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Goodness of fit between prenatal maternal sleep and infant sleep: Associations with maternal depression and attachment security

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Abstract

The current study prospectively examined the ways in which goodness of fit between maternal and infant sleep contributes to maternal depressive symptoms and the mother-child relationship across the first years of life. In a sample of 173 mother-child dyads, maternal prenatal sleep, infant sleep, maternal depressive symptoms, and mother-child attachment security were assessed via self-report, actigraphy, and observational measures. Results suggested that a poor fit between mothers' prenatal sleep and infants' sleep at 8 months (measured by sleep diary and actigraphy) was associated with maternal depressive symptoms at 15 months. Additionally, maternal depression mediated the association between the interplay of mother and infant sleep (measured by sleep diary) and mother-child attachment security at 30 months. Findings emphasize the importance of the match between mother and infant sleep on maternal wellbeing and mother-child relationships and highlight the role of mothers' perceptions of infant sleep.

Keywords

Parent-child relationships; Infant sleep; Maternal depression; Goodness of fit

1. Introduction

Disruptions in sleep are a nearly universal stressor following the birth of a baby. Over the first weeks and months of life, infants wake regularly across day and nighttime. By 6–9 months, sleep is more consolidated and most infants are able to “sleep through the night” (i.e., sleep 6–8 h without signaling their awakenings; Jenni & Carskadon, 2007; Jenni, Fuhrer, Iglowstein, Molinari, & Largo, 2005). However, infants display a great deal of variability in sleep patterns and self-soothing abilities (Goodlin-Jones, Burnham, Gaylor, & Anders, 2001), with estimates of approximately 20–25% exhibiting problematic sleep (Mindell, 1999). Accordingly, sleep problems are one of the most common concerns reported to pediatricians by parents (Anders, Halpern, & Hua, 1992; Ferber, 1985). As infant sleep develops, mothers typically experience sleep fragmentation and deprivation across the postpartum period (Hunter, Rychnovsky, & Yount, 2009; Lee, Zaffke, & McEnany, 2000).

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While evidence suggests that both infant and maternal sleep disruptions are independently associated with postpartum depression (e.g., Dennis & Ross, 2005), little is known about the effect of the interplay between maternal and infant sleep on maternal depression and the mother-child relationship across the first years of life. Moreover, although many have examined concurrent and predictive links between *postpartum* maternal and infant sleep (e.g., Tikotzky, Sadeh, Volkovich, Manber, Meiri, & Shahar, 2015), to our knowledge, little is known about the ways in which mothers' *typical* sleep patterns affect infant sleep processes and the emergence of postpartum depression. The current study examined the interactive effects of infants' sleep and mothers' typical prenatal sleep patterns and the ways in which the match between infant and mother sleep influences maternal depressive symptoms and later mother-child attachment security. Further, we explored possible differences in these processes between objective sleep measures and mothers' perceptions of their infants' sleep.

1.1. Infant and mother sleep: Associations with postpartum depression and mother-infant relationships

The potentially critical influence of maternal sleep disruption has become a recent area of interest for understanding predictive factors for the development and maintenance of postpartum depression. For many new mothers, sleep disturbance is common during pregnancy and the postpartum period. Objective sleep measures reveal decreases in deep sleep and sleep efficiency during pregnancy, and mothers continue to experience poorer sleep efficiency along with less total sleep time in the weeks after birth (Lee et al., 2000). On self-report measures, women report that they face increased night wakings, restless sleep, and daytime fatigue while pregnant (Mindell & Jacobson, 2000), and subsequently, women describe more fatigue and sleep disturbance in the postpartum period than during pregnancy (Gay, Lee, & Lee, 2004). Although these sleep disruptions occur for many women, poor maternal sleep quality, fatigue, and infant sleep difficulties (i.e., night wakings, time awake, maternal perceptions of poor infant sleep) during the postpartum period, both when measured subjectively with sleep diaries and objectively with actigraphy, are associated with postpartum depression (Dennis & Ross, 2005; Goyal, Gay, & Lee, 2009; Karraker & Young, 2007; Posmontier, 2008). Similarly, maternal depressive symptoms have been found to predict infant and toddler sleep problems (Armitage, Flynn, Hoffman, Vazquez, Lopez, & Marcus, 2009; Warren, Howe, Simmens, & Dahl, 2006). A challenge in research exploring associations between sleep and postpartum depression is determining the direction of effect (i.e., poor sleep increases depression versus depression causes poor sleep), but more likely, sleep during the postpartum period is a complex, transactional process, wherein sleep problems are both influenced by and contribute to maternal wellbeing (Sadeh, Tikotzky, & Scher, 2010).

Within many cultures and families, bedtime in infancy and childhood demands a parent-child interactive routine and a separation, and thus sleep and attachment would seem to be connected processes. However, there has been minimal empirical evidence supporting this association (Sadeh et al., 2010). Some research has identified links between mother-reported infant sleep problems and attachment security (Beijers, Jansen, Riksen-Walraven, & de Weerth, 2011; McNamara, Belsky, & Fearon, 2003; Scher & Asher, 2004), but not with

objectively-measured infant sleep (Scher, 2001; Simard, Bernier, Bélanger, & Carrier, 2013), leaving questions about whether and how attachment and sleep are related. In contrast, the associations between maternal depression and attachment problems between a depressed mother and her child are more robust (Martins & Gaffan, 2000). Perhaps, then, maternal depressive symptoms provide the bridge by which sleep disruption affects attachment security; sleep problems may increase and maintain maternal depression during infancy, which then impedes mothers' and infants' ability to form a secure bond.

1.2. Goodness of fit between infant and mother sleep patterns

Goodness of fit calls attention to transactional processes in parent-child relationships and posits that a good fit between child characteristics and the parenting context contributes to positive child adjustment. Despite intuitive appeal, in the decades since Thomas and Chess originally formulated the construct of goodness of fit (Thomas & Chess, 1977; Thomas, Chess, & Birch, 1968), empirical support has lagged. Goodness of fit has been operationalized and measured using three approaches: (1) matching of behavior between parent and child, (2) matching of expectations of parents with children's behavior, and (3) appraisal of how children's behavior facilitates stress and coping of parents (Seifer, Dickstein, Parade, Hayden, Magee, & Schiller, 2014). The first measurement strategy, the behavior matching approach, may have particular relevance to the context of infant and maternal sleep patterns, as one would expect that a good fit between mothers' and infants' sleep behaviors would lead to better outcomes than a dyad with poorly fitting sleep patterns. For example, mothers who typically required more sleep prior to the birth of their infants may be better matched with infants who sleep more and/or have more predictable sleep habits, whereas, in contrast, mothers who slept less prenatally might be better able to adapt to an infant with highly fragmented sleep.

Jenni and O'Connor (2005) highlighted the potential importance of good fit between an individual child's sleep and the cultural (and, more directly, parental) expectations for sleep practices. Similarly, Sadeh, Anders, and colleagues embed infant sleep within a transactional model of cultural, environmental, and parent-child influences (Sadeh & Anders, 1993; Sadeh et al., 2010), which serves to emphasize the complexity of bidirectional influences on and by infant sleep. Although goodness of fit is typically discussed with a focus on child outcomes (i.e., in the case of sleep, well-matched child sleep characteristics with parental sleep expectations and behavioral sleep strategies are proposed to decrease child sleep problems), a broader conceptualization draws attention to the impact of parent-child fit on parental wellbeing, as well (Newland & Crnic, 2016). Specifically, poorly-matched infant and mother sleep patterns may contribute to maternal postpartum depression. Indeed, some of the mixed findings regarding the associations between postpartum sleep and depression (e.g., Gress, Chambers, Ong, Tikotzky, Okada, & Manber, 2010; Warren et al., 2006) may be accounted for by individual differences in mothers' sleep needs and the match with their infants' sleep patterns.

1.3. The present study

Although much is known about direct relations between infants' sleep and maternal psychopathology, the interplay of mothers' and infants' sleep on maternal wellbeing and

mother-infant relationships deserves further consideration, to better identify ways in which individual mother-child match may contribute to family processes in early childhood. Further, sleep research varies in choice of measurement approach. Although subjective sleep measures (parental-reported sleep diaries) and objective sleep measures (activity-based monitoring, i.e., actigraphy) are relatively consistent for some measures of infant sleep, including sleep onset and duration, parents tend to underestimate night wakings and overestimate proportion of time sleeping (Sadeh, 1996). While objective measures provide more accurate estimates of infant sleep, subjective measures remain essential to understand parental perceptions of infant sleep, which may provide insight into parent-child bedtime interactions. Thus, we considered both objective and subjective measures of infant sleep in the current investigation.

The current study operationalizes poorly matched mother-infant sleep as the combination of a mother who experiences many hours of sleep prenatally with an infant who experiences highly disrupted sleep (i.e., more night wakings, less sleep efficiency, more night-to-night variability). A ideal fit for a mother who slept many hours prenatally would be represented by an infant who has few sleep disruptions and sleeps for longer periods of time. We expect that a mother who receives few hours of sleep prenatally would be better able to adjust to an infant with varying sleep patterns, and thus have no a priori predictions about good or poor fit for these mothers. Given that goodness of fit using the behavior matching approach is inextricably tied to outcomes (that is, good fit cannot be defined without attention to mother and/or child adjustment), these operational definitions of good and poor fit will be tested in terms of their relations to later outcomes (i.e., maternal depression and mother-child attachment security).

We addressed the following research questions:

1. Is goodness of fit between mothers' prenatal sleep and infant sleep at 8 months associated with maternal depressive symptoms at 15 months?
 - a. Do these associations differ based on different objective and subjective measurements of infant sleep?
2. Does goodness of fit between mother and infant sleep influence mother-infant attachment security at 30 months, through the effect on maternal depressive symptoms?

2. Material and methods

2.1. Participants

Participants included 173 mothers and their infants. Families were drawn from a larger longitudinal investigation, the Goodness of Fit (GOF) study, which included assessments prenatally and at 4, 8, 15, and 30 months. The larger study aimed to understand goodness of fit in parent-child dyads using the behavioral matching and subjective appraisal approaches. The sample was recruited such that half of the families were at high-risk for suboptimal child outcomes (i.e., half of families had a mother with a history of maternal depression). Identifying the ways in which infant and parent sleep patterns impact goodness of fit was a

core component of the study. The current investigation includes data from the prenatal, 8, 15, and 30 month assessments. In the larger study, the timing of the assessments was chosen to reflect transitions during infancy and toddlerhood (i.e., the 8 month assessment captured infants before they were able to walk, the 15 month assessment captured most infants after they were mobile). For the current study, these assessment periods were chosen to capture mother-child sleep patterns across infancy, with maternal depression and attachment security as distal outcomes during the toddler period; in addition, the choice of assessment periods allowed for the ability to investigate maternal depression at 15 months as a possible mediator of association between earlier sleep and later attachment. By the 30 month assessment, 132 families were retained. There was little evidence of differential attrition from the prenatal period to the 30 month visit on any of the demographic characteristics discussed below, except that mothers retained at 30 months were slightly more educated than those who attrited (i.e., 87% of mothers who remained through 30 months had at least some college education, versus 73% of mothers who attrited). Socioeconomic status was used as a covariate in all analyses.

Families were recruited during the prenatal period at the main obstetrics hospital that accounted for approximately 90% of the births in a metropolitan area in northeastern United States. Parents were approached during prenatal birthing classes and given a brief presentation about the study, including a description of procedures and a statement that we were recruiting mothers with and without a history of emotional problems (especially depression). Interested mothers provided their contact information and were then contacted by project staff for a more thorough study description. If interested, parents were scheduled for a prenatal assessment to begin study participation. All participating mothers gave written informed consent. Prenatal assessments were conducted during the third trimester.

At the prenatal visit, mothers' mean age was 29 years old (ranging from 17 to 45). Twenty-one mothers (12%) were of minority racial status. The remaining 152 were White, non-Hispanic. One hundred thirty five of the mothers were married and living with their spouse, 26 were single or divorced and currently living with a partner, and the remaining 12 were not living with a partner. The large majority of the sample was middle or upper socioeconomic status (SES). Eleven mothers had less than a high-school education, 17 were high school graduates, 50 had completed some college, 64 were college graduates, and an additional 31 mothers had graduate training. One hundred twenty eight (74%) of the mothers were first-time mothers. For the families retained at the time of the child's birth, infants included 85 boys and 75 girls.

2.2. Procedures and measures

Procedures for the larger study included home visits, laboratory sessions, phone interviews, sleep assessments, and completion of questionnaires. Sample sizes for each of the below measures are listed in Table 1.

2.2.1. Socioeconomic status—Demographic information was collected prenatally from the families. Hollingshead (1975) 4-factor SES scores were computed from the education and occupation scores of the two adults in the household. For those families where only the

mother was in the home, her education and occupation were used to determine the SES classification.

2.2.2. Maternal sleep—Maternal sleep was measured before the birth of the infant, in order to characterize mothers' beliefs about their own typical sleep habits. Of relevance to maternal sleep, 45 mothers had children in the home at the time of the prenatal visit. During the prenatal visit, which occurred most often in the third trimester, mothers completed a questionnaire regarding their sleep habits. Mothers were instructed to answer questions based on the prior week. However, if the prior week was atypical, or if sleep during pregnancy had been atypical, they were instructed to answer questions based on a typical week of sleep before becoming pregnant. Among other questions about sleep, mothers reported on their average amount of sleep on a typical work day and non-work day, including nighttime sleep and naps. Sixty-seven mothers reported no difference between work day and non-work day sleep, five reported more sleep on work days (ranging from 1 to 3.5 more hours) and seventy-seven reported less sleep on work days (ranging from 0.5 to 3.5 fewer hours). Values for typical amount of sleep, including nighttime and naps, were averaged to calculate mean hours of sleep prenatally. This measure, then, provides as estimate of mothers' perceived typical nightly sleep patterns.

2.2.3. Infant sleep—Infant sleep was measured both objectively (with actigraphy) and subjectively (using mother-reported sleep diary), over an identical time frame at 8 months of age. Mothers were asked to monitor infants' sleep, by recording sleep in the sleep diary and attaching the actigraph to the infants, for a period of 7 days. If the first week did not include sufficient usable data, families were given an extra week to monitor sleep. Sleep measures were utilized in the current study when they included of at least 5 days of usable actigraphy data.

Sleep-wake activity was measured with an actigraph (Mini-Motion Actigraph, Ambulatory Monitoring, Inc., Ardsley, NY), which is a small device worn on the infant's ankle. Actigraphy is a valid measure of infant sleep-wake patterns in a naturalistic setting (Sadeh, 2015). Activity was measured in 1 min epochs. Actigraphy data was then scored using a validated algorithm (Sadeh, Lavie, Scher, Tirosh, & Epstein, 1991). Infant mean sleep efficiency was the percentage of epochs that the infant was sleeping divided by the total number of epochs. Night-to-night variability in infant sleep efficiency was the standard deviation of infant sleep efficiency across the days wearing the actigraph. Duration of night wakings was the average amount of minutes awake during the night across the days the infant wore the actigraph.

Over the same time period that infants wore the actigraph, mothers recorded infant sleep patterns using a sleep diary. Mothers recorded the time that infants were put to bed and got out of bed for the day, times the infant was asleep, caretaking behaviors, and possible disruptions in the actigraph (e.g., taken off during baths, external motion). Frequency and duration of night wakings are often chosen to measure problematic child sleep (Warren et al., 2006), and as the two constructs were highly correlated in our sample ($p = 0.96$), we chose duration (in min) of time awake at night to represent infant night wakings.

2.2.4. Maternal depressive symptoms—As mothers in the study were over-sampled for a history of depression, the Structured Clinical Interview for DSM-III-R (Spitzer, Williams, Gibbon, & First, 1990) was administered to mothers in the prenatal period and the LIFE (Keller et al., 1987) was administered every 6 months in the postpartum period to assess symptoms and diagnostic criteria on a month-by-month basis. About half of the mothers (93 out of 173) had a lifetime history of major depression. Throughout the study, 80 were depressed prior to pregnancy, 25 during pregnancy, and 48 between 0 and 30 months postpartum.

For the current study, maternal depressive symptoms were measured prenatally and at child age 15 months using the modified Hamilton Rating Scale for Depression (HRSD; Miller, Bishop, Norman, & Maddever, 1985), a 17-item clinician-rated interview assessing current severity of depressive symptoms. The HRSD was administered by doctoral-level clinicians.

2.2.5. Attachment security—The 90-item Attachment Q-Set (Waters & Deane, 1985) was utilized as a measure of attachment security at 30 months, in order to consider a distal goodness of fit outcome of mother-infant sleep processes. The Attachment Q-Set is a well-established home-based attachment assessment, which provides a systematic way of summarizing home observations of child behavior and is thus derived from naturally-occurring behaviors in a child's everyday environment. It was completed at 30 months by the research assistant who conducted the home observations. Given the length of home observations for the larger study, research assistants had extensive knowledge of the families (i.e., at least 6 h of observations). In our laboratory, Q-correlation of independent sorts on the same child by observers (after single 3-h home visits) exceeds the standard of 0.70. Criterion sorts for Security were used for the present analyses. The Security scores had 6 outliers at the low end of the distribution. To minimize the influence of outliers, these 6 cases were recoded to a value of -0.25 to bring them closer to the remaining cases (the nearest score of the remaining cases was -0.23). This Winsorized distribution was used in all analyses presented below.

3. Results

3.1. Data analytic plan

Analyses focused on the relations among prenatal maternal sleep, infant sleep at 8 months, maternal depressive symptoms at 15 months postpartum, and attachment security at 30 months. All regression and path models were tested using Mplus 7.2 (Muthén & Muthén, 1998–2014), using full information maximum likelihood estimation (FIML) to account for missing data (Enders & Bandalos, 2001). First, four multiple regression models, exploring the effect of infant sleep as assessed by (1) mean sleep efficiency measured by actigraphy, (2) variability in sleep efficiency measured by actigraphy, (3) duration of night waking measured by actigraphy, and (4) duration of night waking measured by sleep diary, were conducted. Each regression included maternal depressive symptoms at 15 months as the dependent variable and prenatal maternal sleep, infant sleep at 8 months, and the maternal by infant sleep interaction as the predictor variables. Statistical interactions are the recommended approach for measuring behavior-matching goodness of fit (Plomin &

Daniels, 1984). All analyses also controlled for prenatal maternal depressive symptoms and socioeconomic status (SES). Next, post-hoc probing was conducted to follow up significant interactions using the approach recommended by Aiken and West (1991), wherein the effect of infant sleep on maternal depression was estimated at one standard deviation below the mean, at the mean, and above the mean on the maternal prenatal sleep variable. Finally, for significant interactions, structural equation modeling (SEM) was used to explore the ways in which the interaction between maternal and infant sleep may indirectly affect mother-infant attachment security at 30 months, via maternal depression.

3.2. Associations between sleep and maternal depression

Descriptive statistics and intercorrelations are shown in Table 1. Of note, mother-report of infant night wakings was correlated with actigraphy-measured night wakings at $r = 0.49$ and with actigraphy-measured sleep efficiency at $r = -0.51$, suggesting that the constructs were associated, but tapped into somewhat different representations of infant sleep.

The significant associations between SES and the primary outcome (maternal depressive symptoms at 15 months) led us to covary SES in all analyses. Additional covariates, including marital status, maternal age, child sex, and presence of additional siblings, were explored but were not significantly associated with maternal depression, and thus were not included in the final analyses.

3.2.1. Question 1: are mothers' prenatal sleep, mean infant sleep efficiency at 8 months, and the mother by infant sleep interaction associated with maternal depressive symptoms at 15 months?—Regression analyses predicting maternal depression are displayed in Table 2. In the regression model using mean sleep efficiency as the infant sleep variable (Model 1), maternal depressive symptoms at 15 months postpartum were only predicted by prenatal depressive symptoms.

3.2.2. Question 2: are mothers' prenatal sleep, variability in infant sleep efficiency at 8 months, and the mother by infant sleep interaction associated with maternal depressive symptoms at 15 months?—In the regression model using variability in sleep efficiency (Model 2, Table 2), maternal depressive symptoms at 15 months were predicted by SES, prenatal depression, and the maternal by infant sleep interaction. Probing the significant interaction (see Fig. 1) indicated that maternal prenatal sleep moderated the relation between variability in infant sleep efficiency and maternal depression, such that more variability in infant sleep was associated with higher levels of depression only for mothers who got more sleep in the prenatal period ($\beta = 0.28$, $p = 0.001$). Variability in infant sleep was not associated with maternal depression among mothers who got average ($\beta = 0.14$, ns) or below average ($\beta = 0.01$, ns) amounts of sleep in the prenatal period.

3.2.3. Question 3: are mothers' prenatal sleep, infant night waking at 8 months according to actigraphy, and the mother by infant sleep interaction associated with maternal depressive symptoms at 15 months?—In the regression model using

mean sleep efficiency as the infant sleep variable (Model 3), maternal depressive symptoms at 15 months postpartum were only predicted by SES and prenatal depressive symptoms.

3.2.4. Question 4: are mothers' prenatal sleep, infant night waking at 8 months according to sleep diary, and the mother by infant sleep interaction

associated with maternal depressive symptoms at 15 months?—In the regression model using night waking on the sleep diary as the infant sleep variables (Model 4, Table 2), maternal depressive symptoms at 15 months were predicted by SES, prenatal depression, and the maternal by infant sleep interaction. Probing the interaction (see Fig. 2) suggested that maternal prenatal sleep interacted with infant night waking such that more infant time awake was associated with higher levels of depression for mothers who themselves slept longer in the prenatal period ($\beta = 0.21, p = 0.013$). For mothers who slept less in the prenatal period, more infant time awake was associated with lower levels of depression ($\beta = -0.28, p = 0.015$). Infant time awake was not associated with maternal depression among mothers who got average amounts of sleep in the prenatal period ($\beta = -0.04, ns$).

3.3. Pathway to attachment security

3.3.1. Question 4: does the interaction between mother and infant sleep at 8 months indirectly affect mother-infant attachment security at 30 months, via maternal depressive symptoms?

—The moderated relation between infant sleep and maternal depression depending upon amount of maternal sleep in the prenatal period, as well as the significant correlation between maternal depression and attachment security at 30 months, suggested a potential pathway by which the goodness of fit between mother and infant sleep influenced the mother-child attachment relationship through the impact on maternal depression. Thus, two SEM models (one using variability in sleep efficiency as the infant sleep measure and one using night wakings on the diary as the infant sleep measure) were analyzed to investigate potential moderated mediation, wherein maternal depression at 15 months might mediate the relation between the mother by infant sleep interaction and attachment security at 30 months. Given significant associations between child gender and attachment security, gender was added as a covariate, in addition to SES and prenatal maternal depression. Additional SEM models using mean sleep efficiency and night wakings measured by actigraphy as the infant sleep measures were not tested, as there was no evidence of a mother-infant sleep interaction (i.e., goodness of fit) in those two regression models tested above.

Using variability in sleep efficiency as the infant sleep predictor, a mediated path was not detected. However, using duration of night waking on the sleep diary as the infant sleep predictor, a mediated pathway was identified (see Fig. 3). The model provided a good fit to the data: $\chi^2(2) = 0.63, p = 0.59$; CFI = 1.00; RMSEA = 0.00; SRMR = 0.01. Results revealed a significant indirect effect, such that maternal depression at 15 months mediated the link between the mother by infant sleep interaction and attachment security at 30 months ($\beta = -0.06, p = 0.026$). Results suggest that the emergence of a secure mother-child relationship is predicted, in part, by infant sleep through its effect on maternal depression, but only for mothers and children with poorly matched sleep patterns.

4. Discussion

Research on sleep processes in the postpartum period tends to focus on direct relations between sleep and postpartum depression, without attending to potentially important individual differences in these processes across mother-infant dyads. The current study highlights the importance of match between mother and infant sleep, while also emphasizing the impact of maternal perceptions of infant sleep. Results suggest that goodness of fit between mothers' and infants' sleep patterns contributes to maternal postpartum depressive symptoms, over and above direct effects of maternal prenatal sleep or infant sleep. Further, findings suggest a pathway of influence from goodness of fit of mother-infant sleep to attachment security, through the effect on depressive symptoms.

In contrast to some evidence suggesting direct associations between infant sleep and maternal depressive symptoms (e.g., Dennis & Ross, 2005; Karraker & Young, 2007), we did not find direct relations between infant sleep (neither objectively nor subjectively measured) and the emergence of maternal postpartum depression, when controlling for previous depressive symptoms. Previous evidence (Karraker & Young, 2007) highlighted that subgroups of mother-infant dyads exhibited different patterns of associations between sleep and depression, suggesting that these processes are best understood at a more nuanced level. Similarly, we uncovered more complex, individualized associations between mother and infant sleep.

Infant sleep did not contribute to depression for *all* mothers. Instead, as hypothesized based upon the behavior matching conceptualization of goodness of fit (Seifer et al., 2014), mothers' individual sleep patterns moderated the links between infant sleep difficulties and depression. For mothers who got more sleep prior to the birth of their infants, more variability in infant sleep (i.e., more inconsistency in sleep efficiency from night-to-night measured by actigraphy) and longer perceived infant night wakings measured by sleep diary at 8 months postpartum were associated with increased depressive symptoms at 15 months. Somewhat surprisingly, for mothers who got less sleep before their infants were born, infant night wakings were actually associated with fewer depressive symptoms. This moderated effect might reflect the benefits of mothers and infants with similar biologically-determined sleep patterns and suggests that maternal sleep disruptions in the postpartum period do not universally contribute to depression. In addition, it may be that mothers have varying sleep needs and are differentially tolerant of their infants' awakenings. For example, perhaps mothers who slept less before giving birth were better able to cope with their infants' unpredictable night wakings than mothers who require more sleep. Although additional studies are warranted to test these potential explanations, the results underscore the possible role of fit between infant and mother sleep during the postpartum period (Jenni & O'Connor, 2005; Sadeh & Anders, 1993; Sadeh et al., 2010).

The interplay between mothers' prenatal sleep and infants' sleep (measured by sleep diary) at 8 months produced an indirect effect on mother-child attachment security at 30 months, through the effect of sleep on maternal depression at 15 months. Maternal depression contributes to disruptions in mother-child attachment (Martins & Gaffan, 2000); goodness of fit between mother and infant sleep may provide an additional risk for insecure attachment

due, in part, to the effect on maternal wellbeing. Some mother-infant dyads, including those with poorly fitting sleep patterns, may develop a dysregulated relationship across both day and nighttime, which may, then, set into motion a dynamic process of increasing risk throughout early childhood. This possible pathway of influence from poorly fitting sleep to mother-child attachment through maternal depression deserves further consideration.

Results were not universal across infant sleep measurement approach. When considering mean infant sleep efficiency and mean infant night wakings measured via actigraphy, few associations emerged. However, variability in infant sleep across nights was more predictive of maternal depression, for mother-infant dyads with poorly-matched sleep patterns (i.e., high maternal prenatal sleep and high infant sleep variability). Night-to-night variability is relatively normative during infancy (Sadeh, Acebo, Seifer, Aytur, & Carskadon, 1995). Nevertheless, it may be that mothers who slept more in the prenatal period require more nightly sleep and, perhaps, had a more consistent sleep schedule; thus, unpredictable sleep disruptions may be most challenging for these mothers. Further, in our sample, sleep efficiency was in the normal range for the majority of infants (>90%; Barkoukis & Von Essen, 2012). Thus, unpredictability in nightly infant sleep, more so than overall sleep efficiency, may be more distressing to mothers in our sample.

Mothers' perceptions of their infants' sleep, based on their reports on the sleep diary, may be especially salient in terms of pathways from sleep to maternal depression and mother-child attachment relationships. Although mother-reports of infant sleep may not be entirely accurate in terms of infant night wakings and total sleep time (Sadeh, 1996), mother-reports identify times in which mothers are awoken by their infants. Thus, mother-reported sleep diaries may be most representative of mothers' perceptions of their infants' sleep and, in turn, most indicative of the impact that infant sleep has on mothers. Indeed, maternal perceptions of infant sleep might be most associated with mother-infant fit and attachment security (Simard et al., 2013). Further, the ways that mothers think about infant sleep plays a role in their sleep-related behaviors and infants' sleep patterns (Tikotzky & Sadeh, 2009). Thus, mother-reports of infant sleep provide insight into how infant sleep affects mothers, as an infant who awakes and quietly returns to sleep may not have the same effect on maternal wellbeing as one who signals during the night. The combination of objective and subjective sleep measurements may provide the most comprehensive conceptualization of infant sleep processes, in line with the goodness of fit model.

Of note when interpreting the findings, approximately half of our sample had a lifetime history of depression, which provides rich information about mother-child dyads along a continuum of risk. Depression is bidirectionally associated with sleep disturbance in non-pregnant individuals (Reimann, Berger, & Voderholzer, 2001). During pregnancy, depressed women suffer from more sleep disturbances than non-depressed women (Field, Diego, Hernandez-Reif, Figueiredo, Schanberg, & Kuhn, 2007), and poor sleep quality early in pregnancy may increase depressive symptoms later in pregnancy (Skouteris, Germano, Wertheim, Paxton, & Milgrom, 2008). Further, infants of depressed mothers also experience increased sleep problems (Armitage et al., 2009; Field et al., 2007; Warren et al., 2006). Although we controlled for prenatal depression in all of our analyses, our findings should be interpreted within the context of the high depression rates in our sample. Future work should

also consider these associations in a normative population in order to better generalize our understanding of the impact of mother and infant sleep goodness of fit on maternal depression.

Despite the many strengths, including a longitudinal, multi-method design, several limitations should be considered when interpreting the results. First, the sample was predominantly comprised of middle and upper socioeconomic status, White families, which may limit generalizability. Second, although we utilized appropriate missing data strategies and there was little differential attrition in the sample, not all families completed all measures, with relatively higher proportions of missing data in the sleep measures. Third, mothers reported on their own sleep while pregnant. Mothers were told to report on their typical sleep habits, before pregnancy if they differed from sleep during pregnancy, and the influence of mothers' *perceived* sleep is salient in it of itself. However, mothers' reports were likely not fully representative of their exact sleep patterns, and the impact of pregnancy on sleep may have further affected their reports.

4.1. Conclusions

The goodness of fit concept calls for more a more individualized understanding of parent-child relationships and developmental processes. By examining infant sleep through the lens of goodness of fit, the current study provides more specificity to our understanding of the interplay between infant and mother sleep and the ways in which the match between dyads' sleep patterns contribute to maternal and relational risk. Further, results suggest critical implications for targeting infant sleep with the aim of preventing or alleviating postpartum depression, as a "one-size-fits-all" approach may not be appropriate for all families. Rather, understanding a mother's sleep needs and nighttime behaviors may help shape the best strategy for managing her baby's sleep, early relationship formation, and maternal mood. Future research should continue to elaborate upon the transactional dyadic and family factors which may modify the impact of infant sleep on family processes across the postpartum period.

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Fig. 1.

Plot of simple slopes depicting relation between infant sleep variability (measured by actigraphy) at 8 months and maternal depressive symptoms at 15 months at 1 SD above the mean (high), the mean (mean), and 1 SD below the mean (low) of prenatal mother sleep. Simple slopes which are significant at $p < 0.05$ are denoted with an *.

Fig. 2.

Plot of simple slopes depicting relation between infant night wakings (measured by sleep diary) at 8 months and maternal depressive symptoms at 15 months at 1 SD above the mean (high), the mean (mean), and 1 SD below the mean (low) of prenatal maternal sleep. Simple slopes which are significant at $p < 0.05$ are denoted with an *.

Fig. 3.

Structural equation model predicting attachment security from infant and mother sleep and maternal depressive symptoms. Numbers indicate standardized path coefficients. Solid lines indicate significant pathways. Dashed indicate nonsignificant pathways. Bold lines refer to the mediated pathway. † $p < 0.065$. * $p < 0.05$. ** $p < 0.01$.

Table 1

Descriptive Statistics and Intercorrelations of Key Variables.

Variable	1	2	3	4	5	6	7	8	9	10
1. SES, prenatal	–	0.02	–0.11	0.15	–0.12	–0.16	–0.02	–0.07	–0.19 [*]	0.33 ^{**}
2. Child gender		–	–0.05	0.11	0.00	–0.12	–0.17 [*]	–0.19 [*]	–0.04	0.23 [*]
3. Mother sleep time, prenatal			–	–0.19 [*]	0.20 [*]	0.14	0.11	0.00	0.20 [*]	–0.10
4. Infant mean sleep efficiency, 8 mos.				–	–0.64 ^{**}	–0.97 ^{**}	–0.51 ^{**}	–0.01	–0.19 [*]	0.13
5. Infant variability sleep efficiency, 8 mos.					–	0.62 ^{**}	0.31 ^{**}	0.07	0.33 ^{**}	–0.17
6. Infant night waking actigraphy, 8 mos.						–	0.49 ^{**}	0.02	0.15	–0.10
7. Infant night waking diary, 8 mos.							–	0.12	0.14	–0.22 [*]
8. Mother depression, prenatal								–	0.47 ^{**}	–0.21 [*]
9. Mother depression, 15 mos.									–	–0.34 ^{**}
10. Attachment security, 30 mos.										–
–										
<i>M</i>	5.40	–	8.33	0.94	0.04	37.91	34.56	8.92	5.70	0.35
<i>SD</i>	0.96	–	1.21	0.03	0.03	19.73	34.75	6.79	6.88	0.28
<i>N</i>	173	160	156	133	132	132	143	172	128	132

*
 $p < 0.05$.**
 $p < 0.01$.Bold values indicate significant correlations at $p < 0.05$. Child gender is coded with 1 representing males and 2 representing females. Fifty-three percent of the sample was male.

Table 2
Multiple Regression Models Predicting Maternal Depressive Symptoms at 15 Months Postpartum.

Predictors	Model 1: Actigraphy Mean Sleep Efficiency		Model 2: Actigraphy Variability Sleep Efficiency		Model 3: Actigraphy Duration Night Wakings		Model 4: Diary Duration Night Waking	
	B (SE)	β	B (SE)	β	B (SE)	β	B (SE)	β
	$R^2 = 0.28$		$R^2 = 0.34$		$R^2 = 0.28$		$R^2 = 0.34$	
SES, prenatal	-1.15 (.62)	-0.16	-1.30 (.58) *	-0.18	-1.24 (.63) *	-0.17	-1.22 (.56) *	-0.17
Mother depression, prenatal	0.43 (.07) **	0.43	0.37 (.07) **	0.37	0.43 (.07) **	0.43	0.44 (.07) **	0.44
Mother sleep time, prenatal	0.76 (.51)	0.13	0.69 (.45)	0.12	0.77 (.50)	0.14	0.80 (.44)	0.29
Infant sleep, 8 mos.	-24.30 (18.68)	-0.11	37.50 (27.42)	0.14	0.03 (.03)	0.07	-0.01 (.02)	-0.04
Mother sleep X infant sleep	-8.13 (16.56)	-0.06	32.51 (15.60) *	0.21	0.02 (.07)	0.08	0.04 (.01) **	0.29

Note: The models differ based on the infant sleep measurement used as a predictor in the respective regression analysis

* $p < 0.05$.

** $p < 0.01$.

Bold values indicate significant parameter estimates at $p < 0.05$.