REM Sleep and Mood State in Childbearing Women: Sleepy or Weepy?

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Study Objectives: To test the hypotheses that: 1) an increase in endogenous progesterone levels during the luteal phase of the menstrual cycle will alter REM sleep and mood state, and 2) a decrease in endogenous progesterone levels during postpartum will also alter REM sleep and mood state.
Design: A longitudinal descriptive study utilizing ambulatory polysomnography for two consecutive nights at seven time points.
Setting: Subject's homes
Participants: The first hypothesis was tested with 34 women studied during both the follicular and luteal phases of their menstrual cycle. The second hypothesis was tested with 31 women who completed the sleep studies during pregnancy and at one month postpartum.
Interventions: N/A
Measurements and Results: Women who ovulated (high levels of serum progesterone in the luteal phase) had shorter REM latency, more REM sleep, and more positive mood state compared to those who did not ovulate (low luteal progesterone). Compared to the third trimester (high progesterone), REM latency was significantly shorter at one month postpartum (low progesterone). Mood state was most positive at the second trimester and most negative at one month postpartum.
Conclusions: REM sleep and mood state were related to low progesterone levels during the menstrual cycle, but postpartum REM sleep and mood state were related to increased wake time rather than changes in progesterone levels.
Key words: Premenstrual symptoms; sleep; mood state; depression; women's health; negative affect; postpartum depression; pregnancy; menstrual cycle

INTRODUCTION

REM SLEEP, TYPICALLY 20%—25% OF TOTAL SLEEP TIME, IS THOUGHT TO HAVE AN IMPORTANT INFLUENCE ON MOOD STATE AND COGNITIVE FUNCTIONING.[1,2] The timing of the first REM period, thought to be influenced by body temperature or previous sleep deprivation, usually begins about 90 minutes after falling asleep. Progesterone, secreted in high amounts from the corpus luteum after ovulation and in very high amounts by the placenta during pregnancy, is both thermogenic[3, 4, 5] and soporific and can modulate psychological mood state.[6,7,8,9,10,11]

In a recent review of studies on sleep changes associated with menstrual cycle factors, it was concluded that variations in REM sleep are more likely than variations in slow-wave sleep[12] because the processes that modulate core temperature also influence REM sleep. The ten studies that comprised this review included a total of only 78 women, some of whom were healthy controls for women with premenstrual symptoms and some of whom were using hormonal birth control. Many women in these samples were included only if they had documented ovulatory cycles.[13] Small samples, different inclusion and exclusion criteria, and different sampling intervals limit the conclusions that can be made from previous research on menstrual cycle sleep alterations.

The rapid fall in placental hormones has been implicated in the experience of postpartum emotional distress or "blues" that occurs in 75%—80% of new mothers about three to five days after birth. This "blues" is typically confined to the first week postpartum, but more serious forms of maternal depression and postpartum psychosis typically have an onset about two to four weeks postpartum.[14,15] These more serious forms occur in less than 10% of new mothers and have been attributed to prior history of mental health problems, the stresses of pregnancy and motherhood, role changes within the family, and relationships with the baby's father.

Karacan and colleagues were the first to hypothesize a link between sleep and postpartum depressed mood. They

Accepted for publication July 2000
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found a suppression of REM sleep in early postpartum recovery, but did not assess mood state.[16,17] A short REM latency (70.8±23.1 minutes) has been documented as early as the first postpartum night in eight new mothers after healthy vaginal delivery who were monitored in private rooms of the hospital.[18] In comparison with a healthy non-pregnant sample, the latency was significantly shorter (p=.007) but there was no difference in the percentage of time spent in REM sleep. In a larger sample of 17 healthy women and 14 women with a history of affective disorder, Coble and colleagues[19] found no significant change in the amount of REM sleep over the course of pregnancy. By 36 weeks gestation, however, those with a history of mental health problems had significantly shorter REM latency (69.7±26.9) that continued at one month postpartum.[19] Despite a history of affective disorder prior to pregnancy and high risk for postpartum depression, none of the Beck depression scores obtained during the course of pregnancy and postpartum exceeded the 10-point cutoff score for depression diagnosis, all scores were highest during the third trimester (36 weeks gestation), and only 1 of the 14 at-risk women developed postpartum depression.[20]

The purpose of this longitudinal descriptive study was to compare REM sleep parameters during the menstrual cycle and during pregnancy and postpartum when progesterone influences body temperature and when mood alterations are most likely to occur for women. It was hypothesized that 1) an increase in endogenous progesterone levels during the luteal phase of the menstrual cycle would alter REM sleep and mood state, and 2) a decrease in endogenous progesterone levels during postpartum would also alter REM sleep and mood state.

METHODS

Subjects

To test the hypotheses, there were two parts to this study. Part I included 34 women planning a pregnancy within the next year who were studied during the follicular phase (preovulation day 4—10) and luteal phase (postovulation day 16—25) of their menstrual cycle. This convenience sample was recruited through newspaper and television advertisements as well as posted flyers on the university campus. Healthy women between 25 and 39 years of age were eligible to participate. Women with a diagnosed sleep problem, or with children not yet consistently sleeping through the night, were ineligible. Women with a history of mental health problems or taking antidepressant were excluded. Women who were taking medications on a daily or routine basis, such as synthyroid or multivitamins, were not excluded from participation.

Part II involved 31 of these women who were studied at 11—12 weeks (first trimester), 23—24 weeks (second trimester), and 35—36 weeks gestation (third trimester). They were also studied at 3—4 weeks and 11—12 weeks postpartum to obtain stable points in postpartum recovery and to avoid typical return-to-work stressors at six weeks postpartum. Because of the rapid changes with increasing gestation and growth and development of the newborn, only a narrow two-week window for these measures was allowed. A two-week period also allowed for appointment re-scheduling to obtain a stable measurement time around vacations, visitors, daylight savings, and illnesses or stressful work situations. Subjects were paid $25.00 at each phase, with a bonus of $25.00 at the completion of all time points.

Procedures

After obtaining informed consent, polysomnography was performed in the women's homes for two consecutive nights using Oxford Medilog II ambulatory monitoring. At each of seven time points, a member of the research team arrived at the participant's home at least one hour before bedtime. Application of the sleep EEG electrodes took approximately 45 minutes and were applied using C3/A2, C4/A1, and the outer canthus of both right and left eyes. Women were instructed to go to bed at their normal bedtime. They were allowed to remove the leads in the morning, or wait for the researcher to arrive to collect the equipment at which time a morning blood sample was drawn for a battery of analyses, including serum progesterone, indicators of thyroid function, hemoglobin and hematocrit, and serum iron and ferritin levels.

Measures

In addition to ambulatory sleep monitoring, participants also completed self-report measures of mood and depressive symptomatology. The same measures were used throughout the study and measures were selected because of their minimal emphasis on somatic symptoms that are common during pregnancy and postpartum. While there are measures available for postpartum depression, these measures are not valid for women prior to, or during, pregnancy. Therefore, the 20-item Center for Epidemiological Studies-Depression scale (CES-D),[21] and the 65-item Profile of Mood States (POMS)[22] were selected. The three-item Kansas Marital Satisfaction Scale (KMSS)[23] was also administered as a potential mediator of depressed mood. Items on this scale are rated from 0 (not at all satisfied) to 7 (extremely satisfied), with total scores on the KMSS ranging from 3 to 21.

The CES-D asks respondents to indicate the frequency with which 20 symptoms of depression were experienced during the past week, from 0 (not at all) to 3 (5—7 days). The CES-D was used initially to screen for depression and those with scores>15 (n=1) were excluded from the analysis.

The POMS asks respondents to indicate the severity of mood symptoms from 0 (not at all) to 4 (extreme) during the past week. The time frame was modified for this study to ask about "right now" and the POMS was administered both evenings and mornings during each two-day sleep monitoring session. The POMS consists of six subscales: tension/anxiety (9 items), anger/hostility (12 items), depression/dejection (15 items), confusion/bewilderment (7 items), fatigue/inertia (7 items), and vigor/activity (8 items). Because the vigor score is subtracted from the total of the other five subscales to yield a total mood score, scores can range from below zero (positive mood, low mood disturbance) to 200 (severely disturbed mood state). In a sample of 650 female psychiatric outpatients, the mean was 81.5±44 (SD), higher than the mean for college students (43±31.5 SD).[22]

Participants also completed a seven-day sleep/activity diary which included the two-day ambulatory sleep monitoring sessions at each time point. The purpose of this diary was to document any unusual activities that may have influenced sleep in the home, document any naps, and document any symptoms or stressors that would impact their sleep during the recording period.

Statistical Analyses

Polysomnographic data were analyzed using standardized sleep scoring criteria.[24] The sleep scorer was a sleep technician blind to the subject's pregnancy status and had inter-rater reliability of >90% with other scorers on a random sample of sleep records. Data were entered and analyzed using SPSS statistical software. There were no significant differences in sleep parameters between nights 1 and 2 at any point in the study, and correlations between nights were >.80 on all sleep and mood parameters. However, the correlations were moderate at the follicular time point, indicating a trend for a first-night effect of sleep monitoring at the initial recording period. To allow for adaptation to the monitoring equipment at each time point, night 2 was used for all analyses.

The CES-D, total POMS, and KMSS instruments had adequate internal consistency reliabilities in this sample (Cronbach alpha coefficients >.70). With the exception of the confusion/bewilderment subscale, the other subscales of the POMS were also internally consistent (Cronbach alpha coefficients >.70). The total CES-D score was computed by summing the 20 items after first reverse-coding the positive items. There was very little variation in morning POMS scores in this sample of healthy women. The second evening POMS scores were used in these analyses.

The total POMS and CES-D scores were correlated during the menstrual cycle assessment (r =.37), but less so at one-month postpartum (r=.29). The POMS depression/dejection subscale score was correlated with the CESD score (r=.43, p=.009) during the menstrual cycle assessments, but these two measures were not correlated when administered at one-month postpartum (r=.13). When POMS depression/dejection subscale scores were dichotomized at the median value (0) for the postpartum measure, there were 19 women with 0 and their mean CES-D score was 9.6±7.6 (SD). There were nine subjects with scores from 1—53 and their mean CES-D score was not significantly higher (10.4±7.4). Since CES-D cut-off scores for pregnant and postpartum women are not established, scores were left as continuous values for analyses. With the modest relationships between frequency (CES-D) and severity (POMS) of depression, they could be considered two different ways to operationalize the experience of depressive symptoms in the analysis. Rather than categorizing women into postpartum negative and positive affect groups on the basis of a single evening POMS score or the average of the morning and evening POMS during the 48-hour assessment period, frequency (CES-D) of symptoms was selected because of its one-week time frame. The percent change in CES-D scores from the third trimester to postpartum was calculated and used to dichotomize the sample into a positive postpartum affect group (n=19) with postpartum CES-D scores that did not change or increased less than 30% from their third trimester scores, and a negative postpartum affect group (n=9) with postpartum CES-D scores that increased more than 30% from their third trimester scores. A 30% increase has been used in previous studies of premenstrual symptoms[25] and is often considered an effective, therapeutic level of improvement for symptom management in clinical populations of women.

Pearson correlation coefficients were used to examine relationships between progesterone, mood, and sleep variables. Repeated Measures Analysis of Variance was used to examine changes in REM sleep and mood state from the follicular to luteal phase of the menstrual cycle, with ovulation (presence or absence of increased progesterone) as a between-group factor. Repeated Measures Analysis of Variance was also used to examine changes in REM sleep and mood state from the third trimester to one-month postpartum (fall in progesterone), with CES-D affect group as a between-group factor. Statistical significance was set at $p < .05$ for these analyses.

RESULTS

Sample Characteristics

The sample was upper middle-class, with a median annual income of $45,000 to $50,000, and a mean age of 31.6±4.5 years. Only eight (16%) were homemakers not employed outside the home. The majority had stable, satisfying marriages, with a mean KMSS score of 19.6±2.2 (SD). Marital satisfaction was unrelated to CES-D and POMS subscale scores at both the pre-pregnancy time point and at the one-month postpartum time point.

Menstrual Cycle Changes

Results for the follicular and luteal phases are presented in Table 1. Of the 34 women who participated in the study during both phases, 22 ovulated, as indicated by elevated morning serum progesterone levels during the luteal phase. The other 12 did not have a clinically significant increase (> 5 ng/ml) at the time of the luteal phase sleep study and were therefore considered anovulatory during that cycle. There were no statistically significant correlations between luteal phase progesterone level and sleep parameters. The strongest correlations were with percentage of wake time (r =-.24) and REM latency (r=-.22).

Progesterone level was related to mood during the luteal phase of the menstrual cycle (r=-.37, p=.02) such that the higher the progesterone level, the lower the total POMS score or the more positive the mood state. There was no relationship between progesterone level and CES-D scores or depression/dejection subscale scores of the POMS during the luteal phase. As seen in Table 1, there was a significant within-subject change in POMS total mood score from the follicular to luteal phase, particularly for the anovulatory group. Neither the total POMS nor its subscales were related to sleep parameters during the follicular phase of the menstrual cycle.

There was no relationship between the total POMS mood score and percentage of REM sleep (r=.01) or REM latency (r=-.29, p=.07) during the luteal phase. The actual change in REM latency time from follicular to luteal phase, however, was significantly related to luteal phase mood state (r=.42, p=.02) such that the greater the increase in REM latency from follicular phase to luteal phase, the worse the mood state during the luteal phase. This was also the case for POMS subscale scores for depression/dejection (r=.53, p=.002) and confusion/bewilderment (r=.39, p=.03). The change in %REM sleep from follicular to luteal phase was not related to mood during the luteal phase.

Total POMS mood was also significantly related to total sleep time (r=- .34, p=.04), such that women with more disturbed mood during the luteal phase had less sleep. The two mood subscales implicated in this relationship with total sleep time are fatigue and confusion. The fatigue/inertia subscale score was correlated with total sleep time (r=.33, p=.04) during the luteal phase. As an estimate of cognitive functioning, the confusion/bewilderment subscale score was correlated with total sleep time (r=- .41, p=.008), REM latency (r=-.49, p=.002) and sleep efficiency (r=-.31, p=.05) .

There were no significant menstrual cycle phase differences in total sleep time or non-REM sleep stages. There were no significant within-subject menstrual cycle phase differences in sleep onset latency (min to stage 2), sleep efficiency index (% TST/SPT), or wake time (% stage 0), but there was a significant difference between the ovulatory and anovulatory groups in amount of wake time. During the luteal phase, the anovulatory group experienced significantly more wake time during the night compared to the ovulatory group and their own baseline follicular time; their longer sleep onset latency compared to the ovulatory group during the luteal phase did not reach statistical significance (effect size=.56 SD units) in this small sample.

There was no statistically significant within-subject menstrual cycle change in REM onset latency, yet the anovulatory group had a significantly longer luteal phase REM latency (unpaired t=2.1, p=.048, effect size =.81 SD units) than the ovulatory group. The decreased amount of REM sleep, as a percentage of total sleep time, from the follicular to luteal phase was also significant, particularly for the anovulatory group (see Table 1).

Pregnancy and Postpartum Changes

To test the second hypothesis, sleep and mood were monitored at each trimester and at one month postpartum in 31 women with uncomplicated labor and delivery and postpartum recovery. One mother delivered twins. There were four cesarean births. All mothers continued to breast feed at one month postpartum, but supplemented with bottle feedings to varying degrees. Even when the baby was three to four weeks old, there were significantly disturbed sleep patterns, particularly for the novice mothers compared to the experienced mothers and these results were reported in more detail elsewhere.[26]

REM latency was highly variable during pregnancy but the amount of REM sleep, expressed as a percentage of total sleep time, was very stable across the three trimesters when progesterone is secreted in high amounts from the placenta. Mood state was also very stable during pregnancy, with the most positive mood state occurring during the second trimester. The most negative mood state occurred at three to four weeks postpartum, regardless of parity. Postpartum mood state was not related to third trimester mood state POMS scores. Postpartum CES-D scores were correlated (r =.43) with their third trimester CES-D scores. Six women (22%) had postpartum CES-D scores >15. Mean CES-D scores did not differ by parity or type of delivery.

The dramatic decrease in progesterone from the third trimester to postpartum was unrelated to changes in REM sleep parameters. The %REM sleep was not significantly different from pregnancy values, but REM latency for the entire sample of 28 women decreased significantly, from 87.6 ± 42.2 minutes in the third trimester to 70.8 ± 28.0 minutes at three to four weeks postpartum (paired t=2.1, p=.04).

When participants were categorized into a positive postpartum affect group (<30% change from third trimester CES-D scores) or negative postpartum affect group (>30% change), interesting differences in their sleep architecture

Table 1—Menstrual cycle changes in sleep and mood (mean±SD).

	Ovulatory (N = 22)	**Anovulatory (N = 12)**	**Significant Differences**
Serum progesterone (luteal)	13.4 ± 6.0	2.5 ± 1.9	t=7.9, p<.001
Sleep onset (mins to Stage 2)			
Follicular	10.5 ± 6.4	10.8 ± 4.9	
Luteal	8.1 ± 7.8	12.9 ± 10.0	
Total Sleep Time (TST)			
Follicular	417. 7 ± 77.6	413.5 ± 47.9	
Luteal	425.0 ± 73.1	422.1 ± 55.5	
Sleep Efficiency Index (% TST/SPT)			$F_{1,31}$=4.5, p=.040 (group)
Follicular	90.9 ± 9.7	94.9 ± 1.5	
Luteal	93.0 ± 4.1	90.3 ± 7.6	
Wake (% TST)			$F_{1,31}$=4.0, p=.05 (time X group)
Follicular	8.2 ± 8.8	5.0 ± 1.5	
Luteal	6.8 ± 4.0	9.5 ± 7.7	
REM latency (mins)			$F_{1,31}$=640, p<.001 (time X group)
Follicular	76.3 ± 24.1	76.7 ± 11.6	
Luteal	68.0 ± 20.7	85.9 ± 21.6	
REM (% TST)			$F_{1,31}$=9.0, p=.005 (time)
Follicular	24.6 ± 5.1	25.2 ± 4.0	
Luteal	23.6 ± 5.1	20.5 ± 4.7	
Stage 1 (% TST)			$F_{1,31}$=218, p<.001 (group)
Follicular	3.4 ± 2.1	3.6 ± 1.5	
Luteal	2.8 ± 0.9	3.6 ± 1.3	
Stage 2 (% TST)			
Follicular	51.5 ± 9.9	53.9 ± 3.3	
Luteal	53.0 ± 10.3	54.3 ± 7.1	
SWS (% TST)			
Follicular	13.5 ± 6.7	12.2 ± 3.3	
Luteal	13.7 ± 6.2	12.0 ± 3.6	
Depression (CES-D) -Luteal	8.5 ± 6.2	5.8 ± 5.7	
Depression (POMS) - Luteal	1.0 ± 1.6	1.0 ± 1.3	
Tension (POMS) - Luteal	2.7 ± 2.3	4.3 ± 3.8	
Anger (POMS) - Luteal	0.9 ± 2.0	2.3 ± 3.0	
Fatigue (POMS)- Luteal	8.3 ± 6.7	13.2 ± 7.3	t=1.95, p=.06
Vigor (POMS) - Luteal	8.0 ± 5.1	7.2 ± 4.9	
Confusion (POMS) - Luteal	4.3 ± 3.4	5.7 ± 1.8	
Total Mood State (POMS)			$F_{1,30}$=5.2, p=.03 (time)
Follicular	7.0 ± 18.3	10.0 ± 18.2	$F_{1,30}$=13.9, p=.001 (group)
Luteal	8.4 ± 16.1	19.3 ± 16.7	

emerged (see Table 2). There were significant within-subject changes in REM sleep parameters between their third trimester and postpartum. The amount of REM sleep at one month postpartum was not significantly different from the third trimester, but there was a significant time-by-group interaction whereby the negative affect group had a shorter REM sleep latency and less REM, while the positive affect group also had a shorter REM latency, but more REM sleep (see Table 2).

Affect group was also a significant between-subjects factor for total sleep time and wake time. The positive affect group had stable sleep time, almost seven hours, at both time points. The negative affect group, on average, slept 20 minutes longer during the third trimester but had 80 minutes less sleep at one month postpartum. The positive and negative affect groups had similar wake time (11%) during the third trimester, but wake time for the negative affect group averaged 25% of their sleep at one month postpartum compared to the positive affect group's 16%. As expected, POMS subscale scores were worse for the negative affect group, but there were no statistically significant group differences in POMS mood scores during either the third trimester or postpartum assessments.

DISCUSSION

The first hypothesis was supported by findings that progesterone levels influence REM sleep, and the shortened REM latency during the luteal phase is consistent with other studies of progesterone's effect on increased body temperature and earlier REM onset latency.[26,27,28,29] Whereas administration of exogenous progesterone resulted in increased amount of REM sleep in cats,[9] there was no significant increase in the %REM sleep as a result of increased endogenous progesterone in these women during the luteal phase. The lack of an increase in REM sleep from the follicular to luteal phase conflicts with Armitage and Yonker's[30] case study report of an increase from 20% to 28% and Driver and colleagues' report of a trend toward less REM sleep during the luteal phase in comparison with their follicular phase.[31]

Parry and colleagues[13] found a similar REM latency but less REM sleep in eight ovulating women with premenstrual mood disturbance compared to controls, while others have noted shorter REM latencies and higher amounts of REM sleep with depressed mood[32,33,34,35] In this study, mood state was more positive for those with shorter REM latency during the luteal phase of their menstrual cycles. The relationship between mood and REM latency in our study supports the findings that symptomatic perimenopausal women also have longer REM latency.[36] The conflicting findings may be explained by the common practice of excluding anovulatory women from participating in sleep, temperature, and mood studies,[13,29] but more research is needed with both ovulating and nonovulating women before conclusions can be made about the relationships between endogenous gonadal hormones, sleep, and alterations in mood.

Findings from this study support research on the anti-anxiety and soporific properties of progesterone when administered exogenously.[7,8,9] The sedating effect of endogenous progesterone was evident in the ovulatory group during the luteal phase, as manifested by the trend in less time to fall asleep and less wake time during the night compared to the anovulatory group. The lack of statistical significance may be due in part to the small sample size. The group of ovulating women, with higher progesterone levels during the luteal phase, also had less anxiety and anger on the POMS subscale measures, but no difference in depression/dejection POMS subscale scores.

The poor sleep experienced by women during the menopausal transition has been attributed to low levels of endogenous estrogen.[37] One limitation of our study was the absence of measures of serum estrogen levels. Progesterone acts to neutralize estrogen,[38] and the anovulatory group may have been experiencing changes in sleep and mood because of unopposed estrogen rather than lack of progesterone. While it may be that progesterone only indirectly influences REM sleep parameters through its effect on estrogen receptors, ovarian secretion of estrogen will also be lower in anovulatory women and postpartum women.

Immediately after childbirth and delivery of the placenta, postpartum progesterone levels become nil compared to pregnancy measures, and core body temperature is no longer elevated. Yet, REM latency was shortest at one month postpartum, confirming findings from previous research.[16,18,19] While %REM sleep remained stable at 20%—22%, the average REM latency was less than an hour in the postpartum women with increased CES-D scores. A shorter REM latency and more REM sleep are thought to be characteristic of affective disorder,[30,31,32] and thus may indicate a higher risk for postpartum depression.

The selection of self-report measures for estimates of depression was also a limitation of this study. The CES-D and POMS were used at each time point for consistency in measurement, but a specific instrument for assessing postpartum depression was not added to the protocol during the postpartum period. Future research should consider the use of clinical observation as well as specific instruments developed for assessment of postpartum depression.

Results from this small sample of healthy, educated, primarily caucasian women in stable and satisfying relationships cannot be generalized to all childbearing women. In addition to replication of this study, further research is needed to examine postpartum sleep in a more controlled environment where such variables as infant awakenings, daytime naps or prior sleep deprivation will not influence SWS or REM sleep.[39,40] A final limitation of this study was

Table 2—Pregnancy and postpartum changes in sleep and mood (mean±SD).

	Positive Postpartum Affect Group (N = 19)	Negative Postpartum Affect Group (N = 9)	Significant Differences
Serum progesterone (ng/ml)			
3rd trimester	173 ± 80.6	199 ± 57.1	
postpartum	.18 ± .07	.24 ± .16	
Total Sleep Time (mins TST)			
3rd trimester	411.7 ± 68.8	430.1 ± 33.2	$F_{1,23}$=12.3, p=.002 (time)
postpartum	410.2 ± 70.2	327.5 ± 70.6	$F_{1,23}$=11.6, p=.002 (group)
Sleep Efficiency (% TST/SPT)			
3rd trimester	88.8 ± 6.0	89.5 ± 5.6	$F_{1,23}$=10.1, p=.004 (time)
			$F_{1,23}$= 7.3, p=.014 (group)
postpartum	84.1 ± 7.2	75.5 ± 5.7	F1,23= 3.8, p=.06 (parity)
Wake (% TST)			
3rd trimester	11.2 ± 6.0	10.5 ± 5.7	$F_{1,23}$=10.1, p< .004 (time)
postpartum	15.9 ± 7.2	24.5 ± 5.7	$F_{1,23}$= 6.6, p=.014 (group)
REM latency (mins)			
3rd trimester	88.0 ± 21.0	75.3 ± 43.7	$F^{1,23}$= 3.5, p=.065 (group)
postpartum	79.3 ± 20.6	55.9 ± 28.4	
REM (% TST)			
3rd trimester	19.7 ± 4.3	22.3 ± 7.0	$F_{1,23}$= 5.3, p=.03 (group)
postpartum	22.3 ± 4.5	19.9 ± 3.6	
Stage 1 (% TST)			
3rd trimester	3.4 ± 1.1	4.2 ± 1.4	
postpartum	3.9 ± 2.9	3.2 ± 0.8	
Stage 2 (% TST)			
3rd trimester	56.7 ± 5.9	56.7 ± 5.7	$F_{1,23}$=34.6, p<.001 (time)
postpartum	47.4 ± 6.5	40.1 ± 6.8	
SWS (% TST)			$F_{1,23}$=13.1, p=.002(time X group)
3rd trimester	8.4 ± 4.3	7.4 ± 3.1	
postpartum	11.1 ± 4.8	13.0 ± 5.4	
Depression (CES-D)			$F_{1,26}$=15.0, p=.001 (time)
3rd trimester	10.1 ± 4.5	7.3 ± 5.3	$F_{1,26}$=38.8, p<.001 (group)
postpartum	7.8 ± 5.0	16.9 ± 9.4	
Depressed (POMS)			$F_{1,26}$=3.6, p=.07 (time)
3rd trimester	1.4 ± 2.8	1.3 ± 1.8	$F_{1,26}$=3.8, p=.06 (group)
postpartum	1.4 ± 3.0	9.3 ±18.6	
Tension 3rd trimester	2.9 ± 2.8	3.4 ± 4.5	
postpartum	3.0 ± 2.3	8.1 ± 9.4	
Anger 3rd trimester	1.9 ± 4.7	2.6 ± 4.7	
postpartum	1.6 ± 3.1	6.6 ±11.8	
Fatigue 3rd trimester	11.8 ± 7.0	10.5 ± 7.4	
postpartum	12.4 ± 7.1	12.8 ± 6.8	
Vigor 3rd trimester	5.5 ± 4.0	6.9 ± 5.4	
postpartum	6.4 ± 6.1	3.1 ± 2.4	
Confusion 3rd trimester	5.8 ± 3.0	5.0 ± 2.5	
postpartum	5.6 ± 2.9	8.1 ± 7.0	
Total Mood State (POMS)			
3rd trimester	18.3 ± 18.4	16.0 ± 22.2	$F_{1,23}$=3.2, p=.09 (time)
postpartum	17.6 ± 13.0	41.8 ± 51.7	$F_{1,23}$=3.5, p=.07 (group)

the absence of continuous 24-hour sleep recording to capture the sleep architecture during daytime naps that could influence the sleep architecture at night. Women were instructed to limit or avoid naps when they enrolled in the study, but if they were accustomed to napping, they were told to continue to do so as part of their regular routine. By diary reports, none of the women napped during the follicular and luteal phases of their menstrual cycle and seven (25%) of the new mothers reported a nap between 11:30 and 18:30 hours, for between 30 to 120 minutes, on the second day of sleep monitoring. Sleep data for these women were scrutinized for outlying data, and there were no obvious outliers among the seven who napped.

Most women are prepared to cope with interrupted sleep once the baby is born and expect that their sleep will never return to its past quality and quantity. Sleep and mood were significantly affected at one month postpartum because of awakenings during the night. These findings are similar to findings in Coble and colleagues' study,[19] and also support the restorative theory of deep sleep taking precedence over REM sleep during opportunities for recovery from sleep deprivation.[39,40] These findings also demonstrate that alterations in mood during the postpartum period may be particularly related to high fatigue that results from interrupted sleep or lack of sleep. These symptoms can mimic depressive symptoms or place the new mother at risk for postpartum depression, particularly when sufficient opportunity for sleep is unsupported by family members or there are excessive maternal role demands.

Depressed mood and fatigue are commonly discussed outcomes of poor sleep for new mothers. Yet in this study, it was confusion/bewilderment that surfaced as a significant correlate of poor sleep in both the luteal phase as well as postpartum period. Future research should also be aimed toward further exploration of the relationship between poor sleep and daytime cognitive functioning[41,42] that can be estimated with this seven-item subscale of the POMS. This subscale includes such items as "confused," "unable to concentrate," "muddled," "bewildered," "efficient" (reverse coded), "forgetful," and "uncertain about things." At extreme severity, these symptoms would have even greater clinical implications for the health and safety of both the mother and her newborn infant than depressed mood or fatigue.

ACKNOWLEDGMENTS

This study was funded by the National Institute of Nursing Research (NINR), R29 NR02247.

We wish to thank Doug Yost, Anne Byars, and Kristen Hoehler for their technical assistance and thank the women and their families for participating in this study.

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