

VII. INFANT SLEEP DEVELOPMENT FROM 3 TO 6 MONTHS POSTPARTUM: LINKS WITH MATERNAL SLEEP AND PATERNAL INVOLVEMENT

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ABSTRACT The aims of this longitudinal study were to examine (a) development of infant sleep and maternal sleep from 3 to 6 months postpartum; (b) concomitant and prospective links between maternal sleep and infant sleep; and (c) triadic links between paternal involvement in infant caregiving and maternal and infant sleep. The study included 57 families that were recruited during pregnancy. Maternal and infant sleep was assessed using actigraphy and sleep diaries for 5 nights. Both fathers and mothers completed a questionnaire assessing the involvement of fathers relative to mothers in infant caregiving. The results demonstrated moderate improvement in infant and maternal sleep percent between 3 and 6 months. Maternal sleep percent at 3 months significantly predicted infant sleep percent at 6 months. Greater paternal involvement in infant daytime and nighttime caregiving at 3 months significantly predicted more consolidated maternal and infant sleep at 6 months. These findings suggest that maternal sleep is an important predictor of infant sleep and that increased involvement of fathers in infant caregiving responsibilities may contribute to improvements in both maternal and infant sleep during the first 6 months postpartum.

The maturation of sleep-wake patterns is one of the most important developmental tasks in infancy. The most prominent part of this process, the consolidation of nocturnal sleep (i.e., “sleeping through the night”), occurs rapidly during the first 6 months of life (Goodlin-Jones, Burnham, Gaylor, & Anders, 2001; Mirmiran, Maas, & Ariagno, 2003). Although most infants attain consolidated sleep during the first year of life, it has been repeatedly

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demonstrated that the sleep of 20–30% of infants and toddlers continues to be characterized by multiple and/or prolonged night wakings (Henderson, France, Owens, & Blampied, 2010; Mindell, Kuhn, Lewin, Meltzer, & Sadeh, 2006; Tikotzky & Sadeh, 2010).

Infant sleep consolidation has been conceptualized in the context of a transactional model that emphasizes the ongoing bi-directional links between infant sleep problems and intrinsic (e.g., temperament, medical) and extrinsic (e.g., parental soothing behaviors) factors (Sadeh & Anders, 1993; Sadeh, Tikotzky, & Scher, 2010). For example, infant sleep problems have been associated with parenting factors such as maternal depression, parenting stress, parental sleep-related cognitions, and especially parental bedtime and nighttime soothing behaviors (Morrell & Cortina-Borja, 2002; Tikotzky & Sadeh, 2009; Touchette, Petit, Paquet, Boivin, Japel, Tremblay et al., 2005). Infant sleep could also influence parental functioning. For instance, infant sleep problems may cause maternal sleep disruptions that in turn exert a negative influence on maternal mood (Hall, Clauson, Carty, Janssen, & Saunders, 2006; Ross, Murray, & Steiner, 2005). This study is based on the premises and assumptions of the transactional model described above and focuses specifically on the relations between parenting factors and infant sleep. The study fits also into the *immediate context* of the systems perspective which has been adapted to infant sleep by El-Sheikh and Sadeh as depicted in Figure 1 (Chapter I) in this volume.

Infant Sleep and Maternal Sleep

Compared with sleep during pregnancy, sleep during the postpartum period is shorter, more fragmented, and associated with increased daytime sleepiness (Hunter, Rychnovsky, & Yount, 2009; Montgomery-Downs, Insana, Clegg-Kraynok, & Mancini, 2010). It has been suggested that mothers' postpartum sleep disturbances are caused by the infant's sleep patterns and feeding schedules (Hunter et al., 2009; Meltzer & Montgomery-Downs, 2011). Though it may be reasonable to attribute changes in maternal sleep to the influences of infant sleep, there is little direct empirical evidence to support this assumption. Most studies in the field have relied solely on subjective maternal reports of their own and/or infant sleep (Dennis & Ross, 2005; Huang, Carter, & Guo, 2004; Thomas & Foreman, 2005), and only a few small-scale studies examined objective sleep patterns of mothers or mother-infant dyads (Matsumoto, Shinkoda, Kang, & Seo, 2003; Nishihara & Horiuchi, 1998; Nishihara, Horiuchi, Eto, & Uchida, 2002). To explore the links between maternal sleep and infant sleep, we employed a longitudinal study design and objective measures of sleep in a sample of 57 mother-infant dyads.

Fathers and Infant Sleep

Most studies of infant sleep ignore the role of fathers (Sadeh, Tikotzky, & Scher, 2010). The dearth of research on fathers is surprising because many father–infant interactions occur in the evenings and around bedtime (Keener, Zeanah, & Anders, 1988), and in light of the growing evidence that paternal involvement in child care has a positive influence on children’s development (Atzaba-Poria et al., 2010; Bogels & Phares, 2008; Lamb, 1997; Sarkadi, Kristiansson, Oberklaid, & Bremberg, 2008). The few studies of infant sleep that have included fathers suggest that although mothers are more dominant in nighttime caregiving, fathers also contribute significantly to the management of infant night waking (Ball, Hooker, & Kelly, 2000; Goodlin-Jones et al., 2001), and may also experience significant sleep disruptions in the postnatal period (Damato & Burant, 2008; Sinai & Tikotzky, 2012).

A longitudinal study examined the links between paternal involvement in infant care and infant sleep (assessed by actigraphy). Paternal overall involvement in infant care when the infant was 4-weeks-old predicted more consolidated infant sleep and shorter total sleep time when the infant was 6-months-old (Tikotzky, Sadeh, & Glickman-Gavrieli, 2011). Similarly, in a longitudinal study, Bordeleau, Bernier, & Carrier (2012) demonstrated that positive father–infant daytime interactions predicted higher sleep percentages in preschoolers.

Aims and Hypotheses

The specific aims of this longitudinal study were to examine (a) changes in infant and maternal sleep from 3 to 6 months; (b) concomitant and predictive links between infant and maternal sleep; and (c) concomitant and prospective links between infant sleep, maternal sleep, and paternal involvement in overall and nighttime infant care using objective and subjective measures of sleep. We decided to focus on assessment at 3 and 6 months postpartum because the first 6 months are characterized by the most rapid developmental changes in the consolidation of infants’ nocturnal sleep (Goodlin-Jones et al., 2001; Mirmiran et al., 2003). We did not start before 3 months because many parents are reluctant to attach the actigraph to the infant at very young ages.

We hypothesized that infant and maternal sleep would become more efficient and consolidated from 3 to 6 months (infant’s age) and that napping would decrease from 3 to 6 months. Regarding the links between infant sleep and maternal sleep, we expected to find significant concomitant and prospective correlations, indicating that better infant sleep will be associated with better maternal sleep. Finally, we hypothesized that higher paternal involvement in infant care would be concomitantly and prospectively associated with better infant and maternal sleep.

METHOD

Participants

Fifty-seven married couples were recruited for this study during the third trimester of their first pregnancy through the hospital's prenatal courses and announcements on Internet forums for expectant parents. At the end of their pregnancy (between pregnancy week 34–37), mothers' mean age was 28.56 ± 2.39 years and their average education was 16.27 ± 1.91 years. The fathers' mean age was 31.13 ± 4.11 years and their average education was 15.61 ± 1.86 years. The mean number of rooms at home was 3.21 ± 0.81 . These sociodemographic data place the parents in the middle-upper socioeconomic strata in Israel.

The sample included only full-term infants (31 girls, 54%). Mean age at first assessment point (Wave 1) was 3.09 months ($SD=0.19$) and at second assessment point 6.08 ($SD=0.23$) (Wave 2). Mean birth weight (kg) was 3.17 ± 0.43 . Mean weight at 3 months was 5.87 ± 0.67 and at 6 months 7.57 ± 0.96 . All infants were healthy during the assessment period. At the age of 3 months, 80% of the infants were cared for by their mothers at home, 11% were cared for by a baby-sitter and 9% were in day-care. Sixty-six percent were fully breastfed, 29% were partially breastfed, and 5% received formula. At the age of 6 months, 54% of the infants were cared for by their mothers at home, 22% stayed with a baby-sitter and 24% were in day-care. Forty-one percent were still fully breastfed, 29% were partially breastfed, and 30% received formula.

Procedures

The study was approved by the Institutional Ethics Committee—the university's committee, and the hospital's Helsinki Committee. A home visit was scheduled when the infant reached the age of 3 months. During this home visit, mothers were instructed how to use the actigraph and sleep diaries to assess their own and their infant's sleep for five nights. They also completed an infant sleep questionnaire, a depression questionnaire, and a background questionnaire. Both parents separately completed a questionnaire assessing the relative involvement of mothers versus fathers in infant care. The same procedures were repeated when the infant reached the age of 6 months. Parents were instructed to record sleep only on weekdays when a regular family routine was maintained. At the end of each assessment period, parents received a gift (value of about \$15) and a printout of the infant's actigraphic sleep patterns. Valid actigraphy data were available for 56 mother-infant dyads at 3 months and for 54 dyads at 6 months. At 3 months we had valid data for all five nights for 27 mother-infant dyads, four nights for 25 dyads and three

nights for 4 dyads. At 6 months, there were valid data for five nights for 29 dyads, four nights for 18 dyads, three nights for 5 dyads and two nights for 2 dyads.

Measures

Actigraphy

Actigraphy is a valid and reliable method for studying sleep-wake patterns in infants, children, and adults in their natural sleep environment (Ancoli-Israel, Cole, Alessi, Chambers, Moorcroft, & Pollak, 2003; Sadeh, Lavie, Scher, Tirosh, & Epstein, 1991). We used the Micro Motionlogger actigraph (Ambulatory Monitoring Inc., Ardsley, NY). Data were analyzed with validated sleep-wake scoring algorithms for infants (Sadeh, Acebo, Seifer, Aytur, & Carskadon, 1995) and adults (Sadeh, Sharkey, & Carskadon, 1994). Mothers attached the actigraph to their wrist and were asked to attach it to their infants' ankle. Actigraphic sleep measures used in the present study included: (1) Sleep minutes—sleep minutes excluding wakefulness during the night from sleep onset to morning awakening; (2) Sleep efficiency—percent of actual sleep minutes relative to the time interval from sleep onset to morning awakening; (3) Number of long wake episodes (5 minutes or longer) from sleep onset to morning awakening. Each measure was averaged across the monitoring period.

Sleep Diary

Sleep diaries were completed by the mothers and used to assess infants' daily sleeping patterns and to identify possible actigraphy errors and artifacts (Sadeh, 1996). Sleep diary variables (averaged across the monitoring period) included (a) infant daytime sleep duration; (b) infant number of night wakings; (c) maternal napping duration; (d) maternal number of night wakings.

Parental Involvement in Infant Care

We assessed both nighttime involvement and overall (daytime) involvement. *Nighttime* involvement was assessed by one item from the Brief Infant Sleep Questionnaire (BISQ) (Sadeh, 2004). The item is used to determine the relative involvement of mothers and fathers during the night, using a 5-point Likert scale, "Who usually approaches the infant upon awakenings?" (1 = *only the mother*; 5 = *only the father*). Further, the Parental Involvement Questionnaire (Tikotzky et al., 2011) was used to assess the relative degree of maternal and paternal involvement in *general* infant care. Parents rate their degree of involvement in 10 different child care tasks (e.g., feeding, bathing, playing) on a 7-point Likert-type scale (e.g., "Who usually feeds the infant"? 1 = *only the mother*; 4 = *mother and father equally*; 7 = *only the father*). An averaged

involvement score (based on the 10 items) was calculated for each parent. Both fathers and mothers separately completed the questionnaire. However, because the involvement scores of mothers and fathers were highly correlated ($\rho = .67$, $p < .001$ at 3 months; $\rho = .74$, $p < .001$ at 6 months), we calculated an average score for each pair of parents, thus creating a combined general involvement score. Good internal reliability based on Cronbach's alpha of .80 was found previously for the scale (Tikotzky et al., 2011) and in the present study. In this study, test-retest reliability (3 to 6 months) was .81 ($p < .001$).

Assessment of Depressive Symptoms

Mothers completed The Edinburgh Postnatal Depression Scale, which is a validated perinatal and postnatal depression severity scale (Cox, Holden, & Sagovsky, 1987). This scale was used to assess whether the severity of maternal depressive symptoms would be associated with maternal and infant sleep.

Background Questionnaires

Questionnaires were used to collect demographic and developmental data such as parent's age and education (completed during pregnancy), infant gender, weight, child care (home, daycare), and medical problems. Breastfeeding was rated on a 3-point scale: (a) *none*, (b) *partial breastfeeding*, or (c) *exclusive breastfeeding* (completed at 3 (Wave 1) and 6 months (Wave 2)).

Plan of Analysis

Paired-samples *t* tests were used to compare infant and maternal sleep at 3 and 6 months postpartum. Pearson correlations were calculated to assess the associations between infant sleep, maternal sleep, and paternal involvement. In addition, we used Structural Equation Modeling to further examine the relationships between infant sleep, maternal sleep, and paternal involvement within unified multidimensional models.

RESULTS

Correlations Between Demographic Variables and Sleep Measures

Pearson or Spearman correlations were calculated to examine whether any of the demographic variables reported above was associated with the sleep measures. Infant gender was associated with actigraphy-based long wake episodes at 3 months: boys had on average more long wake episodes ($M = 2.86$, $SD = .99$) than girls ($M = 2.17$, $SD = .87$) ($t(54) = 2.77$, $p < .01$). Maternal higher education was correlated with a lower number of infant long wake episodes at 3 months ($r = .29$, $p = .04$). Other demographic variables,

including maternal depressive symptoms, were not significantly associated with any of the infant or maternal sleep measures (all p values > 0.05). Breastfeeding at 3 months was prospectively associated with more infant actigraphy-based long wake episodes at 6 months ($\rho = .41, p = .002$) and diary-based night wakings ($\rho = .47, p < .001$). Similarly, breastfeeding at 3 months was prospectively associated with lower maternal sleep efficiency ($\rho = -.36, p = .01$) and more maternal long wake episodes based on actigraphy ($\rho = .39, p = .004$) and night wakings based on sleep diaries ($\rho = .45, p = .002$). There were also significant concomitant correlations between breastfeeding and infant/maternal long wake episodes, maternal sleep efficiency as well as night wakings based on diaries at 6 months postpartum. Thus, breastfeeding was controlled in subsequent analyses and was included as a three-level variable (none; partial; exclusive). As most infants were independent sleepers, and only two infants at 3 months and four infants at 6 months were co-sleepers, we did not include sleeping arrangement in our analyses.

Stability and Changes in Infant and Maternal Sleep From 3 Months to 6 Months

Table 1 summarizes results of paired-samples t tests comparing infant and maternal sleep at 3 and 6 months postpartum, and the correlations between the sleep variables at the two waves. There was an increase in infant and

TABLE 1
DESCRIPTIVE STATISTICS, PAIRED-SAMPLES t TESTS AND PEARSON CORRELATIONS FOR INFANT SLEEP AND MATERNAL SLEEP AT 3 AND 6 MONTHS POSTPARTUM

<i>Infant sleep</i>	3 months				6 months				$t(52)$	Pearson r
	Mean	<i>SD</i>	Min	Max	Mean	<i>SD</i>	Min	Max		
Sleep minutes, A	567.45	68.35	373.67	676.40	580.33	49.80	399.33	676.50	1.63	.28*
Sleep efficiency A	91.40	4.61	76.20	98.89	92.96	3.80	79.56	99.48	2.35*	.32*
N. Long wake episodes, A	2.49	0.98	00	5.33	2.19	1.14	00	5.00	-1.65	.35**
Daytime sleep, D	207.30	68.52	87.50	396.00	163.16	49.29	65.00	354.00	-6.05***	.58***
N. Night wakings, D	2.52	1.17	00	5.80	3.17	1.74	0.20	7.40	2.80**	.48***
<i>Maternal sleep</i>										
Sleep minutes, A	387.71	51.04	210.5	486.40	374.65	48.34	271.80	478.40	-1.87	.63***
Sleep efficiency, A	85.82	5.06	69.72	95.19	92.96	3.80	76.87	98.82	5.29***	.51***
N. Long wake episodes, A	2.61	0.96	1.00	5.25	2.36	1.12	00	6.00	-1.45	.28*
Nap duration (min), D	58.45	50.18	00	180	25.80	27.64	00	96.00	-3.38***	.55***
N. Night wakings, D	2.88	1.08	0.40	5.80	3.11	1.54	0.40	6.94	1.13	.42***

Note. A = Actigraphy; D = Diary; N = Number.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

maternal sleep efficiency (defined by actigraphy) from 3 to 6 months. No significant change was found for sleep minutes during the night or for the number of long wake episodes for either infants or mothers. However, the general trend was a decrease in the number of infant and maternal long wake episodes over time. According to the sleep diaries, there was a significant decrease in infant daytime sleep and maternal nap duration and an increase in the number of infant night wakings. As shown in Table 1, infant sleep parameters as measured by actigraphy (sleep minutes, sleep efficiency, number of long wake episodes) at the two waves were moderately correlated. The correlation for the number of infant night wakings based on the sleep diaries at the two waves appears to be higher than the correlation based on actigraphy. Maternal sleep minutes and sleep efficiency demonstrated high stability from 3 to 6 months.

Concomitant and Predictive Correlations Between Infant Sleep and Maternal Sleep

Pearson correlations were calculated between the actigraphic infant sleep measures and maternal sleep measures to assess concomitant and prospective correlations between infant sleep and maternal sleep. Statistically significant concomitant relations were found between infant sleep efficiency and maternal sleep efficiency at 3 months ($r=.51, p<.001$) and at 6 months ($r=.59, p<.001$), and between infant and maternal number of long wake episodes at 3 months ($r=.36, p=.007$) and at 6 months ($r=.62, p<.001$).

Maternal sleep efficiency at 3 months significantly predicted infant sleep efficiency at 6 months ($r=.56, p<.001$). Similarly, the number of maternal long wake episodes at 3 months predicted the number of infant long wake episodes at 6 months ($r=.31, p=.02$). However, infant sleep measures at 3 months did not significantly predict the same maternal sleep measures at 6 months ($r=.14, ns$, for sleep efficiency and $r=.22, ns$, for long wake episodes).

General Parental Involvement in Infant Care and Infant and Maternal Sleep

The parental involvement questionnaire included a sleep item (“Who usually approached the infant during the night?”). After removing this item, the correlations between the general involvement scale and infant/maternal sleep remained the same and we therefore decided to report the results for the general involvement scale including the sleep item.

Spearman correlations (controlling for breastfeeding) were calculated between the general combined (father and mother) involvement scores (3 and 6 months), and the infant and maternal sleep parameters (See Table 2). The findings demonstrated significant concomitant and predictive links

TABLE 2
 CONCOMITANT AND PREDICTIVE SPEARMAN CORRELATIONS BETWEEN PATERNAL INVOLVEMENT,
 MATERNAL SLEEP AND INFANT SLEEP

	3 Month Combined General	6 Month Combined General	3 Month Nighttime	6 Month Nighttime
	Involvement	Involvement	Involvement	Involvement
3 months				
Infant Min, A	.04	-.01	.08	-.12
Infant SEF, A	.05	.22	-.24	.04
Infant LWE, A	-.07	-.22	.10	-.24
Infant NW, D	-.30* (^)	-.47*** (^)	.01	-.20
Mother Min, A	.06	.03	-.13	.04
Mother SEF, A	.25	.21	.04	.18
Mother LWE, A	-.25	-.19	-.05	-.13
6 months				
Infant Min, A	-.23	-.24	-.03	-.16
Infant SEF, A	.23	.16	-.13	.10
Infant LWE, A	-.38** (^)	-.35* (^)	-.23	-.41*** (^)
Infant NW, D	-.30*	-.30* (^)	-.23	-.29*
Mother Min, A	-.09	.10	-.21	.19
Mother SEF, A	.35** (^)	.20	.30*	.30*
Mother LWE, A	-.37** (^)	-.17	-.33*	-.24

Note. (^) identifies correlations that remained significant after controlling for breastfeeding. Min = sleep minutes; SEF = sleep efficiency; LWE = number of long wake episodes; NW = number of night wakings; A = actigraphy; D = diary.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

between paternal general involvement and infant sleep after controlling for breastfeeding. Higher scores on the general involvement scale (indicating relatively higher general involvement of fathers in infant care) at 3 months predicted a lower number of infant long wake episodes at 6 months (actigraphy). Similar associations were found for the concomitant links between paternal general involvement and infant long wake episodes (actigraphy) and night wakings (diaries) at 6 months. Thus, relatively higher paternal general involvement in infant care was associated with more consolidated infant sleep. Also, higher paternal general involvement at 3 months significantly predicted a lower number of maternal long wake episodes and higher maternal sleep efficiency at 6 months (controlling for breastfeeding). The opposite prediction was significant only for the sleep diaries: a higher number of infant night wakings based on sleep diaries at 3 months predicted lower paternal general involvement in infant care at 6 months (controlling for breastfeeding).

Paternal Involvement at Night and Infant Sleep

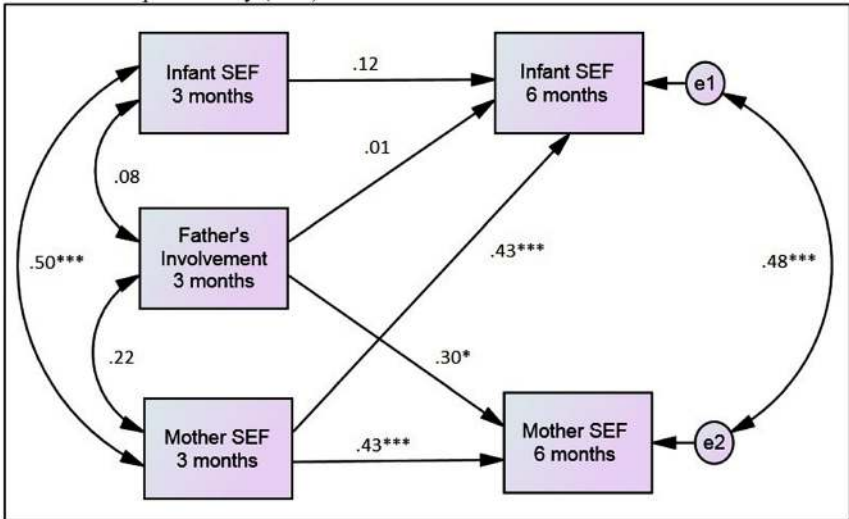
Using the single nighttime involvement sleep item from the BISQ, higher paternal nighttime involvement at 6 months was associated with a lower number of infant long wake episodes at 6 months (assessed by actigraphy), controlling for breastfeeding (Table 2). There were no significant correlations between paternal nighttime involvement and maternal sleep after controlling for breastfeeding.

Structural Equation Modeling (SEM)

SEM was used to assess the relationships between infant sleep, maternal sleep, and paternal general involvement within unified multidimensional models. Because of the small number of subjects, we were limited in the number of variables that could be included in each model. Therefore, we chose to use only observed variables and two analyses focusing on the two objective measures of sleep quality, namely sleep efficiency and the number of long wake episodes. SEM analyses were conducted with the AMOS program (Version 20) using the Maximum Likelihood estimation method. We tested two SEM models that were based on a symmetrical cross-lagged observed variables model of maternal sleep, infant sleep and paternal general involvement at both 3 months and 6 months. Three types of effects were specified (1) concomitant associations (i.e., correlations between maternal sleep, infant sleep and paternal involvement at 3 months and correlations between the “disturbances”—the residual variances—of maternal sleep and infant sleep at 6 months), (2) stability effects (maternal and infant sleep at 3 months relative to maternal and infant sleep at 6 months), (3) cross-lagged effects, namely, the effect of 3 month maternal sleep on 6 month infant sleep, and vice versa (see Shahar & Davidson, 2003, for more details on cross-lagged models) and (4) prediction effects from paternal involvement at 3 months to maternal and infant sleep at 6 months. To enable model fit, we removed the cross-lagged association between infant’s sleep at 3 months and mother’s sleep at 6 months (the Pearson zero-order correlations between infant’s sleep at 3 months and mother’s sleep at 6 months were insignificant).

Adequate fit indices were obtained for the structural models presented in Figure 1. For Model A: χ^2 [df = 1] = 1.30, $p = .10$; χ^2 /df = 1.30; NNFI = .98, CFI = 1.00, RMSEA = .07; and for Model B: χ^2 [df = 1] = .72, $p = .10$; χ^2 /df = .72; NNFI = .99, CFI = 1.00, RMSEA = .00). In Model A, maternal sleep efficiency and infant sleep efficiency were correlated at both 3 months ($r = .50, p < .001$) and at 6 months ($r = .48, p < .001$). Maternal sleep was stable over time ($\beta = .43, p < .001$) whereas infant sleep was not ($\beta = .12, ns$). Maternal sleep at 3 months predicted infant’s sleep at 6 months after controlling for infant’s sleep at 3 months ($\beta = .48, p < .001$). Finally, paternal

Model A: Sleep efficiency (SEF)



Model B: Number of long wake episodes (wakings)

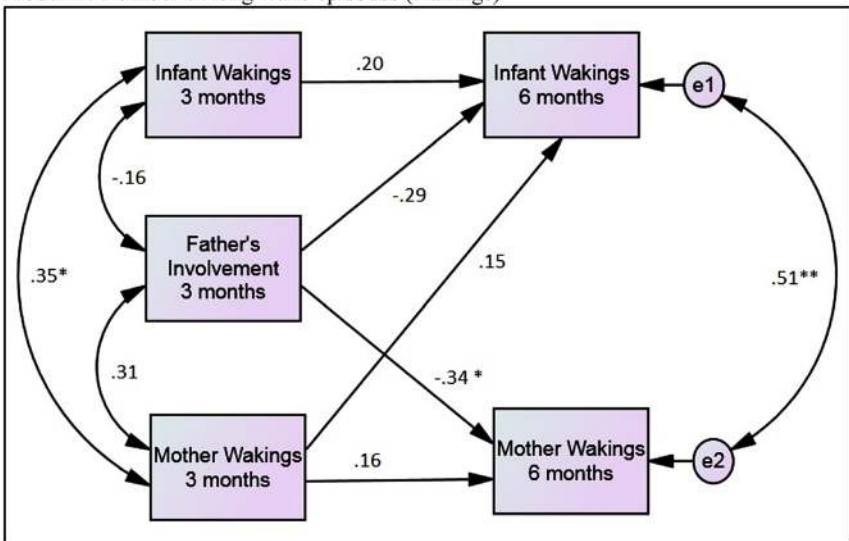


FIGURE 1.—Structural Equation Models depicting links between infant sleep, maternal sleep and paternal involvement for sleep efficiency (SEF – Model A) and long wake episodes (Wakings – Model B). Standardized coefficients are presented in the figures. * $p < .05$. *** $p < .001$.

general involvement at 3 months predicted maternal sleep at 6 months ($\beta = .30, p = .01$), but was not a significant predictor of infant sleep.

In Model B, predicting the number of long wake episodes, maternal sleep and infant sleep were correlated at both 3 months ($r = .35, p = .01$) and at 6 months ($r = .51, p < .001$). Neither maternal sleep nor infant sleep was stable over time for this sleep parameter. No significant predictions were found from maternal sleep at 3 months to infant sleep at 6 months. However, paternal general involvement at 3 months predicted both maternal sleep ($\beta = -.34, p = .01$) and infant sleep ($\beta = -.29, p = .03$) at 6 months. More paternal general involvement in caregiving predicted fewer maternal and infant long wake episodes.

DISCUSSION

This study assessed the changes in infant sleep and maternal sleep from 3 to 6 months postpartum, and to the best of our knowledge is the first to investigate the triadic links between infant sleep, maternal sleep, and paternal involvement in infant care. Regarding changes and stability in infant and maternal sleep from 3 to 6 months, a statistically significant increase in objectively measured infant sleep efficiency and decrease in daytime sleep minutes from 3 to 6 months were consistent with previous findings on the consolidation of nocturnal sleep and reduction in daytime sleep in the early postpartum months (Burnham, Goodlin-Jones, Gaylor, & Anders, 2002; Henderson et al., 2010; Mindell, Sadeh, Wiegand, How, & Goh, 2010; Tikotzky & Sadeh, 2009). Consistent with an earlier study (Montgomery-Downs et al., 2010), we found that maternal sleep minutes remained stable, but sleep quality improved during the postpartum period. Nonetheless, it is important to note that at 6 months postpartum, the sleep efficiency of many mothers (56%) was lower than 90%, and that 40% of the mothers slept less than 7 hr per night on average, indicating that many mothers still experienced disturbed sleep.

Infants showed low-moderate stability in actigraphic sleep measures (minutes, sleep efficiency, and number of long wake episodes). Low-moderate stability in infant sleep has been reported in prior studies (Scher, Epstein, & Tirosh, 2004), and may reflect rapid maturation processes in the early months. Mothers, however, showed high stability in sleep efficiency and sleep minutes and moderate stability in the number of long wake episodes.

As expected, we found strong concomitant links between maternal and infant sleep quality at both 3 and 6 months. A novel finding supported by the SEM analysis is that maternal sleep efficiency at 3 months predicted infant sleep efficiency at 6 months. However, infant sleep at 3 months did not predict maternal sleep at 6 months. Although other studies (mostly based on maternal subjective reports) suggest that infant sleep affects maternal sleep

(Hunter et al., 2009), our findings suggested that disturbed maternal sleep may contribute to the development of problematic infant sleep patterns. It could be that mothers who experience more nighttime alertness, vigilance, or wakefulness respond faster to the infants' signals at night and are more involved with active nighttime soothing, a behavior that may reinforce infant night wakings (Tikotzky & Sadeh, 2010). Mothers with poor sleep may also be more stressed or anxious during the day and may inadvertently influence their infant's overall level of calmness, of which poorer sleep may be a correlate. Because it is impossible to infer causality from a prospective correlational study design, both of these speculative explanations require further testing in future studies.

Our findings show that higher paternal general involvement in care of their 3-month-old infant (based on ratings of both parents) predicted more consolidated sleep for the infants at 6 months and for their mothers at 6 months after controlling for breastfeeding. Actigraphy revealed that paternal general involvement correlated with fewer infant and maternal long wake episodes and with higher maternal sleep efficiency. The SEM analyses supported these findings. In addition, significant concomitant links were found between the degree of paternal nighttime involvement and infant actigraphic long wake episodes, after controlling for breastfeeding. These findings are in line with a previous study that examined paternal involvement and infant sleep (Tikotzky et al., 2011) and with earlier findings linking paternal involvement in child care to positive children's outcomes (Bogels & Phares, 2008; Lamb, 1997; Sarkadi et al., 2008). However, to our knowledge, this is the first study demonstrating that paternal involvement is also relevant to maternal sleep. It is important to clarify that the range of scores on the parental involvement scales varied among mothers assuming sole responsibility for caregiving and among both parents sharing equally. Therefore, these findings do not imply that having fathers who are more involved with caregiving than mothers leads to better infant sleep, but, instead, suggest that having two parents who share infant caregiving responsibilities contributes positively to the consolidation of infant and maternal sleep. This is in line with the findings of Teti et al. (Chapter X, in this volume) who found that marital adjustment and co-parenting are significantly associated with infant sleep arrangements.

Only the general paternal involvement scale, and not the nighttime scale at 3 months, was associated with maternal sleep at 6 months. We speculate that the overall distribution of caregiving responsibilities at 3 months reduces maternal stress and exerts a calming atmosphere, which has a positive long-term influence on both maternal sleep and infant sleep. Combining these results with the finding of a predictive link between maternal sleep and infant sleep may suggest that parental sharing of infant caregiving might help mothers achieve better sleep, which in turn may contribute to more consolidated infant sleep.

Infant long wake episodes (actigraphy-based) were associated with both the general involvement scale and the nighttime scale, and the two paternal involvement scales (general and nighttime care) were correlated with each other. A possible explanation may be that couples who share caregiving during the day and at night hold similar and consistent expectations regarding infant sleep and adopt an approach that encourages infant self-soothing, an approach consistently related to more consolidated infant sleep (Mindell, Kuhn, Lewin, Meltzer, & Sadeh, 2006).

Limitations

Our study has some limitations that need to be considered. First, the relatively small sample size poses some qualifications for the interpretation of findings. Second, the sample was comprised mainly of middle to high-income families in Israel, which could limit the generalization of the findings to parents and infants from other cultures and sociodemographic strata. Third, although the longitudinal nature of the study is a clear advantage, the design is still correlational, which precludes inferences about causal links between the study variables.

Future Directions

In addition to the evident need for longitudinal investigations with larger samples for explication of study findings, assessment of plausible mechanisms of effects (e.g., reduced maternal stress; parents sharing similar and consistent expectations regarding infant sleep) in the observed links between paternal involvement in caregiving and maternal and infant sleep is warranted. Further, previous studies that have focused on infant sleep interventions have suggested that improving infant sleep may also lead to better maternal sleep and functioning (Hall et al., 2006; Ross et al., 2005). The findings of the present study underscore the importance of addressing postpartum maternal sleep and suggest that focusing on ameliorating maternal sleep problems may also lead to more consolidated infant sleep. Moreover, the findings imply that one possible way to help mothers and infants achieve more consolidated sleep might be through encouraging fathers to increase their involvement in caregiving responsibilities not just at night but throughout the day.

CONCLUSION

This longitudinal study demonstrated complex relationships between maternal sleep, infant sleep, and paternal involvement in daytime and

nighttime infant care. Strong concomitant links between maternal and infant sleep quality at both 3 and 6 months were observed. Further, building on this area of research, maternal sleep efficiency at 3 months predicted infant sleep efficiency at 6 months; the reverse direction of effects was not supported. Results support the importance of general paternal involvement in their infants' care at 3 months as a predictor of more consolidated sleep for both the infants at 6 months and for their mothers.

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