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# Sleep and Attachment in Preterm Infants

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## Abstract

Infants born preterm are at elevated risk for social emotional difficulties. However, factors contributing to this risk are largely understudied. Within the present study, we explored infant sleep as a biosocial factor that may play a role in infant social emotional development. Within a prospective longitudinal design, we examined parent-reported sleep patterns and observed parenting quality as predictors of infant-mother attachment in 171 infants born preterm. Using structural equation modeling, we examined main effect and moderator models linking infant sleep patterns and parenting with attachment security. Sleep patterns characterized by more daytime sleep and positive/responsive parenting predicted infant attachment security. Parent-reported nighttime sleep patterns were unrelated to attachment in this sample of infants born preterm. These results indicate that daytime sleep and parenting quality may be important for emerging attachment relationships in infants born preterm.

### Keywords

sleep; attachment; preterm

Sleep is a critical element of development for all children. Infants spend a significant proportion of their time sleeping, and early sleep behaviors are associated with learning, memory, impulse control, behavior problems, and social competence (Bates, Viken, Alexander, Beyers, & Stockton, 2002; Bernier, Carlson, Bordeleau, & Carrier, 2010; Gomez, Bootzin, & Nadel, 2006; Lam, Hiscock, & Wake, 2003; Ward, Gay, Alkon, Anders, & Lee, 2008). Sleep may be particularly important for children's social emotional development, as certain sleep patterns are associated with later behavior problems and disruptions in the parent-child relationship (Anders, Goodlin-Jones, & Sadeh, 2000; France, 1999). The present study examined infant sleep and parenting as predictors of infant-mother attachment security in toddlers born preterm (<36 weeks gestation). Although preterm infants are at risk for adverse social emotional development (Landry, Smith, Miller-Loncar, & Swank, 1997; Vergara & Bigsby, 2004), the role of sleep in the social emotional development of preterm infants has not been examined.

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## Preterm Infant Sleep

Early in development, infants born preterm engage in longer, lighter and more active sleep than infants born at term (Vergara & Bigsby, 2004). As preterm infants develop, their sleep patterns gradually begin to resemble the sleep patterns of infants born at term, although their sleep tends to be more variable and not as consistent across the first year of life compared to full-term infants (Anders & Keener, 1985).

Although there is no universally agreed-upon definition of what constitutes optimal sleep for preterm or full-term infants, ‘good’ sleep for young children is generally characterized by independent sleep onset, longer consolidated sleep periods, self-soothing at night, and more sleep per sleep-wake cycle (Burnham, Goodlin-Jones, Gaylor, & Anders, 2002; Goodlin-Jones, Burnham, Gaylor, & Anders, 2001). Recommendations for infant daytime sleep include semi-structured naps that do not occur too late in the day or for too long, so that nighttime sleep disruptions are minimized (Mindell & Owens, 2003). Parents often strive to foster such sleep patterns while exhibiting sensitive responsiveness to the infant’s fatigue as well as the infant’s bids for social attention (Benoit, Zeanah, Boucher, & Minde, 1992; Paret, 1983).

Daytime sleep patterns may be particularly important for preterm infants, who often exhibit signs of biobehavioral disorganization during play, face-to-face interactions, and other daytime activities (Barnard, Bee, & Harmmond, 1984; Feldman & Eidelman, 2006; Landry, 1995). For example, preterm infants do not show the range of joint attention and interactional skills seen in full-term infants (Barnard et al., 1984; Landry, 1995). They are less able to provide clear distress signals and are more easily stressed and over-stimulated compared to full-term infants (Feldman & Eidelman, 2006). A recent study by Schwichtenberg and colleagues (2010) found that at 4 and 9 months corrected age, preterm infants appeared to benefit from more “breaks” (i.e., naps) during the day to help them reorganize and maintain their engagement in the social environment. They suggested two possible reasons for this finding: (1) mothers who are more sensitive and responsive toward their infants may be more likely to notice infant fatigue and allow more naps for the baby compared to mothers who are less sensitive; and (2) infants who are more rested during the day are more regulated and able to benefit from positive parental behaviors over time, whereas infants who are less rested become more dysregulated, especially in the context of parental negative behaviors or intrusiveness. In the present study, we build on these findings by testing the associations between daytime sleep (i.e., number of daytime naps, duration of daytime sleep) and parenting with infant-mother attachment security. We also examined the relation between nighttime sleep patterns and attachment to test the specificity of our models. These models assess the unique and combined effects of sleep and parenting on infant-mother attachment security.

## Preterm Infants and Attachment

The quality of an early attachment relationship, often described as secure or insecure, is a robust predictor of later social-emotional development in children (Sroufe, 1989). Secure infant-mother attachment has been associated with social competence, protection against stress, empathy, and more optimal academic outcomes (Fish, 2004; Sroufe, 1989), whereas insecure infant-mother attachment may function as a nonspecific risk factor for later psychopathology (Bakermans-Kranenburg, van Ijzendoorn, & Juffer, 2003; Green, Wan, & DeKlyen, 2008). Early studies of attachment in healthy, low risk preterm infants suggested that there were no differences in attachment security between preterm and full-term infants (Easterbrooks, 1989; Frodi & Thompson, 1985). However, later studies of attachment in preterm infants have suggested that lower birthweight preterm infants may be at increased risk for insecure infant-mother attachment (Brisch et al., 2005; Mangelsdorf et al., 1996; Plunkett, 1986), with elevated risk seen in preterm infants with neurologic impairment (i.e., history of intraventricular hemorrhage) or who experience more socioeconomic stressors (Cox, Hopkins, & Hans, 2000; Wille, 1991). In the present study, we examined family sociodemographic stressors and infant prematurity level as covariates in our sample of preterm infants who did not have significant neurological findings during their NICU stay.

The "secure base" characteristics seen in infants who are deemed "good sleepers" at night (i.e., the ability to self-soothe and tolerate separation from caregivers) are also features demonstrated in infants with secure attachments (Ainsworth, 1978). Although similarities between infant-parent bedtime separations and the separations seen in the Strange Situation have been noted (Anders, 1994), a robust association between observed infant nighttime sleep behaviors and infant-mother attachment in healthy term infants has not been demonstrated. Modest but significant relations have emerged between parents' *perceptions* of their infants' sleep and insecure attachment, with parents who report more difficulties with infant nighttime sleep being more likely to have insecurely attached infants (McNamara, Belsky, & Fearon, 2003; Morrell & Steele, 2003). However, no studies have explored the association between infant daytime sleep and emerging attachment relationships in preterm infants.

## Theoretical Model

To examine sleep in preterm infants, we applied elements of ecological (Bronfenbrenner, 1979) and resilience (Masten, 2001) models along with attachment theory (Bowlby, 1982). Whereas ecological models emphasize the importance of bidirectional effects across multiple contexts, attachment theory focuses on the quality of parent-child interactions as contributors to children's social emotional development. Dyadic interactions such as those that foster attachment security are examples of proximal processes that function as key contextual mediators or "the primary engines" of development (Bronfenbrenner & Ceci, 1994, p. 572). Bronfenbrenner (1979) originally referred to the context in which proximal processes occur as the child's microsystem or the activities, roles, and relationships experienced by the child on a daily basis. Biological influences, including sleep, are also thought to be important for children's development (Bronfenbrenner & Ceci, 1994).

Although research has documented less optimal parent-child interactions and development in preterm infants compared to full-term infants (Bhutta, Cleves, Casey, Cradock, & Anand, 2002; Fiese, Poehlmann, Irwin, Gordon, & Curry-Belggi, 2001), preterm infants do not uniformly exhibit such poor outcomes (e.g., Poehlmann et al., 2010, 2011). Further study of preterm infants who develop positive interactions and secure attachments can reveal protective processes associated with resilience, or successful adaptation in the presence of risk or adversity (Masten, 2001, 2007).

The present study examined several microsystem processes, including infant daytime and nighttime sleep, parenting interactions, and infant-mother attachment. Unlike previous research, we examined infant sleep as a predictor of attachment security to acknowledge the importance of the infant's early biobehavioral regulation for subsequent relationship development in the family context (main effect model). We also tested a model in which parenting quality functioned as a protective mechanism (i.e., moderator) in the relation between sleep and attachment, consistent with resilience models.

## Research Questions

1. Do infant sleep patterns predict infant-mother attachment security in toddlers born preterm, controlling for infant prematurity level and family sociodemographic stressors/risks? (Main Effect Model)

2. Is the relationship between sleep and attachment security moderated by parenting quality? (Moderator Model)

In the main effects model, we hypothesized that infants who took more and longer naps during the day and those who woke less/slept more at night would be more likely to be securely attached when compared to infants with less optimal sleep regulation. In the moderator model, we hypothesized that sensitive/responsive parenting would promote resilience (i.e., higher rates of secure attachment) in infants with short/fragmented sleep patterns.

## Method

### Participants

In this study, 171 preterm infants (gestational age ≤ 36 weeks) were included. A total of 181 mothers and their infants were initially recruited from three neonatal intensive care units (NICUs) in southeastern Wisconsin between 2002 and 2005 as part of a larger longitudinal study focusing on infants born preterm or low birthweight. A research nurse from each hospital followed IRB approved procedures of informed consent if they met the following criteria: (a) infants were born ≤ 35 weeks gestation or weighing < 2500 grams, (b) infants had no known congenital problems, major neurological problems (e.g., Down Syndrome, periventricular leukomalacia), or prenatal drug exposures), (c) mothers were at least 17 years of age, (c) mothers could read English, and (d) mothers self-identified as the child's primary caregiver. For multiple births, one infant was randomly selected to participate. Because the hospitals would not allow us to be 'first contact' for families and they only provided us with information about families who signed consent forms for the study, we were unable to calculate a participation rate or ascertain other population descriptive statistics from each hospital (e.g., ethnicity). However, recruiting nurses estimated that approximately 85% of families approached chose to enrol and participating family characteristics paralleled the population of Wisconsin in education and poverty, although participant families were more racially diverse. Data from four of the 181 families were removed because we later discovered that a grade IV IVH had occurred and/or the child was diagnosed with cerebral palsy. Six additional cases were removed because the infants were born ≥ 36 weeks, despite having low birthweights. Additional descriptive statistics are provided in Table 1.

### Procedure

Multiple methods were used to collect data just prior to the infant's hospital discharge (mean age 36 weeks), and at 4, 9 and 16 months corrected for gestational age. At hospital discharge, infant birthweight and gestational age were collected from hospital records and mothers completed a demographic questionnaire. When infants were 4 and 9 months postterm, infant sleep information was collected via a parent-report infant sleep log. Additionally, they participated in a play session. Mothers were instructed to "play with your infant as you would normally do" and dyads were videotaped during a 15-minute in-home interaction. Mothers were instructed to complete the infant sleep log for a minimum of 4 consecutive 24 hour periods and then return the log in a post-paid envelope. At 16 months corrected age, infants completed a laboratory visit. A portion of which included the Strange Situation Procedure.

## Measures

**Sleep Parameters—**Infant sleep was estimated as two latent constructs (i.e., daytime and nighttime sleep). Daytime sleep included 4 and 9 month estimates for duration of daytime sleep and number of naps. Nighttime sleep included duration of nighttime sleep and number of parent-reported night awakenings at 4 and 9 months. We asked parents to report night awakenings that were greater than 15 minutes. Nighttime sleep duration estimates were the total time from parent-reported sleep onset to offset minus any night awakening durations. Each element of the latent construct was generated via parental-report sleep logs. Sleep logs instructed mothers to shade in the times that their infants slept for a minimum of 4 consecutive 24-hour periods. If sleep logs were returned with missing data or the child was sick during the reporting week, parents were asked to record/report on the subsequent week. Previous research has established this measure's reliability, with 90% agreement between parental reports and video monitoring and a .70 ($p < .01$) correlation between infant sleep patterns and infant sleep log reports (Elias et al., 1986).

**Parenting Interactions—**The first five minutes of each play interaction was coded using the parenting variables of the Parent Child Early Relational Assessment (PCERA; Clark, 1985). The PCERA is a coding system designed to assess dyads on 65 interaction quality items (29 parent, 28 infant, and 8 dyadic). Each item/variable is coded on a scale ranging from 1 (negative relational quality) to 5 (positive relational quality). The variables focus on the frequency, duration, and intensity of affect and behavioral characteristics in an attempt to assess the interactional strengths and limitations of the parent, child, and dyad. Coders completed a PCERA training workshop with Dr. Roseanne Clark or a master coder and continued training until 80% inter-coder agreement was achieved. Additionally, 10% of all tapes were coded by two independent coders with 94% agreement within-one point across items (the standard used for the PCERA). For this study, three established PCERA parenting subscales were used (Clark, 1999). The three parent subscales were (a) *Positive Affect, Involvement, and Verbalizations*, (b) *Negative Affect and Behavior* (e.g., anger) and (c) *Intrusiveness, Insensitivity, and Inconsistency*. These parenting subscales were generated through a factorial validity study (Clark, 1999) and are commonly used in research (e.g., Eiden, Schuetze, & Coles, 2001; Faugli, Emblem, Veenstra, Bjornland, & Diseth, 2008). Higher scores on each scale represent more positive parenting (i.e., higher scores on the Negative Behavior and Affect subscales indicates *less* negative behavior). In the present study, the parenting subscales are highly correlated; therefore, one parenting latent construct was generated using the established subscales. The child subscales were not used in the present study. Alphas for each parenting subscale are provided in Table 2.

**Infant Prematurity—**Infant medical records were reviewed to collect infant prematurity data. Because infant birthweight and gestational age were highly correlated ($r = .88$, $p < .001$), we standardized and summed them to generate an index of infant prematurity, with higher scores representing more prematurity.

**Family sociodemographic risks—**Mothers completed a demographic questionnaire while their infants were in the NICU. On the basis of previous research (e.g., Burchinal, Roberts, Hooper, & Zeisel, 2000; Sameroff, Bartko, Baldwin, Baldwin, & Seifer, 1998), one point was given for each of the following risks: the family's income was below the federal poverty guidelines adjusted for family size, both parents were unemployed, the mother was single, the mother gave birth to the target child as a teen, the family had four or more dependent children in the home, the mother had less than a high school education, and the father had less than a high school education. This index could range from0 to 7, with higher scores reflecting more sociodemographic risks.

**Infant-Mother Attachment—**Infant-mother attachment was assessed at 16 months corrected age using Ainsworth's Strange Situation Procedure (SSP) (Ainsworth, Blehar, Waters, & Wall, 1978). The SSP is the gold-standard for assessing quality of attachment in 12–18 month old infants. The videotaped procedure includes a series of mother-child separations and reunions with a goal of providing an environment that arouses the infant's motivation to explore (when not distressed) and the urge to seek proximity to the caregiver (when distressed). Classification is based on 4 categories (Secure, Insecure-Avoidant, Insecure-Resistant, Disorganized) coded from the child's reunion behaviors. A trained attachment researcher blind to study variables coded the tapes. Additional tapes (14%) were coded by a second trained attachment researcher, with a kappa of .80 across the secure (coded as 1) and insecure (coded as 0) categories. Fifty-nine percent (n = 86) of the infants were classified as secure and 41% of infants were classified as insecure (Anxious-avoidant, $n = 21$; Anxious-resistant, $n = 37$, Disorganized, $n = 1$).

## Results

Basic demographic and parameter descriptive statistics are provided in Tables 1 and 2. As expected longitudinal infant sleep parameters are correlated and the three parenting subscales are significantly correlated. Family sociodemographic risks are also correlated with a number of the variables of interest (i.e., infant sleep and parenting) but not infant attachment security.

Model preparations included attrition analyses. There was a 15% attrition rate between NICU discharge and 16 months. A MANOVA conducted on infant health variables revealed no significant differences between infants who continued in the study and those lost to attrition, $F(6, 165) = 0.96$, $p = .45$, on infant gestational age, birthweight, 1- and 5-minute Apgar scores, days hospitalized, or a neonatal health risk index. A MANOVA conducted on family SES variables (measured at Time 1) revealed significant differences between families who participated in the study for 16 months and families lost to attrition, $F(7, 164) = 5.06$, $p < .05$. Follow-up univariate tests indicated that mothers lost to attrition were younger, $F(1, 170) = 7.24$, $p < .05$, and had completed fewer years of education, $F(1, 170) = 13.19$, $p < .05$, compared to those who continued in the study. In addition, families were more likely to be lost to attrition when the fathers had completed fewer years of education, $F(1, 170) = 8.24$, $p < .05$, and when the families had more SES risk factors, $F(1, 170) = 8.28$, $p < .05$. However, there were no differences in mothers who participated in the study for 16 months and mothers lost to attrition on the number of children in the family, the father's age, or family income. Chi-square analyses revealed that mothers lost to attrition were more likely to be single, $\chi^2(1) = 8.12$, $p < .05$; however, attrition groups did not differ on maternal race.

To address our research questions, a series of structural equation models (SEM) were tested in Mplus 5 (Muthen & Muthen, 2007). SEM was chosen over other analytic approaches because it affords the simultaneous testing of latent constructs and the hypothesized associations between variables. The SEM models were specified, identified, and tested for assumption violations prior to model and path estimation and interpretation. Transformations were employed to reduce non-normality bias. Additionally, a full information maximum likelihood (FIML) procedure was used to address missing data. In the Mplus FIML procedure, individual missing data patterns are assessed, and means and covariances for each missing data pattern are calculated to inform the observed information matrix (Arbuckle, 1996; Kaplan, 2009). The observed information matrix is used to generate estimates (Kenward & Molenberghs, 1998). Addressing missing data via FIML assumes data missing at random (MAR; Little & Rubin, 1989) and is preferable to pair-wise or list-wise deletion (Arbuckle, 1996). Within the present study, the highest rates of missingness were with the parent-report sleep diary. The observed information matrix was used to generate estimates for 13% infants at 4 months and 15% at 9 months for whom a sleep diary was not returned or was returned with incomplete data and the family opted not to complete another diary in the subsequent week.

Models were compared using the Bayesian Information Criterion (BIC) and standardized path coefficients (β). The BIC is an index of single sample cross-validation. This cross-validation index is not a hypothesis test, but rather is used to compare the magnitude of uncertainty across models. Lower BIC values are indicative of better cross-validation. Standardized estimates (Z) that reached the critical ratio of 1.96 were considered significant. Standardized path coefficients are provided in Figure 2. The standardized path coefficients allow for direct comparisons of magnitude across paths. For unspecified paths, modifications indices were assessed to confirm that no significant paths were excluded (e.g., from family sociodemographic risk to attachment security). Models are described below by research question.

### Infant Sleep and Attachment (Main Effects Model)

To test our first research question, whether infant sleep predicted infant-mother attachment security, models were specified (Figure 1a) for daytime and nighttime sleep separately. As illustrated in Figure 2a, infant daytime sleep patterns (across 4 and 9 months postterm) predicted infant-mother attachment security at 16 months (Table 3). Infants with higher daytime sleep scores (i.e., who napped and slept more during the day) were more likely to be securely attached. However, infant nighttime sleep did not predict infant-mother attachment security (Figure 2b; Table 3). Consistent with previous research, parenting behaviors predicted infant-mother attachment security (Figure 2; Table 3). Parenting characterized by more *positive affect and involvement*, less *negative affect and behavior* and less *intrusiveness and insensitivity* predicted infant-mother attachment security at 16 months. More family sociodemographic risks predicted less daytime sleep and less optimal parenting behaviors. However, infant prematurity did not relate to infant sleep or parenting behaviors.

To aid in our interpretation of the daytime sleep findings we explored two additional post-hoc models. One with only number of naps (at 4 and 9 months) and another with only amount of daytime sleep (at 4 and 9 months). This allowed us to investigate if one element of daytime sleep may be more salient for later infant-mother attachment. In sum, both amount of daytime sleep ($Est = .34$, $p < .05$) and number of naps ($Est = .26$, $p < .05$) may be used to predicted later infant-mother attachment.

### Interaction between Sleep and Parenting (Moderator Model)

For our second research question, whether the interaction between parenting and infant sleep predicted infant-mother attachment security, a sleep X parenting interaction term was added to each model (Figure 1b). Within these models, the interaction between sleep and parenting is adjusted for the main effects of sleep and parenting. The interaction between daytime sleep and parenting did not reach our threshold for statistical significance ($z = 1.65$, $p < .10$). Similarly, for nighttime sleep the sleep X parenting interactions did not predict attachment security.

## Discussion

Although previous studies with healthy full-term infants have examined infant-mother attachment and parenting behaviors in relation to infant nighttime sleep (Higley & Dozier, 2009; McNamara et al., 2003; Morrell & Steele, 2003; Scher & Asher, 2004), prior research has not focused on the role of daytime sleep in developing attachments or examined these associations in the context of infant prematurity. Examination of daytime sleep is particularly important for preterm infants, who often exhibit behaviors reflective of biobehavioral disorganization during social interactions and other daytime activities (Barnard et al., 1984; Feldman & Eidelman, 2006; Landry, 1995). We hypothesized that preterm infants may need more sleep during the day to help them maintain optimal levels of social engagement. To examine this idea, we assessed main effect and moderator models linking daytime sleep, parenting quality, and infant-mother attachment.

Consistent with attachment theory (Bowlby, 1982) and previous research (Ainsworth et al., 1978; Teti, Nakagawa, Das & Wirth, 1991), we found main effects of parenting on attachment. Mothers who exhibited more positive affect and involvement, less negative affect, and less intrusiveness and insensitivity with their preterm infants at 9 months postterm were more likely to have secure infants at 16 months postterm compared to other mothers. However, mothers who were more sensitive to their infants' cues during face-to-face interactions (i.e., play) were *not* more likely to put their infants down for naps during the day. Indeed, there was no association between daytime sleep patterns and quality of parenting interactions during play.

However, our models documented main effects of daytime sleep on infant-mother attachment security. Infants who slept more at 4 and 9 months postterm were more likely to be securely attached to their mothers at 16 months postterm compared to infants who took fewer/shorter naps. This finding is consistent with our hypothesis; early biobehavioral regulation had a direct impact on preterm infant social-emotional development. With replication, our results suggest that more daytime sleep during infancy, in conjunction with positive parenting, may function to facilitate positive social emotional development of preterm infants and contribute to resilience processes. When considering generalizability of these findings to other preterm infants, it is important to note that a majority of the infants in the present study were put down for nap by their mothers exclusively or alternating between their mothers and another family member (e.g., father, grandmother). Less than 15% of the enrolled infants napped at daycare or another location.

Previous research linking sleep and attachment have focused almost exclusively on nighttime sleep and emphasize conformity to what is viewed as 'good' infant sleep patterns; that is, consolidated nighttime sleep (McNamara et al., 2003; Morrell & Steele, 2003; Scher & Asher, 2004). The present study's focus on daytime sleep highlights that preterm infants may benefit from a sleep pattern that consists of more sleep during the day rather than focusing on longer nighttime sleep consolidation. Securely attached infants took (on average) 1 more nap a day than infant's classified as insecurely attached. This additional rest may allow infants to benefit from positive parenting interactions over time (Schwichtenberg et al., 2010).

The present study found no link between infant nighttime sleep and subsequent attachment. Previous studies focusing on infant nighttime sleep and attachment have included healthy full-term infants, with mixed results (e.g., Higley & Dozier, 2009; Scher & Asher, 2004). The lack of association between nighttime sleep and attachment may reflect the elements of sleep included in our estimate (i.e., duration and number of night awakenings > 15 minutes) rather than parental behaviors around the waking. Previous research by Higley and Dozier (2009) illustrated that parental response to night awakenings was more influential in infant-mother attachment than the number of awakenings. Additionally, parent reports of night awakenings may represent a distinctly different phenomenon than physiologically-measured night awakenings. In the present study, parent reports of night awakenings are likely underestimates for a number of reasons (i.e., lack of child signaling, distance from child, parental tiredness, and the sleep dairy used in this study only asked parents to note awakenings > 15 minutes). Additionally, infant feeding route (breast or bottle) may affect parental reports. Within the present study, the effects of infant feeding route are likely modest with low rates of breast feeding at 4 (15%) and 9 (8%) months. Under reporting of night awakenings may have inflated child nighttime sleep duration estimates which in turn could have contributed to lack of association between nighttime sleep and attachment security.

## Implications

The results of our study have implications for practitioners and programs that attempt to support parents and their preterm infants, particularly in the area of sleep and social emotional development. Daytime sleep (i.e., napping) may provide an opportunity for preterm infants to “regroup” or “reorganize”. Previous studies of typically developing infants highlight the organizing effects of naps in abstract language learning, affect expression, and cortisol regulation (Gomez et al., 2006; Ward et al., 2008) and in preterm infants, nap organizing benefits may also be apparent. Interventions with preterm infants and their parents may wish to explore quality of daytime sleep. Parents should also be made aware that sleep models and recommendations put forth for infants born at term may not be applicable to preterm infants, especially early in development.

Improving quality of parenting interactions, including parental sensitivity, responsiveness, and positive affect, is also likely to benefit preterm infants and their families. Previous intervention studies using such approaches with high risk (Bakermans-Kranenburg et al., 2003) and preterm infants (Newnham, Milgrom, & Skouteris, 2009) have reported improvements in infant-mother attachment and infant sleep, also contributing to resilience.

## Limitations

Our study has several limitations, including the use of parental report sleep logs rather than actigraphy, videosomnography or poloysomnography. We relied on sleep logs for a number of pragmatic reasons, but also because parental perceptions of infant sleep appear important for developing attachment relationships (e.g., McNamara et al., 2003; Morrell & Steele, 2003). In this analysis, we also did not make use of our longitudinal infant-parent interaction data because of sample size limitations (i.e., maintaining an appropriate sample size/estimate ratio) (Kaplan, 2009). Additionally, our coded video segment was brief and only provided a ‘snapshot’ of parent-child relations, it may not capture the complex and dynamic nature of such interactions over time. Although attrition between NICU discharge and 16 months was relatively low for a study of high risk infants, attrition was more likely to occur when families experienced more sociodemographic risks. In addition, we did not assess infant-father interactions or infant-father attachment security, nor did we include infant temperament variables in these analyses, which have been highlighted as important in several sleep studies (Ednick et al., 2009; Scher & Asher, 2004). Finally, we did not collect data on a comparison group of children born at term. Although such a comparison group could expand the research questions address by this study, previous studies have documented elevated risks in preterm infants (Vergara & Bigsby, 2004) and the present study focused on within group associations and predictors of resilience that may be applicable to the larger population of infants born preterm.

Despite these limitations, the present study increased our understanding of the implications of early daytime sleep development and the proximal parenting context for social emotional development in toddlers born preterm.


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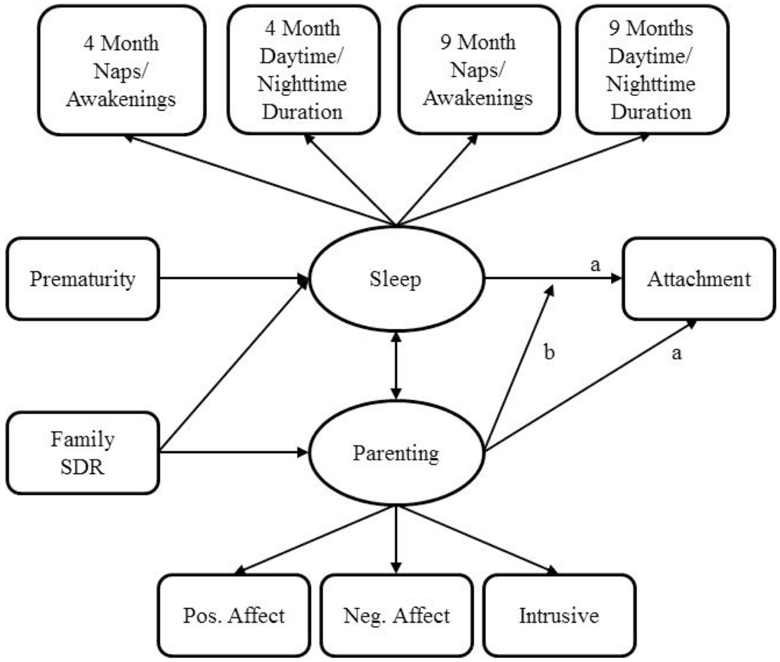


**Figure 1.**
Conceptual model of main effect (a) and moderating (b) pathways linking sleep and parenting to infant-mother attachment security.

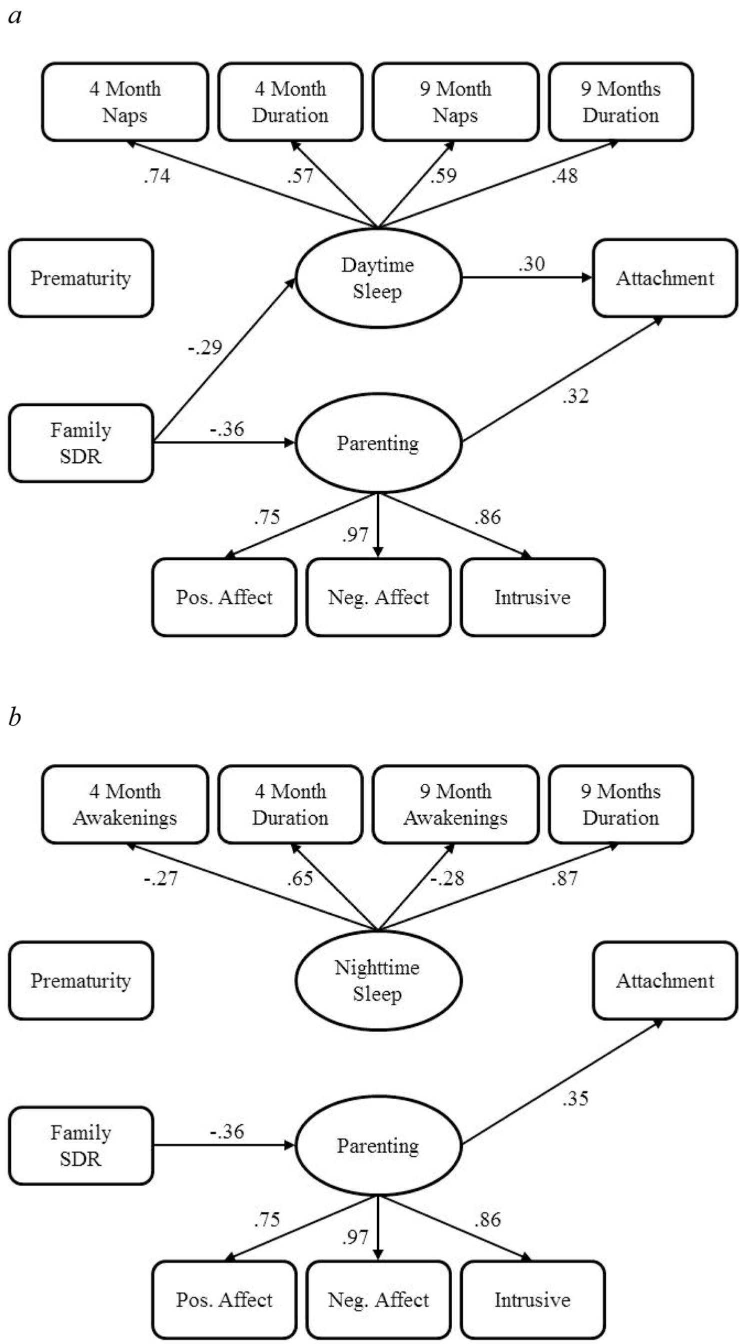


**Figure 2.**
Standardized path coefficients for daytime (a) and nighttime (b) sleep.

## Table 1

Family Demographic and Infant Neonatal Health Characteristics (n = 171)

| Variable | Range | *M* or Frequency | *SD* or % |
|---|---|---|---|
| Maternal age (years) | 17 – 42 | 29 | 6.29 |
| Maternal education (years) | 8 – 21 | 14 | 2.69 |
| Family income | 0 – 500,000 | 59,287 | 53,102 |
| Marital status (% married) | | 117 | 68% |
| Gender (female) | | 81 | 47% |
| Multiple birth (% yes) | | 32 | 19% |
| Birthweight (grams) | 490 – 3328 | 1711g | 580g |
| ELBW | | 28 | 16% |
| VLBW | | 37 | 22% |
| LBW | | 93 | 54% |
| NBW | | 13 | 8% |
| Appropriateness of weight | | | |
| LGA | | 8 | 5% |
| AGA | | 144 | 84% |
| SGA | | 19 | 11% |
| Apgar 1 minute | 1 – 9 | 5.88 | 1.97 |
| Apgar 5 minute | 2 – 10 | 7.91 | 1.32 |
| Days Hospitalized | 2–136 | 33.44 | 28.03 |

*Note*. ELBW = extremely low birth weight < 1000g; VLBW = very low birth weight < 1500g; LBW = low birth weight < 2500g; NBW = normal birthweight = ≥ 2500g; LGA = large for gestational age; AGA = appropriate for gestational age; SGA = small for gestational age.

**Table 2**

Descriptive Statistics for Variables used in Analyses

| | Range | *M* | *SD* | α |
|---|---|---|---|---|
| 4 Month | | | | |
| Daytime Sleep[a] | 0 – 450 | 228 | 79 | .72[c] |
| Number of Naps | 0 – 6 | 2.85 | .93 | .80[c] |
| Nighttime Sleep[a] | 368 – 710 | 578 | 70 | .67[c] |
| Night Awakenings | 0 – 5 | .91 | .86 | .87[c] |
| 9 Month | | | | |
| Daytime Sleep[a] | 10 – 315 | 155 | 51 | .69[c] |
| Number of Naps | .33 – 3.33 | 1.89 | .55 | .69[c] |
| Nighttime Sleep[a] | 378 – 746 | 607 | 68 | .81[c] |
| Night Awakenings | 0 – 7.25 | .74 | 1.12 | .92[c] |
| Prematurity Index | −4.39 – 3.90 | −.02 | 1.89 | .94 |
| Family SDR | 0 – 6 | 1.05 | 1.54 | .75 |
| Positive Affect | 1.91 – 4.91 | 3.67 | .75 | .94 |
| Negative Affect | 1.40 – 5.00 | 3.98 | .75 | .91 |
| Intrusiveness | 2.25 – 4.75 | 3.70 | .60 | .84 |
| Attachment Security[b] | | 86 | 59% | |

*Note.*

[a]reported in minutes,

[b]frequency and percentage of secure infants,

[c]alpha for these indices indicate day-to-day agreement within parent reports

## Table 3

Model Cross-Validation and Estimates for Daytime and Nighttime Sleep Models

| | Estimate (*SE*), *Z* | | | |
|---|---|---|---|---|
| **Sleep by** | **Daytime Sleep** | | **Nighttime Sleep** | |
| 4 Month sleep duration | .57(.10), 5.83** | | .65(.10), 6.64** | |
| 4 Month Naps | .74(.09), 8.41** | | | |
| 4 Month Awakenings | | | −.27(.10), −2.62** | |
| 9 Month sleep duration | .48(.11), 4.58** | | .87(.11), 7.69** | |
| 9 Month Naps | .59(.08), 7.63** | | | |
| 9 Month Awakenings | | | −.28(.10), −2.91** | |
| Parenting by | | | | |
| PCERA Positive Affect | .75(.04), 17.08** | | .75(.04), 18.99** | |
| PCERA Negative Affect | .97(.02), 57.47** | | .97(.02), 59.67** | |
| PCERA Intrusiveness | .86(.03), 31.43** | | .86(.03), 32.09** | |
| Sleep on | | | | |
| Prematurity | .14(.10), 1.42 | | .01(.10), −.07 | |
| Family SDR | −.29(.11), −2.68** | | −.06(.11), −.56 | |
| Sleep with Parenting | .03(.11), .28 | | .04(.11), .37 | |
| Parenting on | | | | |
| Family SDR | −.36(.08), −4.50** | | −.36(.08), −4.57** | |
| Attachment on | | | | |
| Sleep | .30(.12), 2.51** | | −.05(.11), −.43 | |
| Parenting | .32(.10), 3.28** | | .35(.09), 3.73** | |
| Sleep x Parenting [b] | 1.78(1.08), 1.65[t] | | .43(.47), .92 | |
| BIC | 2,613 | 2,442 [b] | 2,645 | 2,649 [b] |

*Note*. All reported test statistics are from the main effect model (Figure 1a) unless indicated;

[b] from the moderator model (Figure 1b); standardized estimates are reported for the main effect models and unstandardized estimates for the moderator model, BIC = Bayesian Information Criterion,

* $p < .05$,

** $p < .01$,

[t] $p < .10$