2013

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Biological Research for Nursing
00(0) 1-9

DOI: 10.1177/1099800412445612
http://brn.sagepub.com
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Bright Light Therapy to Promote Sleep in Mothers of Low-Birth-Weight Infants: A Pilot Study

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Abstract

Having a low-birth-weight (LBW) infant in a neonatal intensive care unit (NICU) can intensify a mother's sleep disturbances due to both stress and the dim lighting in the ICU setting, which desynchronizes circadian rhythms. The purpose of this pilot study was to examine the effectiveness of a 3-week bright light therapy intervention on sleep and health outcomes of mothers with LBW infants in the NICU. Controlled stratified randomization was used to assign 30 mothers to a treatment or control group. Data were collected at pretreatment (second week postpartum) and after the 3-week intervention. Sleep data were assessed by wrist actigraph (total sleep time [TST], circadian activity rhythms [CARs]) and the General Sleep Disturbance scale. Other outcome variables were measured by the Lee's Fatigue scale, Edinburgh Postpartum Depression scale, and the Medical Outcomes Short Form 36, version 2. Mothers averaged 26.6 ($SD = 6.3$) years of age, and the majority were Black (73%). The mean gestational age for the infants was 27.7 ($SD = 2.0$) weeks. Small to large effect sizes were found when comparing the pre- to posttreatment differences between groups. Although none of the differences were statistically significant in this small sample, for mothers in the treatment group nocturnal TST ($d = .33$), CAR ($d = 1.06$), morning fatigue ($d = .22$), depressive symptoms ($d = .40$), physical health–related quality of life ($d = .33$), and mental health–related quality of life ($d = .60$) all improved compared to the control group. Bright light therapy is feasible for mothers with infants in an NICU. Clinically significant improvements have been evidenced; a larger-scale trial of effectiveness is needed.

Keywords

sleep, mothers, bright light therapy, low-birth-weight infant, randomized controlled trial

Sleep disturbances are common in mothers of healthy infants (Gay, Lee, & Lee, 2004). Having a low-birth-weight (LBW) infant hospitalized in a neonatal intensive care unit (NICU) could intensify sleep disturbances (Lee & Kimble, 2009). In particular, the standard NICU setting features dim lighting, which is designed to minimize stimulation and promote the medically fragile infant's development and healing. However, extended/repeated exposure to the dim lights while visiting the NICU could desynchronize circadian rhythms for mothers, leading to sleep disturbances.

According to the two-process model of sleep regulation (Borbely, 1982), normal sleep/waking rhythms are determined by interactions between the homeostatic process (drive for sleep) and circadian process (drive for wakefulness). Exposure to sunlight helps to set circadian cycles so they are consistent from day to day. Specialized neurons on the retina initially transmit messages about light and darkness through the suprachiasmatic nuclei (SCN), whose neurons exhibit inherent circadian electrical rhythms and constitute the brain's biological clock. The SCN are thought to be the primary circadian clock in human beings, and light is one of the most potent external factors that can alter the period of the SCN (Chesson et al., 1999). Indeed, the relationships between bright light exposure, sleep (Dodson & Zee, 2010), and mood status (Golden et al., 2005) have been well documented.

The standard of care for parents with infants in the NICU includes providing information and support for coping. However, a neglected area that may be critical for short- and long-term coping is mothers' sleep. Prior studies with mothers with infants in the NICU have correlated poor sleep with fatigue and depressive symptoms (Lee & Kimble, 2009; S. Y. Lee, K. A. Lee, Rankin, Alkon, & Weiss, 2005; Stremler, Dhukai, Wong, & Parshuram, 2011). The determination of mitigating factors for sleep, such as light exposure, may allow for the

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development of preventive strategies. To date, no interventional studies have tested a strategy for improving sleep of parents with preterm LBW infants in the NICU.

Researchers have found that artificial bright light treatment improves sleep for the population with circadian rhythm disorders (Turek, 2005). Clinicians have safely used light therapy to assist in medical treatments for over 20 years, and it has an established record of safety, evidenced by the absence of ocular changes or other major side effects among a group of patients with seasonal affective disorder after short-term (2–8 weeks) and long-term (3–6 years) daily light therapy (Terman & Terman, 2005).

Thus theoretically, bright light therapy might be useful for reducing sleep disturbances in mothers with LBW infants in the NICU. However, the feasibility and effectiveness of this type of treatment within this population remain to be determined. To the best of our knowledge, the pilot study we describe here is the first to test an intervention to promote sleep and well-being with these mothers. The conceptual model of impaired sleep (K. A. Lee, 2003) provided the theoretical basis for the current study because impaired sleep can lead to adverse physical and mental health outcomes. Our aims were to (1) describe maternal sleep and circadian activity rhythms (CARs) and(2) examine the effect of a bright light therapy intervention on maternal sleep, depressive symptoms, fatigue, and physical and mental health–related quality of life among mothers with LBW infants hospitalized in the NICU.

Material and Method

Research Design and Study Participants

We used a randomized double-blind pretest–posttest design with two groups for this pilot study, which the Institutional Review Boards from the research sites approved. The two groups were a treatment group, which received treatment with blue–green bright light and a sleep hygiene booklet (*Sleep B.E.T.T.E.R.;* Lee, Portillo, & Miramontes, 1996), and a control group, which received a placebo treatment with red light plus the nutrition booklet. Mothers in both groups received an educational package including a booklet (*Early Arrival*) that describes the characteristics of preterm babies and explains how to care for them. Selected maternal sleep variables (subjective and objective measures of sleep) and sleep-related physical and psychological health outcomes (fatigue, depressive symptoms, health-related quality of life, and CARs) served as the outcome variables. Because this was a pilot study, the sample size did not provide sufficient power for formal hypothesis testing. Thus, the focus of the study was on examining the effect size between the two groups on the outcome variables.

For this pilot study, we recruited first-time mothers with LBW (<2,500 g) infants from three NICUs in the metropolitan Atlanta area. After collecting pretreatment data, we randomly assigned participants to the treatment or control group. The randomization process was stratified by recruitment site to ensure that we obtained equal numbers of experimental and control participants from each site during one season. We collected data twice: at the second week postpartum (pretreatment) and immediately following the 3-week intervention of daily bright light therapy or placebo therapy (posttreatment). The principal investigator and all study participants were blinded to group assignment; however, neither the coinvestigator who was responsible for randomization and monitoring the progress and safety of all participants nor the research assistants (RAs) who administered the intervention were blinded to group assignment. We excluded mothers from participation for any of the following criteria: (1) history of an affective illness, (2) use of medications that alter sleep, (3) recent history of shift work that had already affected her circadian rhythm, (4) history of a diagnosed sleep disorder, (5) age under 18 because delayed-sleep-phase-type circadian disorders (late-to-bed, late-to-rise) are very common in teens, (6) need of an extended hospitalization period due to postpartum medical conditions, and (7) Clinical Risk Index for Babies (CRIB; International Neonatal Network, 1993) score above 5 for infant (indicates a mortality risk >5%) per neonatologist assessment.

Protocol

The RAs screened the NICU admission logs weekly to identify potential participants. The bedside nurses informed all mothers who met the study criteria about the study and asked if they would be willing to speak with a research team member. If a mother agreed, an RA approached the potential participant within 5–10 days postpartum and described the study. After giving the mother an opportunity to privately consider the project, the RA later made contact again to answer questions and enroll her in person. Finally, they established an appointment for informed consent and pretreatment data collection (as described in the Measures section). At this appointment, the RA provided mothers with wrist actigraphs and instructed them on the instrument's proper use. They also provided them with sleep logs and self-report instruments. After collection of the pretreatment data, the project coordinator randomly assigned each mother to the treatment or control group and provided them with the appropriate light visor. All mothers slept at home during the protocol.

Treatment group. The treatment intervention included two components administered over 3 weeks: a 30-min daily bright light treatment and a booklet that included information about basic sleep hygiene rules related to bedroom environment, eating and drinking, tension and stress, time trying to sleep, exercise, and regular day–night rhythm (K. A. Lee et al., 1996). At the start of the study period, we conducted a 20-min discussion with each mother about the principles of sleep hygiene and encouraged her to apply them in her daily life. For the bright light treatment, we used a bright light visor (Feel Bright Light model 100, Physician Engineered Products, Fryeburg, ME), which delivers an optional 8,000 or 12,000 lux (similar to full daylight) of gentle blue–green light (wavelengths 470–525 nm), fixed close to the eyes. These wavelengths have been

documented as having the greatest circadian input for regulating melatonin secretion while also avoiding the blue hazard to eyes (Brainard et al., 2001; Thapan, Arendt, & Skene, 2001; Wright, Lack, & Kennaway, 2004). To date, there are no guidelines for bright light therapy; however, authors of a meta-analysis concluded that light therapy (white light) ranging from 2,500 lux for 2 hr/day to 10,000 lux for 30 min/day and lasting from 1 to 3 weeks resulted in a large effect size with respect to reducing both seasonal and nonseasonal depressive symptoms (Golden et al., 2005). Since the participants in the present study were healthy women without any preexisting depression, we used a light therapy intervention with an 8,000 lux blue–green light visor for 30 min during the first waking hour for 3 weeks. We conducted quality control prior to delivering the light visor to each mother to ensure the light level was within the therapeutic range. We asked the mothers to keep a 3-week log during the intervention period to record their daily light visor usage and their daily bed and wake times. The RA made a weekly 10-min follow-up phone call to collect each mother's average daily light therapy usage over the past week and to reinforce adherence to the intervention.

Control group. Mothers in the control group wore a red light (5 lux) visor (Physician Engineered Products, Fryeburg, ME) for 30 min during the first hour after waking for 3 weeks. The red light visor is an attention control strategy and does not have any therapeutic effect. As an additional attention control strategy, mothers in this group participated in 20 min of discussion about proper nutrition for postpartum women and received a nutrition booklet. They also kept a 3-week log tracking sleep and wake times and visor use, as the treatment group mothers did. The RA also made a weekly phone call to this group of mothers. Mothers in the control group received the *Sleep B.E.T.T.E.R.* booklet when they completed the study protocol.

Measures

We used the following instruments for data collection at the second week postpartum (pretreatment) and at the end of 3 weeks of intervention (posttreatment). Mothers wore a wrist actigraph for three consecutive 24-hr periods and simultaneously kept a 3-day sleep diary, which differed from the 3-week log described above. In the diary, mothers recorded their sleep–wake patterns and their perceived quality of sleep. After the mothers completed the diary, they filled out all of the self-reported questionnaires as described below.

Sleep measures. Mothers self-reported their sleep quality and quantity using the General Sleep Disturbance scale (GSDS), which comprises 21 items related to frequency of disturbed sleep, including difficulty getting to sleep (1 item), waking up too early from sleep (1 item), waking up during sleep (1 item), quality of sleep (3 items), quantity of sleep (2 item), daytime functioning (7 items), and use of substances to induce sleep (6 items). Mothers rated their sleep for the past week, scoring each item on a scale of 0–7, with higher scores indicating more severely disturbed sleep. A cutoff score of 3 for the total scale and subscales distinguishes good sleepers from poor (K. A. Lee, 1992). Cronbach's α for the overall scale was .83 for the current study.

We collected objective sleep data, including total sleep time (TST) at night (from bedtime to arise time) and during daytime (the 12-hr period after morning wake time), with a wrist actigraph that included a light sensor up to 40,000 lux (Mini Motionlogger Actigraph, octagonal motionlogger, Ambulatory Monitoring Inc., Ardsley, NY). The instrument also included an event marker that mothers were instructed to press to indicate their bedtime and arise time. In addition, we included a note in the 3-day sleep diary to remind the mothers to use the event marker. We used 1-min intervals to calculate TST. Various researchers have used polysomnographic measures of sleep to validate wrist actigraphy as a measure of TST and wake after sleep onset during the night ($r = .93$ to .99; Ancoli-Israel, Clopton, Klauber, Fell, & Mason, 1997; Jean-Louis et al., 1996). We also calculated daytime TST, which we estimated over a 12-hr period starting from a mother's arise time using actigraphy data. For example, if she got up at 6 a.m., then we estimated her daytime sleep from 6:00 a.m. to 5:59 p.m. We monitored mothers in the present study for three consecutive 24-hr weekday periods per the recommendations from the American Academy of Sleep Medicine (Littner et al., 2003) and used the mean of three nights' sleep for our analysis.

We also asked mothers in this study to keep a 3-day sleep diaries, which we used to confirm the bedtime and arise time from the wrist actigraph event recorder. If the mothers forgot to press the event marker, we manually entered light off and light on time based on the data in the sleep diary.

In addition, we examined CARs using the ratio between amplitude (magnitude of the activity oscillation) and mesor (fitted activity mean) over the 3-day actigraph data-collection period. CAR is an individual's rest/activity patterns. The closer this ratio is to 1, the better synchronized CAR is (Ancoli-Israel et al., 1997), indicating that the activity patterns are highly correlated with each other across the 3 days.

Fatigue and well-being. We measured morning fatigue using Lee's Fatigue scale (LFS), a self-report instrument that includes a 13-item fatigue subscale and a 5-item energy subscale. Participants rate each item on a scale from 0 (*not fatigued*) to 10 (*extremely fatigued*; K. A. Lee, Hicks, & Nino-Murcia, 1991). To decrease participant burden, we used only seven of the fatigue and two of the energy items in the current study. Cronbach's α coefficients for the 9-item version of the LFS ranged from .89 to .97 for mothers who had infants hospitalized in the NICU, and this version demonstrated adequate psychometrics in our prior research (S. Y. Lee, 2004). A mean morning fatigue score of 3.3 or less indicates minor fatigue levels (K. A. Lee et al., 1991).

We operationalized well-being as postpartum depressive symptoms and health-related quality of life. We measured postpartum depressive symptoms with the Edinburgh Postnatal Depression scale (EPDS), is a 10-item, 4-point scale used to

assess severity of depressive symptoms over the previous week, from 0 (*rarely or none*) to 3 (*most or all the time*; Cox, Holden, & Sagovsky, 1987). Higher scores indicate more depressive symptoms, with a score of 10 or above indicative of postpartum depression. We used the EPDS as a continuous measure of depressive symptoms rather than to diagnose postpartum depression. The EPDS is widely used and has been validated against a variety of depressive symptoms scoring systems (Beck, 2001; Murray & Carothers, 1990). The Cronbach's α for the EPDS in the current study was .89.

We measured health-related quality of life with the Medical Outcomes Short Form-36, version 2 (SF36v2). The SF36v2 is a 36-item generic measure of physical and mental health components, and it has demonstrated reliability and validity (McHorney, Ware, Lu, & Sherbourne, 1994; Ware & Sherbourne, 1992). The raw scores (with a possible range of 0–100) were transformed to *Z* scores using the norms (*Z* score = 0 indicates norm) of the United States' population in 1998. A higher score indicates better health-related quality of life. The Cronbach's α for the SF36v2 in this study was .85 for physical health and .84 for emotional health.

Potential Confounding Variables Affecting Outcome Variables

At pretreatment and posttreatment, we also collected data on several confounding variables, including maternal perceived support, perceived infant vulnerability, and perceived stress, which we evaluated prior to the final analyses.

Perceived support. We used the Family Support scale (FSS) to assess the helpful sources of support for the mother's child caretaking (Dunst, Trivette, & Jenkins, 1988). The FSS is an 18-item, 5-point scale that ranges from 1 (*not at all helpful*) to 5 (*extremely helpful*). The total score is the sum of the scores for the 18 items. Higher scores indicate a greater sense of support from the family and other resources. Cronbach's α coefficient for the FSS was .75 for the current study.

Perceived infant vulnerability. At pretreatment, we asked mothers to rate their infant's vulnerability at birth and at pretreatment, using a 10-point self-report scale with higher scores indicating a higher sense of vulnerability. The first author (S.-Y. L.) developed this self-report vulnerability scoring system, and we used it in our preliminary study. It proved to be more accurate in predicting parental stress than the CRIB score (S. Y. Lee, 2004).

Perceived stress. We used the Perceived Stress scale (PSS) and the Impact of Events scale (IES) to measure the mothers' perceived stress from global (e.g., daily life) and situational (e.g., a specific stressful event) perspectives. The PSS is a 10-item, 5-point scale that assesses global perceived stress level over the past month, with higher scores indicating greater perceived stress (Cohen, Kamarck, & Mermelstein, 1983). The Cronbach's α coefficient for the PSS was .88 for the current study. The IES is a 15-item scale that assesses experiences relative to a specific stressful event (i.e., their NICU experience with their LBW infant's hospitalization) in the last week; higher scores indicate a greater impact of the event (Horowitz, Wilner, & Alvarez, 1979). For the current study, the Cronbach's α for this instrument was .79.

Data Analysis

The first author (S.-Y. L.) used the automatic sleep-scoring program (Action 4 Software Program, Ambulatory Monitoring Inc., Arbsley, NY) to analyze the sleep data collected from the wrist actigraph. We entered data into statistical package for the social science, version 18.0. As per the intention-to-treat approach, we included data from all participants who completed the protocol in the final analyses. We present results as frequencies and means, and we set the α level at .05 (two tailed) for statistical significance. We compared the differences between pre- and posttreatment between the two samples using *t* tests, and we used the Cohen *d*s to calculate the effect sizes. To examine adherence (the percentage of the total days' use of visor over the intervention period) to the intervention, we used data recorded in the 3-week log.

Results

Over the18-month recruitment period, we screened 1,902 women who had infants admitted to the NICUs, 90 were eligible and 38 provided consent. Those who declined were mainly not interested or felt they had too much going on at the time. The primary reasons for ineligibility were not being a first-time mother, the infant's birth weight being more than 2,500 g, or the infant not needing more than 5 weeks of hospitalization. Before we randomized the 38 participants into groups, 2 of the mothers changed their minds and 1 baby died. We randomly assigned the remaining 35 eligible mothers to either the treatment or the control group, and 30 of them completed the protocol. Of the five participants who did not complete the protocol, three were discharged early, one baby died, and the last participant was lost to follow-up. Mothers ranged in age from 19 to 41 years with a mean of 26.6 ($SD = 6.4$) and were mostly Black (73%), followed by White (13%) and Hispanic (10%), with annual incomes of less than $40,000 (75%). This sample underrepresented the White population in the Atlanta area. The mean gestational age for the infants was 27.7 weeks ($SD = 2$), with an average birth weight of 1,044 g ($SD = 336$); there were no statistically significant demographic differences between the two groups (see Table 1).

Regarding the confounding variables measured in this study, compared to the control group mothers, the treatment group mothers perceived their infants to be more vulnerable, $t(28) = 2.9$, $p = .03$, and they perceived higher stress deriving from the infant's hospitalization, measured by the IES, $t(28) = 2.9$, $p = .007$. We also examined the outcome variables at pretreatment and found a statistically significant difference between the two groups. Compared to the control group mothers, mothers in the

Table 1. Characteristics of the Study Participants at Pretreatment

Variables	Treatment Group ($n = 16$)	Control Group ($n = 14$)
Maternal age, years ($M \pm SD$)	24.4 ± 5.4	29.1 ± 6.7
Ethnic group (*n* %)		
White	—	4 (28.6)
Black	14 (87.5)	8 (57.1)
Hispanic	2 (12.5)	1 (7.1)
Other	—	1 (7.1)
Education, years ($M \pm SD$)	13.9 ± 3.1	15.7 ± 2.9
Marital status (*n* %)		
Married/partner	8 (50)	9 (64.3)
Single	8 (50)	5 (35.7)
Family income (*n* %)		
<$40,000	12 (75)	9 (64.3)
>$40,000	3 (18.8)	4 (28.6)
Gestational age, weeks ($M \pm SD$)	27.1 ± 1.6	27.9 ± 2.4
Birth weight, g ($M \pm SD$)	912.5 ± 249.8	1,149.5 ± 411.3
Type of delivery (*n* %)		
Vaginal	6 (37.5)	8 (57.1)
Cesarean section	10 (62.5)	6 (42.9)
CRIB score ($M \pm SD$)	3.3 ± 3.4	2.0 ± 2.4
Maternal perceived infant's condition at baseline ($M \pm SD$)	3.25 ± 1.2*	2.4 ± 1.0*
Days postpartum at intervention initiation ($M \pm SD$)	13 ± 1.8	13 ± 1.9

Note: CRIB = Clinical Risk Index for Babies.
*$p < .05$.

treatment group reported a poorer physical health–related quality of life, $t(28) = 2.4$, $p = .03$. In addition, we found clinically significant differences, based on the cutoff points, between groups for the outcome variables at pretreatment. Table 2 shows the pretreatment and posttreatment values for these variables along with the cutoff points separating those with problematic levels from those with healthy levels. For example, clinically significantly more mothers in the treatment group had poor sleep quality (50% vs. 28.6%), poor daytime functioning (62.5% vs. 35.7%), less than 7 hr nocturnal TST (66.7% vs. 50.0%), and poor physical (87.5% vs. 57.1%) and mental (68.8% vs. 35.7%) health–related quality of life. The mothers in the treatment group also had a clinically significantly higher number of depressive symptoms compared to the mothers in the control group ($\chi^2 = 7.2$, $p = .01$). Thus, we compared the differences between groups using the differences between participants' pre- and postvalues. We then used the t values and the degree of freedom to compute the Cohen's d (http://www.uccs.edu/~faculty/lbecker/).

Outcome Measures

At the end of the 3-week intervention, self-reported sleep quality measured with the GSDS had improved for the mothers in the treatment group but not for the mothers in the control group. Women in the treatment group were also getting almost 30 min more nighttime sleep posttreatment than at pretreatment, while nocturnal TST remained the same for the control group. Conversely, the mothers in the treatment group were getting 15 min less daytime sleep at posttreatment than they were at pretreatment, while the mothers in the control group were sleeping 22 min more during the daytime posttreatment. The CARs in the treatment group mothers improved after the 3-week intervention but worsened in control group mothers (see Table 2).

The two groups of mothers experienced similar fatigue severity at both time points; however, the control group mothers perceived a lower morning energy level at posttreatment as compared to their pretreatment measurement. Both groups of mothers perceived fewer depressive symptoms at the end of the 3-week intervention period. Physical health–related quality of life improved for both groups of mothers from pre- to posttreatment, but only the treatment group showed improvement in mental health–related quality of live after the 3-week intervention.

Effect Sizes

We calculated Cohen's d using t values of differences in changes in means (see Table 2). There were small-to-medium effects in improving self-reported sleep quality ($d = .24$), increasing nocturnal TST ($d = .33$), decreasing daytime TST ($d = .36$), increasing morning energy level ($d = .55$), decreasing depressive symptoms ($d = .40$), and increasing health-related quality in both physical health ($d = .33$) and mental health ($d = .60$). We found a large effect in improving CARs ($d = 1.06$). However, there were no statistically significant group differences in the outcome measures; given the small-to-large effect sizes, this was likely due to insufficient power in this small sample.

Table 2. Outcome Variables ($M \pm SD$) at Pretreatment and Posttreatment for Mothers Receiving Bright Light Treatment and Control Group

	Treatment Group ($n = 16$)		Control Group ($n = 14$)		
Variable (Cutoff Point)	Baseline	Posttreatment	Baseline	Posttreatment	Cohen's d[a]
Sleep measures					
GSDS (> 3)					
Sleep quality	3.2 ± 1.9	2.9 ± 1.5	2.5 ± 1.6	2.6 ± 1.0	.24
Daytime functioning	3.2 ± 1.5	2.8 ± 1.5	2.5 ± 1.3	2.3 ± 1.1	.12
Noctornal TST (<420 min)	383 ± 109	414 ± 89	380 ± 95	385 ± 91	.33
Daytime TST	49.2 ± 51.8	34.9 ± 44.7	54.6 ± 31.1	76.2 ± 105	.36
Circadian activity rhythms (amp/mesor)	.69 ± .21	.81 ± .13	.71 ± .15	.61 ± .15	1.06
LFS					
Fatigue (≥3.3)	4.5 ± 1.8	4.2 ± 1.7	3.6 ± 1.6	3.1 ± 1.5	.22
Energy	5.6 ± 1.9	5.6 ± 1.9	6.6 ± 1.9	5.5 ± 1.9	.55
EPDS (≥10)	11.2 ± 6.6	7.2 ± 5.1	7.4 ± 5.8	5.6 ± 4.5	.40
SF36v2 (<0)					
Physical health–related QOL	−1.3 ± .89	−.86 ± .94	−.47 ± 1.0	−.24 ± .89	.33
Mental health–related QOL	−.53 ± 1.17	−.13 ± 1.1	−.07 ± 1.2	−.33 ± 1.2	.60

Note. EPDS = Edinburgh Postnatal Depression scale; GSDS = General Sleep Disturbance scale; LFS = Lee's Fatigue scale; SF36v2 = Medical Outcomes Short Form-36, version 2; TST = total sleep time.

[a]Cohen's d was calculated using the t values and degree of freedom. None of the differences were statistically significant in this small sample.

Adherence to the Bright Light Therapy

Adherence is an important adjunct in the analysis and interpretation of findings by intention to treat (Friedman, Furbert, & DeMets, 1998). We defined adherence as the ratio between the total visor usage days and the 3-week intervention. We asked mothers in both groups to use the provided visor for 30 min daily for a 3-week period and to keep a 3-week log recording, among other things, their usage of the light visor. The sleep hygiene booklet introduced mothers in the treatment group to the importance of light exposure. The adherence rate for the light therapy intervention was 87.2 ± 10% (mean of 18.3 ± 2.1 days, range 14–21) for the mothers in the treatment group and 86.9 ± 9% (mean of 18.3 ± 1.9 days, range 15–21) for the mothers in the control group. We also analyzed light exposure data from the wrist actigraph during the 12-hr periods in which we estimated the daytime TST. The light exposure level for the mothers in the control group decreased from pretreatment to posttreatment period (73.4 vs. 66.3 lux) but increased for the mothers in the treatment group (54.2 vs. 89.1 lux). To confirm our assumption about the dimness of the light in the NICU, we also randomly checked the light levels at bedside (<10 lux) and in the lobby area (around 100 lux) in the NICU.

Discussion

The present study was the first randomized controlled trial to evaluate the effectiveness of bright light therapy for improving sleep and well-being among mothers with infants hospitalized in the NICU. Both self-reported and objective sleep measures demonstrated that these mothers experienced sleep disturbances. They also experienced depressive symptoms, severe fatigue, and poor physical and mental health–related quality of life. The 3-week bright light therapy intervention combined with the provision of sleep hygiene materials is feasible and appears promising for promoting maternal sleep in the early postpartum period, as evidenced by increased nocturnal TST, decreased daytime TST, and improved CARs. In addition, bright light therapy appeared likely to be beneficial to maternal well-being as evidenced by decreased depressive symptoms measured by EPDS and increased physical and mental health–related quality of life for the mothers in the treatment group. However, we must use caution when interpreting the effect of the light therapy because we observed differences in outcome variables between the two groups at pretreatment; thus, the demonstrated effectiveness could be due to statistical regression. Therefore, though the findings from this pilot study are promising, it is essential for the results to be replicated in a larger trial.

The prevalence of sleep deprivation among mothers with healthy newborns is well known. Our findings in the current study demonstrated that mothers with a hospitalized LBW infant also experience sleep disturbances. The stress of having an infant hospitalized in an NICU may play an important role in mothers' impaired sleep. Researchers have documented stress to be the most common cause of transient or short-term insomnia (Roehrs, Zorick, & Roth, 2000). The neurological response to stress occurs quickly and lasts only a short time but can result in hyperarousal. A state of hyperarousal decreases the likelihood of sleep onset and can result in insomnia. The endocrine response to stress is initiated more slowly and lasts longer but can alter circadian rhythms for adrenal function and cortisol levels in a manner incompatible with sleep. Normal sleep–wake cycles are determined by interactions between the homeostatic and circadian processes (Borbely, 1982). When the circadian process is disturbed, one result can be disturbed sleep.

To date, sleep assessment for mothers during their postpartum period have been mainly focused on nocturnal TST and

awakenings rather than on circadian rhythms. It is easy to understand how CARs become disrupted in mothers with newborns at home; however, findings from the current study show that mothers with infants in the NICU also had disrupted CARs. We hypothesized that these mothers might have poor CARs may be associated with the infant's hospitalization due to (1) circadian phase shift resulting from prolonged exposure to artificial dim light in the NICU and (2) disturbances in social rhythms resulting from altered daily routines and changed social activities. Our finding that CARs improved in mothers in the treatment group, while worsening in mothers in the control group suggests that the bright light therapy played a clinically significant role in the improvements of the treatment groups' outcome measures. Examination of synchrony in CARs may further explain why and how sleep quality regulates the stress–health relationship, particularly for those mothers who spend longer time periods in the NICU, where dim lighting is typical. Though dim light decreases stimuli for preterm infants and promotes their development, it may contribute to the disregulation of circadian rhythms in mothers visiting the NICU for prolonged periods.

While sleep deprivation could be a symptom of parental stress (S. Y. Lee et al., 2005; S. Y. Lee & Kimble, 2009), it could also become a stressor for mothers in its own right, causing these women's allostatic loads to exceed their thresholds and leading to adverse mental health effects (Ganzel, Morris, & Wethington, 2010). The majority of mothers in this study experienced high levels of depressive symptoms, which is consistent with earlier findings that mothers with LBW infants have a greater likelihood of experiencing depressive symptoms as compared to mothers with full-term babies (Vigod, Villegas, Dennis, & Ross, 2010). Prior studies have found an association between sleep disturbance and depression (Ross, Murray, & Steiner, 2005) and a negative relationship between postpartum depression and physical health (Da Costa, Dritsa, Rippen, Lowensteyn, & Khalifé, 2006). Researchers have suggested that sleep disturbance and major depression have a dynamic, reciprocal relationship (Benca et al., 1997). Depression is a major risk factor for the onset of sleep disturbance, and sleep disturbance can prolong and even amplify depressive symptoms. Recent evidence, however, suggests that the bidirectional relationship between depression and sleep disturbance may not be a linear pattern and that the amplifying process between depression and sleep disturbances exists only in milder forms of insomnia (Sbarra & Allen, 2009). It is clear that the relationships between depressive symptoms and sleep problems among postpartum women call for further examination.

These relationships may be even more complex among women with preterm labor. Researchers have theorized that rapid reproductive hormonal changes are the etiology for PPD (Susman & Katz, 1988). Estrogen and progesterone levels peak at the end of the last trimester and drop rapidly after labor. For women with preterm labor, the trajectory of hormonal change deviates from the norm; therefore, this theory regarding a hormonal etiology of PPD may not apply to depressed women with preterm labor (Chatzicharalampous et al., 2010). Given our findings in the current pilot study along with those of previous researchers, we hypothesize that desynchronized CARs also play a role in PPD (Germain & Kupfer, 2008; Monteleone, Martiadis, & Maj, 2010). The combined effects of a deviant trajectory of hormonal change and disrupted CARs may explain the heightened rate of PPD in mothers of preterm infants.

Findings from the present study may be useful for encouraging clinicians to initiate preventive care for postpartum women who have infants hospitalized in the NICU. For example, clinicians should assess maternal sleep and depressive symptoms during the postpartum period. Sleep hygiene information should be included in the NICU package for parents, and it should emphasize exposure to daylight during the first hour after awakening. In addition, mothers should be advised to avoid bright light during nighttime, particularly if they need to pump their breasts during the night.

The present study had several limitations. First, the majority of the study participants were Black with a lower socioeconomic status; thus, the generalizability of the findings may be limited. However, overrepresentation of this understudied population is also a strength of this study. Because of the relatively small sample size, we could not control for contextual variables (e.g., ethnicity) and confounders (e.g., perceived stress, infant's vulnerability). Future studies with larger sample sizes should consider these variables. Generalizability of the study findings is also limited by the inclusion of mothers of infants admitted to the NICU in teaching hospitals during an acute but stable stage of their medical conditions. Unfortunately, we did not collect the total NICU visit time from mothers; therefore, we could not validate if a prolonged stay in the NICU is one of the factors disrupting a mother's CARs. Also, the sleep intervention consisted of bright light therapy combined with a sleep hygiene education booklet; therefore, it is not possible to say the effect resulted purely from the light therapy. However, sleep hygiene education should always be included in interventions designed to improve sleep. Future studies should involve a larger sample of ethnically diverse primiparous and multiparous women of varied socioeconomic status, at different postpartum periods, and with infants who differ in health status. Further, additional objective measurements, such as biomarkers for physical (proinflammatory cytokines) and mental health (e.g., cortisol, serotonin), could also provide validation for the self-reported data.

Conclusion

Findings from the present study indicate that sleep disturbances along with depressive symptoms characterize the daily experience of mothers with LBW infants in the NICU. Light therapy is a promising strategy to improve maternal sleep, CARs, and mental health–related quality of life. Maternal stress and mental health problems were identified as risk factors for poor parenting in preterm infants more than two decades ago (Crnic & Acevedo, 1995; Zekoski, O'Hara, & Wills, 1987). However, to date, there has been limited research on whether and how sleep may affect mothers' parenting behavior and further alter

the quality of the mother–infant relationship. Future research is needed to investigate the role of sleep in maternal efficacy and to test the impact of light therapy on mother–infant interactions.

Acknowledgments

The authors thank all the mothers who participated in this study and the staff and managers at Grady Health System, Emory Hospital at Midtown, and the Women's Center at DeKalb Medical Center. They also thank Dr. Kathy Lee at the University of California, San Francisco, for her consultation as well as the RAs, Sarah Harris, Wendy Barnes-Mellstrom, Bhakti Dave, Jency Thomas, Kelly Hunter, and Yassin Munye.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This study was awarded to the first author by the National Institutes of Health/National Institute of Nursing Research (NIH/NINR, 1R15NR010152-01A1).

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