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Discrepancies in Sleep Diary and Actigraphy Assessments in Adults with Fibromyalgia: Associations with Opioid Dose and Age

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Summary

Sleep diary and actigraphy assessments of insomnia symptoms in patients with fibromyalgia (FM) are often discrepant. We examined whether opioid dose and age interact in predicting magnitude or direction of discrepancies. Participants (*N*=199, *M*=51.5 years, *SD*=11.7) with FM and insomnia completed 14 days of diaries and actigraphy. Multiple regressions determined whether average opioid dose and its interaction with age predicted magnitude or direction of diary/actigraphy discrepancies in sleep onset latency (SOL), wake after sleep onset (WASO), and sleep efficiency (SE), controlling for sex, use of sleep medication, evening pain, and total sleep time. Higher opioid dose predicted greater magnitude of discrepancy in SOL and SE. Opioid dose interacted with age to predict direction but not magnitude of discrepancy in SOL and SE. Specifically, higher opioid use was associated with better subjective (shorter SOL, higher SE) than objective reports of sleep among younger adults, and longer subjective than objectively measured SOL among older adults. Opioid dose did not predict magnitude or direction of WASO discrepancies. In FM, higher opioid dose increases diary/actigraphy SOL and SE discrepancies; and direction of discrepancies may depend on age. We speculate that increased opioid use combined with age-related factors, such as slow wave sleep disruption, increased awakenings, and/or cognitive decline, may impact perceived sleep.

Keywords

chronic pain; sleep discrepancy; opioids; aging

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Introduction

Patients with fibromyalgia (FM) suffer from chronic widespread pain, with up to 80% experiencing insomnia (Baker et al., 2017). Insomnia symptoms are assessed by sleep diaries (subjective measures) and physiological (objective) measures such as actigraphy. Older adults with insomnia typically report shorter diary than actigraphy estimates (Van Den Berg et al., 2008, Kay et al., 2015), whereas FM patients with poor sleep quality typically report longer subjective than objective estimates (Okifuji and Hare, 2011). Thus, diary and actigraphic methods may measure different constructs. Research shows that increasing age (Van Den Berg et al., 2008), use of sleep medications (Van Den Berg et al., 2008), and pain ratings (Wilson et al., 1998) increase discrepancies. Another potential source of variability between diary/actigraphy measures in FM patients is use of pain medication. Opioid use has been associated with changes in sleep architecture in adults (Dimsdale et al., 2007). Therefore, we aimed to determine whether opioid dose and its interaction with patient age impact the level or direction of diary/actigraphy sleep parameter discrepancies in FM. Knowledge regarding factors that influence sleep ratings in patients with FM and insomnia could improve interpretation of clinical symptoms and understanding of intervention outcomes.

Methods

Participants

Data were derived from a clinical trial investigating the effectiveness of cognitive behavioral therapy for insomnia in patients with FM (NCT02001077; PI, McCrae). Participants (*N*=235) completed 14 days of baseline sleep diaries (Lichstein et al., 1999) and actigraphy. Criteria for inclusion: at least mild evening pain (10+ on a 0–100 scale), 30+ minutes average diary reported total wake time [sleep onset latency (SOL) + time spent awake after sleep onset (WASO) + early morning awakening (time between last awakening and arising)], and normal global cognition (i.e., scores of ≥24 on the Mini Mental State Examination). There were 199 patients with comorbid FM and insomnia included (see Table 1). The University of Florida Institutional Review Board approved procedures.

Measures

Demographics—Age, sex, and daily use of sleep/pain medication were collected. Participants who used pain medication provided drug names and daily dosage. Using values in the Physician's Desk Reference (Staff, 2011), milligrams of opiates were converted into lowest recommended dosage units per day (e.g., codeine: 15mg=1; 30mg=2)

Sleep and Pain Diaries—Participants were instructed to complete a morning diary for 14 days, reporting evening pain severity, total sleep time (TST), SOL, WASO, and time spent in bed (TIB). Sleep efficiency (SE) was computed as: SE=(TST/TIB)*100.

Actigraphy—Participants wore an actigraph (Actiwatch2, Phillips Respironics) on their non-dominant wrist for all 14 baseline days. Actiwatch2 records the intensity and frequency of wrist motion at 32 cycles/second. Activity counts were analyzed in Actiware Sleep

Analysis Software v.5.3.2 using validated algorithms (Oakley, 1997) and 30s epochs. Scoring period was set to diary reported initial bedtime and final waketime. SOL, TST, WASO, and SE were computed.

Data Analysis

Two measures of disagreement were calculated for each sleep variable. *Magnitude* of discrepancy was computed as the absolute difference between average actigraphy and diary estimates. *Direction* of discrepancy was computed by subtracting actigraphy from diary estimates (i.e., positive values indicate greater diary than actigraphy estimates). Multiple linear regressions were carried out in SPSS (Version 24). Criterion variables included diary and actigraphy estimates of SOL, TST, WASO, and SE. Predictor variables included age, daily opioid dose, and the age by opioid dose interaction term. Patient sex, use of sleep medication, average evening pain ratings, and average TST were entered as covariates. Significant age by opioid dose interactions were clarified by calculating simple slopes of the association between opioid dose and sleep discrepancies for different sample estimated age values characterized as follows: younger (1 SD below mean age, ~40 years), middle-aged (mean age, ~51 years) and older (1 SD above, ~63 years) adults.

Results

Participant characteristics are presented in Table 1.

Results of models predicting magnitude of diary/actigraphy discrepancy are displayed in Table 2. As opioid dose increased, SOL and SE discrepancy increased. Opioid dose did not interact with age in the prediction of SOL, WASO, or SE discrepancy.

Results of models predicting direction of diary/actigraphy discrepancies are depicted in Table 3. Opioid dose interacted with age to predict SOL and SE discrepancies. As Figure 1a illustrates, higher dosage was associated with shorter diary than actigraphy SOL in younger adults (B=−11.02, SE=4.65, p=.02), and longer diary than actigraphy SOL in older adults (B=9.09, SE=3.66, p=.01). Opioid dose was not associated with SOL discrepancy in middle-aged adults (B=−.97, SE=2.83, p=.73). As Figure 1b illustrates, higher opioid dose predicted greater diary than actigraphy SE in younger adults (B=3.27, SE=1.36 p=.02) and was not a predictor in older (B=−.63, SE=1.07 p=.56) or middle-aged (B=1.32, SE=.83 p=.11) adults. Opioid dose did not predict WASO discrepancies.

Discussion

This study examined independent and interactive effects of opioid dose and age on the magnitude and direction of diary/actigraphy sleep parameter discrepancies in patients with FM and insomnia. Findings show that higher opioid dose increases the magnitude of diary/actigraphy discrepancies. However, the direction of discrepancy depends on age, with higher opioid dose in younger adults (~40 years) leading to shorter SOL and higher SE subjective than objective estimates. In contrast, higher dose led to longer subjective than objectively measured SOL among older adults (~63 years).

There are several potential explanations for these variations in diary/actigraphy estimates. First, research shows that, relative to younger adults, older adults experience less slow wave sleep (SWS), and opioid use has been shown to decrease amount of SWS (Wang and Teichtahl, 2007). Thus, in older adults with FM, there may be an additive effect of age and opioid dose on SWS, leading to a greater likelihood of attributing lighter sleep as 'wake', resulting in perceptions of longer sleep onset. Second, as older adults experience more brief nighttime awakenings than younger adults (Scullin and Bliwise, 2015), it is possible that opioid use exacerbates this effect and contributes to sleep misperception. Third, given that both opioid use (Schiltenwolf et al., 2014) and FM (Glass, 2008) have been associated with worse cognition, normal age-related cognitive decline may exacerbate cognitive effects, increasing the likelihood of subjective/objective SOL discrepancies. However, it would be important for future research to compare results to a control group without FM in order to provide evidence for a specific opioid/cognition association. For younger adults, in the absence of decreased SWS, higher opioid dose may have a greater sedative effect, resulting in lower self-report versus actigraphic sleep estimates, as well as greater subjective than objective SE.

A potential limitation concerns the validity of actigraphy in distinguishing sleep from wake. While actigraphy versus polysomnography estimates of SE are highly correlated, SOL estimates show only weak correlation (Lichstein et al., 2006). Thus, diary versus polysomnography patterns of discrepancy and associations with opioid dose and age should also be compared. Additionally, given that the average age of FM participants was approximately 51 years, results for younger adults (~40 years) are not necessarily representative of the young adult population. Finally, future work should compare results to those in older adults with insomnia and no FM, in order to determine whether findings are specific to FM – important information for the clinical care of these comorbid conditions.

Results suggest that associations between opioid dose and direction of diary/actigraphy discrepancies depend on patient age, with older adults most vulnerable to perceptions of worse sleep onset. Because self-reported sleep is strongly associated with health outcomes in older adults (Dew et al., 2003), it may be important for clinicians to carefully monitor opioid dosage in older adults with FM. Implications of the associations between higher opioid dose and better subjective than objective reports of sleep in younger adults remain to be determined.

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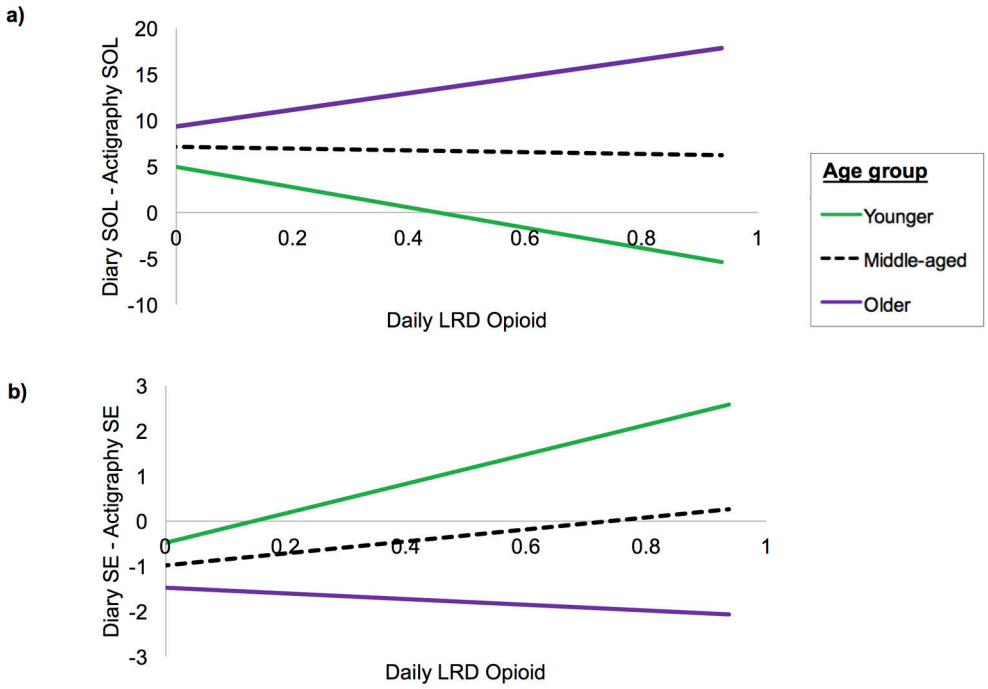

Figure 1.

Direction of sleep diary/actigraphy discrepancies in SOL (a) and SE (b) as a function of average daily opioid dose (lowest recommended dosage, LRD) and age (younger adults, middle-aged adults, older adults)

Table 1

Demographics and Sleep Outcomes of Study Sample (N = 199)

Variable	Mean (*SD*)	Range
Age	51.46 (11.57)	18–77
Sex (M:F)	11:188	--
Average LRD opiates per day	.58 (.93)	.00–4.00
Use of sleep meds (*n*, %)	81 (41%)	--
Benzodiazepines (*n*, %)	26 (13%)	--
Benzodiazepine-like hypnotics (*n*, %)	19 (10%)	--
Antidepressants (*n*, %)	41 (21%)	--
Evening pain severity	51.3 (19.00)	10.71–95.71
Sleep Diary Measures		
SOL (minutes)	50.30 (38.98)	3.07–229.93
WASO (minutes)	44.05 (36.15)	.93–231.00
TST (minutes)	398.33 (80.18)	192.00–631.93
TWT (minutes)	122.45 (66.44)	31.92–410.30
TIB (minutes)	520.87 (77.62)	343.21–786.43
SE (%)	76.42 (11.53)	32.59–93.26
Actigraphy Measures		
SOL (minutes)	43.11 (35.99)	1.93–200.65
WASO (minutes)	51.52 (23.37)	5.40–147.58
TWT (minutes)	118.44 (60.36)	12.67–351.17
TST (minutes)	394.71 (73.33)	159.80–822.00
TIB (minutes)	513.16 (79.61)	346.43–834.67
SE (%)	77.29 (9.95)	31.82–98.71

Note. LRD = lowest recommended dosage; SOL = sleep onset latency; WASO = wake after sleep onset; TST = total sleep time; TWT = total wake time; TIB = total time in bed; SE = sleep efficiency

Table 2

Determinants of magnitude of disagreement of sleep parameters

	Absolute difference of sleep parameter (diary – actigraphy)			
Variable	***B***	***Std error (B)***	***t***	***P-value***
SOL				
Opioid dose	6.10	2.29	2.66	.008 **
Age	.08	.18	.46	.65
Opioid dose x age	.26	.218	1.19	.24
TST	−.04	.03	−1.61	.11
Use of sleep medication[a]	1.97	4.17	.47	.64
Evening pain rating	−.07	.11	−.63	.53
Sex	5.36	9.53	.56	.57
WASO				
Opioid dose	1.59	2.05	.77	.44
Age	−.22	.16	−1.37	.17
Opioid dose x age	−.12	.20	−.60	.23
TST	.02	.02	.75	.45
Use of sleep medication[a]	−1.13	3.74	−.30	.76
Evening pain rating	.12	.10	1.19	.23
Sex	16.81	8.5	1.97	.051
SE				
Opioid dose	1.92	.70	2.75	.007 **
Age	−.02	.05	−.29	.77
Opioid dose x age	−.05	.07	−.72	.77
TST	−.02	.07	−.72	.47
Use of sleep medication[a]	−2.95	1.17	−2.32	.02 *
Evening pain rating	.03	.03	.96	.34
Sex	3.15	2.89	1.09	.28

Note. Multiple regression analyses controlling for patient sex, total sleep time (TST), use of sleep medication, and evening pain ratings. SOL = sleep onset latency; WASO = wake after sleep onset; SE = sleep efficiency

[a]Use of sleep medications entered as a dichotomous covariate (y/n) in regression model. When this variable was entered as a continuous covariate (total average lowest recommended dosage of sleep medications per day), regression results were unchanged.

*$P < .05$;

**$P < .01$

Table 3

Determinants of direction of disagreement of sleep parameters

	Difference of sleep parameter (diary – actigraphy)			
Variable	***B***	***Std error (B)***	***t***	***P-value***
SOL				
Opioid dose	−.97	2.83	−.34	.73
Age	.19	.22	.87	.38
Opioid dose x age	.88	.27	3.26	.001**
TST	−.16	.03	−4.88	.000***
Use of sleep medication[a]	−1.24	11.77	−.11	.92
Evening pain rating	−.46	.14	−3.37	.001**
Sex	−1.24	11.77	−.11	.92
WASO				
Opioid dose	−3.07	2.50	−1.23	.22
Age	−.12	.19	−.63	.53
Opioid dose x age	−.12	.24	−.50	.53
TST	−.26	.03	−9.16	.000***
Use of sleep medication[a]	−1.16	4.56	−.25	.80
Evening pain rating	.20	.12	1.69	.09
Sex				
SE				
Opioid dose	1.32	.83	1.60	.11
Age	−.04	.06	−.67	.50
Opioid dose x age	−.17	.08	−2.17	.03*
TST	.10	.009	11.00	.000***
Use of sleep medication[a]	−3.36	1.51	−2.23	.03*
Evening pain rating	.04	.04	.87	.39
Sex	−6.07	3.44	−1.77	.08

Note. Multiple regression analyses controlling for patient sex, total sleep time (TST), use of sleep medication, and evening pain ratings. SOL = sleep onset latency; WASO = wake after sleep onset; SE = sleep efficiency

[a]Use of sleep medications entered as a dichotomous covariate (y/n) in regression model. When this variable was entered as a continuous covariate (total average lowest recommended dosage of sleep medications per day), regression results were unchanged.

*$P < .05$;

**$P < .01$;

***$P < .001$