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Poor sleep maintenance and subjective sleep quality are associated with postpartum maternal depression symptom severity

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Abstract

Women are at increased risk of developing mood disorders during the postpartum period, and poor postpartum sleep may be a modifiable risk factor for the development of depression. This longitudinal study investigated the relationship between sleep variables and postpartum depression symptoms using wrist actigraphy and self-report surveys. Twenty-five healthy primiparous women were recruited from their outpatient obstetricians' offices from July 2009 through March 2010. Subjects wore wrist actigraphs for 1 week during the third trimester of pregnancy and again during the 2nd, 6th, 10th, and 14th weeks postpartum while completing sleep logs and sleep surveys. Subjective assessments of mood were collected at the end of each actigraph week. Subjective sleep assessments were strongly predictive of depression severity scores as measured by the Edinburgh Postnatal Depression Scale (EPDS) across all weeks (p<0.001). Actigraphic measures of sleep maintenance, such as sleep fragmentation, sleep efficiency, and wake time after sleep onset, were also significantly correlated with EPDS scores postpartum. However, there was no relationship between nocturnal sleep duration and EPDS scores. This study provides additional evidence that poor sleep maintenance as measured by wrist actigraphy, rather than lesser amounts of sleep, is associated with EPDS scores during the postpartum period and that subjective assessments of sleep may be more accurate predictors of postpartum depression symptoms than wrist actigraphy. It also supports the hypothesis that disrupted sleep may contribute to the development and extent of postpartum depression symptoms.

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Keywords

Postpartum depression; Sleep; Maternal depression

Introduction

Postpartum depression is an increasingly recognized public health problem with far-reaching consequences for both infants and mothers (Fitelson et al. 2010). Changes in sleep have been hypothesized as a modifiable risk factor for the development of postpartum depression. Poor postpartum sleep may serve as not only a marker of impending depression but also as a contributing cause (Ross et al. 2005).

Explanations for the heightened risk of depression symptoms in the postpartum period are varied, and many factors have yet to be adequately investigated (Swain et al. 1997). Among the potential biologic and social hypotheses is the impact of sleep disorders. The nearly constant need to attend to a newborn infant leads to sleep deprivation, interrupted sleep, and fatigue (Hunter et al. 2009). In addition, physiologic changes that occur during late pregnancy and early postpartum period often make restful sleep difficult to obtain (Brunner et al. 1994). These changes in sleep often occur in the context of concurrent postpartum depression, and in one study of perinatal women seeking outpatient psychiatric treatment, over 50 % reported symptoms of insomnia (Swanson et al. 2011). In the past several years, studies have suggested a bidirectional causal relationship between these phenomena (Field et al. 2007; Armitage et al. 2009).

Studies have identified fatigue and sleep difficulties as common complaints among new mothers, especially those suffering from affective disturbance (Posmontier 2008). Researchers have also investigated the role of child sleep disorders (Armstrong et al. 1998; Swanson et al. 2010), infant temperament (Swanson et al. 2010; Stremler et al. 2006), poor prepartum sleep (Bei et al. 2010; Marques et al. 2011), and time of delivery (Wilkie and Shapiro 1992) as risk factors of postpartum depressed mood. Yet, few studies have evaluated both subjective and objective assessments of postpartum sleep in relation to maternal mood.

Several studies employing only subjective assessments of sleep have reported that mothers' self-assessment of their sleep quality was strongly associated with their mood rating (Huang et al. 2004; Wolfson et al. 2003), and a 2009 cross-sectional, population-based study found that self-reported poor sleep quality was significantly associated with postpartum depression (Dorheim et al. 2009a). Several studies of postpartum women employing wrist actigraphy have offered variable results. In one study of 40 women, there was no significant difference in actigraphy variables between depressed and non-depressed women at 2 months postpartum (Dorheim et al. 2009b). Other researchers, however, have found differences in nocturnal time spent awake, sleep efficiency, and sleep latency in women 3 months postpartum with symptoms of depression as compared to women without elevated depression scores (Goyal et al. 2009; Posmontier 2008). What remains unclear from the literature is how various aspects of sleep may differentially affect postpartum mood. Are aspects of sleep maintenance (such as sleep efficiency) more predictive of depression symptoms in the postpartum period than the total amount of sleep obtained? Are objective

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measures of sleep equally predictive of postpartum mood disturbance as subjective sleep assessments?

Increased attention to the role of sleep disturbance as a risk factor for the development of postpartum depressive symptoms is important because prophylactic sleep interventions may reduce the impact of this disease (Rowe and Fisher 2010), which carries both high prevalence and morbidity (Wisner et al. 2002). If the severity of postpartum sleep disturbances does indeed influence postpartum depression symptoms, then measures such as changes in sleep hygiene could be a useful adjunct in the treatment of these women (Stremler et al. 2006).

Our goals of this study were the following: (1) to compare subjective assessments of sleep quality to more objective measures of sleep by actigraphy in women during the perinatal period, (2) to assess the relationship between subjective sleep assessments with severity of depressive symptoms as measured by the Edinburgh Postnatal Depression Scale (EPDS), (3) to evaluate the association between perinatal sleep as measured by wrist actigraphy and EPDS depression scores, and (4) to determine whether subjective assessments of sleep were more accurate predictors of depression scores as compared to sleep assessment through wrist actigraphy.

In this prospective and longitudinal study of depression symptoms in primiparous mothers, we measured sleep both subjectively and objectively over time, thereby allowing us to evaluate the effects of postpartum sleep on mood as it evolves during the early postpartum period. Our use of a repeated measures design was critical due to the dramatic variability in sleep among newly postpartum mothers. We hypothesized that actigraphic indications of sleep disruption, such as deteriorations in wake time after sleep onset (WASO), sleep efficiency, fragmentation, and sleep duration, as well as subjective assessments of sleep quality, would be associated with the severity of depression symptoms as measured by the EPDS and that women with prior history of affective disorder would demonstrate greater changes in sleep parameters.

Materials and methods

Subjects

Twenty-five healthy primiparous women, nearly half with clinically documented histories of depression as documented in their obstetrical record, in their second or early third trimester (gestational weeks 28–35) of pregnancy were recruited from local hospital-affiliated obstetric–gynecologic offices from July 2009 to March 2010. Women were excluded if they had a diagnosed sleep disorder such as insomnia, serious medical illness, history of non-depressive psychiatric disorders, or were <18 years old. All had singleton pregnancies, uncomplicated term deliveries, and healthy infants.

Measures—actigraphy

Women wore wrist actigraphs continuously for 1 week during their third trimester of pregnancy and then again during the 2nd, 6th, 10th, and 14th postpartum weeks. The actigraph (Actiwatch-64, Mini Mitter Company, USA) contains an accelerometer and

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records movements of the arm over time, providing a reliable measure of periods of wake and sleep (Cole et al. 1992). To help identify these periods, subjects were instructed to press an event marker on the actigraph before going to sleep and again after waking, whether going to sleep for the night or for a nap. Data were collected in 1-min epochs, scored for periods of wake and sleep, and aligned with self-reports of awakenings and infant feedings collected from the sleep logs. Actigraphy measures were analyzed with "High" threshold setting using Respironics Actiware software (v 5.59.0015) and averaged for each week. Only weeks with at least three nights of data were included in the analyses. On average, 6.1 nights were analyzed per week. Key variables were calculated using standard algorithms (Respironics 2009) and included sleep efficiency (as percent of time in bed), percent sleep (as percent of time from sleep onset to morning awakening), sleep fragmentation (number of wake bouts between sleep onset and sleep offset expressed per hour), and WASO.

Measures—sleep logs

For every night of wrist actigraphy, subjects completed sleep logs assessing their estimated morning awakening and bedtimes, nap times, total sleep times, minutes spent awake at night, quality of their sleep, and estimated number of awakenings. Subjects received daily reminders to complete their sleep logs via e-mail or text message. Subjects completed the sleep logs and other self-report instruments through an online survey web site or by hand if they did not have access to the Internet.

Measures—questionnaires

Subjects completed three questionnaires for each study week: the EPDS (Cox et al. 1987), the Center for Epidemiologic Studies Depression Scale (CES-D; Radloff 1977), and the General Sleep Disturbance Scale (GSDS; Lee 1992). Subjects were also surveyed at regular intervals regarding their breastfeeding status, infant's sleep location, and attitudes toward their infant's sleeping patterns.

The EPDS is a ten-item self-report instrument and the most common survey tool currently used to assess symptoms of postpartum depression and identify women at risk for depression. It is not a diagnostic tool, but has well-documented reliability and validity (Wisner et al. 2002). The EPDS assesses depression symptoms for the previous 7 days on a four-point scale (0–3; total score range, 0–30). Scores>12 on the EPDS are associated with a diagnosis of major depressive disorder (Cox et al. 1987). For the purpose of this study, scores were considered a continuous measure of depression symptoms. The EPDS contains one question pertaining to sleep quality, which was excluded from all analyses.

The CES-D is a 20-item self-report survey designed to assess symptoms of depression over the previous 7 days on a four-point scale (0–3; score range, 0–60; Radloff 1977) and is often used in studies of postpartum women (Lee et al. 2000; Radloff 1977). Like the EPDS, scores for this survey were used as a continuous variable and one question pertaining to sleep quality was excluded from analyses.

The GSDS is a 21-item self-report survey of sleep over the previous 7 days (0–7; total range, 0–147). The cutoff score of 42 is frequently used to differentiate poor sleepers. The GSDS

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has good internal consistency and is frequently used in the postpartum population (Lee 1992).

Subjects who scored >12 on the EPDS or >16 on the CES-D were offered psychiatric referral to the hospital outpatient clinic, but maintained in the study. Previous research has indicated that scores above these thresholds are predictive of clinically diagnosed moderate to severe depression (Dennis and Ross 2005).

Written informed consent was obtained from all participants. This study was approved by the Institutional Review Board for the Beth Israel Deaconess Medical Center.

Statistical analyses

Univariate ANOVAs were used to study the relationship between depression symptom scores and both subjective and objective sleep parameters across time, with subject as a random effect to avoid artificial inflation of degrees of freedom. Repeated measures ANOVAs were used to assess change over time in actigraphy measures of objective sleep, self-reported sleep scores (GSDS), and mood ratings (EPDS, CES-D). Given the correlation between the two depression scales, all results below are based on EPDS scores; reanalysis using CES-D scores gave similar, albeit less robust, results. Age, education and marital status, and pre-partum depression severity scores were used as covariates based on previous studies indicating that these factors could affect postpartum depression scores (Yamazaki 2007). Bonferroni or Greenhouse–Geisser corrections were applied for post hoc analyses. All data analyses were performed using SPSS 18.0 (SPSS Inc., Chicago, IL, USA) and a two-tailed significance level of 0.05. Values are presented as the mean±SD.

Results

All 25 women completed the study and 120 subject-weeks of data are included in the final analyses. Two weeks were removed due to inadequate data, and a third week of data was lost due to equipment failure. Through a review of records, one subject was identified as using marijuana during the last 2 weeks of her study participation; these 2 weeks were excluded from the final analyses.

Demographics

Subject demographics are presented in Table 1. The average age was 28.4±4.4 years and 64 % (n=16) identified as Caucasian. Many had college degrees (n=17, 68 %) and approximately half (n=13, 52 %) were employed postpartum. Nine of the 25 women had histories of depression as reported by their referring obstetrician–gynecologist, and two were taking antidepressant medications at the start of the study. On average, the subjects' first week of participation occurred at 31±1 weeks of pregnancy, and all women completed their first week of data collection by their 36th week of pregnancy. Most subjects (n=21, 84 %) anticipated exclusively or partially breastfeeding their infants at the time of study screening. By week 2 postpartum, 76 % (n=19) were breastfeeding and 60 % (n=15) by postpartum week 14. All women reported receiving some help from partners or family members during the early postpartum period, and all considered themselves the primary caregiver of their infants.

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Edinburgh Postnatal Depression Scale ratings

Depression severity scores varied, sometimes dramatically, across the study period, with 10 of the 25 subjects showing changes equal to or greater than seven points on the EPDS. More generally, the average score for the EPDS was 5.7± 4.2 during pregnancy (range, 0–24), increasing to 6.4±3.2 on week 2 postpartum and then dropping to 4.6±3.5 during week 6, 3.5±3.0 during week 10, and 3.6±2.7 during week 14, with the changes between postpartum week 2 and postpartum weeks 6, 10, and 14 significant (see Fig. 1). Four women (16 %) were given referral to the hospital's outpatient psychiatry clinic, three based on survey scores and one on the subject's belief that she was depressed at the time of data collection (mean EPDS score at time of referral=14.5, range=8–24). Of these women, one was started on an antidepressant (Sertraline). One woman met the criteria for depression at week 1; removing her from the above analysis did not alter the findings. Women with prior histories of depression were no more likely to develop elevated postpartum depressive symptoms in this study, though this may be due to the limited sample size. Their EPDS scores, subjective sleep scores, and actigraphy measures were not statistically different from the scores of women without history of affective disorder, differing, on average, by <3 %, and with minimal effect sizes (all $p>0.5$; all Cohen's d scores <0.10).

Relationship between EPDS scores and both subjective and objective sleep measures

Sleep efficiency, percent sleep, sleep fragmentation, WASO, and GSDS scores varied significantly from the third trimester of pregnancy (time point 1) through postpartum week 10 (time point 4). Nearly all subjects experienced significant deteriorations in sleep maintenance as measured by percent sleep, sleep efficiency, and fragmentation between the pre-partum period and the second postpartum week, followed by a gradual improvement over the course of the remaining study weeks. By the 14th postpartum week (time point 5), most women's sleep maintenance improved, as measured by actigraphy, similar to that seen in their third trimester of pregnancy (see Table 2 and Fig. 1), although this still represented relatively poor sleep compared to healthy control women who were not pregnant or postpartum.

Importantly, percent sleep (F=5.7, df=23, p=0.020) and sleep efficiency (F=5.5, df=23, p=0.022) were significantly correlated with EPDS depression scores from the second postpartum week (time point 2) through the 14th postpartum week (time point 5). This relationship approached, but did not reach, statistical significance during pregnancy (time point 1). Separate analyses of the subject who met criteria for depression prepartum did not demonstrate a strong correlation between sleep and depression measures; therefore, her data were included in the final analyses. Fragmentation demonstrated a slightly stronger relationship with the EPDS (F=6.4, df=24, p=0.014). The EPDS scores were also significantly correlated with WASO (F=4.8, df=24, p=0.030). While these sleep parameters were associated with postpartum EPDS scores when measured at the end of the week, they were not predictive of scores obtained 1 month later.

All actigraphy variables, except sleep duration, were highly correlated with each other. There was a wide range of sleep duration scores across subjects, from 233 to 804 min. Perhaps surprisingly, nocturnal total sleep duration did not change significantly across weeks

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and was not predictive of EPDS scores. The number of naps and total daytime nap minutes did vary across weeks, with significant increases during postpartum weeks 2 and 6, but was not associated with the EPDS scores.

Subjective sleep assessments and correlation with EPDS scores

Consistent with known understanding of sleep during the third trimester of pregnancy, subjects' GSDS scores (average, 47.3 ±14.5) qualified most participants as "poor sleepers" as defined by the authors of the GSDS. Self-reported sleep quality as measured by the GSDS dramatically worsened during the immediate postpartum period (time point 2) to an average GSDS score of 65.4, reflecting a nearly 40 % increase from prepartum values. As expected, the effect of time on the GSDS values was high (F=15.8, df=24, p<0.001). Subjective sleep quality gradually improved postpartum, and by week 14 (time point 5), the average scores were not significantly different from the notably poor assessments obtained during pregnancy. This trend of rapid deterioration of subjective sleep quality immediately postpartum with slow improvement during the remaining 12 weeks paralleled the changes seen with actigraphy, and the GSDS scores were highly correlated with actigraphy measures at all time points.

Perhaps our most important finding was that across all weeks, subjective sleep scores were highly associated with depression symptom severity scores (F=34.2, df=24, p< 0.0001). As participants' subjective sleep quality worsened, the EPDS scores increased (see Fig. 2). Subjective sleep quality was a far more accurate predictor of EPDS than actigraphic measures; when subjective sleep ratings were entered into a stepwise regression analysis along with percent sleep, sleep efficiency, and fragmentation, the predictive strength of these objective measures was no longer significant (p>0.75).

Discussion and conclusion

Sleep in the postpartum period is fragmented and inefficient, characterized by multiple and frequent awakenings (Montgomery-Downs et al. 2010b). The effect of sleep quality and sleep maintenance on postpartum depression has only recently received increased attention in the literature. Data from this study provide additional evidence that poor sleep is associated with depression severity symptoms in women during the early postpartum period.

Three particular strengths of this study are worth noting. First, we recruited a diverse sample of women, with 36 % non-Caucasian women, compared to 0–33 % in comparable studies (Goyal et al. 2009; Swanson et al. 2010; Damato and Burant 2008; Stremler et al. 2006). Second, we collected data in a repeated measures design, from late pregnancy through 3.5 months postpartum, with five full weeks of sleep recording over this period. Finally, we had no attrition among our 25 participants. Participants found the availability of online study questionnaires and text messages helpful reminders of their study participation, and this likely contributed to our high compliance and retention. Women in this study participated for a minimum of 5 months, and our results indicate that more intensive studies are warranted as well as feasible.

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In our sample of primiparous women, subjective sleep disturbance and EPDS scores were consistently associated across time from late pregnancy to the third postpartum month. The relationship between sleep objectively measured by actigraphy and depression severity symptoms was similarly present, although comparatively weaker. While there was high multicollinearity between the subjective and objective measures, our findings indicate that the subjective sleep assessments explained the bulk of the variance and that the objective measures did not add significantly to the total explained variance. While the subjective sleep measure predicted depressive symptoms better than did objective sleep measures, there is undoubtedly a shared method variance between the GSDS and EPDS, even with the sleep question (no. 7) removed from the EPDS. The relative strength of the subjective sleep correlation is consistent with findings from Dorheim et al. (2009b) and Bei et al. (2010) who also reported stronger correlations of mood with subjective assessments of sleep than with objective sleep measures. However, unlike Dorheim and Bei, we did find significant correlations between depression scores and the actigraphic measures of sleep. This may be due to the frequent and repeated assessments of both sleep and mood in our study. While it is possible that more depressed subjects negatively biased their subjective ratings of sleep, the high degree of correlation between actigraphy measures and the GSDS scores would argue that these subjective sleep assessments are reflective of actual differences in sleep maintenance, perhaps reflecting aspects of sleep quality not captured by actigraphy.

But importantly, these results indicate that subjective perception of sleep may be a stronger predictor of postpartum depression symptoms than actigraphy. In addition, objectively poor sleep maintenance variables (characterized as fragmentation and reductions in both percent sleep and sleep efficiency) appear to be more closely related to depression severity symptoms than total sleep duration. These results confirm findings by other researchers that total sleep duration does not significantly decrease in the early postpartum period (Montgomery-Downs et al. 2010b) (Dorheim et al. 2009b). Thus, reduced sleep maintenance, as opposed to sleep quantity, may be more important in the development of postpartum mood disorders. If confirmed, this finding would argue that efforts focused on improving sleep maintenance in the postpartum period can have a greater impact on reducing depressive symptoms than simply focusing on total sleep duration.

A limitation of this study is the lack of structured clinical interview diagnostic assessments of depression by clinicians. Thus, diagnoses of major depressive disorder using the Diagnostic and Statistical Manual of Mental Disorders, 4th edition, criteria are not available for subjects who demonstrated elevated EPDS scores. In addition, we did not directly assay infant sleep, nor did we ask participants to indicate which awakenings were due to infant care, which could provide additional data on the relative concordance between maternal and infant sleep patterns. Interestingly, other researchers have not found a relationship between infant feeding method and sleep parameters (Montgomery-Downs et al. 2010a). Future studies utilizing these assessments would enhance our understanding of the relationship between postpartum maternal sleep and depression symptoms. Finally, while we controlled for certain demographic variables such as age and marital status in our analyses, there are multiple other psychosocial variables that can affect depression that were not included.

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Women in this study who carried histories of depressive disorder were not more likely to develop depression symptoms postpartum, though this may be due to the small sample size of the study population. It is also possible that the regular contact with the study coordinator was protective against mood deterioration. As the changes in depression severity symptoms across time in this study were relatively modest, it may be that poor sleep is a better predictor of postpartum blues or a milder form of depression than a major depressive episode, a theory postulated by Swain et al. (1997) in their study of sleep, mood, and cognitive function in the early postpartum period. Notably, the four women in this study eventually referred for psychiatric evaluation did not show significantly worse sleep than other subjects, although the small number of these subjects prevents drawing any strong conclusions about this hypothesis.

Sleep efficiency and comparable actigraphy measures were lower in this study than figures cited in previous studies (Huang et al. 2004; Dorheim et al. 2009b). Actigraphy, particularly the Respironics Actiwatch-64 brand, may overestimate the amount of wake time or underestimate the amount of sleep obtained during brief periods of inactivity. A limitation of the existing data on postpartum sleep is the use of different wrist actigraphy monitors across studies. Although polysomnography can be cumbersome and expensive, further research utilizing this measure would yield more precise measures (Nishihara and Horiuchi 1998).

Additional studies evaluating women who are at increased risk of depression and other mood disorders due to sleep disturbance are needed. There are still inadequate data on the influence of maternal sleep interventions, such as critically timed sleep deprivation, on postpartum depression (Ross et al. 2005). Studies evaluating women at their true baseline sleep (pre-pregnancy) would also help clarify the complex relationship between sleep and mood disturbance in pregnancy. While actigraphy scores by the 14th week postpartum were on average equivalent to sleep obtained measured during the third trimester of pregnancy, the 70 % sleep efficiency seen in the third trimester is already dramatically lower than the 87 % seen in actigraphy studies for non-pregnant, healthy women (Wright et al. 2007).

In conclusion, our findings lend further credence to the growing amount of data suggesting that poor subjective sleep quality is associated with postpartum depression symptoms. The results from this study also indicate that sleep maintenance may play a more important role than actual sleep quantity in the development of postpartum mood symptoms. Given the strength between subjective sleep disturbance and depressive symptoms in our study, clinicians evaluating women with postpartum depressive symptoms should consider monitoring subjective sleep quality in the postpartum period in addition to directly assessing mood symptoms. Measures to improve sleep in the postpartum period could also represent a valuable and benign intervention. Future work should examine the relationship between postpartum depression and measures to improve sleep quality, such as sleep education or prescribed naps.

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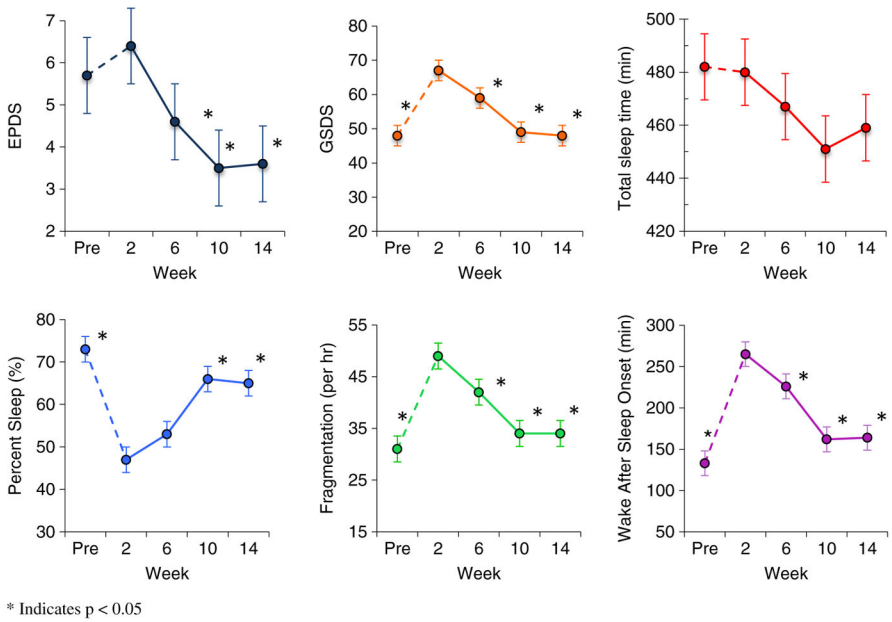

Fig. 1.

Actigraphy, mood, and subjective sleep across weeks

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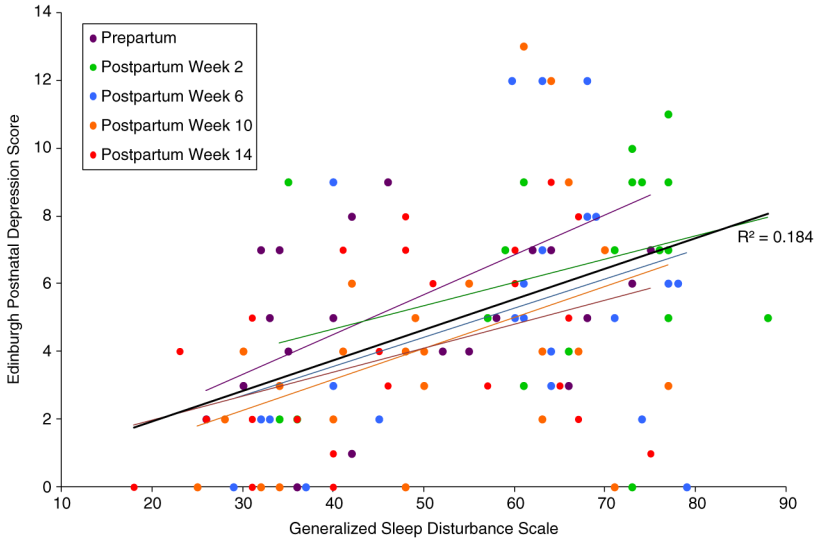

Fig. 2.

Depression scores and self-reported sleep disturbance for all subjects and all weeks. One data point with EPDS score of 22, while included in analyses, is not shown

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Table 1

Subject demographics

Patient characteristic	**Mean**	**SD**
Age at enrollment	28.4	4.4
Gestation at study entry	31.1	1.0
Gestational age at delivery (weeks)	39.9	7.5
	N	%
Caucasian	16	64
Married	18	72
College graduate	17	68
Employed postpartum	13	52
Caesarian delivery	6	24
Male infant	18	72

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Table 2

Repeated measures analyses of sleep and mood characteristics

Characteristic	Healthy controls[a]	Week 1 (prepartum)	Week 2 (postpartum week 2)	Week 3 (postpartum week 6)	Week 4 (postpartum week 10)	Week 5 (postpartum week 14)	*F*	*p* value (ANOV)A	Post hoc tests
Sleep Measures (actigraphic)									
Total sleep time (min)	366.8±100.3	480.9±60.3	492.3±73.6	489.1±73.6	460.7±79.9	462.5±57.4	1.9	0.113	–
Percent sleep	–	73.3±15.0	45.5±9.3	51.5±9.5	64.5±12.3	67.2±15.9	29.5	<0.001	W1>WK2, WK3; <0.001 WK2<WK4, WK5; *p*<0.001
Sleep efficiency (%)	86.6±6.9	69.9±15.1	41.9±9.2	48.5±11.1	61.0±10.8	64.2±15.0	30.5	<0.001	WK1>WK2, WK3; *p*<0.001 WK2<WK4, WK5; *p*<0.001 WK1<WK2, WK3; *p*<0.003
Fragmentation	–	32.7±10.6	50.4±11.1	42.3±11.8	33.5±10.7	32.8±12.2	22	<0.001	WK2>WK3; *p*=0.014 WK2>WK4, WK5; *p*<0.001
WASO (min)	48.0±29.8	129.2±69.0	273.5±60.1	241.5±57.6	170.4±67.1	156.1±79.2	26.2	<0.001	WK<WK2, WK3; *p*<0.001 WK>WK4, WK5; *p*<0.001
Sleep scale									
GSDS	–	47.3±14.5	65.4±15.4	56.9±16.6	48.3±15.6	45.5±15.8	34.2	<0.001	WK<WK2; *p*<0.001 WK>WK3; *p*<0.015 WK>WK4, WK5; *p*<0.001 WK>WK4, WK5; *p*=0.019
Depression scales									
EPDS	–	5.7±4.2	6.4±3.2	4.6±3.5	3.5±3.0	3.6±2.7	7.7	<0.001	WK1>WK4; *p*=0.01 WK2>WK4; *p*<0.001 WK2>WK5; *p*=0.002
CES-D	–	7.8±8.6	9.4±6.1	7.0±5.9	7.0±8.7	5.2±5.3	2.9	0.048	WK>WK5; *p*=0.03

GSDS General Sleep Disturbance Scale, *EPDS* Edinburgh Postnatal Depression Scale, *CES-D* Center for Epidemiological Studies Depression Scale, *WASO* wake after sleep onset, *WK1* week 1, *WK2* week 2, *WK3* week 3, *WK4* week 4, *WK5* week 5

[a]Control data (healthy, non-pregnant women without insomnia or depression; mean age, 37 years) using Respironics Actiwatch-64 (Wright et al. 2007)