conduct of this study.

Results

Of the 177 patients who were screened for the study, 50 were eligible for inclusion (Fig. 1). The patients had a mean age (and standard deviation) of 58 ± 14 years, and 38 patients (76%) were female (Table I). PROMIS score distributions were comparable between patients who were and were not eligible (see Appendix). Of the eligible patients, 28 (56%) were diagnosed by the clinical psychologist with a DSM-5 depressive disorder and 15 (30%) were diagnosed with a DSM-5 anxiety disorder; 7 of these patients (14% of all patients) were diagnosed with comorbid depressive and anxiety disorders on the basis of DSM-5 criteria (Table II; see also Appendix).

The ROC curve for PROMIS Depression had an AUC of 0.82 (Fig. 2). The optimal PROMIS score cutoff to predict a diagnosis of a DSM-5 depressive disorder as determined by the clinical psychologist was ≥ 53 (sensitivity, 79% [95% confidence interval (CI), 63% to 94%]; specificity, 86% [95% CI, 72% to 100%]; PPV, 88% [95% CI, 75% to 100%]; NPV, 76% [95% CI, 59% to 93%]) (see Appendix). Based on the minimum sensitivity and specificity values specified a priori, PROMIS Depression demonstrated adequate specificity but not adequate sensitivity to identify patients who met DSM-5 criteria for a depressive disorder among this patient population.

The ROC curve for PROMIS Anxiety had an AUC of 0.67 (Fig. 3). The optimal PROMIS score cutoff to predict a diagnosis of a DSM-5 anxiety disorder determined by the clinical psychologist was ≥ 59 (sensitivity, 60% [95% CI, 35% to 85%]; specificity, 74% [95% CI, 60% to 89%]; PPV, 50% [95% CI, 27% to 73%]; NPV, 81% [95% CI, 68% to 95%]) (see Appendix). Based on the minimum sensitivity and specificity values specified a priori, PROMIS Anxiety did not demonstrate adequate discriminant ability to identify patients who met DSM-5 criteria for an anxiety disorder among this patient population.

Discussion

In patients with chronic musculoskeletal conditions who were evaluated by a clinical psychologist, the optimal PROMIS

TABLE II Mental Health Characteristics of 50 Patients Who Were Evaluated by a Clinical Psychologist as Part of an Interdisciplinary Program for Musculoskeletal Conditions*†

Previous mental health diagnosis (<i>no. of patients</i>)	
Depression	26 (53%)
Anxiety	18 (36%)
Onset timing of psychological symptoms (<i>no. of patients</i>)	
Prior to musculoskeletal pain	14 (28%)
Near onset of musculoskeletal pain	3 (6%)
After onset of musculoskeletal pain	6 (12%)
No psychological symptoms endorsed	15 (30%)
Unclear	12 (24%)
PROMIS CAT Mental Health scores‡	
Depression	52.2 \pm 9.1 (34.2-78.1)
Anxiety	54.9 \pm 9.4 (35.9-73.4)
Met DSM-5 criteria for mental health disorder (<i>no. of patients</i>)	
Any depressive disorder	28 (56%)
Major depressive disorder	5 (10%)
Any anxiety disorder	15 (30%)
Generalized anxiety disorder	1 (2%)

*N = 49 for previous diagnosis of depression. †PROMIS = Patient-Reported Outcomes Measurement Information System, CAT = Computer Adaptive Test. ‡The values are given as the mean and the standard deviation, with the range in parentheses.

Depression cutoff score to predict the presence of a DSM-5 depressive disorder was ≥ 53 (sensitivity, 79%; specificity, 86%), with overall good performance (AUC, 0.82). The optimal PROMIS Anxiety cutoff score to predict the presence of a DSM-5 anxiety disorder was ≥ 59 (sensitivity, 60%; specificity, 74%), but overall, the ROC curve performed poorly (AUC, 0.67). As hypothesized, neither measure demonstrated adequate discriminant ability to definitively identify patients who meet DSM-5 criteria.

Comparison with Prior Literature

Our PROMIS Depression cutoff score of 53 is close to the U.S. population mean of 50, yet it is consistent with prior literature that aimed to detect at least mild depression in a screening setting. The PROsetta Stone project developed crosswalk tables between PROMIS measures and legacy depression self-reported assessments. In volunteers from the general U.S. population, the project showed that a score of 52.5 on PROMIS Depression corresponded

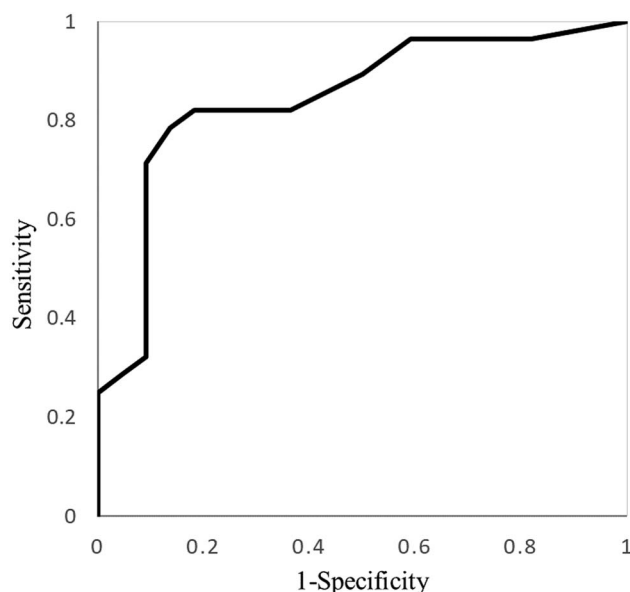


Fig. 2
ROC curve for the ability of the Adult PROMIS Depression CAT to accurately diagnose a depressive disorder, as defined by DSM-5 criteria, in musculoskeletal patients who were evaluated by a clinical psychologist ($n = 50$; AUC, 0.82; optimal cutoff, 53; sensitivity, 79%; specificity, 86%).

to a PHQ-9 score of 5, which suggests at least mild depression^{25,27}. Analysis of 2 cohorts of oncology patients, including 1 in which the gold standard for diagnosing depression was a structured diagnostic interview by a psychologist, also identified 53 as the optimal PROMIS Depression cutoff score^{29,34}. Finally, in a cohort of orthopaedic patients undergoing spine surgery, a slightly higher cutoff score of 55 was determined to indicate “probable major depression” when compared with a legacy depression assessment²⁴.

In contrast, our PROMIS Anxiety cutoff score of 59 approaches 1 standard deviation worse than the U.S. population mean and is somewhat higher than what would be expected on the basis of previous literature. In volunteers from the general U.S. population, the PROsetta Stone project showed that a PROMIS Anxiety score of only 54.6 corresponds with a Generalized Anxiety Disorder-7 (GAD-7) score of 5, which is the cutoff for at least mild anxiety^{26,28}. Similarly, in patients undergoing spine surgery who completed PROMIS Anxiety and a legacy anxiety assessment, a PROMIS Anxiety cutoff score of 57 was determined to best predict the presence of generalized anxiety disorder²⁴.

Interpretation of Findings

Although DSM-5 diagnoses and PROMIS mental health measures are conceptually different and were created for different purposes^{18,31}, the present study adds to the body of literature that suggests PROMIS mental health measures can be useful screening tools to identify patients who may be at risk for worse orthopaedic outcomes because of a mental health comorbidity. In the present study, modestly elevated PROMIS Depression scores were suggestive of the presence of a true DSM-5 de-

pressive disorder for which a mental health specialist would consider the use of psychotherapy and/or an antidepressant. In contrast, elevations in PROMIS Anxiety scores seemed to have less association with DSM-5 anxiety disorders. Rather, they may more closely reflect a patient’s worry, concern, or vigilance about recurring pain flares and/or fear about further physical health declines due to a musculoskeletal condition. Validation of the cutoff scores that we identified could efficiently be conducted via secondary analysis of previously completed longitudinal cohort studies in which PROMIS Depression and/or Anxiety scores were collected at baseline. In the meantime, while referral for mental health evaluation is never inappropriate, elevated PROMIS Depression scores may be more indicative of a true underlying mental health disorder than elevated PROMIS Anxiety scores.

In addition to serving as an efficient screening tool, collecting PROMIS mental health measures can also open the door for an orthopaedic clinician to discuss and normalize the importance of mental health within the context of musculoskeletal care. However, clinicians’ comfort with discussing mental health can be a persistent barrier to addressing it in the orthopaedic setting¹². Table III provides examples of efficient, non-stigmatizing approaches to discuss patients’ mental health as it relates to their orthopaedic condition.

Strengths and Limitations

The present study provides context to interpreting PROMIS mental health measures specifically for patients who are seeking care for chronic musculoskeletal conditions. Furthermore, in contrast to the limited existing literature investigating this topic as

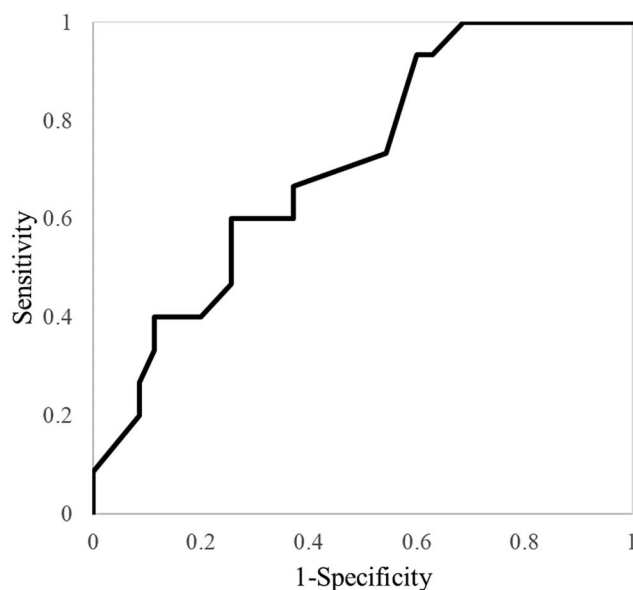


Fig. 3
ROC curve for the ability of the Adult PROMIS Anxiety CAT to accurately diagnose an anxiety disorder, as defined by DSM-5 criteria, in musculoskeletal patients who were evaluated by a clinical psychologist ($n = 50$; AUC, 0.67; optimal cutoff, 59; sensitivity, 60%; specificity, 74%).

TABLE III Examples of Efficient, Non-Stigmatizing Statements That Orthopaedic Clinicians Can Use to Discuss Patients' Mental Health Screening Scores and the Importance of Mental Health in the Context of Musculoskeletal Care

Instead of This...	Say This...
"Your depression scores are high, which puts you at higher risk for postoperative complications. Do you see a psychiatrist?"	"Your score on this survey suggests you might have some symptoms of depression. That's very common in my patients, but having these symptoms around the time of surgery can affect your recovery. Do you have support for your mental wellness as we prepare for surgery?"
"Before I operate, you have to get your anxiety under control."	"Surgery is a stress on both your body and your mind. To get the best results, I take a whole-person approach to preoperative care for my patients."
"Your depression and anxiety are causing your pain more than your arthritis is. There's nothing I can do for you."	"A lot of my patients tell me that stress makes their pain worse, and pain makes their stress worse. I've found that sometimes we make the fastest progress when we address a patient's overall well-being first and then focus on whatever joints are still bothersome."


it pertains to these patients²⁴, the gold-standard mental health assessment in the present study was a face-to-face psychiatric interview rather than a legacy patient-reported measure. The primary limitation of the present study is that the analysis was performed on a convenience sample using data collected as standard care. As such, even though PROMIS measures ask respondents to answer questions while reflecting on the previous 7 days, patients were included in the present study if they had completed PROMIS Depression and Anxiety measures within 1 month before or after the psychologist's psychiatric interview. Nevertheless, this approach has proven to be valid for the legacy GAD-7 measure, which asks respondents to reflect on the previous 2 weeks even though DSM-5 diagnostic criteria for generalized anxiety disorder require symptoms to be present for at least 6 months²⁸. Regarding generalizability, the present study was designed to be particularly applicable for patients presenting for specialty orthopaedic care. Although the patients in this study most strongly represent patients with chronic musculoskeletal pain who are pursuing conservative management (potentially in preparation for orthopaedic surgery), the demographic and PROMIS score distributions of patients in the present study generally mirrored the profile of all adult patients who present to our orthopaedic department^{20,36}. Given the rarity with which orthopaedic patients routinely undergo psychiatric evaluation, the insights offered by analysis of this patient population still contribute novel information regarding how PROMIS mental health measures can be interpreted when collected in the context of orthopaedic care.

Conclusions

In patients seeking care for chronic musculoskeletal conditions, the optimal PROMIS Depression cutoff score to predict the presence of a DSM-5 depressive disorder was a modest 53 points (sensitivity, 79%; specificity, 86%), whereas the optimal PROMIS Anxiety cutoff score to predict the presence of a DSM-5 anxiety disorder was almost 1 standard deviation worse than the general U.S. population, at 59 points (sensitivity, 60%; specificity, 74%). Although neither PROMIS measure demonstrated adequate discriminant ability to definitively iden-

tify patients who meet DSM-5 criteria, the findings of the present study can still assist clinicians with interpretation of PROMIS Depression and Anxiety measures in the orthopaedic setting. That is, even modestly elevated PROMIS Depression scores may be indicative of a true depressive disorder that could negatively impact orthopaedic outcomes, whereas mildly to moderately elevated PROMIS Anxiety scores seem less reliably suggestive of a true anxiety disorder. We advocate for using PROMIS mental health measures as a screening tool in the orthopaedic setting. They can provide a window of opportunity to discuss the importance of mental health within the context of musculoskeletal care and to identify patients who may benefit from referral for further mental health evaluation.

Appendix

 Supporting material provided by the authors is posted with the online version of this article as a data supplement at [jbjs.org \(http://links.lww.com/JBJSOA/A467\)](http://links.lww.com/JBJSOA/A467). ■

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