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Associations of Self-Report and Actigraphy Sleep Measures with Experimental Pain Outcomes in Patients with Temporomandibular Disorder and Healthy Controls

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Abstract

Objective—Discrepancies between self-reported and actigraphy sleep measures are common, producing ambiguity about which are better predictors of experimental pain outcomes. The current study tested if pain intensity and situational pain catastrophizing following experimental pain were differentially predicted by self-reported or actigraphy sleep measures in patients with chronic temporomandibular disorder (TMJD) or healthy controls (HCs).

Methods—Forty patients with TMJD and 20 HCs completed self-report sleep measures (Pittsburgh Sleep Quality Index, PSQI; Insomnia Severity Index, ISI; PROMIS Sleep-Related Impairment [SRI] and Sleep Disruption [SD]), underwent an experimental pain induction consisting of four consecutive cold-water hand immersions, and provided pain intensity and situational pain catastrophizing ratings. Participants also wore an actigraphy watch and completed sleep diaries for seven days, which were averaged for actigraphic indices of total sleep time, sleep efficiency, wake after sleep onset, and self-reported sleep quality and restfulness.

Results—Individuals with TMJD reported higher pain intensity during experimental pain (M=65.81 vs. 47.77, p=.007) and self-reported worse sleep compared to HCs (all p's< .02, Cohen's D=0.73–1.25). No group differences emerged for actigraphy measures (all p's> .05, Cohen's D=0.05–0.53). Sleep variables did not interact with group to predict responses to experimental pain (all p's>.05). Across groups, PROMIS-SRI predicted pain intensity (β=0.36, p=.008) and catastrophizing (β =0.36, p=.009) after controlling for multiple comparisons, smoking, medications, and age.

Conclusion—Self-reported sleep (but not actigraphy) measures differentiate patients with TMJD from HCs. Sleep-related interference may place people at particular risk for higher pain intensity and catastrophizing following experimental pain.

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Introduction

Temporomandibular joint disorder (TMJD) affects 7–15% of the population and is associated with impaired sleep.[1–7] Two common methods to measure sleep, self-report and actigraphy, are only moderately correlated[8–11] and differentially predict chronic pain outcomes in some chronic pain conditions.[8–13] However, little is known about how self-report and actigraphy sleep measures differ between patients with TMJD and healthy controls (HCs), or about how they predict responses to experimentally-induced pain. Examining responses to experimentally-induced pain is important for predicting clinical outcomes and categorizing patients into clinically-meaningful subgroups.[14]

The current study sought to compare self-report and actigraphy measures between individuals with TMJD and HCs, and to test whether self-report or actigraphy measures were stronger predictors of pain intensity or situational pain catastrophizing (defined as magnification, rumination, and perceived helplessness from pain)[15] following experimental pain. We hypothesized that TMJD patients would report poorer sleep based on self-report but not actigraphy compared to HCs. Additionally, we hypothesized that poorer self-reported sleep (but not actigraphy) would be associated with higher pain intensity and situational pain catastrophizing following experimental pain.

Methods

Participants

The current study presents data from a parent study examining immunological activation following experimental pain in TMJD. The sample size was selected to adequately power the parent study. A post-hoc power analysis revealed the current study was 80% powered to detect regression effects of R^2=.12 or larger. Participants were recruited from the general community including Cincinnati Children's hospital and the surrounding area using print and social media.

Sixty-two participants (n=40 TMJD, n=22 HCs) met the following inclusion criteria: age 18–50; English-speaking; no cancer treatment in the past year; not diagnosed with or receiving treatment for diabetes, thyroid disorders, cardiovascular disease, hypertension, pulmonary disease, chronic obstructive pulmonary disease (COPD), neurological disorders, or psychiatric disorders requiring hospitalization in the past year; not pregnant; not using opioids; and no hospitalization/surgery within the past 6 months. TMJD patients met the additional criteria of having a confirmed myofascial, arthralgia, or mixed facial pain diagnosis, having pain five or more days in the last month, and having a history of facial pain for more than six months.

Procedures

Participants came into the lab for two visits, seven days apart. Between visits, they continuously wore an actigraphy watch (*Actiwatch2*, *Respironics*) on their non-dominant wrist and completed sleep diaries each morning. The study was approved by the IRB (IRB#2015–4992).

Visit 1. Participants provided consent, completed a diagnostic exam to determine TMJD/HC status,[16] completed self-report questionnaires, and were given the actigraphy watch.

Visit 2. Participants completed additional self-report questionnaires before undergoing the experimental pain induction involving four subsequent 60-sec immersions of their non-dominant hand into 8°C water bath. They rested 30-sec between immersions. After the task, they completed a situational pain catastrophizing questionnaire. Participants were compensated $45.

Materials

Demographics included self-reported age, race, marital status, smoking status, medication use, pain duration and severity (TMJD only), and health history.

Experimental Pain Intensity was reported at 30- and 45-sec for each immersion, producing eight total ratings (α=0.98). A verbal numeric rating scale ranging from 0 (no pain) to 100 (most pain imaginable) was used. An average across all eight ratings was computed.

Situational Pain Catastrophizing[15] was measured using six items (α=0.67). Each item was rated on a 1–5 scale, with higher scores indicating greater catastrophizing. Participants were asked to refer to the pain induction procedure when completing the questionnaire.

Self-Reported Sleep Measures

1. ***Pittsburgh Sleep Quality Index (PSQI)***[17] measured sleep quality and patterns in the last month using 19 items (α=0.77). A global score ranging from 0–21 was computed, with higher scores indicating poorer sleep quality.
2. ***Insomnia Severity Scale (ISI)***[18] gauged the severity, distress, and daytime impairment of insomnia in the last two weeks using seven items (α=0.88). Each was scored on a 0–4 scale. Higher scores indicated greater insomnia symptomatology.
3. ***Patient-Reported Outcomes Measurement Information System (PROMIS) Sleep-Related Impairment (SRI).***[19] Sleep impairment over the last seven days was measured with eight items (α=0.77). Each was assessed on a 1–5 scale. Positively-worded items were reverse scored and all items were summed so that higher scores indicated greater dysfunction.
4. ***PROMIS Sleep Disturbance (SD).***[19] Sleep disturbance over the last seven days was evaluated with eight items (α=0.77). Each item was assessed on a 1–5 scale. Positively-worded items were reverse scored and all items were summed so that higher scores indicated greater sleep disturbance.
5. ***Sleep Diary - Sleep Quality and Restfulness.*** Each morning between visits, participants completed a daily diary assessing sleep the previous night. Sleep quality and restfulness were self-reported each day using single items. For each item, participants used a 1–5 scale. Across the seven days, α=0.76 for sleep quality and α=0.82 for restfulness.

Actigraphy Measures—Actigraphy data were compared to sleep diary data at the second visit. Discrepancies were discussed with the participant and adjusted in the actigraphy report. The following variables were calculated using Respironics software algorithms:

1. ***Total Sleep Time*** measured the duration in minutes of sleep onset to wake time (α=0.47 across seven days).
2. ***Sleep Efficiency*** was calculated by dividing sleep time by the number of minutes in the rest interval (α=0.69).
3. ***Wakefulness after Sleep Onset (WASO)*** measured the minutes of wakefulness after falling asleep (α=0.67).

Data Analysis

Variables were checked for missingness, normality, and outliers using a criterion of +/− 4 *SD*. Descriptive statistics and *t*-tests compared TMJD and HC groups. Effect sizes were calculated using Cohen's D. To predict pain intensity during experimental pain, separate linear regression models were run using each sleep measure as the unitary predictor. Models were tested with a main effect for group (TMJD vs. HC) and a groupXsleep-measure interaction term. Models were tested with and without the covariates of medication usage (1=participants using prescribed/over-the-counter medication [n=42], 0=no medication [n=18]), smoking status (1=any current smoking [n=11], 0=no current smoking [n=49]), and age. A Holm-Bonferroni correction was used to control for multiple comparisons (9 IVs × 2 DVs × 2 [with/without covariates]=36 total models).[20]

Results

Missing Data and Outliers

There were no missing data for the PSQI or ISI. One HC participant did not return for Visit 2, leaving 61 cases available for PROMIS, pain intensity, and situational pain catastrophizing variables. One watch malfunctioned, leaving 60 participants for actigraphy analyses. Of those, 58 provided complete data (3.7% missing actigraphy data across the entire sample). No daily diary data were missing.

Group Differences in Sleep and Pain

Table 1 provides descriptive statistics. The TMJD group reported poorer sleep than the HC group, but did not differ based on actigraphy. The TMJD group reported higher pain intensity during experimental pain (p=.007) and marginally higher situational pain catastrophizing (p=.09) than the HC group.

Sleep Variables Predicting Experimental Pain Outcomes

Table 2 reveals that PSQI and PROMIS-SRI were significantly associated with pain intensity during experimental pain (Model 1), but only the PROMIS-SRI relationship remained significant after controlling for multiple comparisons and covariates (Model 2).

PSQI, ISI, and PROMIS-SRI were associated with situational pain catastrophizing following experimental pain, but only the PROMIS-SRI relationship remained significant after controlling for multiple comparisons and covariates (Models 3–4).

Diagnosis group did not interact with sleep measures to predict pain intensity or situational pain catastrophizing (all *p*'s>.05, results available upon request).

Discussion

Consistent with our first hypothesis, patients with TMJD self-reported poorer sleep than HCs on all sleep measures but did not differ from HCs on actigraphy measures. In partial support of our second hypothesis, self-reported sleep-related impairment predicted pain intensity and situational pain catastrophizing following experimental pain. The effects of sleep variables on experimental pain outcomes were similar between groups.

Each sleep measure included in the self-report battery represents a distinct aspect of sleep. The PSQI and PROMIS-SRI assess the impact of poor sleep,[17,19] whereas the ISI and the PROMIS-SD assess the symptoms of poor sleep.[18,19] Given that the PSQI and PROMIS-SRI had the largest effects on experimental pain outcomes, the *impact* of poor sleep may be more strongly associated with pain outcomes than the *symptoms* of poor sleep. Future work is needed to explicitly test this hypothesis.

Unexpectedly, no relationships were found between pain outcomes and self-reported sleep quality or restfulness from the daily diaries. Because diaries were completed between visits, they may be less strongly associated with experimental pain outcomes than measures completed the same day as the induction. Alternatively, single-items may not reliably capture between-person variance. This study is further limited by small sample size and the subclinical nature of the TMJD group (only 1/40 rated their jaw pain as "severe"). Findings may not generalize to other pain populations or to those with more severe TMJD. Method variance could account for why self-reported measures were stronger predictors of self-reported DVs than actigraphy measures. Data were collected by the same unblinded experimenter, introducing a possibility for bias.

Despite these limitations, the current study contributes to the literature by describing TMJD/HC differences in self-reported and actigraphy sleep measures and by examining the relationships between sleep measures and experimental pain outcomes in chronic pain. Results highlight the importance of assessing patient sleep perceptions even in the absence of objective sleep deficits.

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Table 1.

Differences in Self-Reported Sleep, Actigraphy, and Pain Outcomes

	Full Sample Mean (SD)	TMJD (n=40)[1] Mean (SD)	HC (n=22)[2] Mean (SD)	*t*	*p*	Cohen's D
Demographics and Pain Description						
Age	29.47 (6.58)	30.40 (6.19)	27.77 (7.07)	1.52	.29	0.40
% Female	85.5	87.5				
Race						
Caucasian	80.6	90.0	63.6	-	-	-
African American	6.5	2.5	13.6	-	-	-
Asian American	4.8	2.5	9.1	-	-	-
Mixed/Other	8.1	5.0	13.6	-	-	-
% Married	35.5	47.5	13.6	-	-	-
Pain Duration (in years)	-	7.71 (5.71)	-	-	-	-
Pain Severity						
Mild n, (%)	-	16 (40.0%)	-	-	-	-
Moderate n, (%)	-	23 (57.5%)	-	-	-	-
Severe n, (%)	-	1 (2.5%)	-	-	-	-
Self-Report Measures						
Sleep Surveys						
PSQI (range)	6.68 (3.62)	7.90 (3.12)	4.45 (3.46)	4.00	<.001	1.05
ISI Total (0–28)	6.92 (5.00)	8.83 (4.36)	3.45 (4.22)	5.37	<.001	1.25
PROMIS SRI (range)	17.03 (4.84)	18.70 (4.93)	13.86 (2.63)	4.19	<.001	1.22
PROMIS SD (range)	21.15 (5.14)	22.43 (4.30)	18.71 (5.82)	2.83	.006	0.73
Sleep Diary						
Sleep Quality (0–5)	3.49 (0.55)	3.32 (0.48)	3.79 (0.56)	3.49	<.001	0.90
Restfulness (0–5)	3.04 (0.68)	2.83 (0.59)	3.43 (0.68)	3.62	<.001	0.94
Actigraphy Measures						
Total Sleep Time (minutes)	414.70 (45.78)	413.80 (44.01)	416.36 (49.99)	0.21	.84	0.05
Sleep Efficiency (%, 0–100)	82.60 (5.58)	82.81 (5.70)	82.21 (5.45)	0.36	.69	0.11
Wake After Sleep Onset (minutes)	40.53 (14.23)	37.98 (14.27)	45.26 (13.21)	1.93	.058	0.53
Pain Outcomes						

	Full Sample Mean (SD)	TMJD (n=40)[1] Mean (SD)	HC (n=22)[2] Mean (SD)	*t*	*p*	Cohen's D
Average Cold Pain Intensity (0–100)	59.68 (25.13)	65.81 (21.65)	47.99 (27.61)	2.77	.007	0.72
Situational Pain Catastrophizing (range)	2.75 (1.24)	2.95 (1.25)	2.39 (1.16)	1.71	.09	0.46

Abbreviations: HC = Healthy controls; ISI = Insomnia Severity Index; PROMIS = Patient Reported Outcome Measurement Information System; PSQI = Pittsburgh Sleep Quality Index; TMJD = Temporomandibular joint disorder; SRI = Sleep-Related Impairment; SD = Sleep Disturbance.

Note:

[1]One participant from the TMJD group did not complete actigraphy data, leaving 39 cases available for analysis of objective sleep measures in that group.

[2]One participant in the HC group did not return for a second visit, leaving 21 cases available for analysis in that group on all measures except for PSQI and ISI which were collected at visit one.

Table 2.

Predicting Pain Intensity and Situational Pain Catastrophizing from Self-Reported and Actigraphy Sleep Measures

	DV: Pain Intensity						DV: Situational Pain Catastrophizing					
Model[1]	**1 (unadjusted)**			**2 (adjusted)**			**3 (unadjusted)**			**4 (adjusted)**		
	β	***t***	***p***	***β***	***t***	***p***	***β***	***t***	***p***	***β***	***t***	***p***
Self-Report Sleep Measures												
PSQI	0.30	2.43	*.018*	0.28	2.07	*.04*	0.29	2.32	*.024*	0.30	2.29	*.026*
ISI Total	0.21	1.62	.11	0.16	1.16	.25	0.27	2.15	*.036*	0.28	2.06	*.044*
Sleep Diary Sleep Quality	−0.05	−0.35	.73	0.02	0.15	.88	−0.04	−0.03	.98	−0.01	−0.08	.93
Sleep Diary Restfulness	−0.03	−0.23	.82	0.05	0.34	.73	0.05	0.37	.71	0.06	0.42	.68
PROMIS SRI	0.37	3.04	**.004**	0.36	2.74	**.008**	0.36	2.97	**.004**	0.36	2.71	**.009**
PROMIS SD	0.06	0.44	.66	0.01	0.11	.92	−0.02	−0.17	.87	−0.02	−0.11	.91
Actigraphy Sleep Measures												
Total Sleep Time	−0.16	−1.21	.23	−0.16	−1.17	.25	−0.03	−0.25	.80	−0.01	−0.07	.95
Sleep Efficiency	−0.19	−1.51	.14	−0.19	−1.45	.15	−0.24	−1.86	.068	−0.21	−1.65	.11
Wake After Sleep Onset	0.004	0.03	.98	0.01	0.10	.92	0.05	0.38	.71	0.05	0.38	.71

Abbreviations: DV = Dependent Variable; ISI = Insomnia Severity Index; PROMIS = Patient Reported Outcome Measurement Information System; PSQI = Pittsburgh Sleep Quality Index; SRI = Sleep-Related Impairment; SD = Sleep Disturbance.

Note:

[1]Each predictor was tested in a separate model. Model columns 1 and 3 show results of unadjusted analyses, where the predictor was the only independent variable in the model. Model columns 2 and 4 show these results controlling for medication use (Yes [1]/No [0]), smoking status (Yes [1]/No [0]), and age.

[2]*Italicized* values are less than .05 but become nonsignificant after controlling for multiple comparisons using the Holm-Bonferroni correction. Bolded p-values are significant after controlling for multiple comparisons using the Holm-Bonferroni correction.