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Stress and health-related well-being among mothers with a low birth weight infant: The role of sleep

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Abstract

This U.S.A.-based study examined the quantitative and qualitative characteristics of sleep, as well as the role of sleep, in the association of stress with depression, fatigue, and health-related quality of life (H-QOL) among mothers with a low-birth-weight, preterm infant in the neonatal intensive care unit at early postpartum. Fifty-five first-time mothers kept a sleep diary and filled out a battery of questionnaires. The wrist actigraphy method was also applied to collect information on maternal sleep. We tested a path model, with sleep disturbance and depression mediating the effect of stress on health-related well-being. Results showed that the majority of the study participants were stressed, depressed, fatigued, and at risk for poor physical and mental health. Poor sleep quality as perceived by mothers was significantly associated with their stress, fatigue, and poor mental and physical H-QOL. A cascading effect was found in the path model where maternal stress contributed to poor sleep quality and depression, which in turn contributed to poor mental H-QOL. In addition, poor sleep quality was associated with fatigue, which in turn contributed to poor physical and mental H-QOL. The underlying neurobiological mechanisms through which sleep affects the stress–health relation are discussed. The implications of sleep for intervention and prevention are also addressed.

Keywords

U.S.A.; Low birth weight preterm infant; Stress; Postpartum depression; Sleep; Path analysis

Introduction

Sleep deprivation and disruption are common among mothers with healthy newborns (Gay, Lee, & Lee, 2004; Montgomery-Downs, Insana, Clegg-Kraynok, & Mancini, 2010), presumably due to societal expectations for mothers and the demands of night waking to care for the infant (Karraker & Young, 2007). Sleep disturbances are correlated with stress and adverse well-being among postpartum women with healthy newborns (Posmontier, 2008). Although sleep deprived, most parents experience the birth of an infant as a joyful life event. By contrast, the birth of a premature infant is viewed as a crisis to the family. Parents of premature babies are most distressed by the infant's hospitalization (Reid, Bramwell, Booth, & Weindling, 2007) and by uncertainty about the infant's medical condition (Holditch-Davis et al., 2009). Although they were not the primary caregivers and were able to sleep at home, mothers with a low-birth-weight (LBW, birth weight <2500 gm) preterm infant hospitalized in a neonatal intensive care unit (NICU) reported disrupted sleep

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(Lee & Kimble, 2009; Lee, Lee, Rankin, Weiss, & Alkon, 2007). More needs to be learned about the sleep characteristics of these women and the impact of these sleep characteristics on health outcomes. The present study was guided by the Impaired Sleep Model (Lee, 2003), which suggests that sleep deprivation and sleep disruption characterized by fragmented sleep during the night contribute to physical and mental health problems. In this study, we investigated the association of maternal stress with health-related well-being, including depression, fatigue, and health-related quality of life (H-QOL), and focused on the mediating role of sleep disturbance in linking stress to health-related well-being.

Sleep and postpartum women

During pregnancy, sleep is altered by hormonal and physical changes. Whereas high concentration of progesterone causes profound sleepiness, frequent urinary needs disrupt sleep continuity. After childbirth, the concentration of progesterone drops dramatically, which may impair sleep quantity and quality (Lee, Baker, Newton, & Ancoli-Israel, 2008). During early postpartum, nocturnal total sleep time (TST) for first-time mothers with a healthy infant has been documented to be less than 7 h (Gay et al., 2004). Despite no need to sacrifice their sleep for infant care, mothers with a preterm infant hospitalized in the NICU also reported a disrupted and inadequate amount of sleep, which was associated with the situational stress of infant hospitalization (Lee et al., 2007).

For a healthy adult, adequate sleep is defined as falling asleep within 5–10 min after the light is off, staying asleep for at least 90% of the time, and feeling refreshed after awakening (Lee, 2003). Compared to adult norms, mothers with a preterm infant in the NICU may be sleep deprived. However, there are marked individual differences in preferred TST to feel rejuvenated after awakening (Lee, 2003). Individuals who sleep too much (i.e., more than 9 h) or too little (i.e., less than 6 h) tend to show increased morbidity in cardiovascular function and in their metabolism system (e.g., Chandola, Ferrie, Perski, Akbaraly, & Marmot, 2010). To understand the effect of sleep on health, one must recognize the relation between nocturnal TST and health-related well-being is not linear. Individuals differ in how much sleep they need, so an investigation of the quantitative characteristics of maternal sleep requires an index that reflects the degree of match between actual and preferred TST. According to the Impaired Sleep Model, in addition to the quantity of TST, the self-perceived quality of sleep also plays an important role in maintaining health-related well-being (Lee, 2003).

Stress and sleep in mothers of preterm infants

While hormonal and physical changes can alter postpartum women's sleep patterns, psychosocial factors such as stress may also impair sleep. For healthy adults, stressful life events and chronic stress are major causes of impaired sleep (Lee, 2003). In addition to normal stressors associated with parenthood, having a LBW infant in the NICU increases the number of stressors for parents, ranging from an overwhelming amount of medical equipment connected to the infant to an altered parental role because of extended separation from the infant (Holditch-Davis et al., 2009). Infants' gestational age (an index of health condition for preterm infants) was found to be positively associated with maternal well-being (Eiser, Eiser, Mayhew, & Gibson, 2005; Hill & Aldag, 2007). Maternal stress resulting from an infant's unstable medical condition was significantly correlated with mothers' self-reported sleep disturbance (Lee et al., 2007). Although a great deal has been learned about the nature and effect of the situational stress associated with having a sick infant (e.g., Holditch-Davis et al., 2009; Lee et al., 2007; Reid et al., 2007), parents also face a multitude of stressors in their daily lives. In fact, preterm delivery has been suggested to be one of the outcomes of maternal stress during pregnancy (Hedegaard, Henriksen, Secher,

Hatch, & Sabroe, 1996). Therefore, it is important to explore the role of global stress (stress in general) in mothers' sleep and health-related well-being.

Mediating role of sleep and depression in linking stress to health

Stress is one of the most important precipitators of impaired sleep (Lee, 2003) and depression in adults (Kendler, Karkowski, & Prescott, 1999). Stressful life events (O'Hara, 2009) and insomnia (Ross, Murray, & Steiner, 2005) have been identified as risk factors for postpartum depression (PPD) in mothers with a healthy newborn. Self-reported disrupted sleep and objectively measured awake time of more than 2 h have also been identified as a predictor of PPD (Goyal, Gay, & Lee, 2009). After controlling for the severity of PPD, sleep disruption and global life stress are still strong predictors of health-related well-being for women (Da Costa, Dritsa, Rippen, Lowensteyn, & Khalife, 2006). Stress experienced by mothers with a hospitalized infant in the NICU is concomitantly associated with sleep disturbance, fatigue, depression, and poor H-QOL (Lee & Kimble, 2009). Some of the bivariate relations between stress and health-related well-being, however, may not be direct associations. Rather, they may simply reflect indirect associations mediated through sleep and depression. To discern the direct and indirect relations among these variables, we proposed and tested a fully recursive path model depicting the relations between stress, sleep, and health as suggested by the Impaired Sleep Model (Lee, 2003). This path model offered a better illustration of the direction of effect than simple bivariate correlations, as reported in previous research. To extend the overall stress–sleep–health pathway postulated by the Impaired Sleep Model, the current path model (see Fig. 1) further proposed that 1) stress would make a direct contribution to sleep disturbance, depression, fatigue, and adverse H-QOL; 2) disturbed sleep and depression would also mediate the effect of stress on fatigue and poor H-QOL in addition to direct contributions to fatigue and adverse H-QOL; and 3) fatigue would also mediate the relation of stress, depression, and sleep disturbance to adverse H-QOL in addition to direct contributions to adverse H-QOL.

In sum, the purpose of this study was to examine the relations between sleep, stress, depression, fatigue, and H-QOL among mothers with a LBW infant in the NICU during early postpartum. The specific study aims were to: 1) describe the quantitative and qualitative characteristics of sleep among these mothers, 2) explore the associations of mothers' perceived global and situational stress with their sleep quantity and quality as well as health-related well-being, and 3) test a conceptual model in which the effect of stress on health-related well-being is mediated through sleep and depression.

Methods

Research design and study participants

The data used in the current study were part of a feasibility study which occurred between October 2007 and December 2007 (Lee & Kimble, 2009) and a pilot randomized clinical trial which occurred between October 2008 and April 2010 (Lee, Aycock, & Moloney, 2010) for testing the effect of a bright-light therapy on the improvement of sleep and health-related well-being of mothers with a LBW infant in the NICU. The protocols for the feasibility and pilot study were identical, except for the duration of wrist actigraphy data collection (48 h in the feasibility study, 72 h in the pilot study). In this study, all study participants slept at home during the actigraphy data collection. The average TST derived from these two monitoring durations were similar ($t[51] = -.9, p = .37$), and the correlation between TST and sleep quality index (see below) was identical.

After obtaining permission from the Institutional Review Boards of the participating university and hospitals, the mothers were identified based on the NICU records and input

from the discharge coordinators. A research team member approached potential participants within 5–10 days postpartum. Fifty-five first-time mothers (one mother had twins) with no other children at home were recruited from three NICUs in a southern metropolitan city in the United States. The characteristics of the infants and mothers are summarized in Table 1. Mothers were excluded if they: 1) had a history of depression or other affective illness, 2) had a history of diagnosed sleep disorder, 3) were shift workers, 4) required an extended hospitalization period, 5) had an infant with CRIB score >10 (The International Neonatal Network, 1993) as rated by the physicians indicating a high morbidity, or 6) were using medications (e.g. central nervous system stimulants, depressants) that might alter sleep. The majority of mothers were Black, with at least a high school diploma. More than half (62%) of the mothers reported having had sleep problems during pregnancy. Twenty-nine (53%) of them had had a Cesarean section; however, they did not differ from the mothers who had a vaginal delivery in any sleep- or health-wellbeing measures described below.

Measures

After obtaining informed consent, eligible mothers were instructed to put on a wrist actigraph for monitoring their rest/activity patterns and to fill out a daily sleep diary. Only the baseline data collected during the second week of postpartum were used for this report. After the objective and subjective sleep data were collected, mothers completed a battery of questionnaires to assess their sleep, global and situational stress, depressive symptoms, fatigue, and H-QOL. Mothers also reported their preferred TST on the demographic form. They were given a baby blanket or a \$50 gift card after completing the protocols. In addition, a booklet entitled Sleep B.E.T.T.E.R was also provided to the mothers after the study was completed.

Sleep assessment

Wrist actigraphy, a non-invasive motion sensor monitor, has been established as a valid and reliable method for assessing rest/activity patterns (Ancoli-Israel et al., 2003). A wristwatch-like device (Mini Motionlogger Actigraphy, octagonal motionlogger, Ambulatory Monitoring Inc., Ardsley, N.Y.) was attached to the mother's non-dominant wrist during the 48- ($n = 20$) or 72-h ($n = 35$) recording period. Actigraphy data were collected in 30-s periods. Using an automatic sleep scoring system (Action 4 software), TST and percentage of wake after sleep onset (WASO) were derived and reported in 1-min intervals. TST was used as the index for actual sleep time in subsequent analysis. WASO instead of sleep efficiency is the variable typically used to measure sleep disruption in wrist actigraphy measurements (Mullaney, Kripke, & Messin, 1980). A few mothers forgot to press the event marker on their wrist actigraphy to indicate their bedtimes and waking times. Information based on sleep diary entries (see below) was used for data derivation. Three mothers' wrist actigraphy data were not available because of equipment failure.

Sleep deviation index. Given that longer TST is not necessarily linked to better health outcomes, the amount of sleep should be matched with an individual's need. For this reason, a nonlinear sleep deviation index was devised, which is an absolute value of the ratio of the difference between actual TST and preferred sleep time to 24 h. For example, if a mother slept 5 h and needed 8 h to feel refreshed, the sleep deviation index for her is .13 ($=|(5-8)/24|$). If another mother slept 11 h, which is 3 h more than her needed 8 h, the sleep deviation index for her ($|(11-8)/24| = .13$) is also .13. The sleep deviation index ranges from 0 to 1. A deviation index of 0 reflects a perfect match between the amount of sleep that is needed and the amount of sleep actually acquired. Too little or too much sleep would both yield a deviation index closer to 1.

Sleep diary. Mothers kept a sleep diary to record their bedtimes and waking times. Immediately on awakening, mothers also recorded their diets, consumption of caffeine and/or alcoholic beverages, daytime activities, and sleep evaluations (i.e., degree of alertness, degree of feeling rested, and sleep quality) of the previous day. In addition, mothers were asked to report what woke them up during bedtime. Eleven of them (20%) woke up because of the need to pump breast milk. Mothers who did or did not pump breast milk did not differ in any of the sleep measures examined in this study.

General Sleep Disturbance Scale (GSDS) was used to collect information regarding mothers' subjective evaluation about their sleep over the past week (Lee, 1992). This 21-item instrument was rated on 8-point Likert scales ranging from 0 (never during the past week) to 7 (every day during the past week). Six questions tapped into mothers' perceptions about difficulty in falling asleep, frequency of waking up during sleep, problems with waking up too early from sleep, feeling rested upon awakening, feeling satisfied with the quality of sleep, and sleep quality. A principal axis factor analysis was conducted. All six items loaded on one factor that accounted for 55.4% of the common variance. Internal consistency indexed by Cronbach's alpha was .84. Thus, these six items were averaged to serve as the index of perceived sleep quality for subsequent analysis. A score of 3 or higher was considered a clinically significant sleep disturbance (Lee, 1992). This index of perceived sleep quality was significantly correlated with the average of mothers' daily quality evaluations obtained from sleep diaries ($r = .64, p < .001$). The remaining questions in this questionnaire tapped into three additional areas of sleep problems: 1) quantity of sleep, 2) daytime sleepiness, and 3) use of sleep aids (e.g., herbal tea) to help induce sleep.

Stress and health-related well-being assessment

A battery of questionnaires was administered to obtain data related to stress, depression, fatigue, and H-QOL as perceived by mothers.

Perceived Stress Scale (PSS), a 10-item, 5-point Likert scale was used to assess global, everyday stress experienced by the mother in the past week. Higher scores indicated greater stress as experienced by mothers. The PSS possesses adequate psychometric qualities (Cohen, Kamarck, & Mermelstein, 1983). In this study, the internal consistency was .85.

Impact of Events Scale (IES), a 15-item scale, was used to assess situational stress experienced by the mothers (Horowitz, Wilner, & Alvarez, 1979). Mothers were asked to evaluate stress that was specifically related to the experience of having a LBW infant hospitalized in a NICU. Higher scores indicated a greater impact from the event. In the current study, the internal consistency was .80.

Lee's Fatigue Scale (Lee, Hicks, & Nino-Murcia, 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). To reduce the burden on study participants, nine items were selected from the original scale for this study. During the actigraphy sleep data collection period, mothers were asked to answer these questions twice a day before bedtime and immediately upon awakening. The internal consistency ranged from .86 to .97. An average fatigue score was computed for subsequent analysis. Following previous research (Fletcher, Paul, Dodd et al., 2008), a cut-off score of 3.2 or greater was used to indicate high levels of fatigue. In the current study, the severity of fatigue was significantly correlated with the self-reported daytime sleepiness subscale from the GSDS ($r = .65, p < .001$).

Edinburgh Postnatal Depression Scale (EPDS). The EPDS is a widely used 10-item questionnaire for assessing the severity of depressive symptoms (Cox, Holden, & Sagovsky, 1987). Mothers reported any depressive symptoms experienced in the past week on 4-point

rating scales ranging from 0 (rarely or none) to 3 (most or all the time). Higher scores indicated more depressive symptoms. A score of 13 or above has been used to classify probable PPD in childbearing-age women (Gibson, McKenzie-McHarg, Shakespeare, Price, & Gray, 2009). All mothers in this study reported “never” on the question about the thought of harming oneself. As a precaution, weekly phone calls were made for a 3 weeks to check on the mothers for any complaints about distress. The EPDS has been validated with a variety of depressive symptoms scoring systems (Beck, 2001). The internal consistency for this study was .89.

Health-Related Quality of Life (H-QOL). A 36-item Medical Outcomes Short Form-36version 2 (SF36v2) (Ware & Sherbourne, 1992) was administered to evaluate mothers’ subjective perceptions of their H-QOL. The SF36v2 consists of two components: physical health and mental health. A higher score indicates better H-QOL. In this study, the internal consistency was .85 for physical health and .84 for mental health.

Data analysis

Descriptive statistics were derived to describe the characteristics of mothers’ socioeconomic backgrounds (e.g., age, education, ethnicity, and family size), sleep quantity and quality, stress, depression, fatigue, and H-QOL. Bivariate correlations among these variables were also computed. Several regression analyses were conducted to determine whether maternal demographic backgrounds were the covariates of sleep quantity and quality as well as health-related variables. None of these variables significantly accounted for maternal objective sleep quantity and subjective sleep quality as well as health-related variables. Therefore, these potential covariates were not considered any further. A post hoc power analysis for multiple regression analysis with a maximum of four predictors in the equation was performed. Using an alpha of .05 and a power of .80, a total sample size of 48 would be required. Thus, the current study was sufficiently powered with a total sample size of 55.

One major goal of this study was to test and extend the Impaired Sleep Model. The mediating role of sleep and depression in the effect of stress on health-related well-being variables was conceptualized in a path model (see Fig. 1). Given that the sample size was relatively small and a single indicator was used to measure each construct, this conceptual model was evaluated with path analysis through a series of multiple regression analyses. Similar to other related statistical techniques for causal modeling, path analysis tests theoretical propositions about cause and effect without experimental manipulations. The causal relations described in a path model refer to an assumption of the data, rather than a property of the data. In other words, variables in the proposed path model are theorized to be causally related, and path analysis is designed to test these propositions.

Path analysis can assess the plausibility of a particular model. In path analysis, the correlation matrix is estimated based on the assumed parameters. Thus, this analysis is used to evaluate causal hypotheses, but cannot establish causality (Russo, 2009). The derived path coefficients represent standardized beta weights. They are interpreted as estimating the direct effect of an independent variable on a dependent variable while partialling out the shared variances with other independent variables in the regression equation. A variable proposed as the outcome of other variables in the model was regressed on all those variables proposed as having possible direct or indirect effects (Klem, 1995). The indirect effect of one variable on another is determined by summing the products of relevant paths. The criterion for retaining a path in the model was based on the significance of the path coefficient (i.e., $p < .05$). The final model displays significant standardized path coefficients so that the strength of the coefficients can be compared with each other.

Results

Characteristics of maternal sleep

Sleep quantity. Based on GSDS, mothers reported disturbed sleep quantity for an average of 4 days during the past week. The preferred sleep time for the mothers averaged 7.5 h, which was within the range of 7–8 h recommended by the National Sleep Foundation (NSF, 2007). According to the wrist actigraphy data, about 66% of the mothers slept less than 7 h and sleep efficiency was poor ($80.5 \pm 11.2\%$). The average actual maternal TST (6.3 h) was significantly lower than their preferred sleep time to feel refreshed (paired $t[52] = -4.6$, $p < .001$). Furthermore, the sleep deviation index was $.089 \pm .058$ (ranged .01 to .25, median = .084). When compared to the sleep deviation index of 0 (i.e., perfect match between actual and needed sleep time), it was clear that there was a gap between how much sleep mothers needed and how much sleep they actually got ($t[51] = 11.1$, $p < .001$). Finally, mothers' fragmented sleep was also evidenced by the percentage of WASO ($20 \pm 12\%$; average WASO was 96 ± 65 min), which was significantly higher than the adult norm (compared to 10% of WASO, $t[51] = 5.94$, $p < .001$; compared to 15% of WASO, $t[51] = 3.0$, $p = .005$). Taken together, it was evident that the mothers in this study were not only sleep deprived but also sleep disrupted.

Sleep quality. Based on the perceived sleep quality index derived from the GSDS, more than half of the mothers showed clinically significant disturbed sleep (scores ≥ 3). As a group, mothers' self-perceived quality of sleep was significantly lower than the clinical cut-off point ($t[54] = 2.25$, $p < .03$). However, the quality of sleep as perceived by mothers was not significantly correlated with the objective measures of TST and sleep deviation index (see Table 2).

Stress and sleep

Two types of stress, situational and global, were examined in this study. Although the infant-focused situational stress was not significantly correlated with sleep quality perceived by mothers, greater global stress was significantly correlated with poorer perceived sleep quality (see Table 2). Mothers who perceived greater global and situational stress reported significantly greater depression, more fatigue, and lower mental H-QOL. Applying Fisher's r - z transformation (Glass & Hopkins, 1984), statistical tests comparing the respective correlations of global stress and situational stress with two sleep-related and five health-related variables revealed that one out of seven pairs was significantly different. The strength of the association of mental H-QOL with global stress was significantly greater than that with situational stress ($z = -3.68$, $p < .001$). Except for this difference, the two types of stress showed a similar pattern that was either positively or negatively associated with the sleep measures as well as health-related well-being variables. Global stress and situational stress were also significantly correlated (see Table 2). Thus, the standardized scores of these two types of stress were summed together as total stress for subsequent analysis.

Linking stress, sleep, and depression to fatigue and health-related quality of life: the path model

The average score for postpartum depression was greater than 13, indicating that many mothers experienced depressive symptoms during early postpartum. As a group, fatigue severity reported by these mothers was significantly higher than the clinical cut-off point ($t[54] = 3.3$, $p = .002$). Mothers who were classified with a significant clinical depressive symptomatology were also more likely to report a clinically significant fatigue severity ($\chi^2[1, N = 55] = 4.44$, $p < .05$). The mothers' scores for mental and physical H-QOL were about 1 standard deviation (SD) below the norms for age-matched females in the U.S. Poorer mental H-QOL as rated by mothers was significantly correlated with greater total

stress, poorer perceived sleep quality, more depressive symptoms, and greater fatigue. Similarly, poorer physical H-QOL reported by mothers was associated with poorer perceived sleep quality and greater fatigue (see Table 2). Because objective sleep measures were not significantly correlated with any of the health-related well-being variables, they were not included in the path model.

The direct effect of total stress on depression and perceived sleep quality was analyzed separately in the first set of regression analyses. Mothers' total stress had a significant effect on their poor sleep quality ($t = 2.32, p < .03$) and depression ($t = 7.0, p < .001$). The second set of regression models analyzed the direct effects of total stress, depression, and perceived sleep quality on fatigue severity. After controlling for total stress, poor sleep quality significantly contributed to fatigue ($t = 3.83, p < .001$). The last set of regression analyses examined the effects of stress, depression, perceived sleep quality, and fatigue on physical and mental H-QOL. The effect of total stress on mental H-QOL was indirect, via depression ($t = -3.9, p < .001$) and sleep quality ($t = -2.2, p < .04$). Another indirect pathway of total stress exerting its effect on mental H-QOL was mediated by poor sleep quality, which in turn contributed to greater fatigue, which further contributed to poorer mental H-QOL ($t = -2.1, p = .04$). The effect of total stress on physical H-QOL was also indirect. Its effect was first via poor sleep quality, which in turn contributed to greater fatigue, which further contributed to poorer physical H-QOL ($t = -2.3, p < .03$) (see Fig. 2). Taken together, the effect of total stress on physical and mental H-QOL was not direct. Rather, a cascading pattern with maternal depression and perceived sleep quality serving as the mediators linked maternal stress to mental and physical H-QOL.

Discussion

Results from this study highlighted a serious clinical problem faced by the mothers with hospitalized LBW infants. These mothers were stressed out, sleep disrupted and sleep deprived, depressed, highly fatigued, and with poor H-QOL. Their actual nocturnal TST averaged only about 6 h, which was comparable to the mothers caring for a healthy newborn at home (Gay et al., 2004; Stremler et al., 2006). Although all of the mothers in this study slept at home and had no infant with them, they still experienced fragmented sleep. Both global daily stress and the situational stress of having a hospitalized infant were significantly associated with depression, fatigue, and poor mental H-QOL. The path analysis suggested that perceived sleep quality served as the mediator in linking maternal stress to health-related well-being. The cascading pathway from stress to health-related well-being was further mediated by fatigue. Furthermore, consistent with the prediction of the Impaired Sleep Model (Lee, 2003), findings from this study demonstrated that maternal stress contributed to sleep disturbance and depressive mood. The relations of impaired sleep to physical and mental H-QOL were complex. In addition to contributing to mental H-QOL, poor perceived sleep quality resulted in fatigue, which in turn contributed to poor physical and mental H-QOL. The proposed and tested path model that highlights the mediating role of sleep is not limited to mothers of LBW infants. Application of this model to other distressed populations, such as parents of children with chronic diseases, could further validate its use in understanding the mediating role of sleep.

Stress and health

Global and situational stressors were not significantly correlated with objective sleep measures or physical H-QOL. However, the correlation of mental H-QOL with global stress was greater than it was with situational stress, with the difference in their magnitude reaching statistical significance. During early postpartum, global stress experienced by mothers may have a relatively greater impact on mothers' mental well-being than the impact of the specific stress of infant hospitalization. Previous research has found that the source of

stress changed throughout the hospitalization period, shifting from the infant's medical condition to financial and emotional issues (Affonso et al., 1992). Due to a cross-sectional design, the changing and multifaceted nature of stress was not captured in this study, which may explain the relatively weaker link of stress to objective sleep measures and mental H-QOL. The effect on health of stress that is specific to infant hospitalization needs to be further explored in future studies.

Biological adaptation to stress leads to both short- and long-term adverse physical changes during pregnancy, early postpartum, and beyond. Neurological, endocrine, and immune axes involved in individuals' reactivity to stress are inextricably linked to sleep disturbance and daytime sleepiness (Zee, 2006). Grounded in the underlying psychoneurological mechanisms, the theory of allostasis (McEwen & Stellar, 1993) can provide an explanation for the stress–health link in mothers of hospitalized LBW preterm infants.

Allostatic load is the concept of cumulative risk across multiple physiological regulatory systems resulting from chronic exposures to stressors that influence health (McEwen & Stellar, 1993). After the brain perceives stress, physiologic and behavioral responses are activated, leading to a reestablished physiological equilibrium following the stressful challenge. Over time, the allostatic load of wear and tear on physiological systems can accumulate (Ganzel, Morris, & Wethington, 2010). In this study, the majority of participants were Black mothers with lower socioeconomic backgrounds, whose stress level was found to be similar to those who suffered from post-traumatic stress disorder (Holditch-Davis et al., 2009). In addition to socioeconomic status, social-societal risk such as racial discrimination is a potent, chronic stressor for Black women. Lifetime exposure to racial discrimination has been linked to a variety of health outcomes (for a review, see Dunkel-Schetter, 2011; Giscombe & Lobel, 2005), and it was the strongest predictor of adverse birth outcomes, above and beyond socioeconomic and medical risks (Collins, David, Handler, Wall, & Andes, 2004; Dominguez, Dunkel-Schetter, Glynn, Hobel, & Sandman, 2008). Compared to Whites, Black women have an elevated probability of high allostatic load scores, particularly during childbearing years (Geronimus, Hicken, Keene, & Bound, 2006). For the Black women in this study, chronic stress, such as racial discrimination stress, may have accumulated over their life course and exerted a stronger impact on their mental health than the recent, acute stress of infant hospitalization. The stress–health relation may be best conceptualized as the interplay over time between context, current and cumulative stressor exposures, and biological regulation. This conjecture, however, will need to be tested in future studies with a prospective design.

In this study, mothers' reports of their mental and physical H-QOL were not significantly correlated, indicating the relative independence of these two aspects of health. This finding corroborated previous research (Ware & Sherbourne, 1992). Moreover, maternal depression predicted mental H-QOL, but not physical H-QOL. By contrast, perceived sleep quality as reported by mothers played a significant mediating role in linking stress to adverse mental and physical H-QOL. Drawing on the theory of allostasis (discussed above), self-perceived sleep quality may serve as a buffer for the physiological system to prevent the accumulation of allostatic load by enhancing neural processing of stress-related information (e.g., effective stress appraisal) and activating effective coping behavior (e.g., adopting a healthy lifestyle).

Sleep quantity and quality

It was evident that the mothers in the current study with hospitalized LBW infants were sleep deprived and sleep disrupted. However, none of the objective sleep measures was significantly associated with maternal stress or health-related well-being variables. This null finding was consistent with previous findings that objective sleep indicators were not significant predictors of parental stress or mood (Goyal et al., 2009; Lee et al., 2007).

Normal sleep progresses through a series of five stages (Lee, 2003). Only stages 3 and 4 are believed to be the recuperative components of sleep (Lee, 2003). Actigraphy data used in this study measured the TST across all sleep stages. The lack of specific information on the sleep time in stages 3 and 4 may explain why the objective sleep measures did not predict health-related well-being. Furthermore, it is well documented that normal sleep–wake cycles are disrupted by caregiving activities among mothers of healthy newborns (Gay et al., 2004). Examination of synchrony in the circadian activity rhythm in mothers whose infants remain in the NICU after birth may further explain why and how perceived sleep quality regulates the stress–health relation (Germain & Kupfer, 2008).

Sleep disturbance and depression

The majority of the mothers in this study experienced clinically significant depressive symptomatology, which confirmed earlier findings that mothers with a LBW infant are more likely to experience depressive symptoms at second week postpartum as compared to mothers with a term infant (for a review, see Vigod, Villegas, Dennis, & Ross, 2010). Maternal depression was significantly correlated with both situational and global stress. By contrast, despite a positive trend, depression was not significantly correlated with sleep quantity or quality. The null findings may be due to a relatively small sample size and compressed variations in maternal depression scores (more than half of the mothers scored above the clinical cut-off point). Postpartum women with depressive symptoms experience lower sleep efficiency (SE) as measured by 7-day wrist actigraphy than those who are free of the symptoms (Posmontier, 2008). Thus, SE derived from a laboratory polysomnographic assessment with greater accuracy than SE derived from wrist actigraphy may be another dimension that needs to be closely examined in future research.

There is another alternative explanation for the lack of a relation between sleep disturbance and depression found in this study. The relation between sleep disturbance and major depression has been characterized as a dynamic, reciprocal process (Benca et al., 1997). For example, pregnancy insomnia is a risk factor for PPD (Marques et al., 2010), and postpartum fragmented sleep is a predictor of maternal depressive symptoms (Goyal et al., 2009; Karraker & Young, 2007). Recent evidence, however, suggests that the relation between depression and sleep disturbance may not be a linear. Low levels of depressive symptoms lead to increased sleep disturbances, whereas high levels of sleep disturbance exert a dampening effect on depression (Sbarra & Allen, 2009). The amplifying process between depression and sleep problems exists only in the condition of milder forms of insomnia. As sleep problems worsen, the pattern reverses and a dampening effect of sleep disturbance on depressive symptoms begins to emerge. Given that mothers in the current study were significantly disturbed in their sleep, it is plausible that a tipping point was reached where an amplification effect was gradually replaced by a dampening effect. Consequently, the positive correlations between sleep measures and depressive symptoms were not statistically significant.

Research limitation and implications

The generalizability of the current findings may be limited to low-income, first-time mothers with healthy, preterm infants in teaching hospitals. Further studies need to include a larger sample of ethnically diverse women who vary in socioeconomic status, are at different postpartum periods, and who have infants differing in health status. Because of the relatively small sample size, contextual variables such as social support could not be controlled. A more advanced statistical approach, such as structural equation modeling, could not be applied to evaluate the overall fit of the proposed path model. In addition, mothers were the only informants and several constructs were measured by only a single instrument. To prevent biases, multi-method and multi-informant data collection strategies should be

employed in future studies. Specifically, sensitive biomarker measures such as cortisol as an indicator for stress, serotonin for depression, clinical assessments for mental health, and medical evaluations for physical health should be considered.

Findings from this study indicate that stress and sleep disturbance reflect the difficulties faced by women with a hospitalized, LBW, preterm infant. The number of sleep hours required by each mother is an individualized condition. Thus, the sleep deviation index devised for the current study captures a nonlinear relation in the gap between the actual and preferred sleep time for those who slept more or less than their ideal number of sleep hours. Such a bidirectional deviation measure is useful when addressing questions about the role of sleep hours in mental and physical health. To promote mothers' mental and physical health, clinicians may need to consider developing therapeutic interventions to help mothers reduce stress and improve sleep. In addition to an infant's physical condition, maternal stress and mental health problems are known risk factors for poor parenting and insecure attachment in preterm infants (Crnic & Acevedo, 1995). Given the current findings that disturbed sleep may be a symptom of maternal stress that has a strong link to mental and physical health concerns, future research is needed to investigate the role of sleep in maternal parenting and parent-infant attachment. Other causal models should also be tested in future studies. As a mediator in the stress–health pathway, improvement in sleep is expected to buffer the impact of stress on a mother's mental and physical health. Because the mother-infant relational system is a complex and reciprocal process co-regulated by both mother and infant (Hsu & Fogel, 2003), a positive change in maternal health may further affect how a mother feels about and interacts with her infant. As such, sleep is an ideal intervention target for prevention programs designed to promote healthy mother–infant relationships.

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Fig. 1.
The proposed path model.

Fig. 2.

Path analysis results predicting mental and physical health aspects of quality of life (Path coefficients are standardized regression coefficients. Residual variances are listed above dependent variables in respective regression models. * $p < .05$ ** $p < .01$).

Table 1Characteristics of the study participants ($N = 55$).

Variables (cut-off point)	Frequency (%)	Mean (SD)	% Above the cut off
Maternal age (year)	–	25.5 (6.1)	–
Maternal education (year)	–	14.1 (2.0)	–
Infant gestational age (week)	–	27.6 (2.5)	–
Infant birth weight (gm)	–	1023 (341)	–
Infant CRIB score	–	2.9 (2.8)	–
Ethnic group			
White	9 (16.4%)	–	–
Black	38 (69.1%)	–	–
Hispanic	7 (12.7%)	–	–
Other	1 (1.8%)	–	–
Family income			
No income	2 (3.9%)	–	–
<\$20,000	17 (30.9%)	–	–
\$ 20,000 to \$ 40,000	20 (36.4%)	–	–
\$ 40,001 to \$ 60,000	4 (7.3%)	–	–
\$ 60,001 to \$ 80,000	5 (9.1%)	–	–
>\$ 100,000	3 (5.5%)	–	–
Family size (number of family members in the household)	–	2 (2)	–
Sleep measures	–	3.5 (1.7)	58.2%
Quality (3)			
Quantity			
Total sleep time (<420 min)	–	378 (105)	66%
Deviation index (>0)	–	.09 (.06)	100%
Sleep time needed to feel refreshed	–	452 (78)	–
Percentage of wake after sleep onset (>10%)	–	20 (12)	81%
Sleep efficiency (<85%)	–	80.5 (11.2)	63.5%
Impact of Event Scale (9)	–	31.2 (13)	87.3%
Perceived Stress Scale (13.7)	–	17.5 (7.6)	63.6%
Edinburgh Postnatal	–	13.6 (5.6)	63%
Depression Scale (10)			
Fatigue scale (3.2)	–	4.0 (1.8)	70.9%
Health-related quality of life			
Physical (<0)	–	–.87 (.96)	74.5%
Mental (<0)	–	–.72 (1.27)	65.5%

Note. CRIB: Clinical risk index for babies. The cut-off point for each instrument was based on the developer's suggestion.

Table 2

Zero-order correlations between stress, depression, sleep, fatigue, and H-QOL (N= 55).

	2	3	4	5	6	7	8	9	10
1. Impact of Event Scale	.59**	.59**	.18	.09	-.12	-.21	.35**	-.20	-.40**
2. Perceived Stress Scale	-	.65**	.36**	-.12	-.06	-.01	.47**	-.21	-.72**
3. Edinburgh Postnatal Depression Scale		-	.22	-.01	-.26	-.15	.40**	-.19	-.70**
4. Sleep Quality Index			-	-.19	.16	.10	.54**	-.34*	-.49**
5. Total Sleep Time				-	-.39**	-.60**	-.26	.07	.17
6. Wake after sleep onset					-	.48**	.05	-.07	.01
7. Sleep deviation index						-	.16	-.06	.10
8. Fatigue							-	-.45**	-.60**
9. H-QOL: Physical								-	.14
10. H-QOL: Mental									-

H-QOL: Health-related quality of life.

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