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Objective and subjective sleep and caregiving feelings in mothers of infants: a longitudinal daily diary study

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Abstract

Study Objectives: This study explored the links between mothers' objective and subjective sleep and their caregiving feelings toward their infant (i.e. patience for the infant, desire to be with the infant, and anger toward the infant), using a diary study design. We were particularly interested in examining whether nights of lower sleep quality within individual mothers predict more negative maternal caregiving feelings the following day.

Methods: The sample included 151 women, who were recruited during pregnancy. Data were collected at 4 and 8 months after delivery. Maternal sleep was monitored at home for seven nights using actigraphy and sleep diaries. Mothers rated their caregiving feelings each evening.

Results: Multilevel modeling (controlling for depressive symptoms, feeding method, and background variables) revealed that actigraphic and subjective sleep variables were associated with maternal caregiving feeling, both at the between- and within-person levels. For example, lower sleep percent predicted reduced levels of maternal patience for the infant at 4 and 8 months (between-person effect). Moreover, when a mother had a lower sleep percent on a given night (compared to her average), she reported lower levels of patience for her infant the following day (within-person prospective effect).

Conclusions: The findings demonstrate, for the first time, that maternal nightly variations in objective and subjective sleep quality predict daily changes in maternal feelings toward her infant at two different assessment points. Improving maternal sleep quality might be an important target for future interventions which may help mothers to feel more positively toward their infants.

Statement of Significance

Research suggests that disturbed maternal sleep is associated with compromised mother-infant relationship. However, previous work was mainly based on cross-sectional designs and self-reported measures. The present longitudinal study employed a diary-study design to examine, for the first time, whether nightly fluctuations in maternal sleep quality explain day-to-day disruptions in the mother-infant relationship. Our analyses revealed that when a mother had lower objective and subjective sleep quality on a given night, she reported lower levels of patience for her infant and more anger on the following day. Future studies should explore the role of emotional regulation and energy depletion in explaining these links and examine generalizability to fathers. Sleep intervention may be helpful in improving the mother-infant relationship.

Key words: sleep; mother; infant; diary study; actigraphy; mother-infant relationship; caregiving

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Introduction

Positive parenting (e.g. sensitivity, warmth) has been consistently associated with various child developmental outcomes, including better cognitive, social, and emotional functioning [1–3]. Thus, identifying factors that promote positive parent-infant relationships during the postpartum period, a challenging and stressful period for many parents, is crucial to minimize the risk for negative developmental outcomes [3, 4]. Research has demonstrated that maternal depression and poor maternal self-regulation may increase the risk for compromised mother-infant interactions and relationships [5–8]. Another factor that may influence the quality of the parent-infant relationship is disturbed parental sleep. Broad evidence has demonstrated that, across the life span, sleep disturbances negatively affect emotional, cognitive, and relationship functioning [9–14]. Nevertheless, only recently has research begun to investigate how parental sleep disturbances contribute to parental functioning and parent-child relationships [15–18].

The paucity of research on parents of young children in this context is surprising, given that, due to reasons such as the unconsolidated nature of infant sleep, hormonal changes, and psychological factors (e.g. parenting stress), mothers of infants frequently suffer from sleep disturbances [19–24] and are, therefore, at risk for the negative implications of poor sleep. Moreover, maternal sleep disturbances are associated with greater maternal emotional distress [25–29] and increased levels of sleepiness and fatigue, which may persist long into the postpartum period [30–32].

Recent studies have started to examine the role of maternal sleep disturbances in explaining the quality of the mother-infant relationship. The first studies on this topic examined whether disturbed maternal sleep predicts the mother's subjective experience of her attachment relationship with her infant [17, 33, 34], specifically focusing on facets of maternal attachment that have been previously associated with maternal depression [35]. These aspects include maternal pleasure in proximity and desire for interaction with the infant, tolerance and patience for the infant, and negative feelings toward the infant, such as frustration and anger [36]. For instance, in women who were depressed during pregnancy, poorer subjective maternal sleep at 3 months was a significant predictor of lower maternal acceptance and tolerance of her infant at 6 months, suggesting that in the face of disturbed sleep, the infant's needs may be experienced as a burden, leading to feelings of anger [34]. Similar results were found in a nonclinical sample of mothers of infants aged 3–18 months; higher levels of insomnia symptoms and poorer maternal sleep assessed by sleep diaries were associated with lower maternal bonding scores. In particular, mothers who reported poorer sleep quality were less likely to enjoy being with the infant, more likely to feel distant from their infants, and more likely to feel angry and annoyed with the infant [17]. Maternal negative feelings, such as anger toward the infant, are an important area of research in the context of maternal sleep disturbances, as they may have long-term effects on infant development and on the nature of interactions between mothers and infants [37–39].

Although these studies highlight the importance of considering maternal sleep as a factor that may contribute to the evolving mother-infant relationship, they were limited by their sole reliance on maternal subjective reports of both their sleep and relationship with their infant. In fact, only a few studies

have examined the links between objective maternal sleep and observed quality of maternal behavior or the mother-infant relationship. King et al. [40] found that mothers with poorer objective (actigraphic), but not self-reported sleep quality, showed decreasing sensitivity toward their 18-month-old infants during a 10-minute play interaction in their home environments. Similarly, in a study of 314 mothers of toddlers, actigraphic sleep quality (e.g. sleep activity, sleep onset latency) was associated with less observed positive parenting (e.g. parental responsiveness, involvement) during the hour before the child's bedtime, even after controlling for stress and socio-demographic measures [15]. Last, using multilevel modeling (MLM), Bai et al. [41] found that mothers with more irregular sleep patterns (e.g. greater average variability in sleep period) demonstrated lower emotional availability at bedtime, especially when infants were 6 months old.

These studies provide valuable information about the links between poor maternal sleep quality and the difficulties mothers may experience in providing sensitive care to their infants and in regulating their feelings toward their infants. However, these studies used cross-sectional and large-interval (between time points) longitudinal designs, which focused mainly on analyzing the links between maternal sleep and the mother-infant relationship based on mean levels of the variables across a given period. In addition to this important work, it is essential to understand whether natural *nightly fluctuations* in maternal sleep quality may account for day-to-day disruptions in the mother-infant relationship. This is a more fine-tuned question that may help clarify the temporal relationship between these variables on a daily basis. The most appropriate methodology to capture these daily variations is a diary study design. In addition, daily diary studies have the advantage of reducing recall bias and improving measurement accuracy compared to single-point assessments, which are vulnerable to retrospective recall biases [42, 43].

Previous diary studies on sleep and daytime functioning in adults have demonstrated that nights characterized by poorer sleep quality and longer sleep latency (i.e. longer time taken to fall asleep) predict lower positive affect and higher negative affect and fatigue on the following day. These links were found across both healthy and clinical samples [43–47]. Notably, most of these studies were based on self-report measures of both sleep and functioning, and only a few studies assessed sleep with a daily objective measure. The findings of these studies are far less consistent and provide only limited support for significant associations between sleep quality and following-day mood [48–50].

To the best of our knowledge, so far only one study focused on the role of nightly sleep quality fluctuations in parents of young children. The findings showed that in first-time mothers (3–6 months after delivery), above-average sleep quality on a certain night buffered the effects of daily negative social interaction on mood [51]. However, that study focused on general mood as the main outcome and did not examine parenting quality.

Diary studies of parenting have demonstrated that parental behaviors and emotional responses towards their children are not entirely stable and are likely to fluctuate to some degree on a daily basis [52, 53]. Sleep quality may be one factor that affects parents' ability to regulate their day-to-day interactions and feelings about their children. Still, as described above, links

between maternal sleep quality and the mother-infant relationship have only been examined based on mean-level associations and not as a dynamic, daily phenomenon.

Thus, in the present study, we applied a diary study design to examine whether nights of lower sleep quality and duration within individual mothers predict negative maternal caregiving feelings the following day. We focused on maternal caregiving feelings (i.e. a desire for proximity with the infant, patience for the infant, and anger toward the infant) that can be measured on a day-to-day basis and are closely linked with mother's attachment to her infant. As described above, previous studies reported significant associations between mother-infant attachment and maternal depression and reported maternal sleep [17, 35, 36]. Moreover, we used actigraphy, in addition to maternal daily reports of sleep, to limit shared method variance and to examine whether changes in maternal caregiving feelings are predicted by both objective sleep measures and her own reports of sleep.

We expected to find both between- and within-person effects of maternal sleep on caregiving feelings. Thus, our first hypothesis was that maternal lower sleep quality and shorter sleep duration across the assessment periods would predict more negative maternal caregiving feelings (between-person effect). Our second hypothesis was that poorer maternal sleep quality and shorter sleep duration on one night would prospectively predict more negative caregiving feeling the following day (within-person effect).

Methods

Participants

One hundred and fifty-one married Israeli women expecting their first ($n = 135$) or second ($n = 16$) child were recruited during pregnancy through prenatal courses and announcements on internet forums for expectant parents. Inclusion criteria included a singleton, full-term pregnancy (i.e. > 37 weeks), and complete mastery of Hebrew. Exclusion criteria were maternal chronic health conditions, including breathing-related sleep problems (based on self-report).

Procedures

The study was approved by the Helsinki Committee of Soroka Medical Center in Israel. All participants signed informed consent before the first study assessment (third trimester of pregnancy). The analyses presented in this study are based on two assessment points (4 and 8 months after delivery). At each assessment point, participants were visited at their homes by a research assistant, who instructed them about the study procedures (e.g. actigraphy use and diary completion). Maternal and infant sleep was assessed for seven weeknights (i.e. weekends were not included) using actigraphy and sleep diaries. Mothers completed the sleep diaries in the morning and then reported on their feelings toward the infant that same evening. Assessments took place only on days when the mother and infant slept at home and were healthy. Questionnaires were used to assess maternal depressive symptoms, socio-demographic measures, and feeding methods. After completing each assessment week, participants received a small gift (value of about 20\$) and a graphic report of their actigraphic sleep.

Measures

Actigraphy. Actigraphy, a motility-based watch-like device, has been established as a reliable and valid objective method to continuously assess sleep-wake patterns in the participants' natural sleep environment [54, 55]. We used the micromotion logger sleep watch (Ambulatory Monitoring, Inc. Ardsley, NY) with a 1 min epoch interval, according to the standard working mode for sleep-wake scoring. The Actigraphic Sleep Analysis (ASA) program was used to score the data, based on Sadeh's validated scoring algorithm for adults [55]. Sleep onset was defined as the first minute after reported bedtime that was identified as sleep by the ASA sleep-wake algorithm and that was followed by at least 15 min of uninterrupted sleep. The end of the night was defined as the last minute identified as sleep that was preceded by at least 15 min of uninterrupted sleep [56]. Mothers were asked to wear the actigraph on their nondominant wrist and to attach it to the infant's ankle 15 min before they went to bed and to remove it 15 min after they woke up. Most mothers and infants (~85%) had valid actigraphy data for at least five assessment nights per assessment period—the minimum number of nights recommended for obtaining reliable measures [57]. However, because of technical problems (e.g. actigraph fell off in the middle of the night), some data were missing. Because fewer than 5 days have been reported before with reasonable reliability [58] and to maximize available data, we retained participants with at least three nights, after ensuring that the mean scores of actigraphic measures for mothers and infants with fewer than five nights were not significantly different than those who were assessed for five or more nights. Thus, the minimum number of nights to be included in the analyses was three. Actigraphy data were obtained for at least three nights for 96.9% of mothers and 91.6% of infants at 4 months and 93.5% of mothers and 87.6% of infants at 8 months.

The actigraphic measures included in the present study were (1) sleep minutes—true sleep time, excluding night-time wakefulness; and (2) sleep percent—percentage of sleep minutes out of total sleep period (from sleep onset to morning wake-up time).

Sleep diaries. Sleep diaries are commonly used in sleep research and have been validated relative to objective sleep measures such as polysomnography [59]. In the present study, mothers were instructed to complete sleep diaries of their own and their infant's sleep in parallel to the actigraphic assessment. These diaries were completed in the morning following each assessment night. Diary data were obtained for at least three nights for all mothers and infants.

The sleep measures included in the study were: (1) Sleep minutes; (2) Sleep percent (ratio calculated based on maternal reports of sleep minutes and total sleep period); (3) Sleep quality—subjective sleep quality as rated on a 1–10 Likert scale ("rate the quality of your own/your infant's sleep last night: 1 = very poor; 10 = excellent").

Actigraphic and diary sleep measures were significantly correlated: The correlations between actigraphic and diary sleep percent were 0.52 ($p < .001$) at 4 months and 0.47 ($p < .001$) at 8 months. The correlations between actigraphic and diary sleep minutes were 0.66 ($p < .001$) at 4 months and .66 ($p < .001$) at 8 months.

Maternal caregiving feelings. Each evening, mothers rated the level of agreement with statements regarding their feelings toward

the infant on a 1–5 Likert scale (1 = highly disagree; 5 = highly agree). The following statements were presented: (1) “Today I had patience to care for my baby”; (2) “Today I had a desire to be with my baby”; (3) “Today I felt anger toward my baby.” As presented in Table 1, the correlations of these statements across the 4-month and 8-month assessments were in the moderate to strong range.

The three statements were chosen based on three subscales from the validated Maternal Postnatal Attachment Questionnaire (MPAQ) [36], a self-report questionnaire used to assess mother-to-infant attachment. Specifically, our “patience,” “desire,” and “anger” statements are based on the MPAQ Competence (“The mother perceives herself as being *patient* in interactions with the baby”), Proximity (“A *desire* for proximity, and enjoyment of interaction with the infant”), and Tolerance (“An absence of feelings of anger and hostility towards the baby”) subscales respectively [36].

The Edinburgh Postnatal Depression Scale. The Edinburgh Postnatal Depression Scale (EPDS) is a widely used screening tool for postpartum depression that has been validated for use in the postpartum period [60]. It consists of 10 short statements asking about depressive symptoms during the past week. Each item is rated on a 4-point scale (0–3), and the total score ranges from 0 to 30, with a higher score representing greater depressive symptom severity. In the present study, Cronbach’s alpha was .77 at 4 months and .73 at 8 months. At 4 months, three mothers scored above the clinical cutoff of >12, and at 8 months only one mother scored > 12. EPDS was used as a covariate in the present study.

Background data. During the third trimester of pregnancy, mothers were asked to provide the following background

information: age, education (high-school education, bachelor’s degree, master’s degree, doctoral degree), household income (1–3 Likert scale ranging: 1 = below average; 2 = average; 3 = above average). Feeding method was assessed at 4 and 8 months using a 3-point scale: (1) exclusive breastfeeding (BF); (2) partial BF; (3) formula feeding. Information on the number of children and infant gender was collected at 4 months.

Analytic Approach

Our data had a nested structure, as nights nested within stages, and stages nested within participants (i.e. each participant had two stages, with several nights in each stage) [61]. Therefore, we first ran a set of unconditional models to test whether the data necessitated the use of MLM. The results of these models indicated that a three-level structure fitted the data best. The intraclass correlations (ICCs) for the three measures of maternal caregiving feelings at level 3 were .33, .49, .18, for patience for the infant, desire to be with the infant, and anger toward the infant, respectively. The ICCs at level 2 were .07, .05, .08, for “patience,” “desire,” and “anger,” respectively. This suggests that considering between-person (level 3), between-stage (level 2), and within-person (level 1) variability is necessary. Thus, even though our hypotheses focused on between-person and within-person effects, the between-stage effects were also included in our models.

To test our hypotheses, we ran a series of three-level MLMs, one for each of the five sleep variables (i.e. diary and actigraphic sleep minutes, diary and actigraphic sleep percent, and diary subjective sleep quality) to predict each of the three outcomes (i.e. maternal patience for the infant, desire to be with the infant, and anger toward the infant). Fifteen models were estimated in total. These models included predictors at the three levels.

Table 1. Descriptive statistics, repeated-measures t-tests, and Pearson correlations across assessments

	4 Months (N =130)		8 Months (N =108)			
	Mean (SD)	Range	Mean (SD)	Range	t(df)	r
Maternal sleep						
Diary sleep percent	88.51 (7.10)	63.05–100.00	90.97 (6.82)	63.73–100.00	−4.15*** (104)	.58***
Act sleep percent	86.90 (6.67)	68.58–99.43	89.41 (6.47)	70.15–98.81	−2.93** (96)	.46***
Diary sleep minutes	405.94 (53.40)	276.38–527.83	394.85 (51.80)	276.00–493.60	1.92 (104)	.45***
Act sleep minutes	394.79 (48.69)	268.50–504.00	385.55 (49.43)	261.00–503.14	1.57 (96)	.37***
Sleep quality	6.21 (1.33)	1.00–9.71	6.26 (1.46)	2.14–9.14	−.52 (104)	.49***
Infant sleep						
Diary sleep percent	93.44 (4.20)	78.80–100.00	94.76 (3.86)	80.39–100.00	−3.10** (101)	.48***
Act sleep percent	87.78 (6.48)	67.50–98.69	90.13 (5.78)	74.52–98.73	−3.36** (85)	.16
Diary sleep minutes	590.29 (64.47)	420.86–764.29	599.01 (58.12)	451.67–742.50	−1.24 (101)	.54***
Act sleep minutes	537.95 (75.62)	348.50–738.50	557.64 (65.30)	375.35–712.14	−.19* (85)	.39***
Sleep quality	7.04 (1.29)	3.50–10.00	6.84 (1.45)	2.86–10.00	4.78*** (101)	.39***
Maternal caregiving feelings						
Patience	4.45 (.53)	2.80–5.00	4.50 (.51)	2.89–5.00	.06 (104)	.63***
Desire	4.49 (.58)	1.57–5.00	4.57 (.61)	1.00–5.00	−.57 (104)	.80***
Anger	1.17 (.33)	1.00–2.60	1.16 (.30)	1.00–2.33	−.73 (104)	.44***

Sleep percent—the percentage of nocturnal sleep minutes out of night duration (from sleep onset to morning awakening); *Sleep minutes*—true sleep time; *Sleep quality*—maternal subjective evaluation of sleep quality (1 = poor; 10 = excellent); *Patience*—“Today I had patience to care for my baby” (1 = highly disagree; 5 = highly agree); *Desire*—“Today I had a desire to be with my baby” (1 = highly disagree; 5 = highly agree); *Anger*—“Today I felt anger toward my baby” (1 = highly disagree; 5 = highly agree).

* $p < .05$, ** $p < .01$, *** $p < .001$.

Specifically, the between-person effect examined the association between the deviation of the mother's sleep average from the sample's sleep average and maternal caregiving feelings across the assessment period. The between-stage effect examined the association between the deviation of a specific stage sleep average from the mother's sleep average level and maternal caregiving during this specific stage. Finally, the within-person effect examined the association between the deviation of a specific night sleep from the mother's sleep average on a specific stage and maternal caregiving feelings the following day. The intercept and slopes were considered to be random. However, the final models included only random effects that significantly improved model fit (as determined by the deviance test) [62]. In addition, BF (dummy coded) and maternal depressive symptoms were included as level-2 covariates. Maternal age, maternal education (dummy coded), and household income (dummy coded) were included as level-3 covariates. Finally, we tested whether the within-person and between-person sleep effects interacted with the level-2 stage variable (effect coded as $-.5$ and $.5$). The generic models' equations are described in the [Supplementary Material](#).

All analyses were performed in the R software environment [63]. "lmerTest" package [64] was used for estimating MLMs, "performance" package [65] for ICC calculation, and "emmeans" package [66] for simple slopes estimation.

Results

Preliminary analysis

Sample characteristics. Demographic characteristics were collected during the third trimester of pregnancy. Mothers were between 22 and 37 years old ($M = 28.85$, $SD = 2.77$). Most participants had a bachelor's degree or higher (86%), and most reported having an average (23.8%) or higher (48.3%) household income. At 4 months, the sample included 76 female infants (58%).

Of the 151 mothers recruited, 18 dropped out from the study before the 4 months assessment point, and 25 dropped out before the 8 months assessment. Three mothers completed the 8-month, but not the 4-month, assessment. The main reasons for discontinuation were overload or change of residence. The families who withdrew from the study were compared to the retained families on socio-demographic variables, and those who withdrew at 8 months were also compared to participating families on the main variables (i.e. sleep and maternal caregiving feelings) at 4 months. No differences were found for any of the variables except for one of the three maternal caregiving scales: maternal patience to care for her infant at 4 months ($t_{(129)} = 2.18$, $p < .05$). Mothers who withdrew from the study at 8 months reported lower level of patience (Mean = 4.25, $SD = .62$) than mothers who participated (Mean = 4.50, $SD = .49$).

Descriptive statistics and comparison between the two assessment points. Descriptive statistics of the study's variables are presented in [Table 1](#).

Repeated-measures t-tests were conducted to examine changes in maternal and infant sleep and in maternal caregiving feelings from 4 to 8 months after delivery. For mothers, the analysis indicated a statistically significant increase in actigraphic and diary sleep percent from 4 to 8 months. For infants, a significant increase from 4 to 8 months was found in actigraphic and diary sleep percent, actigraphic sleep minutes,

and diary sleep quality ([Table 1](#)). There were no significant differences in maternal caregiving feelings between the 4-month and 8-month assessments.

Pearson correlations were calculated for all measures between the 4-month and 8-month assessments. Significant correlations were found for all maternal and infant sleep variables (except infant actigraphic sleep percent) across the two assessments. Maternal caregiving feelings were also significantly associated across the two assessments ([Table 1](#)).

Correlations between maternal and infant sleep. Maternal and infant sleep measures were significantly correlated. The correlation for actigraphic sleep percent was .34 ($p < .001$) at 4 months and .33 ($p < .001$) at 8 months. For diary sleep percent, the correlation was .76 ($p < .001$) at 4 months and .80 ($p < .001$) at 8 months. The correlation for actigraphic sleep minutes was .22 at 4 months ($p < .05$) and .16 (ns; $p > .05$) at 8 months. For diary sleep minutes, the correlation was .37 ($p < .001$) at 4 months and .38 ($p < .001$) at 8 months. Last, the correlation for diary sleep quality was .66 ($p < .001$) at 4 months and .79 ($p < .001$) at 8 months.

Correlations between background variables and main study variables. Pearson or Spearman correlations were estimated between the background variables (i.e. mothers' age, education, income, feeding method) and the sleep and maternal caregiving feeling measures to examine whether any background variables should be controlled for in the main analyses ([Table 2](#)). A few significant correlations were found between the sleep and the background variables: Higher maternal age was negatively associated with actigraphic sleep percent at 4 months ($r = -.18$, $p < .05$) and with diary sleep percent at 8 months ($r = -.24$, $p < .05$). It was also positively associated with actigraphic sleep minutes at 8 months ($r = .22$, $p < .05$). Higher household income was negatively associated with diary sleep percent at 4 months ($r = -.22$, $p < .05$). There were also some significant correlations with the feeding method (a three-level variable—exclusive BF, partial, none). BF at 4 months was associated with lower sleep percent ($r = .23$, $p < .01$) and lower maternal subjective sleep quality ($r = .29$, $p < .01$). The only maternal caregiving feeling measure associated with BF was maternal report of lower anger toward the infant at 4 months ($r = .23$, $p < .01$). Because of these significant correlations, feeding method and the background variables (i.e. maternal age, education, and household income) were controlled for in subsequent analyses.

As previous research has demonstrated significant links between maternal depression and sleep, as well as between maternal depression and parenting quality [3, 6, 26, 28], we calculated Pearson correlations between the main study variables and maternal depressive symptom scores (i.e. EPDS) to examine whether EPDS should be controlled for in the main analyses (see [Table 2](#)). EPDS was not associated with maternal sleep but was significantly associated with all three measures of maternal caregiving feelings at 4 months and with maternal reports of patience and anger at 8 months. Because of these consistent correlations, EPDS was controlled for in subsequent analyses.

Main analyses: Maternal sleep predicting maternal caregiving feelings

Our main analyses focused on examining between- and within-person effects of maternal sleep on her caregiving feelings.

Table 2. Descriptive statistics of covariates (maternal depressive symptoms, feeding method, maternal age, household income, and maternal education) and Pearson/Spearman correlations between the covariates and maternal sleep and caregiving feelings at 4 and 8 months

	EPDS		Feeding method		Maternal age		Household income		Maternal education	
	4 Months	8 Months	4 Months	8 Months	4 Months	8 Months	4 Months	8 Months	4 Months	8 Months
Mean (SD)	4.26 (3.25)	4.35 (2.99)			29.00 (2.74)					
Range	0.0–13.0	0.0–13.0			22.00–37.00					
%			Full BF 65.9	Full BF 30.6			Below-average 29.00		High-school education 9.93	
			Part BF 19.7	Part BF 30.6			Average 22.91		Bachelor degree 55.72	
			Formula 14.4	Formula 38.8			Above-average 48.09		Master/Doctoral degree 34.35	
Diary	4 Months	8 Months	4 Months	8 Months	4 Months	8 Months	4 Months	8 Months	4 Months	8 Months
Sleep percent	-.06	-.13	.17	.16	-.16	-.24*	-.22*	-.17	-.11	.03
Sleep minutes	-.09	-.12	.11	.02	.04	.04	-.15	-.13	-.08	-.01
Sleep quality	.01	.14	.29**	.08	-.03	-.07	.12	.04	.05	-.06
Actigraphy										
Sleep percent	.02	.06	.23**	.23	-.18*	.01	-.14	-.04	-.08	.07
Sleep minutes	-.01	-.03	.05	.09	.08	.22*	-.01	-.05	-.05	.06
Maternal feelings										
Patience	-.38**	-.31**	-.07	.02	-.15	-.08	-.03	-.04	-.11	-.19
Desire	-.35**	-.16	-.13	-.06	-.15	-.15	-.04	-.12	-.17	-.19
Anger	.23**	.23*	.23**	-.04	.07	.12	-.09	.00	.00	.11

EPDS—the Edinburg Postnatal Depression Scale; Feeding method—breastfeeding (BF): 1 = full BF; 2 = partial BF; 3 = formula; Maternal education—1 = high-school education; 2 = bachelor degree; 3 = master/doctoral degree; household income—1 = below-average; 2 = average, 3 = above-average (the average was defined according to the Israeli Central Bureau of Statistics).

Sleep percent—the percentage of nocturnal sleep minutes out of night duration (from sleep onset to morning awakening); Sleep minutes—true sleep time; Sleep quality—maternal subjective evaluation of sleep quality (1 = poor; 10 = excellent); Patience—“Today I had patience to care for my baby”; Desire—“Today I had a desire to be with my baby”; Anger—“Today I felt anger toward my baby” (for the three caregiving feelings: 1 = highly disagree; 5 = highly agree).

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

Between- and within-person correlations between maternal sleep and maternal feelings toward the infant are displayed in [Supplementary Table 1](#). The fixed effects from the MLMs are presented in [Table 3](#). To illustrate some of the effects, [Figure 1](#) presents the between- and within-person effects of actigraphic and diary sleep percent predicting maternal patience for her infant at 4 and 8 months.

Between-person effects

ACTIGRAPHIC SLEEP MEASURES. The between-person effect of sleep percent was positively associated with maternal patience for the infant and desire to be with the infant—higher maternal sleep percent was associated with more positive maternal caregiving feelings. There was also a significant interaction of this sleep variable with stage in predicting maternal anger. Simple slope analysis indicated that sleep percent was negatively associated with maternal anger at 4 months (Est. = $-.02$, SE = $.00$, Std. Est. = $-.18$, $p < .001$); no such association was found at 8 months (Est. = $-.00$, SE = $.01$, Std. Est. = $-.09$, $p = .52$). The between-person effect of sleep minutes was not associated with any of the three maternal caregiving feelings.

DIARY SLEEP MEASURES. The between-person effects of sleep percent interacted with stage in predicting maternal patience for the infant and desire to be with the infant. Simple slope

analyses revealed that this variable was positively associated with maternal patience (Est. = $.02$, SE = $.01$, Std. Est. = $.12$, $p < .05$) at 8 months but not at 4 months (Est. = $.00$, SE = $.01$, Std. Est. = $.03$, $p = .91$ for patience). Although sleep percent also interacted with stage in predicting maternal desire to be with the infant, the simple slope analyses were not significant at 4 months (Est. = $.00$, SE = $.01$, Std. Est. = $.03$, $p = .94$) or 8 months (Est. = $.02$, SE = $.01$, Std. Est. = $.09$, $p = .10$). The between-person effects of sleep minutes were not significant regarding any of the three maternal feelings. The between-person effect of sleep quality was positively associated with maternal patience and negatively associated with maternal anger; higher maternal sleep quality was associated with more patience and lower anger.

Within-person effects

ACTIGRAPHIC SLEEP MEASURES. The within-person lagged effect of sleep percent was positively associated with maternal patience; when a mother had lower actigraphic sleep percent than her average on a given night, she reported a lower level of patience for her infant the following day. The within-person lagged effect of sleep minutes was not associated with any of the three maternal caregiving feelings.

DIARY SLEEP MEASURES. The within-person lagged effect of sleep percent was positively associated with maternal patience for the infant and desire to be with the infant; when a mother

Table 3. Multi Level Models (MLM) of maternal diary and actigraphic sleep measures predicting maternal caregiving feelings at 4 and 8 months (controlling for depressive symptoms, feeding method, maternal age, maternal education, and household income)

		Patience				Desire				Anger			
		Diary		Actigraphy		Diary		Actigraphy		Diary		Actigraphy	
Predictor		Est. (SE)	Std. Est.	Est. (SE)	Std. Est.	Est. (SE)	Std. Est.	Est. (SE)	Std. Est.	Est. (SE)	Std. Est.	Est. (SE)	Std. Est.
Sleep percent	Intercept	4.55 (.12)	-.76	4.63 (.19)	-.88	4.72 (.19)	-.48	4.79 (.19)	-.40	1.15 (.09)	0.71	1.07 (.10)	0.43
	Time	.01 (.06)	0	.06 (.07)	0.04	.01 (.05)	0	.05 (.06)	0.04	.01 (.04)	0.02	-.05 (.04)	-.05
	Sleep percent BP	.01 (.01)	.08 ^b	.03 (.01)	.23***	.01 (.01)	0.06	.02 (.01)	.16*	-.01 (.00)	-.06	-.01 (.00)	-.14*** ^a
	Sleep percent BS	.01 (.01)	0.09	.01 (.01)	0.08	.02 (.01)	.13**	.01 (.01)	0.04	-.01 (.00)	-.13*	.00 (.01)	-.01
	Sleep percent WP	.01 (.00)	.10***	.01 (.00)	.11**	.00 (.00)	.05*	.00 (.00)	0.03	.00 (.00)	-.01	-.01 (.00)	-.06
	Sleep percent BP × Time	.03 (.01)	.09*	.01 (.01)	0.03	.02 (.01)	.06*	.01 (.01)	0.02	-.01 (.01)	-.05	.02 (.01)	.09*
	Sleep percent WP × Time	.01 (.01)	0.04	.01 (.01)	0.04	.00 (.00)	-.02	.00 (.01)	-.01	.00 (.00)	-.01	.00 (.01)	-.01
Sleep minutes	Intercept	4.57 (.19)	-.85	4.51 (.20)	-.97	4.72 (.19)	-.57	4.72 (.20)	-.44	1.20 (.10)	0.81	1.12 (.11)	0.49
	Time	.02 (.07)	0.01	.05 (.07)	0.03	.03 (.06)	0.02	.05 (.05)	0.03	.01 (.04)	0.01	-.05 (.04)	-.05
	Sleep minutes BP	.00 (.00)	-.05	.00 (.00)	0.05	.00 (.00)	-.05	.00 (.00)	0.06	.00 (.00)	0.04	.00 (.00)	-.02
	Sleep minutes BS	.00 (.00)	-.03	.00 (.00)	-.05	.00 (.00)	0.02	.00 (.00)	-.04	.00 (.00)	0.01	.00 (.00)	0
	Sleep minutes WP	.00 (.00)	.07*	.00 (.00)	0.05	.00 (.00)	0.01	.00 (.00)	0.03	.00 (.00)	-.02	.00 (.00)	-.06
	Sleep minutes BP × Time	.00 (.00)	0.03	.00 (.00)	-.02	.00 (.00)	0.03	.00 (.00)	-.01	.00 (.00)	-.01	.00 (.00)	0.03
	Sleep minutes WP × Time	.00 (.00)	0.05	.00 (.00)	0.02	.00 (.00)	0.01	.00 (.00)	0.02	.00 (.00)	0.02	.00 (.00)	0.02
Sleep quality	Intercept	4.59 (.19)	-.76			4.76 (.19)	-.47			1.17 (.10)	0.68		
	Time	.03 (.06)	0.02			.04 (.05)	0.03			-.01 (.04)	0		
	Sleep quality BP	.10 (.04)	.14*			.08 (.04)	0.11			-.06 (.02)	-.13**		
	Sleep quality BS	.06 (.04)	0.07			.07 (.03)	.07*			-.05 (.02)	-.08*		
	Sleep quality WP	.07 (.01)	.14***			.03 (.01)	.06*** ^a			-.02 (.01)	-.07*		
	Sleep quality BP × Time	.04 (.05)	0.03			-.01 (.04)	-.01			.05 (.03)	0.05		
	Sleep quality WP × Time	.00 (.03)	0			-.05 (.02)	-.05*			.03 (.02)	0.04		

Sleep percent—the percentage of nocturnal sleep minutes out of night duration (from sleep onset to morning awakening); *Sleep minutes*—true sleep time; *Sleep quality*—maternal subjective evaluation of sleep quality (1 = poor; 10 = excellent); *Patience*—"Today I had patience to care for my baby"; *Desire*—"Today I had a desire to be with my baby"; *Anger*—"Today I felt anger toward my baby" (for the three caregiving feelings: 1 = highly disagree; 5 = highly agree).

^aSignificant only at 4 months postpartum.

^bSignificant only at 8 months postpartum.

BP, between-person effects; BS, between-stage effects; WP, within-person effects.

* $p < .05$, ** $p < .01$, *** $p < .001$.

had lower diary-based sleep percent than her average on a given night, she reported more negative caregiving feelings the following day. Moreover, the within-person lagged effect of *sleep minutes* was positively associated with maternal patience, and the within-person lagged effect of *sleep quality* was positively associated with maternal patience and negatively associated with maternal anger. In addition, *sleep quality* interacted with stage in predicting maternal desire to be with the infant the following day. Simple slope analyses revealed a significant effect at 4 months (Est. = .06, SE = .01, Std. Est. = .09, $p < .001$), but no such lagged effect was found at 8 months (Est. = .00, SE = .02, Std. Est. = .04, $p = .89$).

Between-stage effects

ACTIGRAPHIC SLEEP MEASURES. There were no significant between-stage effects of sleep percent and sleep minutes on any of the three maternal feelings.

DIARY SLEEP MEASURES. The between-stage effect of *sleep percent* was positively significant with maternal desire to be with the infant and negatively significant with maternal anger toward

the infant; when a mother had higher diary sleep percent on a specific stage than her average across stages, she reported more positive caregiving feelings at this stage. The between-stage effect of *sleep minutes* was not significant in regard to any of the three maternal caregiving feelings. Finally, the between-stage effect of *sleep quality* was positively significant with maternal desire to be with the infant and negatively significant with maternal anger toward the infant.

Discussion

The findings of the present study demonstrate for the first time that maternal nightly variations in sleep quality predict daily changes in maternal feelings toward her infant. The findings support previous studies that demonstrated cross-sectional and macro-longitudinal links between maternal sleep quality and the mother-infant relationship [6, 15, 17, 34, 40].

Our findings revealed significant associations between maternal objective and subjective sleep quality (sleep percent and subjective ratings of sleep quality) and her feelings toward the infant at 4 and 8 months after delivery both on a within and

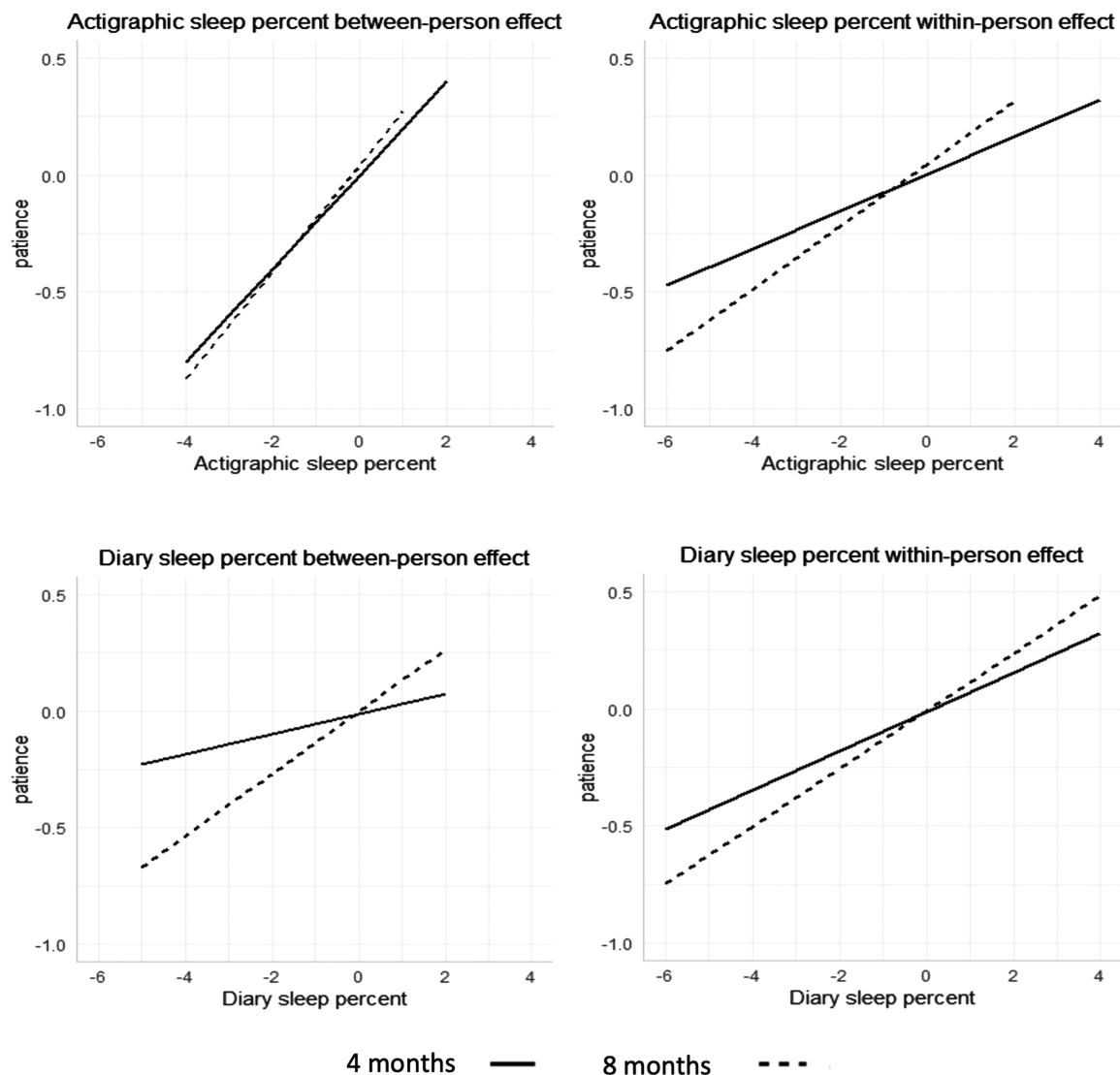


Figure 1. Actigraphic and diary sleep percent predict maternal patience to care for her infant at 4 and 8 months after delivery - between and within subject effects.

a between-subject level. Sleep quality predicted maternal caregiving feelings independent of maternal depressive symptoms and feeding status (BF vs. formula-feeding). Specifically, the between-mother effects showed that mothers who, on average, had lower *actigraphic* sleep percent reported lower levels of patience for their infants, lower desire to be with their infant, and more anger toward their infant. Maternal *reported* sleep percent was also positively associated with higher levels of patience for the infant, but only at 8 months. Moreover, mothers who, on average, reported lower diary-based sleep quality, experienced less positive caregiving feelings at both time points. The *within-subject* analysis revealed that when a mother had lower actigraphic and diary-based sleep percent and lower diary-based sleep minutes than her average on a given night, she reported lower patience for her infant the following day. Decreased diary-based sleep percent was also associated with lower desire to be with the infant the following day. Furthermore, maternal subjective sleep quality below the mother's average was associated with lower desire to be with the infant, lower patience, and higher anger on the following day. Thus, the findings provide

preliminary evidence that better sleep quality on a given night may result in an immediate gain relative to the previous day, with mothers feeling more positively toward their infant compared to the previous day. Moreover, the fact that there were significant daily links between sleep and maternal feelings toward the infant at both assessment points suggests that these links are not restricted to a momentary assessment, but may characterize daily fluctuations throughout infancy. Importantly, the findings demonstrate, for the first time, that even small variations in sleep quality may have implications for the quality of the mother-infant relationship. However, as this is the first study to demonstrate these links on a daily basis, they should further be tested in additional diary studies.

Whereas consistent associations were found between maternal sleep quality variables (sleep percent and subjective ratings of sleep quality) and mothers' caregiving feelings, almost no significant associations were found with the sleep duration variable. In fact, lower diary-based sleep minutes on a given night was associated only with lower maternal patience for her infant the following day. These findings may suggest that the

quality of sleep plays a more significant role in how a mother feels toward her infant than the total amount of her sleep.

The fact that significant associations were found for both self-reported sleep variables and objective sleep measures reduces the chance that the findings are merely a result of a report bias. Previous diary studies on sleep and emotional functioning in the general adult population were based mostly on self-report measures of sleep and functioning, and the few studies that used actigraphy reported mixed results [49, 50]. The problem with relying solely on subjective reports of both sleep and mood is that the subjective ratings might be influenced to some degree by retrospective recall or by expectancy biases. This is especially problematic when reports of sleep and mood are collected at the same time [43]. The present study addressed these obstacles by separating in time the sleep reports (morning) from the ratings of feelings toward the infant (evening), and by using actigraphy in addition to sleep diaries. Thus, the findings of the present study suggest that both objective sleep efficiency and the mother's experience of her sleep quality may contribute to daily maternal caregiving feelings.

Generally, mothers in this study reported positive feelings toward their infants: they mostly felt low anger at their infants, felt patient toward their infants, and desired being with their infants. This general high level of positive caregiving feelings might be due to the small proportion of women in the present sample who had elevated depressive symptoms. Interestingly, despite these average high scores, maternal nightly fluctuations in sleep quality were meaningful enough to explain day-to-day variability in these caregiving feelings.

The most direct interpretation of our findings is that following a night of poor sleep, some mothers are more likely to experience feelings of frustration that they did not sleep well because of the infant. Throughout the day, these mothers may get preoccupied with unpleasant feelings, attributed to the infant night-wakings ("I'm angry and have no patience to care for him because he woke me up so much"). However, these direct attributions probably do not characterize all mothers. Moreover, the associations between maternal and infant sleep in the present sample were moderate to strong, suggesting that the variability in maternal sleep disturbances is explained not only by the infant's awakenings. Beyond infant night-wakings, factors such as primary insomnia, emotional distress, and hormonal changes may also influence mothers' sleep.

Other explanations of the findings are related to potential underlying mechanisms (i.e. mediators of the links between poor sleep and caregiving feelings). One possible mechanism for the observed links involves the effects of sleep disturbances on mothers' energy levels. Previous studies have shown that efficient and restorative sleep replenish energy resources, enabling people to obtain benefits from positive situations, whereas sleep loss or sleep fragmentation reduces energy supplies [13, 47]. Consistent with these studies, it seems reasonable that after nights of poor sleep, mothers will have diminished energy to cope with the demands and challenges of daytime caregiving and this may negatively impact the accessibility of positive caregiving feelings.

Another possible explanation is related to the effects of poor sleep on mood and emotion regulation. In the present study, the effects of maternal sleep on her caregiving feelings were significant even after controlling for maternal depressive symptoms, suggesting that sleep played a role in explaining relationship

feeling regardless of the general level of maternal depression (which was low overall in our sample). Nevertheless, we cannot rule out the possibility that nights characterized by lower sleep quality led to days with more negative affect (not measured in the current study), which further influenced mothers' caregiving feelings. Prior research has consistently demonstrated impact of sleep on mood, emotion regulation, and emotional information processing in the general population [9, 67, 68]. In addition, research suggests that there is day-to-day co-variation between sleep and affect [43]. In the context of parenting, significant links between maternal sleep and depressive symptoms [25, 27, 29] have been reported, and considerable research has documented associations between more negative mood in mothers and lower quality of caregiving behavior [3, 69]. Combining these prior findings with the results of the current study, it appears as though poorer maternal sleep on one night leads to worse next day mood and emotion regulation, as manifested in more difficulty regulating negative caregiving feelings toward the infant. Future studies should explore this possibility by examining maternal mood on a day-to-day level in addition to sleep and relationship feelings. Overall, as none of these suggested potential mediators has been examined in this study, these theoretical postulations regarding the underlying mechanisms should be treated with caution and should be explored in future studies.

Several limitations of the study need to be considered. Our sample was rather homogeneous, as only married mothers representing the middle-upper SES in Israel participated in the study. Nevertheless, these characteristics enhance the internal validity of the study. The current study was limited also by focusing only on mothers. Future research should investigate daily variability in sleep and caregiving feelings among both mothers and fathers. Another limitation relates to our sole focus on maternal feelings toward her infant. An important next step for future research would be to examine whether nightly fluctuations in sleep quality predict changes in observed daily parent-infant interactions. Also, we used single items to assess caregiving feelings, and these items were used for the first time in the present study. Although these items were based on a validated questionnaire [36], additional research is needed to examine the reliability and validity of these single-item measures. Moreover, as mothers completed the diary questions regarding their feeling toward the infant in the evening after the infant went to sleep, we cannot rule out the possibility that the interactions around bedtime colored the mother's evaluation of her feeling toward the infant during the day. Nevertheless, even if this is the case, maternal sleep still seems to play a significant role in how mothers feel toward their infants towards the end of the day. Future research could add more frequent assessment of mothers' feelings to test whether negative feelings after a bad night of sleep change as the day goes on. Last, we focused on maternal sleep as a predictor of caregiving feelings and did not examine the opposite line of prediction. A direction for further research is to examine whether the distress caused by maternal negative feelings toward their infants drives maternal sleep.

Conclusions and Clinical Implications

This study advances the limited knowledge on the role of maternal sleep in the evolving mother-infant relationship, by demonstrating for the first time that maternal caregiving

feelings fluctuate in response to nightly variations in objective and subjective sleep quality. The findings highlight the meaningful role of a good night's sleep in mothers' next-day caregiving feelings and underscore the importance of elucidating the mechanisms that underlie these links. Future research could focus on several potential mediators, such as negative attributions, emotion regulation, and energy depletion.

The findings that maternal relationship feelings are not an entirely stable trait and that they are susceptible to change in response to sleep quality have important clinical implications, as they suggest that by improving the quality of maternal sleep, we could help mothers to feel more positively about their infant. Well-established research has demonstrated that behavioral sleep interventions lead to more consolidated sleep in infants and mothers [70]. Future intervention research could examine whether efforts to promote maternal sleep may also lead to more positive mother-infant caregiving feelings.

Supplementary Material

Supplementary material is available at SLEEP online.

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Data Availability

The data underlying this article will be shared on reasonable request to the corresponding author.

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