Published in final edited form as:

Arch Womens Ment Health. 2012 June ; 15(3): 185–192. doi:10.1007/s00737-012-0275-1.

Does Activity Matter: an Exploratory Study among Mothers with Preterm Infants?

Shih-Yu Lee, PhD, RNC[Assistant Professor],

Byrdine F. Lewis School of Nursing and Health Professions, Georgia State University

Carol H. Grantham, PhD, RN[Assistant Professor],

Byrdine F. Lewis School of Nursing and Health Professions, Georgia State University

Susan Shelton, PhDc, MSN, RN, CNM[PhD candidate], and

Byrdine F. Lewis School of Nursing and Health Professions, Georgia State University

Dana Meaney-Delman, MD

Department of Gynecology and Obstetrics, Emory University

Introduction

Fragmented sleep is prevalent among postpartum women regardless of whether or not they have a healthy newborn at home (Gay et al. 2004; Goyal et al. 2009; Montgomery-Downe et al. 2010) or a hospitalized, preterm infant (Lee and Lee, 2007). Sleep is one of the fundamental needs of mammals, and the circadian process plays an important role in maintaining normal sleep and wake cycles for human beings (Borbely, 1982). Sleep loss leads to poor health outcomes, such as fatigue, mood status changes, and physical dysfunction (Lee 2003). With new mothers, newborn care requirements result in impaired nocturnal sleep which leads to daytime napping and also desynchronizes their regular circadian rhythms (rest/activity rhythms). Circadian rhythms are generated by a central pacemaker, the suprachiasmatic nuclei (SCN), a self-sustained timing system that is highly regulated and synchronized to elements of the external environment such as light and social activities (Lee et al. 2009). As such, circadian rhythms are closely linked to sleep, wakefulness, and health (Germain and Kupfer 2008). To date, little information is available on daytime activity levels and circadian activity rhythms (CAR) in any population. However, lower levels of self-reported maternal, prenatal, physical activity was found to be associated with preterm labor (Watson and McDonald 2007). Disorganized CAR and lower light exposure levels are related to symptom severity in dementia patients (Gehrman et al. 2005) and seasonal affective disorder patients (Winkler et al. 2005). In our prior studies, poor CAR was found in women with an infant cared for in the neonatal intensive care unit (NICU) during the mother's earlier postpartum period (Lee and Kimble 2009; Lee et al. 2010). Physical activity has been associated with depression due to neurobiological effects from noradrenergic and serotonergic systems (Greer and Trivedi 2009). Therefore, investigation of activity levels and the impact of desynchronized circadian rhythms is of particular importance because of the hypothesized association with depression (Germain and Kupfer 2008; Monteleone et al. 2010).

Problems with sleep are very common in depressed patients, which may be due to sleep disorders, or abnormalities in serotonergic feedback to the SCN and play a role in regulating circadian rhythms and regulating sleep (Borbely and Achermann 1992). Additional study

results also show a relationship between sleep disturbances and poor mental health in pregnant women (Okun et al 2011) and postpartum women, regardless of whether they had a term labor (Goyal et al. 2009; Posmontier 2008) or a preterm labor (Lee and Kimble 2009). Approximately 12.5% of U.S. infants are born prematurely (CDC 2010); however, there is very limited knowledge of the physical activity levels, sleep, and well-being of postpartum women with preterm infants. The specific aims of this exploratory, comparative study were to: 1) describe maternal daytime activity levels (12 hours after arise time) during their second week postpartum; 2) explore the associations between activity levels, and sleep and maternal well-being (fatigue, depressive symptoms, and health-related quality of life (H-QOL). We hypothesized that compared to the mothers with higher daytime activity levels, the mothers with lower activity levels will have: 1) less total nocturnal sleep time, greater daytime sleep time, and poorer sleep quality; and 2) higher levels of depressive symptoms, higher fatigue severity, and poorer H-QOL.

Methods

Participants and data collection procedures

This study, guided by the Impaired Sleep Model (Lee 2003), examined the baseline data that were collected as part of a feasibility study and a pilot randomized clinical trial. The parent studies used the same protocol and were conducted to examine the effectiveness of bright light therapy on sleep and well-being among mothers with preterm infants in the NICU. The inclusion/exclusion criteria have been reported elsewhere (Lee and Kimble 2009; Lee et al. 2010). In brief, the 51 study participants included in this study were recruited from three NICUs in a southern metropolitan city in the U.S. They were healthy first-time mothers without any pre-existing physical or mental conditions. On completion of the post-test data collection, mothers received a baby blanket or a \$50 gift card and a *Sleeping B.E.T.T.E.R.* (Lee et al. 1996) booklet as a compensation for their participation. The majority of mothers were Black, in their mid-twenties, a high school graduate, and with an annual family income of less than \$40,000 (Table 1).

Approvals for this study were obtained from the Institutional Review Boards at the participating universities and research sites, and potential study participants were identified after review of the NICU records. The discharge coordinators and bedside nurses were consulted before the mothers were approached. After passing eligibility screening, mothers were instructed to wear a non-invasive motion sensor monitor (wrist actigraph) for two or three days in order to monitor their rest/activity patterns. All of the mothers slept at home during the data collection period. After the objective rest/activity data were collected from their wrist actigraph, the mothers then completed a demographic form and questionnaires which pertained to their perceptions of sleep disturbances, postpartum depressive symptoms, and H-QOL in both physical and mental components.

Measures

Sleep and activity—Wrist actigraphy with a light sensor up to 40,000 lux (Mini Motionlogger Actigraphy, octagonal motionlogger, Ambulatory Monitoring Inc., Ardsley, N.Y.) was used to measure sleep quantity (TST: total sleep time), fragmented sleep (WASO: wake after sleep onset), activity levels (the data were reported as movements per minute), CAR, and light exposure level. Wrist actigraphy has been used widely since the 1970s, and has been found to be a reliable monitor for assessing rest-activity patterns (Ancoli-Israel et al. 2003). The mothers in the current study wore it on their non-dominant wrist during a 48-hour (feasibility study) or 72-hour (pilot study) recording period. The average 2- or 3-nocturnal TST and the average of 2- or 3-daytime (the 12 hours period after arise time) activity level was used in subsequent analysis. CAR was defined as the ratio of amplitude

and mesor. In general, the larger the quotient (range 0–1), the better the rhythm (Ancoli-Israel et al. 1997).

Self-perceived sleep disturbances—Sleep disturbances, which included self-perception of sleep quality, sleep quantity, and daytime sleepiness, was assessed with the General sleep Disturbance Scale (GSDS) (Lee 1992). GSDS is a 21-item survey assessing difficulty getting to sleep (one item), waking up during sleep (one item), waking up too early from sleep (one item), sleep quantity (two items), sleep quality (three items), daytime sleepiness (seven items), and use of sleep aids (six items) over the past week. It is an 8-point Likert scale ranging from 0 (never during the past week) to 7 (every day during the past week). In this study, the six items pertaining to use of sleep aids to induce sleep was not included for the final analysis because of lack of variance (73% of the participants scored “never during the past week” on this subscale). In this study, the three single-item subscales related to sleep onset, waking during sleep, and waking too early, along with the three sleep quality questions, were computed together to present sleep quality. This decision was based on a principal axis factor analysis that indicated the six items loaded one factor that accounted for 55.4% of the common variance. The Cronbach’s alpha coefficient for the overall scale (15-item) was .86, and for the sleep quality (6-item) and daytime sleepiness were .84 and .77, respectively. A higher score represents greater sleep disturbance with a cut-off score 3 indicating a clinically significant sleep disturbance.

Well-being—Fatigue severity, depressive symptoms and H-QOL were used to represent maternal well-being. The Lee’s Fatigue Scale – LFS (Lee et al. 1991) was used to measure fatigue severity. The original scale had 18 items, with Likert rating scales ranging from 0 (not fatigued) to 10 (extremely fatigued). Cronbach’s alphas have been reported to range from .91 to .96 with healthy adults and sleep disorder patients (Lee et al. 1991). To decrease the burden on the study participants, nine items (seven items measured fatigue and two items measured energy) were selected from the original scale for this study. Mothers were asked to answer these questions twice a day, morning and evening, during the two or three days of the wrist actigraphy data collection period. An average fatigue score was computed for subsequent analysis. A higher score indicates a higher level of fatigue. Previous studies with parents of hospitalized children have shown that these nine items have adequate reliability (Lee 2007; Lee and Kimble 2009). In this study, the obtained Cronbach’s alphas, for the two or three mornings and evenings, ranged from .86 to .97.

The Edinburgh Postnatal Depression Scale (EPDS), a 10-item scale, was used to assess maternal postpartum depressive symptoms. Mothers reported their symptoms experienced in the past week on a 4-point rating scale, ranging from 0 (rarely or none) to 3 (most or all the time). Higher scores indicate more depressive symptoms, and a score of 13 or above is indicative of postpartum depression (Cox et al. 1987). The internal consistency for this study was .89. The 36-item Medical Outcomes Short Form-36version 2 (SF36v2) was used to assess maternal H-QOL (McHorney et al. 1994; Ware and Sherbourne 1992). The SF36v2 consists of two components: physical health (physical functioning, role-physical, bodily pain, and general health perception) and emotional health (vitality, social functioning, role mental/emotional function, and general mental health perceptions). A higher score on the physical health component indicates better physical H-QOL, whereas a higher score in the emotional health component reflects better emotional H-QOL. In this study, the internal consistency was .85 for physical health and .84 for emotional health.

Data analysis

Descriptive statistics, including frequencies and means, were used to analyze demographic characteristics, sleep quantity and quality, activity levels, and well-being. Cosinor analysis

was used to examine CAR (Ancoli-Israel, et al., 2003); the mesor (fitted activity mean), the acrophase (time of the peak of the fitted activity curve), and the amplitude (magnitude of the activity oscillation) were determined by using Action 4 software.

Mothers were categorized into a high activity or a low activity group by using median split (12-hour daytime activity = 133.72) because of a lack of existing data that can be used as a guideline. Data were analyzed for the entire group first, then the differences between the mothers in two activity groups were compared. Chi-square and *t* tests were used to compare demographic data; there was no significant difference between the two groups. Bivariate correlations among these variables were also computed to explore the relationships between activity level, sleep, and well-being. Hypothesis testing was conducted using *t* tests.

Results

Activity levels, circadian activity rhythms, and sleep

The average daytime activity level was 190.6 (SD= 32.5, ranged from 119.8 to 253.8, median= 193.72). The average amplitude and mesor were 90.33 (SD= 22.4) and 134.4 (SD= 21.4), respectively. The average CAR, as presented by the ratio of amplitude and mesor, was .69 (SD= .18, ranged from .08 to 1, median= .71), which is statistically significantly lower than the ideal CAR value of 1.0 ($t[47] = -11.84, p < .001$). The acrophase (peak activity level) in military time was 17:01 (ranged from 14:19 to 20:49), an indication that the majority of the mothers were more active during the evening. During daytime (for an overcast day the light level is about 1,000 lux), the mothers had a low light exposure with an average of 66.2 lux (similar to a typical living room light level) and a median of 48.5 lux.

Sleep quantity was operationally defined as the average of 2- or 3-day nocturnal TST measured by wrist actigraphy. About 66% of the mothers slept less than seven hours. The mean TST was about 6 hours, which is statistically lower than the preferred sleep time (7.5 hours) reported by the mothers for them to feel refreshed (paired $t[50] = -4.3, p < .001$). Mothers reported clinically significant daytime sleepiness from the GSDS subscale (3.1 ± 1.4). They took naps, and the average daytime TST was 70 minutes with a median of 57 minutes. Sleep quality was operationally defined by the average of 2- or 3-day nocturnal WASO measured by wrist actigraphy and the self-reported sleep quality measured by the 6-item sleep quality subscale in the GSDS. The average WASO for the mothers in this study was 20% (SD= 12%). On average, mothers had 12 awakenings during their nocturnal sleep, with an average total awake time at night of 96 (SD= 63) minutes. The mean score for the GSDS whole scale was 2.7 (SD= 1.2); for the 6-item sleep quality it was 3.4 (SD= 1.7), and for the daytime sleepiness it was 3.1 (SD=1.4). More than 50% of the mothers scored above 3 for the whole scale and the subscales of the GSDS, which indicated they experienced clinically significant sleep disturbances.

Well-being

Fatigue severity, postpartum depressive symptoms, and H-QOL were used to assess maternal well-being. The modified LFS was used to measure maternal fatigue severity. The mean morning fatigue severity score was 3.9 (SD= 1.8), and the evening fatigue score was 5.1 (SD=1.7), indicating they experienced moderate fatigue severity level in both morning and evening (Lee et al. 1991). More than 70% of the mothers from this study scored above the fatigue severity cut-off point of 3.3, which was used in one study of female family caregivers for cancer patients (Fletcher et al. 2008). The average score for postpartum depressive symptoms measured by the EPDS was 13.9 (SD=5.5), indicating that the mothers experienced significant depressive symptoms during their early postpartum period. More than 60% of the mothers scored above the cut-off point of 13; however, none of the mothers

reported having an intention to harm themselves. The scores for SF36v2 in mental and physical health were about one standard deviation below the norms for age-matched females in the U.S.

Correlations among activity levels, sleep, and well-being

As detailed in Table 2, a higher 12-hour daytime activity level, as measured by the wrist actigraph, was significantly correlated with fewer postpartum depressive symptoms. Mothers with more postpartum depressive symptoms also experienced higher morning fatigue severity, and reported a poorer mental H-QOL. As expected, mothers who had better CAR had a longer nocturnal TST. The mothers who slept more experienced less severe morning fatigue. The higher fatigued mothers reported poorer sleep quality and more daytime sleepiness ($r = .56, p < .001$), they also reported more postpartum depressive symptoms and poorer physical and mental H-QOL. Poorer physical H-QOL as rated by mothers was significantly correlated with poorer sleep quality, higher daytime sleepiness ($r = -.37, p = .006$), and greater morning fatigue severity. Similarly, the mothers with more adverse mental H-QOL reported poorer sleep quality ($r = -.49, p < .001$) and inadequate sleep quantity ($r = -.32, p = .02$); they also experienced greater daytime sleepiness ($r = -.41, p = .003$) and morning fatigue. As expected, daytime light exposure level was positively related to daytime activity level ($r = .30, p = .03$).

Comparison between two groups

A total of 25 mothers were categorized in the lower activity level group and the other 26 were in the higher activity group. When the low activity group mothers were compared to the high activity group mothers, they slept more during the daytime ($t[49] = 2.3, p < .03$), spent a lower percentage of time awake during the night ($t[49] = 2.0, p = .05$), and reported more postpartum depressive symptoms ($t[49] = 2.2, p = .03$). Mothers in the high activity group slept about 20 minutes more during the night, experienced less morning and evening fatigue, reported higher H-QOL in both physical and mental components, and had a better synchronized CAR than their counter group; however, it was not statistically significant in this small sample (see Table 3).

Discussion

This study extends the understanding of activity levels, CAR, sleep, and well-being in women during early postpartum period while their preterm infants are still hospitalized in the NICU. Sleep is one of the fundamental needs of human beings. To maintain health, a minimum of 7 hours of sleep is recommended by the National Sleep Foundation (NSF, 2010). Sleep deprivation or fragmented sleep is very common in postpartum women, yet no study has been done exploring the relationships between activity level and maternal sleep and well-being. Impaired sleep may predispose postpartum women to sleepiness and consequent daytime sleep which disrupts normal circadian activity rhythms. Therefore, improving daytime activity and night time sleep may be beneficial of intrinsic sleep problems. Studies thus far, have correlated poor sleep with postpartum depression which emphasizes the importance of quantifying the contributing of sleep dynamics on the incidence of postpartum depression. The determination of mitigating factors on sleep quality, such as activity level and rest/activity patterns, may further the understanding of this relationship and allow for the development of preventive strategies for postpartum depression. As demonstrated from wrist actigraphy and self-reported data, mothers in this study were sleep deprived and sleep disturbed despite the infants not being present in the home with them. It is anticipated that sleep problems would only worsen once an infant, with round-the-clock care needs is brought into the home. Data from this study suggests that mothers who had less daytime activity were at higher risk for more postpartum depressive

symptoms. The maternal daytime activity level was positively associated with daytime light exposure but negatively associated with postpartum depressive symptoms. Targeting the subgroup with low daytime activity level or/and less light exposure with interventions that are aimed at increasing activity level and appropriate light exposure may be a useful approach for preventing postpartum depression. This could easily be achieved if new mothers were instructed by their clinicians to engage in simple activities, such as walk outside during daytime.

To date, there is minimal research assessing activity level and CAR in postpartum women. However, compared to prior studies with healthy young adult women, the 24-hour arithmetic mean activity for the mothers in the current study was significantly lower than those women in Brown and colleagues (1990). In addition, the peak activity level (acrophase) for the mothers in the current study was in the evening (17:01), which is later than two prior studies with healthy adult women that showed peak activity levels of 13:42–15:18 (Brown et al. 1990) and 16:00 (Lee and Beyene et al. 2007). As we hypothesized, mothers in the low activity group slept statistically significantly more during daytime, and reported more postpartum depressive symptoms. Both high- and low-activity mothers reported a moderate level of fatigue, which was similar to prior studies in mothers with a healthy newborn (Gay et al. 2004) or with a newborn who had medical conditions and was hospitalized in the ICU (Lee and Lee et al. 2007).

According to the two-process model of sleep regulation (Borbely 1982), normal sleep-wake cycles are determined by interactions between the homeostatic process and the circadian process. In the current study, there was a significant, positive association between CAR and TST ($r = .45$, $p = .001$) indicating that an individual with a more synchronized CAR also had longer nocturnal TST. We hypothesized that the desynchronized CAR for these mothers could be a result of: 1) circadian phase shifting (Postolache and Oren 2005) because of low light exposure, and 2) social rhythms disturbance (Ehlers et al. 1988) resulting from changed social activities because of the infant's hospitalization. In the current study, a low daytime activity level was associated with higher postpartum depressive symptoms; after further exploration via linear regression, results indicated that activity level accounted for about 10% of postpartum depressive symptoms ($F[1, 50] = 5.3$, $p < .03$). Furthermore, the magnitude of the correlation between daytime activity level and postpartum depressive symptoms was almost four times that as the correlation between CAR and postpartum depressive symptoms. Together, the findings suggest that during the early postpartum period, maternal daytime activity level may have an immediate impact on postpartum depressive symptoms. The areas of activity, CAR, and postpartum depression needs more investigation because circadian rhythms have been hypothesized to be associated with depression (Germain and Kupfer 2008; Monteleone et al. 2010). Small exercise studies with postpartum women have indicated there is evidence that physical activity reduces depressive symptoms (Armstrong and Edwards, 2003; Da Costa et al. 2009). Simply walking has been shown to improve depressive symptoms, and increased activity has been associated with improved sleep patterns (Armstrong and Edwards 2003) for postpartum women. While physical activity and exercise are different across studies, there appears to be consistency in the results showing improvement in depressive symptoms (Daley et al. 2007). Exercise can serve as a complimentary treatment option for postpartum depressive symptoms with minimum risk to both mother and infant, but one that can positively improve mental wellness.

In this study, it was found that self-reported poor sleep quality was significantly correlated with severe morning fatigue and poor mental and physical H-QOL. These findings suggest that both adequate sleep quantity and good sleep quality are necessary for better maternal H-QOL. Postpartum depression is one of the most common complications for postpartum

women (Mayberry et al. 2007). The majority of mothers in this study experienced clinically significant depressive symptoms, which confirms earlier findings that mothers with a low birth weight/preterm infant have a greater likelihood of experiencing depressive symptoms as compared to mothers with a term baby (Vigod et al. 2010).

Generalization of the study findings is limited by the nonrandom selection of participants, usage of a cross-sectional design, and maternal self-reports as the main source of information for assessing postpartum depressive symptoms and adverse H-QOL. The associations among the variables may result from a shared variance of self-report methods. In future studies, inclusion of objective assessments of maternal mental and physical health can tease apart the potentially confounding variables. In addition, because of the relatively small sample size, contextual variables such as ethnicity could not be controlled in the study. The cross-sectional design only describes the associations among daytime activity, sleep, and maternal well-being; causality cannot be determined. Longitudinal studies to determine the role of activity/rest patterns and maternal well-being, especially with control for contextual variables are needed. We used wrist actigraphy to measure activity, and findings indicate that maternal activity levels are associated with postpartum depressive symptoms; however, interpretation of this finding needs to be cautious because a prolonged wrist actigraphic monitoring period may reveal more valid information.

In summary, during the early postpartum period, mothers with a preterm infant cared for in the NICU experienced sleep deprivation and disruption, fatigue, depressive symptoms, and poor H-QOL. These experiences may alter their parenting behavior, and decrease their maternal efficacy. Improving nocturnal sleep problems may improve day time alertness/activity and facilitate normal circadian physiology. In the current study, maternal daytime activity is a significant predictor for postpartum depressive symptoms. Future research is needed to investigate the effect of daytime activity in postpartum depression, and to develop interventions for improving activity/rest patterns of new mothers.

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Table 1Characteristics of the study participants (*N*= 51)

Variables (cut-off point)	Frequency (%)	Mean (<i>SD</i>)	Above the cut-off (%)
Age	---	25.1 (5.6)	---
Education (years)	---	14.1 (3.5)	---
Ethnic group			
White	9 (17.6%)	---	---
Black	34 (66.7%)	---	---
Hispanic	7 (13.7%)	---	---
Mixed ethnic groups	1 (2 %)	---	---
Income			
< \$40,000	37 (72.5%)	---	---
\$40,000	11 (21.6%)	---	---
Maternal perception of infant's condition			
Not severe at all	8 (15.7%)	---	---
Minor	13 (25.5%)	---	---
Moderate	15 (29.4%)	---	---
Severe	14 (27.5%)	---	---
Extremely critical	1 (2%)	---	---
Daytime activity *		190.6 (32.5)	---
Sleep Measures			
GSDS	---	2.7 (1.1)	51.0%
Sleep Quality (3)	---	3.4 (1.7)	54.9%
Daytime Sleepiness (3)	---	3.1 (1.4)	56.9%
TST (< 420 minutes)		382 (105)	64.0%
WASO (< 10%)	---	20 (12)	81.6%
Daytime TST (median 57)	---	70 (70)	---
EPDS (13)	---	13.9 (5.5)	62.7%
LFS (3.3)			
Morning	---	3.9 (1.8)	70.6%
Evening	---	5.1 (1.7)	84.3%
Health-related quality of life			
Physical (<0)	---	-.89 (.95)	76.5%
Mental (<0)	---	-.75 (1.28)	66.7%

The cut-off point was based on the instrument developer's suggestion. GSDS= General Sleep Disturbance Scale; TST= total sleep time; WASO= wake after sleep onset; EPDS= Edinburgh

Postpartum Depression Scale; LFS= Lee's Fatigue Scale.

* data were reported movements per minute

Table 2

Zero-order correlations between activity and well-being

	2	3	4	5	6	7	8	9
1. Activity	.09	.02	.20	-.04	-.31*	-.11	.20	.09
2. CAR	---	.45**	.07	-.12	-.08	-.19	.04	.16
3. TST		---	-.39*	-.19	-.01	-.30*	.07	.17
4. WASO			---	.16	-.26	.04	-.04	.01
5. Sleep Quality				---	.22	.38**	-.38*	-.49**
6. EPDS					---	.32*	-.19	-.70**
7. Fatigue: Morning						---	-.36**	-.49**
8. H-QOL: Physical							---	.14
9. H-QOL: Mental								---

Note. TST= total sleep time; CAR= circadian activity rhythms; WASO= wake after sleep onset; EPDS= Edinburgh Postnatal Depression Scale; H-QOL, health-related quality of life.

* $p < .05$;

** $p < .01$.

Table 3

Comparison of Maternal Demographics, Activity Levels, and Well-Being

Variable	Low Activity Mothers (n=25)		High Activity Mothers (n=26)		Total Mothers (n=51)	
	Mean	SD	Mean	SD	Mean	SD
Age	26	5.5	24.3	5.8	25.5	5.6
Years in school	14.4	4.0	13.7	3.0	14.1	3.5
Infant's critical condition	2.7	1.2	2.8	1.0	2.8	1.1
CAR	.65	.20	.72	.17	.69	.18
TST (nocturnal)	372	97	391	116	382	106
TST (daytime)	92*	10	49*	16	70	9.8
WASO	16.3*	9.2	23.2*	14.2	19.8	12.4
Sleep quality	3.3	2.0	3.1	1.6	3.4	1.7
EPDS	15.6*	4.4	12.2*	5.9	13.9	5.5
Fatigue-morning	4.2	1.6	3.6	1.9	3.9	1.8
H-QOL: physical	-.98	.96	-.79	.95	-.88	.95
H-QOL: mental	-.81	1.3	-.69	1.2	-.75	1.3

Note. TST= total sleep time; CAR= circadian activity rhythms; WASO= wake after sleep onset; EPDS= Edinburgh Postnatal Depression Scale; H-QOL, health-related quality of life.

* $p < .05$;

* $p < .01$.