THE MENSTRUAL CYCLE, DYSMENORRHEA,

AND SLEEP

by

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ABSTRACT

The present study examined self-reported sleep across the menstrual cycle and the relationship between dysmenorrhea and sleep. The participants were 89 female college students. Analyses revealed variability in two measures of nighttime wakefulness across the menstrual cycle, as well as variability in global measures of sleep and a measure of nighttime wakefulness as a function of dysmenorrhea severity. Additionally, measures of dysmenorrhea were directly correlated with scores on the Insomnia Severity Index and the Pittsburgh Sleep Quality Index. Further, participants having insomnia rated their dysmenorrhea as being more severe and causing more interference with daily activities than participants not having insomnia. The results are discussed with implications for future research.

LIST OF ABBREVIATIONS AND SYMBOLS

F Fisher's F-ratio

η_ρ^2 partial eta-squared, a measure of effect size

M mean or average

p probability of obtaining a test statistic at least as great as the test statistic that was observed (assuming that the null hypothesis is true)

r Pearson product-moment correlation coefficient

SD standard deviation

SEM standard error of measurement

t test statistic derived from a *t* test

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Introduction

Research has consistently shown that sleep disturbances are more prevalent in women than in men (e.g., Roberts, Shema, & Kaplan, 1999; Lichstein, Durrence, Riedel, Taylor, & Bush, 2004; Leger, Guilleminault, Dreyfus, Delahaye, & Paillard, 2000; Paine, Gander, Harris, & Reid, 2004). It seems plausible that this difference may be accounted for, in part, by the physiological changes regularly occurring in women's bodies due to the menstrual cycle. Unfortunately, there has been relatively little research on this phenomenon, and much of the research that has been done is conflicting (Manber & Bootzin, 1997; Moline, Broch, Zak, & Gross, 2003).

Aspects of the menstrual cycle that may impact sleep include the recurring variations in temperature rhythms and in the production of ovarian hormones, pituitary hormones, melatonin, and cortisol (Moline et al., 2003). Women's core body temperatures are most similar to those of men when women are in the follicular phase, which includes menses and precedes ovulation (Baker & Driver, 2007). During the luteal phase, which follows ovulation and precedes menses, women's body temperatures increase by approximately 0.4°C, with an attenuated decline in nocturnal temperature (Baker & Driver, 2007; Shibui et al., 2000). This increase in body temperature is likely due to the rising level of progesterone during the luteal phase (Baker & Driver, 2007). It is probable that this increased nocturnal body temperature during the luteal phase interferes with sleep.

In recognition of this possibility, a small number of researchers have studied the relationship between sleep and the menstrual cycle and obtained significant results using

subjective measures of sleep. Studies have consistently found poorer sleep quality (e.g., poorer sleep quality ratings, longer sleep onset latency and wake time after sleep onset, and lower sleep efficiency) during the luteal phase relative to other menstrual phases (Patkai, Johannson, & Post, 1974; Manber & Bootzin, 1997; Ishizuka et al., 1989). There is also evidence that sleep may be shorter (Patkai, Johannson, & Post, 1974) and more disturbed around the time of ovulation (Ishizuka et al., 1989).

In addition to the self-report research cited above, a few studies have utilized polysomnography to compare sleep patterns in the follicular phase to sleep patterns in the luteal phase. This research has produced conflicting results. One study found no significant menstrual phase differences on a number of sleep measures (Lee, Shaver, Giblin, & Woods, 1990), whereas a similar study (Shechter, Varin, & Boivin, 2009) revealed significantly increased sleep onset latency (SOL) during the mid-luteal phase compared to the mid-follicular phase.

It is likely that painful menstruation adds to the sleep disturbances associated with normal menstruation. However, little research has examined the effects of dysmenorrhea (painful uterine cramps that begin at the onset of menses and persist for up to 72 hours; Durain, 2004; Proctor, Smith, Farquhar, & Stones, 2002) on sleep. One study (Baker, Driver, Rogers, Paiker, & Mitchell, 1999) found that women having dysmenorrhea reported significantly worse sleep quality ratings (SQRs) during menstruation than asymptomatic women. Furthermore, the dysmenorrheic participants had significantly lower sleep efficiency (SE) during menstruation than during their follicular and luteal phases and compared with the asymptomatic participants during menses. The authors attributed the reduced SE of the dysmenorrheics to their increased time spent awake, moving, and in Stage 1 sleep.

Given that the majority of women of reproductive age experience menstruation, and as many as 90% of women aged 18-45 report dysmenorrhea (Jamieson & Steege, 1996), the lack of research in this area is surprising. Most of the studies performed thus far have had small sample sizes and have only sampled a few nights at different points in the menstrual cycle. The intent of the present study was to examine the relationships between sleep, the menstrual cycle, and dysmenorrhea with a larger sample of women, and to monitor sleep continuously throughout the menstrual cycle. I hypothesized that women would have the greatest sleep difficulties around the time of ovulation and in the luteal phase. I also predicted sleep difficulties to be greatest in women who experience severe dysmenorrhea.

Method

Participants

With the approval of the University of Alabama's Institutional Review Board, #11-OR-110-ME-R1, 247 female participants were recruited and screened from the psychology department subject pool and from an introductory undergraduate course in music. In order to be included in the present study, participants had to have regular menstrual cycles (with menses occurring approximately once every four to five weeks). They could not be pregnant or breastfeeding; use any type of hormonal birth control (e.g., oral contraceptives, hormonally-based intrauterine devices, NuvaRing, implant, patch, DepoProvera); have used hormonal birth control within the previous three months; take sedating or stimulating drugs for reasons other than sleep problems (unless these drugs were taken in the morning and not expected to influence sleep; women taking hypnotic medications for sleep problems were included in order to capture a representative sample of participants having insomnia); have intrusive or unstable medical or psychiatric illnesses; or have sleep disorders other than insomnia. Those who endorsed symptoms consistent with depression, mania, or a substance use disorder were be referred to the University of Alabama's Psychology Clinic and disqualified from the study.

Women using hormonal contraceptives were excluded because use of artificial hormones could confound the results. Research suggests that the exogenous hormones found in oral contraceptives influence core body temperature differently than endogenous progesterone and estrogen (Baker, Mitchell, & Driver, 2001). Additionally, women taking oral contraceptives have

a greater percentage of Stage 2 sleep than women with ovulatory cycles (Baker, Driver, & Mitchell, 2001).

Women who had used hormonal birth control within the previous three months were also excluded because it takes some time for the menstrual cycle to normalize after the discontinuation of hormonal contraceptive use. For example, one study found that menstruation is altered for at least two months following discontinuation of oral contraceptive pills (Nassaralla at al., 2011).

Of the 247 women recruited, 92 (37.2%) did not meet criteria for the study due to symptoms of severe psychiatric disturbance, use of sleep-active medications (i.e., sedating or stimulating medications) in the evenings, presence of a sleep disorder (other than insomnia), current hormonal contraceptive use, or recent discontinuation of hormonal contraceptive use. Thirteen participants dropped out of the study, 14 were excluded due to irregular menstrual cycles, and 39 were excluded due to missing or incomplete data . The final sample included 89 participants ranging in age from 18 to 24 years ($M = 18.6$, $SD = 0.9$). Participants who were part of the psychology department subject pool received class credit for participation. All participants were given detailed information about the study before agreeing to participate. Parental consent was waived for participants who were eighteen years old.

Measures

Screening Questionnaire. Participants were screened to ensure they met inclusion criteria (see Appendix A). The screening questionnaire included questions about demographics, typical menstrual cycle length, use of hormonal contraceptives, and pregnancy. The questionnaire also included questions from the Structured Clinical Interview for DSM-IV Axis I Disorders, Clinical Version (First, Spitzer, Gibbon, & Williams, 1996). Included were two

questions inquiring about depressive symptoms, two about manic symptoms, three about symptoms of substance abuse/dependence, one about panic attacks, and one about dream symptoms of post-traumatic stress disorder (which could influence sleep). An investigator-designed health survey was utilized to inquire about physical and mental illness, symptoms of sleep disorders other than insomnia, and medication use. The final portion of the screening was the Pittsburgh Sleep Quality Index (PSQI; Buysse, Reynolds, Monk, Berman, & Kupfer, 1989), which includes 18 self-report questions assessing seven different components related to sleep quality over the past month: subjective SQR, SOL, total sleep time (TST), habitual SE, sleep disturbances, use of sleep medication, and daytime dysfunction. These components were scored individually and summed to determine a global PSQI score. A global PSQI score greater than 5 indicates that an individual is a poor sleeper and is experiencing severe difficulties on at least two components or moderate difficulties on more than three components. The PSQI has excellent psychometric qualities, with good internal consistency (.83 -.85) and test-retest reliability (.85 - .87), and a strong correlation with sleep diaries (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989; Backhaus, Junghanns, Broocks, Riemann, & Hohagen, 2002). It also displays high sensitivity and specificity for people with insomnia compared to normal sleepers (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989; Backhaus, Junghanns, Broocks, Riemann, & Hohagen, 2002).

Insomnia Severity Index (ISI). The Insomnia Severity Index (Morin, 1993) is a self-report questionnaire that includes three questions related to sleep difficulties (i.e., difficulty initiating or maintaining sleep, waking up too early) over the past two weeks. Four other questions address perceptions about sleep (e.g., satisfaction with sleep, worry/distress about sleep problems). Responses are summed, with a score of 0-7 indicating no clinically significant

insomnia, 8-14 indicating subthreshold insomnia, 15-21 indicating clinical insomnia of moderate severity, and 22-28 indicating severe insomnia. The ISI has strong psychometric properties, with good internal consistency (.74) and significant correlations with sleep diary data (coefficients of.38 with SOL, .35with wake time after sleep onset, .35 with morning wake time, and -.19 with sleep efficiency) (Bastien, Vallie'res, & Morin, 2000).

The International Classification of Sleep Disorders, Second Edition (ICSD-2) diagnostic questions. This self-report questionnaire includes questions pertaining to the ICSD-2 diagnostic criteria for insomnia (AASM, 2005). To meet these criteria one must have difficulty initiating sleep, difficulty maintaining sleep, or early morning awakenings; at least one impairment of daytime functioning (e.g., fatigue, mood disturbance or irritability, worries about sleep); and a symptom duration of at least one month.

Pain Inventory. This assessment included the pain severity and pain interference scales of the Brief Pain Inventory (BPI; Cleeland, 1989), with instructions to respond to the questions only with regard to menstrual pain that occurred during the previous 24 hours. Participants' scores on the inventory (completed on the second day of menses) were used to determine the severity of their dysmenorrhea. Although intended to assess pain associated with cancer, the BPI has been validated for nonmalignant pain. It displays high internal consistency (.85 for intensity items and .88 for interference items) and is responsive in its detection of improvements in pain with treatment (Tan, Jensen, Thornby, & Shanti, 2004). In addition to the scales from the Brief Pain Inventory, participants were also asked several other questions pertaining to their menstrual pain, such as whether they had received a diagnosis of dysmenorrhea or been prescribed medication for their pain.

Consensus Sleep Diary (CSD). The CSD (Carney et al., 2012) was used to gather information about participants' bedtimes, out of bed times, SOL, wake time after sleep onset (WASO), number of awakenings (NWAK), and SQRs. Such information allowed for calculations of TST and SE. Participants' time in bed (TIB) was calculated from their bedtimes and rising times. All wake time (SOL, WASO, and morning wake time) was subtracted from TIB to determine TST. To determine SE, TST was divided by TIB.

Two additional questions at the end of the sleep diary inquired about the presence of menstrual flow the previous day and about the use of pain medication for dysmenorrhea, as some pain medications can affect sleep.

Procedure

Participants were recruited from the psychology department subject pool and from an undergraduate class in the department of music. Participants were first asked to complete the screening questionnaire to determine their eligibility for the study (see Appendix A). Those who met inclusion criteria then completed the ISI and ICSD-2 diagnostic questions. After completing these questionnaires, they began the 35 days of CSDs. On the second day of menses, participants also completed the pain inventory.

CSD data for each participant were divided into follicular phase, ovulation phase, and luteal phase, and the mean of each variable for each phase was calculated. The twelve nights prior to the onset of menses were included in the luteal phase. The ovulation phase included the nights that occurred 13 to 15 days prior to the onset of menses. The remaining nights, which included the menstrual period, were included in the follicular phase. A mean for each variable within each phase was calculated.

Participants were grouped according to dysmenorrhea severity based on their rating of their worst level of pain at the onset of menses. Typically on the BPI, a worst score of 0 indicates no pain, a score in the range of 1 to 4 indicates mild pain, a score in the range of 5 to 6 indicates moderate pain, and a score of 7-10 indicates severe pain (Pain Research Group, n.d.). Because only one participant rated her worst menstrual pain as 0, she was included in the mild pain group, resulting in three pain severity groups (mild, moderate, and severe).

<center>**Results**</center>

Participant Characteristics

   Eighty-nine participants ranging in age from 18 to 24 years ($M = 18.63$, $SD = 0.93$) were included in these analyses. With regard to ethnicity, 83.1% of the sample identified as Caucasian/White, 10.1% as African-American/Black, 3.4% as Asian or Asian-American, 1.1% as Latina/Hispanic, 1.1% as Filipino-American, and 1.1% as Black/Hispanic. The mean BMI for the sample was 23.56 ($SD = 4.51$). The mean score on the PSQI was 4.71 ($SD = 2.42$) and the mean score on the ISI was 5.21 ($SD = 3.89$).

Effects of menstrual cycle and dysmenorrhea on sleep variables

   Because this research included between- and within-subjects independent variables, as well as numerous dependent measures of sleep, MANOVAs were used to examine the main and interaction effects of menstrual cycle and dysmenorrhea on sleep. A mixed design 3 x 3 (menstrual phase as repeated measure x dysmenorrhea status) MANOVA evaluated measures of wakefulness (SOL, NWAK, and WASO). This analysis failed to yield a significant interaction, but there were significant main effects for menstrual phase and dysmenorrhea status. When the results for the dependent variables for each menstrual phase were considered separately, WASO and NWAK both reached statistical significance ($F = 4.99$, $p = .010$, $\eta_\rho^2 = .055$, and $F = 7.68$, $p = 001$, $\eta_\rho^2 = .082$, respectively). Subsequent Bonferroni-adjusted repeated measures t-tests were used for follow-up testing. These revealed a significant difference in WASO between the luteal and ovulation phases ($t = 2.65$, $p = .010$), with WASO being significantly longer during the luteal phase (see Table 1 for group means) than during the ovulation phase. There was also a

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significant difference in NWAK between the follicular and ovulation phases ($t = 3.23$, $p = .002$) and between the ovulation and luteal phases ($t = 3.51$, $p = .001$), with NWAK being significantly lower during the ovulation phase than during the follicular or luteal phases.

The results for the dependent variables for each dysmenorrhea severity group were also considered separately, with SOL reaching statistical significance ($F = 3.91$, $p = .024$, $\eta_\rho^2 = .083$). A subsequent Student Newman Keuls post hoc test was not significant.

A mixed design 3 x 3 (menstrual phase as repeated measure x dysmenorrhea status) MANOVA examined global measures of sleep (SE, TST, and SQR). This analysis did not yield a significant main effect for menstrual phase or significant interaction effects. However, there were significant main effects for dysmenorrhea severity groups. Sleep efficiency and SQR both reached statistical significance ($F = 4.56$, $p = .013$, $\eta_\rho^2 = .096$ and $F = 5.42$, $p = .006$, $\eta_\rho^2 = .112$, respectively). Student Newman Keuls post hoc testing revealed that participants having mild dysmenorrhea had significantly greater SE than those having severe dysmenorrhea (see Table 2 for group means). Additionally, participants having mild dysmenorrhea reported significantly better SQRs than participants having moderate or severe dysmenorrhea.

Correlations between dysmenorrhea and sleep measures

To determine whether dysmenorrhea severity and interference are related to sleep disturbance as measured by the PSQI and the ISI, bivariate correlations were conducted between participants' scores on each of these sleep measures and their numerical ratings of dysmenorrhea severity (at its worst) and interference. Dysmenorrhea severity was correlated significantly with ISI score, with greater pain severity associated with more disturbed sleep ($r = .33$, $p = .001$) but not with PSQI score ($r = .18$, $p = $ ns). Dysmenorrhea interference (i.e., interference with daily

functioning as a result of dysmenorrhea) was correlated significantly with scores on the ISI ($r =$ .37, $p < .001$) and the PSQI ($r = .26$, $p = .02$).

Measures of dysmenorrhea and sleep in participants with insomnia vs. participants without insomnia

Using ICSD-2 criteria and quantitative sleep diary criteria developed by Lineberger and colleagues (2006; i.e., average SOL or WASO $\geq$ 20 minutes), 14 of 89 participants (15.7%) met criteria for a diagnosis of insomnia. Using a Bonferroni adjusted alpha level of .008, participants with insomnia (PWI) had significantly greater SE and shorter SOL than participants not having insomnia (PNI; see Table 3 for means). To examine the relationship between insomnia diagnosis and dysmenorrhea severity, two one-way ANOVAs were conducted with dysmenorrhea severity at its worst and dysmenorrhea interference as outcomes. Using a Bonferroni adjusted alpha level of .025, insomnia diagnosis significantly predicted dysmenorrhea severity at its worst ($F = 7.11$, $p = .009$). Participants with insomnia rated their worst menstrual pain as being significantly more severe than participants not having insomnia (see Table 3 for means). Additionally, PWI experienced significantly more interference with daily activities due to dysmenorrhea than PNI ($F = 6.03$, $p = .016$).

Examination of hypnotic use as a potential confound

To determine whether participants taking hypnotics for sleep problems (a possible confound) and participants not taking hypnotics differ on TST, SE, SOL, NWAK, and WASO, participants were divided into three groups based on their response to the PSQI item inquiring about sleep medication use (i.e., no medication use in the past month, less than once a week, or once or twice a week; none of the participants indicated that they used medication three or more

times a week). For each of the aforementioned outcome variables, a one-way ANOVA was

conducted. None of the ANOVAs were significant at $p < .05$.

Discussion

Sleep fragmentation (WASO and NWAK) varied between menstrual phases. Sleep onset latency, SE, and SQR varied across dysmenorrhea severity groups. Dysmenorrhea severity was directly correlated directly with ISI scores, and dysmenorrhea interference was directly correlated with scores on the ISI and the PSQI. Additionally, PWI had higher scores on dysmenorrhea severity and interference than PNI. Scores on sleep variables were comparable for those participants using hypnotics and those not using hypnotics, suggesting that this is not a confounding factor.

The finding that WASO was shortest and that NWAK was lowest during the ovulation phase seems to be a relatively novel finding. However, it seems that only two studies on sleep across the menstrual cycle have examined sleep during the time of ovulation. One of these studies (Patkai, Johannson, & Post, 1974) found that estimates of TST provided by six participants were shortest around the time of ovulation, and the other found (using a 5-factor rating scale) that difficulty imitating and maintaining sleep were worse around the time of ovulation and prior to menses (Ishizuka et al., 1989). These findings were not replicated in the present study. Given the differences in measures used, it is not surprising that the results from previous research and the present study are not fully congruent. Perhaps the longer WASO and increased NWAK observed in the present study during the follicular and luteal phases are due to such factors as dysmenorrhea and other premenstrual symptoms (e.g., dysphoria, bloating, intestinal upset, etc.) in the late luteal and early follicular phases, the increase in estrogen in the

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late follicular phase, and the increase in progesterone (and thus, core body temperature) in the luteal phase.

The lack of significant differences between other sleep variables across the menstrual cycle is somewhat surprising given previous research findings. However, this could be due in part to methodological differences. A number of previous studies have examined a small number of nights from each phase, whereas the present study included data from nights across each phase. For example, one study (Shechter, Varin, & Boivin, 2009) compared nights from the mid-follicular phase with nights from the mid-luteal phase, and another (Manber & Bootzin, 1997) compared nights from the mid-follicular phase to those from the late luteal phase. Further, there are differences in how phases are defined between studies. The algorithm used to divide nights into phases in the current study is described in the procedures section. In contrast, Manber and Bootzin (1997) categorized the 6 days preceding menstruation as late luteal and days 7 through 12 of the cycle as mid-follicular. The algorithm used in the present study seems preferable, as it adjusts for variation in the length of the menstrual cycle across individuals. Other studies (e.g., Patkai, Johannson, & Post, 1974) have used hormone samples taken throughout the study to categorize nights into menstrual phases.

The current findings pertaining to dysmenorrhea are relatively consistent with previous research which has found (using polysomnography) that women with dysmenorrhea have lower SE during the follicular and luteal phases when compared with their asymptomatic counterparts (Baker, Driver, Rogers, Paiker, & Mitchell, 1999). However, in contrast to previous findings, the present study found that women having mild dysmenorrhea reported better SQRs than those having moderate or severe dysmenorrhea across the menstrual cycle and not simply during menstruation. Additionally, the present study failed to find the significant interaction effects

found in previous research (Baker, Driver, Rogers, Paiker, & Mitchell, 1999). This could possibly be attributed to sleep measurement differences (i.e., sleep diary vs. polysomnography) and pain measurement differences (i.e., Brief Pain Inventory vs. visual analog scale and McGill Pain Questionnaire). Additionally, Baker et al. (1999) asked participants to rate pain severity first thing in the morning prior to taking any pain medication. The time of completion of the pain measure relative to the time of ingestion of pain medication was not considered in the present study. The absence of phase x dysmenorrhea interactions in the presence study seems to suggest that the influence of pain on sleep is not just limited to the time of menses, but persists throughout the cycle. Indeed, although Baker and colleagues (1999) did find the aforementioned interaction, they also found physiological differences between women with and without dysmenorrhea that persisted throughout the menstrual cycle. Specifically, they found that symptomatic women experienced elevated estrogen levels and body temperatures as well as reduced REM sleep throughout the menstrual cycle when compared with asymptomatic women.

The findings that measures of dysmenorrhea are directly related to measures of sleep disturbance and that dysmenorrhea severity and interference is higher in women with insomnia than in women not having insomnia are unsurprising. However, given that previous research (e.g., O'Brien et al., 2011; Brand, Gerber, Pühse, & Holsboer-Trachsler, 2010) indicates that pain can influence sleep and vice versa, it is unclear whether perceived severity and interference of dysmenorrhea increased as a result of poor sleep or whether dysmenorrhea resulted in poorer sleep. Longitudinal studies, particularly those studying girls around the age of menarche, would be most beneficial in determining the primary directionality of this relationship.

There were several limitations in the present study that should be noted. One major limitation is that hormone levels were not measured. Therefore, ovulation could not be

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confirmed. Additionally, participants were not given any instructions regarding the timing of pain medicine, which may have led to confounds in the present data. For example, if participant A rated her pain as being severe prior to taking pain medication, but then took pain medication continuously throughout the rest of menses and participant B rated her pain as being mild after taking pain medication, but then stopped taking pain medication for the rest of menses, participant B may have experienced more sleep disturbance relate to pain than participant A. Such a phenomenon would be consistent with the results of previous research (Iacovides, Avidon, Bentley, & Baker, 2009), that found that women with dysmenorrhea who were administered diclofenac potassium (a non-steroidal anti-inflammatory drug) showed improvement in SE (as measured by polysomnography) and SQRs relative to when they were administered a placebo.

Another limitation in the present study is that the sample size lacked sufficient power to allow for the menstrual cycle to be divided into a greater number of phases (e.g., early, mid-, and late follicular and early, mid-, and late luteal). Using a larger number of phases would have allowed for a more detailed analysis of sleep with variations in sex hormones. It also would have allowed comparable phases to be compared between this study and other such research that included portions of certain phases in analyses (e.g., mid-follicular or late luteal).

Future research should be conducted in an effort to replicate these findings and others from previous studies. It would be helpful for future studies to include both objective and subjective measures of sleep. Additionally, future studies could improve upon the present research by including measures of sex hormone levels across the menstrual cycle. This would allow researchers to gain a better understanding of the influence these hormones have on sleep.

Further, measurement of luteinizing hormone would allow researchers to confirm ovulation and identify more accurately when it occurs.

Additional research should also examine other aspects of dysmenorrhea that could influence sleep in addition to severity and interference. For example, it may be helpful to know how long each participant experiences dysmenorrhea and when the pain is at its worst (e.g., in the morning, afternoon, or evening). It could also be useful to assess participants' cognitions or emotions about their pain and determine how those factors relate to sleep outcomes.

Finally, it would be useful to conduct additional research to determine whether treating dysmenorrhea results in improved prevention and/or treatment of insomnia. Interventions for dysmenorrhea could include pain medications or such alternatives as cognitive-behavioral therapy for pain or oral contraceptives. Additionally, cognitive-behavioral therapy focused on mood or anxiety could be tested as a treatment for comorbid insomnia and dysmenorrhea, as both insomnia and dysmenorrhea have shown significant relationships with emotional dysregulation (e.g., Johnson, Roth, & Breslau, 2006; Sievertsen et al. 2012; Alonso & Coe, 2001), which could be an underlying factor in both conditions.

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Table 1

Variable means (SD) by menstrual phase.

Measure	Follicular	Ovulation	Luteal
Sleep onset latency (min)	18.60 (12.47)	20.17 (19.91)	19.92 (14.40)
Wake time after sleep onset (min)**	7.39 (6.70)	5.54 (6.76)	7.62 (6.74)
Number of awakenings**	.91 (0.70)	.69 (0.71)	.92 (0.84)
Total sleep time (min)	455.37 (48.99)	453.52 (83.42)	454.48 (44.12)
Sleep efficiency (%)	92.68 (3.59)	92.45 (6.74)	92.07 (4.38)
Sleep quality rating	3.84 (0.47)	3.95 (.70)	3.88 (0.50)

$*p < .05.$ $**p < .01.$

Table 2

Variable means (SEM) by dysmenorrhea severity.

Measure	Mild	Moderate	Severe
Sleep onset latency (min)[*]	16.08 (1.79)	22.35 (2.83)	23.67 (2.35)
Wake time after sleep onset (min)	5.85 (0.76)	6.44 (1.21)	8.88 (1.01)
Number of awakenings	.764 (0.10)	.66 (0.15)	1.10 (0.13)
Total sleep time (min)	451.90 (7.28)	464.43 (11.50)	451.99 (9.57)
Sleep efficiency (%)[*]	93.53 (0.56)	91.80 (0.88)	90.85 (0.73)
Sleep quality rating[**]	4.05 (0.07)	3.72 (0.11)	3.74 (0.09)

*$p < .05$. **$p < .01$.

Table 3

Mean (SD) sleep and pain measures by insomnia status.

Measure	Insomnia present ($n = 14$)	Insomnia absent ($n = 75$)
Sleep onset latency (min)*	33.57 (12.55)	16.67 (10.12)
Wake time after sleep onset (min)	11.34 (8.04)	6.50 (4.75)
Number of awakenings	.94 (0.55)	.88 (0.73)
Total sleep time (min)	461.58 (40.61)	453.32 (43.44)
Sleep efficiency (%)[*]	89.03 (3.75)	93.06 (3.27)
Sleep quality rating	3.67 (0.36)	3.91 (0.46)
Dysmenorrhea severity – worst[**]	6.32 (3.17)	4.42 (2.30)
Dysmenorrhea interference[**]	3.32 (2.57)	1.85 (1.94)

* $p < .008$. ** $p < .025$.

Appendix

Screening Questionnaire

This questionnaire will be used to determine if you qualify for this study. Please answer all questions truthfully. You may contact the investigator if you have any questions about this survey.

1) Please enter your participant ID number

2) Please enter your date of birth (xx/xx/xxxx)

3) Please enter your height (inches)

4) Please enter your weight (pounds)

5) Please describe your ethnicity.

6) Are you able to access the internet at the place where you sleep (e.g., home, dorm)?

7) On average, how long (in days) does your menstrual cycle last?

8) On what date did your most recent (or current) period begin? (xx/xx/xxxx)

9) Do you use any type of hormonal birth control? Please select "no birth control" or select the type of hormonal birth control you use:
   No birth control   Birth control pills   Intrauterine device (IUD)
   Nuvaring   Implant   Birth control patch

10) Have you used any type of hormonal birth control within the past 3 months?
    YES   NO

11) Are you currently pregnant, breastfeeding, or trying to become pregnant? Select one.
    None of the above   Pregnant   Breastfeeding
    Trying to become pregnant

12) Have you ever been diagnosed with a gynecological disorder (e.g., endometriosis, cervical cancer, ovarian cysts, etc.)?   YES   NO
    If yes, please explain.

13) Do you have chronic pelvic pain?   YES   NO

If yes, please explain.

14) Do you have heart disease? YES   NO
    If yes, please explain.

15) Do you have high blood pressure? YES   NO
    If yes, please explain.

16) Do you have any neurological diseases such as epilepsy or other seizure disorder or Parkinson's? YES   NO
    If yes, please explain.

17) So you have chronic pain such as arthritis or back pain? YES   NO
    If yes, please explain.

18) Do you have difficulty walking?   YES   NO
    If yes, please explain.

19) Do you have urinary tract problems?   YES   NO
    If yes, please explain.

20) Do you have any other medical problems or handicaps?   YES   NO
    If yes, please list all diagnoses and how long each problem has lasted (in years).

21) Please list ALL of the medications taken within the past month, the dosage, the frequency with which they are taken (e.g., daily, weekly), the time of day you take them, and the purpose for the medication. Include vitamins and over-the-counter medications.

22) In the past, has a mental health professional (psychiatrist, psychologist, or social worker) ever treated you? YES   NO
    If yes, please explain.

23) Are you currently being treated by a mental health professional?   YES   NO
    If yes, please explain. Give diagnosis if possible.
    If yes, how long have you had these difficulties?

24) In the past week have you experienced feelings of worthlessness or excessive or inappropriate guilt?   YES   NO

25) In the past week have you experienced feelings of hopelessness?   YES   NO

26) In the past week have you experienced a flight of ideas or racing thoughts?
       YES   NO

27) In the past week have you been more talkative than usual or felt that your speech was pressured?   YES   NO

28) Does alcohol or drug use prevent you from fulfilling major role obligations at work, school, or home?   YES   NO

29) Do you often drink alcohol or use drugs in larger amounts OR over a longer period than was intended?   YES   NO

30) Have you given up or reduced important social, occupational, or recreational activities because of alcohol or drug use?   YES   NO

31) Do you experience recurrent unexpected panic attacks?   YES   NO

32) Do you experience dreams of a traumatic event?   YES   NO

33) Does your mouth feel dry during the night or in the morning?
    Not at all   Mildly   Moderately   Severely

34) Do you have any unusual sleep experiences?   YES   NO

35) Do your legs jerk during the night?   YES   NO

36) Do your legs feel restless before sleep onset?   YES   NO

37) Do you have sleep attacks during the day or paralysis at sleep onset?   YES   NO

38) If yes to any of the above questions (20-27) please explain:

PSQI

INSTRUCTIONS: The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month. Please answer all questions.

1. During the past month, what time have you usually gone to bed at night?
BED TIME _____

2. During the past month, how long (in minutes) has it usually taken you to fall asleep each night?
NUMBER OF MINUTES _____

3. During the past month, what time have you usually gotten up in the morning?
GETTING UP TIME _____

4. During the past month, how many hours of actual sleep did you get at night? (This may be different than the number of hours you spent in bed.)

HOURS OF SLEEP PER NIGHT _____

For each of the remaining questions, check the one best response. Please answer all questions.

5. During the past month, how often have you had trouble sleeping because you . . .

a) Cannot get to sleep within 30 minutes
Not during the   Less than   Once or twice Three or more
past month_____   once a week_____   a week_____   times a week_____

b) Wake up in the middle of the night or early morning
Not during the   Less than   Once or twice Three or more
past month_____   once a week_____   a week_____   times a week_____

c) Have to get up to use the bathroom
Not during the   Less than   Once or twice Three or more
past month_____   once a week_____   a week_____   times a week_____

d) Cannot breathe comfortably
Not during the   Less than   Once or twice Three or more
past month_____   once a week_____   a week_____   times a week_____

e) Cough or snore loudly
Not during the   Less than   Once or twice Three or more
past month_____   once a week_____   a week_____   times a week_____

f) Feel too cold
Not during the   Less than   Once or twice Three or more
past month_____   once a week_____   a week_____   times a week_____

g) Feel too hot
Not during the   Less than   Once or twice Three or more
past month_____   once a week_____   a week_____   times a week_____

h) Had bad dreams
Not during the   Less than   Once or twice Three or more
past month_____   once a week_____   a week_____   times a week_____

i) Have pain
Not during the   Less than   Once or twice Three or more
past month_____   once a week_____   a week_____   times a week_____

j) Other reason(s), please describe_____
How often during the past month have you had trouble sleeping because of this?
Not during the   Less than   Once or twice Three or more
past month_____   once a week_____   a week_____   times a week_____

6. During the past month, how would you rate your sleep quality overall?
Very good _____
Fairly good _____
Fairly bad _____
Very bad _____

7. During the past month, how often have you taken medicine to help you sleep (prescribed or "over the counter")?

Not during the
past month_____

Less than
once a week_____

Once or twice
a week_____

Three or more
times a week_____

8. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?

Not during the
past month_____

Less than
once a week_____

Once or twice
a week_____

Three or more
times a week_____

9. During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?
No problem at all _____
Only a very slight problem _____
Somewhat of a problem _____
A very big problem _____