Original Article

High Prevalence of Sleep Disturbance Is Associated with Femoroacetabular Impingement Syndrome

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Purpose: The purpose of this study was to identify an association between Patient-Reported Outcomes Measurement Information System (PROMIS) sleep scores and other PROMIS domains in patients with femoroacetabular impingement syndrome (FAIS). **Methods:** Patients were retrospectively identified for FAIS pathology, and PROMIS outcomes were assessed at multiple visits. Individual generalized linear mixed-effects models were fit with PROMIS sleep score as the predictor variable, and each subsequent PROMIS metric as the response variable. Additionally, models were fit using a clinically significant dichotomization of PROMIS sleep score to assess differences in average PROMIS scores between those with disrupted sleep (>55) and those with normal sleep (≤ 55). **Results:** PROMIS scores at baseline differed between those with and without sleep disturbance. Specifically, higher PROMIS sleep scores were associated with higher anxiety, depression, fatigue, pain intensity, and pain interference scores and lower physical function, and social participation. **Conclusions:** An association between PROMIS sleep score and other PROMIS outcomes does exist. Sleep disturbance is associated with increased anxiety, depression, fatigue, pain intensity, pain interference and decreased physical function, and social participation when analyzing PROMIS score, as both a continuous and dichotomized variable. Because of the observational design of this study, no causal inference can be made on these results. **Level of Evidence:** Level III, retrospective comparative trial.

Introduction

The Patient-Reported Outcomes Measurement Information System (PROMIS) surveys provide an objective, validated, and standardized assessment of clinical outcome data for providers to use on both the individual patient and population levels.[1-3] One subset of PROMIS surveys, the adult short-form sleep disturbance survey, allows for the identification and severity grading of sleep dysfunction based on patient activities. This score can then be compared to other PROMIS measures, including physical function, anxiety, depression, fatigue, ability to participate in social roles/activities, pain interference, and pain intensity to identify any potential associations.[4]

Animal models have shown that chronic sleep deprivation has negative effects on bone metabolism with reduced osteogenesis and mineralization with subsequent reduced bone mass.[5] Animal models have also found that acute sleep disturbance causes increased stress, corticosterone levels, and postsurgical pain that delays pain recovery with human studies showing an increase in inflammatory markers.[6,7] Human clinical studies have also corroborated that sleep deprivation in healthy subjects can increase pain perception.[8] The connections between sleep disturbance and its negative impacts on pain, performance, mood, and quality of life, among other aspects, is well established in the literature.[9-12]

The connection between sleep disturbance and its intersection with specific pathologies, such as femoroacetabular impingement syndrome (FAIS) is not well described in the literature. Although there are a multitude of nonoperative and operative treatments of FAIS that include analgesics medications, anti-inflammatory medications, rehabilitation, and injections, the majority of treatment plans do not include

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Table 1. Demographic and Clinical Characteristics at Baseline

	Disrupted Sleep ($n = 202$)	Normal Sleep ($n = 257$)	Total ($n = 459$)
Gender			
Female	146 (72.3%)	172 (66.9%)	318 (69.3%)
Male	56 (27.7%)	85 (33.1%)	141 (30.7%)
Race			
Black or African American	22 (10.9%)	19 (7.4%)	41 (8.9%)
Caucasian/White	147 (72.8%)	204 (79.4%)	351 (76.5%)
Other	33 (16.3%)	34 (13.2%)	67 (14.6%)
Marital Status			
Divorced	10 (5.0%)	12 (4.7%)	22 (4.8%)
Legally Separated	5 (2.5%)	3 (1.2%)	8 (1.7%)
Married	105 (52.0%)	146 (56.8%)	251 (54.7%)
Single	62 (30.7%)	67 (26.1%)	129 (28.1%)
Unknown	17 (8.4%)	25 (9.7%)	42 (9.2%)
Widowed	3 (1.5%)	4 (1.6%)	7 (1.5%)
PROMIS physical function			
Missing	1 (.5%)	2 (.8%)	3 (.7%)
Mean (SD)	36.8 (7.2)	40.4 (8.8)	38.8 (8.3)
Median (Q1, Q3)	37.0 (32.0, 41.0)	40.4 (35.0, 46.0)	39.0 (33.0, 44.0)
Range	(18.1-60.0)	(13.3-73.0)	(13.3-73.0)
PROMIS depression			
Missing	4 (2.0%)	5 (1.9%)	9 (2.0%)
Mean (SD)	51.7 (9.4)	45.9 (8.1)	48.4 (9.2)
Median (Q1, Q3)	52.0 (44.7, 58.5)	46.0 (38.2, 51.0)	48.0 (39.0, 55.0)
Range	(34.0-76.4)	(34.0-70.7)	(34.0-76.4)
PROMIS sleep			
Mean (SD)	62.0 (5.7)	46.7 (6.2)	53.4 (9.7)
Median (Q1, Q3)	61.0 (58.0, 65.0)	47.9 (43.0, 52.0)	54.0 (46.7, 59.1)
Range	(55.3-82.0)	(26.0-54.3)	(26.0-82.0)
PROMIS pain interference			
Missing	1 (.5%)	0 (.0%)	1 (.2%)
Mean (SD)	63.8 (5.5)	58.0 (6.1)	60.5 (6.5)
Median (Q1, Q3)	64.0 (60.0, 67.0)	57.4 (53.2, 62.8)	61.5 (55.0, 65.5)
Range	(47.9-78.0)	(39.0-74.0)	(39.0-78.0)
PROMIS anxiety			
Missing	138 (68.3%)	145 (56.4%)	283 (61.7%)
Mean (SD)	56.2 (8.4)	47.2 (8.6)	50.5 (9.5)
Median (Q1, Q3)	56.4 (52.1, 62.5)	46.9 (37.1, 53.2)	50.8 (43.2, 57.4)
Range	(37.1-78.2)	(37.1-68.7)	(37.1-78.2)
PROMIS fatigue			
Missing	137 (67.8%)	144 (56.0%)	281 (61.2%)
Mean (SD)	56.8 (9.3)	46.8 (9.3)	50.4 (10.5)
Median (Q1, Q3)	54.6 (50.4, 63.3)	48.1 (41.0, 52.5)	50.4 (45.6, 57.5)
Range	(33.1-77.8)	(33.1-66.4)	(33.1-77.8)
PROMIS social participation			
Missing	137 (67.8%)	145 (56.4%)	282 (61.4%)
Mean (SD)	42.1 (9.1)	50.3 (8.9)	47.3 (9.8)
Median (Q1, Q3)	43.0 (36.2, 48.0)	50.8 (44.0, 55.7)	48.0 (42.0, 52.7)
Range	(25.9-65.4)	(25.9-65.4)	(25.9-65.4)
PROMIS pain intensity			
Missing	137 (67.8%)	145 (56.4%)	282 (61.4%)
Mean (SD)	5.8 (2.2)	4.7 (2.2)	5.1 (2.2)
Median (Q1, Q3)	6.0 (4.0, 7.0)	5.0 (3.0, 6.0)	5.0 (3.0, 7.0)
Range	(1.0-10.0)	(1.0-10.0)	(1.0-10.0)

a specific component to address disrupted sleep despite the prevalence of this complaint. The purpose of this study was to identify an association between PROMIS sleep scores and other PROMIS domains in patients with FAIS. We hypothesized that an association would be found between sleep disturbance and at least one of the other PROMIS patient-reported outcomes (PROs) after adjusting for age, sex, race, and marital status.

Methods

Patients with FAIS were retrospectively identified using International Classification of Diseases (ICD)−10 codes, and PROMIS outcomes were evaluated at between 1 and 6 visits from November 2017 through February 2020 (Appendix Box 1). All patients who presented with the included ICD codes and who completed the PROMIS surveys were included.

Table 2. Regression Results for PROMIS Outcomes Using Continuous Sleep Score

	Univariable		Multivariable*	
Outcome	Point Estimate (95% CI)	FDR-Adjusted *P* Value	Point Estimate (95% CI)	FDR-Adjusted *P* Value
Anxiety	.42 (.32, .52)	<.001	.42 (.31, .52)	<.001
Depression	.32 (.26, .38)	<.001	.32 (.26, .38)	<.001
Fatigue	.53 (.43, .63)	<.001	.52 (.42, .62)	<.001
Pain intensity	.08 (.05, .11)	<.001	.08 (.05, .11)	<.001
Pain interference	.33 (.29, .38)	<.001	.33 (.28, .38)	<.001
Physical function	−.20 (−.26, −.14)	<.001	−.19 (−.25, −.13)	<.001
Social participation	−.41 (−.51, −.31)	<.001	−.40 (−.50, −.29)	<.001

*Each multivariable regression model is adjusted for age, gender, race, and marital status.

Individuals who did not complete the surveys were excluded. Associations with age, gender, and other PROMIS PROs were evaluated, including physical function, anxiety, depression, fatigue, ability to participate in social roles/activities, pain interference, and pain intensity. Demographic and clinical characteristics at baseline were summarized separately for those with and without sleep disturbance based on a cut-off sleep score of 55, which corresponds to a clinically meaningful difference from normal based on the general population.[13] This work was determined exempt by the Duke University IRB (protocol ID: Pro00104209) on November 21, 2019.

Statistical Analysis

Baseline summary statistics for categorical variables are presented as the count (percentage) and for continuous variables as means ± SD, median with 25th and 75th percentiles (Q1, Q3), and range (Table 1).

To examine the relationship between sleep disturbance and each of the PROMIS scores, separate univariable and multivariable generalized linear mixed-effects models were fit with PROMIS sleep score as the predictor variable and each PROMIS metric as a response variable; a random intercept term was included for each patient to account for repeated measures at the patient level with a compound-symmetry variance structure. Multivariable models were adjusted for age, sex, race, and marital status. Assumptions of normality, homoscedasticity, and linearity were verified using model residuals. Results are presented as the regression coefficient (β) with 95% confidence interval (CI) (Table 2). PROMIS sleep was also evaluated as a categorical variable (dichotomized at 55) in order to assess clinically meaningful differences between those with and without sleep disturbance (Table 3).

All *P* values were adjusted for multiple testing using the Hochberg's false discovery rate (FDR) method. Statistical significance was assessed at $\alpha = .05$, and analyses were conducted using SAS version 9.4 (SAS Institute, Inc., Cary, NC).

Results

After applying inclusion and exclusion criteria, 459 patients were included in the study cohort, 203 (44.2%) of which had disrupted sleep at baseline. The cohort majority were female ($n = 318$, 69.3%), White ($n = 351$, 76.5%), and married ($n = 251$, 54.7%). A greater percentage of those with disrupted sleep were female, non-White, and not married compared to those with normal sleep. PROMIS scores at baseline differed by sleep category, including those with disrupted sleep having lower physical function, and participation, and higher depression, sleep, pain interference, anxiety, fatigue, and pain intensity scores compared to patients without disrupted sleep. Complete demographic and clinical characteristics of FAI patients at baseline are presented in Table 1.

Table 2 displays the association between PROMIS sleep score and other PROMIS scores using individual univariable and multivariable (adjusted for age, sex, race, and marital status) models. Point estimates are

Table 3. Regression Results for PROMIS Outcomes Using Binary Sleep Score

	Univariable		Multivariable*	
Outcome	Point Estimate (95% CI)	FDR Adjusted *P* Value	Point Estimate (95% CI)	FDR Adjusted *P* Value
Anxiety	6.75 (4.63, 8.87)	<.001	6.85 (4.71, 9.00)	<.001
Depression	4.57 (3.42, 5.71)	<.001	4.56 (3.41, 5.72)	<.001
Fatigue	7.85 (5.76, 9.94)	<.001	7.9 (5.79, 10.02)	<.001
Pain intensity	1.07 (.50, 1.64)	<.001	1.03 (.44, 1.61)	<.001
Pain interference	5.08 (4.17, 5.99)	<.001	4.99 (4.08, 5.90)	<.001
Physical function	−2.95 (−4.08, −1.83)	<.001	−2.81 (−3.93, −1.69)	<.001
Social participation	−6.35 (−8.43, −4.27)	<.001	−6.31 (−8.41, −4.22)	<.001

*Each multivariable regression model is adjusted for age, gender, race, and marital status.

interpreted as a change in score associated with a one-point increase in PROMIS sleep score. For example, a one-point increase in PROMIS sleep score is associated with a .42 (95% CI: .32, .52) point increase in anxiety. All PROMIS scores were significantly associated with PROMIS sleep score before and after adjusting for age, sex, race, and marital status. Specifically, higher PROMIS sleep scores were associated with higher anxiety, depression, fatigue, pain intensity, and pain interference scores and lower physical function, and social participation.

Table 3 provides an alternative interpretation of these results with sleep score dichotomized into normal and disrupted sleep based on a 55-point cut-off. Again, univariable and multivariable (adjusted for age, sex, race, and marital status) are reported. Here, point estimates are interpreted as a difference in mean score between those with normal sleep and those with disrupted sleep. For example, patients with disrupted sleep have, on average, anxiety scores that are 6.75 (95% CI: 4.63, 8.87) points higher than those with normal sleep. Again, all PROMIS scores were significantly associated with disrupted sleep with the same directions of association as detailed above.

Discussion

In our sample of FAIS patients that completed the PROMIS sleep survey, there was a higher prevalence of sleep dysfunction (44%) compared to the national prevalence (35-40%).[14] As hypothesized, further analysis found PROMIS scores differed by sleep category with those with disrupted sleep having lower physical function, and participation along with higher depression, pain interference, anxiety, fatigue, and pain intensity scores.

The concerning prevalence observed in our study has also been seen in other related studies. Young and middle-aged adults with hip pain have been shown to have decreased amounts of sleep and greater levels of insomnia and anxiety when compared to age-matched controls without hip pain.[15] Reddy et al. found that 79% of FAIS and 89% of acetabular dysplasia patients reported poor sleep quality based on the 19-question Pittsburgh Sleep Quality Index (PSQI).[16] Of the FAIS patients who had disrupted sleep in our study, the majority (59%) reported scores with moderate to severe levels of sleep disturbance. This is concerning, as both the prevalence and severity of chronic sleep dysfunction in FAIS patients may be underrecognized in a typical evaluation for FAIS by primary care physicians and orthopaedic surgeons. Prior literature has recommended that patients with hip pain from FAIS or acetabular dysplasia pathology should potentially be screened for sleep disturbances and given considerations for a multidisciplinary treatment approach.[15,16]

In most treatment algorithms of FAIS, there are no recommendations to address the chronic sleep dysfunction in these patients.[17-22] Most treatment modalities focus on addressing physical function with physical therapy for functional range of motion and strength training. Other treatments focus on pain relief with a variety of measures that include use of acetaminophen, NSAIDs, opioids, massage therapy, acupuncture, injection, and/or activity modification to reduce painful activities. For patients that meet surgical treatment indications, there is some literature to support that hip arthroscopy can improve sleep quality. In a case series of 52 patients, Kunze et al. showed that the 92% rate of preoperative reported sleep disturbance was decreased to 31.7% by 24 weeks after hip arthroscopy.[23] This study highlights the fact that a subsection of patients could have potentially benefitted from targeted sleep interventions in addition to their FAIS-specific treatments.

In regard to pain specifically, there is a clear and logical connection between pain and sleep issues with FAIS. In a study investigating pain and sleep issues among patients with FAIS, the distribution of pain intensity was significantly worse in the cohort with disrupted sleep, which suggests that there likely is a correlation between the two that can be targeted for modification. Although there is undoubtably a connection between increased pain and poor sleep, the study subjects that did not have a sleep disturbance still reported pain on their PROs on some level, suggesting that the relationship may be multifaceted, and further inference is warranted. Studies have theorized that the hyperesthesia comes from lack of sleep, which likely compounds the underlying pain from FAIS in these patients and can potentially be addressed by sleep-directed means as part of the multimodal approach that poses no risk to patients but may provide a significant benefit.[24,25]

When comparing the normal sleep and disturbed sleep groups, significant differences were found across all other PROMIS survey domains. This was seen in the PROMIS surveys evaluating the domains of physical function, anxiety, depression, fatigue, social participation, and pain interference. These results suggest that sleep may be associated with other perceived symptoms; however, no direct causal relationship can be discerned from this study. In fact, it is likely that the relationship between sleep and other PROMIS outcomes is a complex biopsychosocial relationship that is influenced in multiple directions. These results raise the question of whether the current multimodal approaches to treating FAIS are comprehensive enough to address the complex nature of the problem. Given the significant prevalence and severity of poor sleep in FAIS patients, sleep medicine could be used as a novel therapeutic agent as suggested by Krause et al.[26] in order to improve sleep outcomes among these patients

and, potentially, other PROMIS outcomes that could be influenced by lack of sleep. Sleep medicine can include counseling or therapy plans to address sleep hygiene, sleep extension, or pharmacological treatments to reduce insomnia and/or sleep latency.

The National Sleep Foundation advocates for optimization of sleep hygiene when addressing sleep disturbances.[27] Sleep hygiene refers to various habits and practices that result in good nighttime sleep quality and full daytime alertness. Examples of sleep hygiene include avoiding stimulants or disruptive foods near bedtime, daily exercising to promote quality sleep, establishing a relaxing bedtime routine, and creating an optimal sleep environment, among other recommendations.[27,28] The addition of sleep hygiene counseling should not pose a substantial additional burden to the provider or any risk to the patient, but could result in improved clinical outcomes. Studies have shown promoting good sleep hygiene to have positive impacts across various populations, particularly in athletes.[9,10,29-31] In addition to improved sleep hygiene, there is literature to support the use of sleep extension, in which patients are recommended to lengthen their sleep periods. Sleep extension is aimed at improving sleep duration and hygiene can optimize athletic peak performance, fatigue, and recovery.[32]

The use of pharmacological treatments has also been studied in other fields of orthopaedic surgery. Anti-insomnia medications such as Zolpidem have been used in orthopedics and has some improved postoperative outcomes with reduction in pain, opioid use, postoperative nausea/vomiting, and poor sleep.[33-36] Sleep hygiene is also a centerpiece component of inpatient hospital attempts to limit postoperative delirium. While it has not been described in the treatment of FAIS, such a medication could be considered for future treatment and study.

Although it is our opinion that a medication to assist with sleep is unlikely to completely eliminate pain in FAIS patients, it could represent an avenue that may shift the distribution of pain intensity patients to match the non-sleep disturbed group more closely and improve outcomes in a variety of physical, pain, mood, and social domains. At the very least, it is clear that sleep disturbance is prevalent among patients with FAIS, so aiming to improve sleep in these patients could very likely improve one component of their quality of life. The connection between FAIS, sleep disturbances, and poor PROs on other PROMIS measures, such as anxiety, depression, fatigue, and social participation are concerning and should be carefully identified by providers. Similar to pain hyperesthesia, sleep disturbances have been shown in the literature to have a significantly negative effect on mood.[37-40] A patient who is suffering from depressed mood, anxiety, or fatigue in addition to their FAIS can be potentially at a poorer outcome compared someone who is not.[41] Therefore, it is important in the FAIS population to identify these additional issues in order to facilitate optimal outcomes.

Limitations

The limitations of this study are primarily the retrospective nature of the study design and the inherent limitations associated with the dependability of survey results, including the participation bias associated with survey response, as well as a dependence on correct CPT coding for inclusion. Additional limitations include no elimination of potential confounders, including lumbar pathology, trochanteric bursitis, or opiate medication use among others. Also, this study is only able to show an association between sleep disturbance and other PROMIS measures; therefore, no causal inference can be made.

Conclusions

An association between PROMIS sleep score and other PROMIS outcomes does exist. Sleep disturbance is associated with increased anxiety, depression, fatigue, pain intensity, pain interference and decreased physical

Appendix Box 1:

International Classification of Diseases (ICD) 10 Codes Utilized.

1. M24.851 Other specific joint derangements of right hip, not elsewhere classified
2. M24.852 Other specific joint derangements of left hip, not elsewhere classified
3. M24.859 Other specific joint derangements of unspecified hip, not elsewhere classified
4. M76.891 Enthesopathy of right hip
5. M76.892 Enthesopathy of left hip
6. M16.11 Degenerative tear of acetabular labrum of right hip
7. M25.859 Femoroacetabular impingement syndrome
8. Note: removed any blue references that had additional osteoarthritis information

v. Labral tear hip:

1. S73.191 Other sprain of right hip
2. S73.191A Initial encounter
3. S73.191D Subsequent encounter
4. S73.191S Sequela
5. S73.192 Other sprain of left hip
6. S73.192A Initial encounter
7. S73.192D Subsequent encounter
8. S73.192S Sequela
9. S73.199 Other sprain of unspecified hip
10. S73.199A Initial encounter
11. S73.199D Subsequent encounter
12. S73.199S Sequela

function, and social participation when analyzing PROMIS score as both a continuous and dichotomized variable. Because of the observational design of this study, no causal inference can be made on these results.

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