Preoperative Performance of the PROMIS in Patients Undergoing Hip Arthroscopic Surgery for Femoroacetabular Impingement Syndrome

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Background: The Patient-Reported Outcomes Measurement Information System (PROMIS) is being increasingly evaluated for use in orthopaedic surgery. The performance of the PROMIS in patients undergoing hip preservation surgery is unknown.

Purpose: To investigate the psychometric performance of the PROMIS compared with legacy patient-reported outcome measures (PROMs) in patients indicated for hip arthroscopic surgery for femoroacetabular impingement syndrome (FAIS).

Study Design: Cohort study (diagnosis); Level of evidence, 2.

Methods: Data from consecutive patients who underwent primary hip arthroscopic surgery between January and October 2018 for the treatment of FAIS were collected and analyzed. Baseline data, including preoperative PROM scores and demographics, were recorded. PROMs included the PROMIS Physical Function (PF), the Hip Outcome Score (HOS), the modified Harris Hip Score (mHHS), the International Hip Outcome Tool–12 (iHOT-12), and the Veterans RAND 12-item health survey (VR-12). Pearson and Spearman coefficient analyses were used to identify correlations between continuous and noncontinuous variables, respectively. Correlation was defined as excellent (>0.80), very good (0.71-0.80), good (0.61-0.70), fair (0.41-0.60), or poor (0.21-0.40). A multivariate linear regression analysis was used to identify preoperative predictors of having higher preoperative PROMIS scores.

Results: A total of 197 patients with a mean age and body mass index (BMI) of 32.8 ± 12.6 years and 25.7 ± 5.6 kg/m^2, respectively, were included in the final analysis. There were no ceiling or floor effects for the PROMIS PF score observed in the study group. With regard to hip-specific measures, PROMIS PF scores demonstrated excellent correlation with HOS–Activities of Daily Living ($r = 0.801$; $P < .001$) scores, very good correlation with mHHS ($r = 0.721$; $P < .001$) and iHOT-12 ($r = 0.722$; $P < .001$) scores, and good correlation with HOS–Sports Specific ($r = 0.675$; $P < .001$) scores. With regard to general health–related quality of life (HRQoL) measures, PROMIS PF scores demonstrated very good correlation with VR-12 mental ($r = 0.721$; $P < .001$) scores, good correlation with VR-12 physical ($r = 0.618$; $P < .001$) scores, and poor correlation with visual analog scale for pain ($r = -0.365$; $P < .001$) scores. Patients who reported being physically active were more likely to have a higher preoperative PROMIS score ($\beta = 3.216$; $P = .004$). Lower PROMIS scores were found in patients with a higher BMI ($\beta = -0.236$; $P = .005$) and in female patients ($\beta = -2.608$; $P = .014$).

Conclusion: In patients with FAIS, the preoperative PROMIS PF scores demonstrated excellent to good correlation with legacy hip-specific instruments as well as with HRQoL measures. No ceiling or floor effects were identified. Notably, of the hip-specific PROMs administered, the PROMIS PF demonstrated the weakest correlation with the HOS–Sports Specific subscale. Physical activity, BMI, and sex were predictors of preoperative PROMIS scores in our patient population.

Keywords: hip arthroscopic surgery; FAIS; PROMIS Physical Function; outcome scores

In 2004, the National Institutes of Health developed the Patient-Reported Outcomes Measurement Information System (PROMIS). This tool utilizes integrated item response theory (IRT) with computerized adaptive testing (CAT) to solve the issue of multiple, noncomparable patient-reported outcome measures (PROMs) by providing a single, generalizable, and validated PROM that assesses patients across a broad set of domains.[5,10] CAT specifically offers the advantage of selecting the best items to estimate the measurable outcomes of a survey (ie, pain, physical

function), resulting in fewer responses needed for accuracy, while IRT matches actual to predicted responses using parametric category response curves to establish item-trait relationships.[6,8] Utilizing IRT and CAT, the PROMIS seeks to accomplish the goal of providing precise health state estimations without floor or ceiling effects while requiring the completion of fewer individual questions when compared with legacy PROMs.[23]

Within the orthopaedic literature, there has been an increase in studies evaluating the psychometrics of the PROMIS for various sports medicine conditions and procedures. Prior investigators have evaluated the use of the PROMIS for knee meniscal surgery, rotator cuff abnormalities, shoulder arthritis, shoulder instability, and anterior cruciate ligament injuries.[1,2,7,12,13] To our knowledge, there has yet to be a study evaluating the performance of the PROMIS in patients undergoing hip arthroscopic surgery for femoroacetabular impingement syndrome (FAIS).

Hip arthroscopic surgery is now an established procedure with demonstrable improvement in PROMs. Traditionally used hip outcome measures include the modified Harris Hip Score (mHHS), the Hip Outcome Score (HOS), and the International Hip Outcome Tool–12 (iHOT-12). While these hip-specific PROMs have been examined to understand their responsiveness and representative clinically significant changes,[17,19,20] previous investigations have not compared these legacy measures with the PROMIS. Interestingly, the PROMIS Physical Function (PF) is traditionally administered for lower extremity conditions, while the PROMIS Upper Extremity (UE) is administered for upper extremity musculoskeletal conditions. The PROMIS does not have hip-specific questions, and patients with hip conditions are defaulted to the PROMIS PF. Little is known about whether this delineation is appropriate.

The purpose of this study was to investigate the performance of the PROMIS in patients indicated for hip arthroscopic surgery for FAIS. We sought to compare the PROMIS PF to legacy hip-specific PROMs as well as general health–related quality of life (HRQoL) measures. Secondarily, we sought to assess for demographic predictors of high PROMIS scores in these patients. We hypothesized that the PROMIS PF would demonstrate very good to excellent correlation with hip-specific PROMs and overall good correlation with HRQoL measures.

METHODS

Patient Selection

After approval of the study by our institutional review board, we prospectively collected data on all patients undergoing hip arthroscopic surgery for the treatment of FAIS by a single fellowship-trained surgeon (S.J.N.). Data were retrospectively analyzed in a clinical repository. Patients undergoing primary hip arthroscopic surgery for the treatment of FAIS between January 1, 2018, and October 15, 2018, were included in this study. Inclusion criteria consisted of clinical and radiographic findings of symptomatic FAIS,[11] failure of conservative management (physical therapy, activity modification, oral anti-inflammatories, or intra-articular cortisone injections), and surgical treatment with hip arthroscopic surgery for FAIS. Exclusion criteria consisted of a history of bilateral hip surgery (including ipsilateral revision), hip arthroscopic surgery for an indication other than FAIS, signs of osteoarthritis (Tönnis grade >1), hip dysplasia (lateral center-edge angle <20°), a history of congenital hip disorders (slipped capital femoral epiphysis, developmental hip dysplasia, etc), or concomitant procedures during the time of surgery.

Preoperative Clinical Function Assessment

Preoperatively, all patients provided demographic data (sex, age, operative extremity, body mass index [BMI], sports participation, duration of symptoms, and comorbidities). All patients also completed preoperative hip-specific PROMs including the HOS–Activities of Daily Living (HOS-ADL),[15] the HOS–Sports-Specific (HOS-SS), the mHHS,[4,14] the iHOT-12,[18] and the Veterans RAND 12-item health survey (VR-12). Preoperative pain level was graded on a visual analog scale (VAS) from 0 to 100.

In addition, all patients completed either the PROMIS PF short form 20a or PROMIS PF bank v 2.0. As described, the interpretation and weight of T-scores for the PROMIS PF short form 20a and PROMIS PF bank v 2.0 are the same.[3] Questionnaires were completed utilizing an electronic data collection service (Outcomes Based Electronic Research Database; Universal Research Solutions).

Statistical Analysis

Analyses were performed to identify any existing floor and ceiling effects for PROMIS PF scores in patients with FAIS. Any percentage ≥15% of the study population in the top or bottom 5% of the score range was deemed as a significant ceiling or floor effect.[2,22] Both absolute ceiling/floor effects (percentage achieving the maximum and minimum scores possible) and relative ceiling/floor effects (percentage achieving the total maximum and minimum scores recorded in the study group) were evaluated.

All data were screened to determine the achievement of all parametric statistical assumptions before analyses.

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TABLE 1
Patient Demographics[a]

Age, mean ± SD, y	32.8 ± 12.6
Sex	
Male	46 (23.4)
Female	151 (76.6)
Body mass index, mean ± SD, kg/m^2	25.7 ± 5.6
Physically active	150 (76.1)
Running	102 (51.8)
Workers' compensation	6 (3.1)

[a]Data are shown as n (%) unless otherwise indicated.

The Pearson coefficient analysis was used to identify correlations between PROMIS PF T-scores and continuous variables including other PROM scores, BMI, and age. The Spearman coefficient analysis was used to identify correlations between PROMIS PF T-scores and noncontinuous demographic variables. Correlation coefficients were classified by the strength of the correlation: excellent (>0.80), very good (0.71-0.80), good (0.61-0.70), fair (0.41-0.60), and poor (0.21-0.40).

A linear regression analysis was performed to identify predictors of PROMIS PF scores. To determine whether multicollinearity existed, an exploratory factor analysis was performed on the variables with statistically significant correlations with the primary outcomes, using principal component extraction (ie, eigenvector decomposition) with a varimax rotation to reduce redundancy in the predictor variables. Variables with a significant correlation with PROMIS PF scores were placed in their own linear regression model. Statistical significance for all analyses was set at $\alpha \leq 0.05$. All statistical analyses were performed using SPSS (version 25; IBM).

RESULTS

A total of 197 patients were included in the study, with a mean age and BMI of 32.8 ± 12.6 years and 25.7 ± 5.6 kg/m^2, respectively (Table 1). The majority of patients were female (75.6%) and physically active (76.1%), with most being runners (51.8%).

PROMIS PF Scores

The mean preoperative PROMIS PF T-score was 40.2 ± 6.0, with a maximum score of 65.0 and minimum score of 23.2 (Table 2). The distribution of the T-scores was approximately symmetric (skewness = 0.383), with a slight rightward deviation (Figure 1). The PROMIS PF did not have either an absolute or relative floor or ceiling effect (all <15%). There was only 1 patient with a score with a relative floor effect and 2 each with scores with absolute and relative ceiling effects.

Correlation Analysis

With regard to hip-specific measures, PROMIS PF scores demonstrated excellent correlation with HOS-ADL ($r =$

TABLE 2
Preoperative PROMIS PF T-Score Analysis[a]

PROMIS score, mean ± SD	40.2 ± 6.0
Absolute threshold	
Ceiling	2 (1.01)
Floor	0 (0.00)
Relative threshold	
Ceiling	2 (1.01)
Floor	1 (0.51)

[a]Data are shown as n (%) unless otherwise indicated. PROMIS PF, Patient-Reported Outcomes Measurement Information System Physical Function.
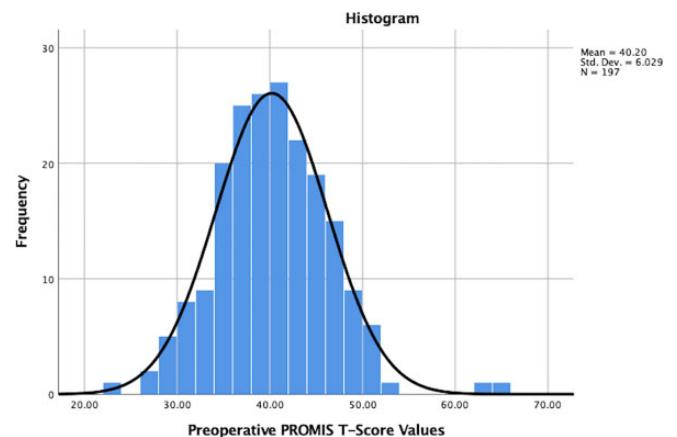

Figure 1. Histogram of the distribution of Patient-Reported Outcomes Measurement Information System Physical Function (PROMIS PF) T-scores.

0.801; $P < .001$) scores, very good correlation with mHHS ($r = 0.721$; $P < .001$) and iHOT-12 ($r = 0.722$; $P < .001$) scores, and good correlation with HOS-SS ($r = 0.675$; $P < .001$) scores. With regard to HRQoL measures, PROMIS PF scores demonstrated very good correlation with VR-12 mental ($r = 0.721$; $P < .001$) scores, good correlation with VR-12 physical ($r = 0.618$; $P < .001$) scores, and poor correlation with VAS for pain ($r = -0.365$; $P < .001$) scores (Table 3). The Pearson coefficient analysis demonstrated poor correlation between PROMIS scores and BMI ($r = -0.259$; $P = .001$), running ($r = 0.237$; $P < .001$), and being physically active ($r = 0.137$; $P < .001$) (Table 4).

PROMIS PF Linear Regression Analysis

Because there was good correlation between PROMIS PF T-scores and other PROM scores, a separate linear regression model was created to determine their linear relationship and to avoid multicollinearity affecting the linear model with demographic variables. Results of the stepwise linear regression model are summarized in Table 5. The PROMs that showed a direct linear relationship included the HOS-ADL ($\beta = 0.147$; $P < .001$), iHOT-12 ($\beta = 0.054$; $P = .024$), and HOS-SS ($\beta = 0.047$; $P = .022$). A predictor of

TABLE 3
Correlation Analysis of Preoperative Outcome Scores[a]

	r Value	*P* Value
HOS-ADL	0.801	<.001
HOS-SS	0.675	<.001
mHHS	0.721	<.001
iHOT-12	0.722	<.001
VAS pain	−0.365	<.001
VR-12 mental	0.721	<.001
VR-12 physical	0.618	<.001

[a]HOS-ADL, Hip Outcome Score–Activities of Daily Living; HOS-SS, Hip Outcome Score–Sports-Specific; iHOT-12, International Hip Outcome Tool–12; mHHS, modified Harris Hip Score; VAS, visual analog scale; VR-12, Veterans RAND 12-item health survey.

TABLE 4
Demographic Correlation Analysis

	r Value	*P* Value
Age	−0.165	.021
Sex	−0.138	.055
Body mass index	−0.259	.001
Physically active	0.137	<.001
Running	0.237	<.001
Workers' compensation	−0.140	.051

TABLE 5
Linear Regression Model of PROMIS PF
and Preoperative PROMs[a]

	β	SE	95% CI	*P* Value
HOS-ADL	0.147	0.025	0.098-0.196	<.001
HOS-SS	0.047	0.020	0.007-0.087	.022
iHOT-12	0.054	0.024	0.007-0.100	.024

[a]HOS-ADL, Hip Outcome Score–Activities of Daily Living; HOS-SS, Hip Outcome Score–Sports-Specific; iHOT-12, International Hip Outcome Tool–12; PROM, patient-reported outcome measure; PROMIS PF, Patient-Reported Outcomes Measurement Information System Physical Function.

having a higher preoperative PROMIS PF score was being physically active (β = 3.216; *P* = .004), and predictors of having a lower PROMIS PF score included having a higher BMI (β = −0.236; *P* = .005) and being female (β = −2.608; *P* = .014) (Table 6).

DISCUSSION

In this study, we demonstrated that in patients with FAIS undergoing hip arthroscopic surgery, the preoperative PROMIS PF scores had good correlation with both legacy hip-specific PROMs and HRQoL measures. Notably, the HOS-SS had weaker correlation with the PROMIS compared with other legacy hip-specific PROMs. Further, no ceiling or floor effect was identified for the PROMIS PF in

TABLE 6
Linear Regression Model of PROMIS PF and
Patient Demographics[a]

	β	SE	95% CI	*P* Value
Physically active	3.216	1.112	1.020 to 5.411	.004
Body mass index	−0.236	0.082	−0.398 to −0.074	.005
Female sex	−2.608	1.046	−4.674 to −0.542	.014

[a]PROMIS PF, Patient-Reported Outcomes Measurement Information System Physical Function.

our patient population. Being more physically active was predictive of higher preoperative PROMIS scores in patients with FAIS, while higher BMI and female sex were predictive of lower PROMIS scores. These findings confirm our hypothesis.

Prior authors have sought to evaluate the psychometrics of the PROMIS for orthopaedic sports medicine procedures and have sought to highlight clinical scenarios in which the PROMIS might be appropriate and/or deficient.[1,2,7,12,13] Anthony et al[2] compared the PROMIS UE with legacy shoulder PROMs in 74 patients with a diagnosis of shoulder instability. The authors noted that for this condition, the PROMIS demonstrated good to excellent correlation; however, there was a significant ceiling effect when administering the PROMIS UE to patients with shoulder instability who were younger than 21 years.[2] Hancock et al[12] evaluated the role of the PROMIS PF CAT in 107 patients undergoing knee meniscal surgery. The authors similarly noted good correlation, and no ceiling or floor effect was found.[12] Similarly, in a cohort of 82 patients with rotator cuff abnormalities, Anthony et al[1] found good correlation with the PROMIS and legacy shoulder instruments. The present study builds on prior work, demonstrating strong correlations between the PROMIS and legacy instruments; however, this is the first such study to perform an analysis for hip-specific PROMs in patients with FAIS. A major strength of this study compared with these prior studies is the utilization of a large patient cohort.

An interesting finding of this study was that the HOS-SS demonstrated only good correlation with the PROMIS PF, while other hip-specific PROMs and even HRQoL measures demonstrated very good or excellent correlation. We theorize that this finding is because of a component of hip-specific disability that is not captured in the PROMIS PF. Nwachukwu et al,[19] when defining the substantial clinical benefit for patients with FAIS undergoing hip arthroscopic surgery, noted that the HOS-SS (compared with others) was a standout instrument for capturing the various subtleties of hip-specific outcomes. This finding is important and warrants continued investigation as policy makers and clinicians consider replacing hip-specific PROMs with the PROMIS. We believe that there may be a component of hip-specific outcomes that is not captured in the PROMIS alone. As such, there may be a role of adaptation of the PROMIS to include a hip-specific module akin to the PROMIS UE.

It is worth noting that in our patient population, the mean PROMIS score was 40.2, while in a normalized cohort, the population mean is 50. This finding highlights the inherent disability associated with FAIS. In a secondary analysis, we found that physically active patients had a higher PROMIS score, while patients with a higher BMI and female patients had lower PROMIS scores. Previous studies have demonstrated similar associations with hip-specific outcomes in patients undergoing hip arthroscopic surgery for FAIS. Frank et al[9] demonstrated in a case-control study that female patients and older patients had lower postoperative HOS-ADL, HOS-SS, and mHHS scores. More recently, Mygind-Klavsen et al[16] compared 2054 preoperative outcomes by sex and observed that female patients demonstrated lower preoperative Copenhagen Hip and Groin Outcome Score (HAGOS), quality of life (EQ-5D), Hip Sports Activity Scale (HSAS), and numeric rating scale (NRS) scores. Both of these studies coincide with the results of the current study in that female patients with FAIS reported lower outcome scores. With regard to BMI, increased BMI has been previously associated with inferior outcomes after hip arthroscopic surgery. Saltzman et al[21] showed that a higher BMI is predictive of increased infection rates, higher reported pain, lower reported outcome scores (HOS-ADL, HOS-SS, and mHHS), and lower satisfaction rates after hip arthroscopic surgery.

Limitations

There are limitations in this study that need to be addressed. A significant limitation is the lack of postoperative data in our cohort. We were unable to evaluate the longitudinal performance of the PROMIS in patients with FAIS undergoing hip arthroscopic surgery. It is possible that after undergoing surgery, the PROMIS tracks poorly with patients and may miss certain hip-specific outcome components. However, our reporting of preoperative performance is consistent with the first stages of investigation as published for other sports medicine procedures.[1,2,7,12,13] Additionally, the study analyzed all consecutive patients treated by the senior author during a defined period, and the results may not be generalizable to a wider patient cohort or less experienced surgeons. Finally, a number of different models were analyzed using the variables in the factor analysis; however, it is possible that confounders and other nonlinear associations existed between the primary outcomes and other variables not tested.

CONCLUSION

In preoperative patients with FAIS, the PROMIS PF demonstrated excellent to good correlation with legacy hip-specific instruments as well as HRQoL measures. No ceiling or floor effects were identified. Notably, of the hip-specific PROMs administered, the PROMIS PF demonstrated the weakest correlation with the HOS-SS. Physical activity, BMI, and sex were predictors of preoperative PROMIS scores in our patient population.

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