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Sleep patterns of co-sleeping and solitary sleeping infants and mothers: A longitudinal study

Subtitle: Sleeping arrangements and sleep quality of infants and mothers

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Sleep patterns of co-sleeping and solitary sleeping infants and mothers: A longitudinal study

Highlights

- Co-sleeping infants had more reported night-wakings than solitary sleeping infants.
- Co-sleeping was not related to objective infant sleep quality.
- Co-sleeping mothers had more fragmented sleep than solitary sleeping mothers.
- Poorer maternal sleep at pregnancy and at 3 months predicted co-sleeping at 6 months.
- Breastfeeding was related to poorer maternal/infant sleep and to co-sleeping.

Abstract

Objective: Controversies exist regarding the impact of co-sleeping on infant sleep quality. In this context, the current study examined: (a) the differences in objective and subjective sleep patterns between co-sleeping (mostly room-sharing) and solitary sleeping mother-infant dyads; (b) the predictive links between maternal sleep during pregnancy and postnatal sleeping arrangement; (c) the bi-directional prospective associations between sleeping arrangement and infant/maternal sleep quality at 3 and 6 months postpartum.

Methods: The sample included 153 families recruited during pregnancy. Data were obtained in home settings during the third trimester of pregnancy and at 3 and 6 months postpartum. Mothers were asked to monitor their own sleep and their infants' sleep for 5 nights using actigraphy and sleep diaries. Questionnaires were used to assess sleeping arrangements, feeding methods, socio-demographic characteristics and maternal depressive and anxiety symptoms.

Results: Mothers of co-sleeping infants reported more infant night-wakings than mothers of solitary sleeping infants. However, none of the objective sleep measures was significantly different between co-sleeping and solitary sleeping infants, after controlling for feeding techniques. Co-sleeping mothers had significantly more objective and subjective sleep

disturbances than mothers in the solitary sleeping group. Moreover, poorer maternal sleep during pregnancy and at 3 months postpartum predicted higher levels of co-sleeping at 6 months.

Conclusion: Mothers of co-sleeping infants report more infant night-wakings, and experience poorer sleep than mothers of solitary sleeping infants. The quality of maternal sleep should be taken into clinical consideration when parents consult about co-sleeping.

Keywords: sleep; infant; mother; co-sleeping; actigraphy; longitudinal

1. Introduction

Parent-infant co-sleeping (parents sharing the same room or bed with the infant) is the most widely used sleeping arrangement in the majority of cultures around the world[1,2]. Even in the western society, where most parents prefer solitary sleeping arrangements (infant sleeping in a different room), co-sleeping has increased significantly during the last decades[3]. Nonetheless, major controversies exist regarding the physical (e.g. Sudden Infant Death Syndrome) and psychological (e.g. dependency, attachment relationship) risks and benefits of co-sleeping[2]. One source of disagreement relates to the impact of co-sleeping on infant sleep quality[4]. Studies based on subjective reports have found that co-sleeping is associated with more sleeping problems[5–12]. However, co-sleeping parents could be more aware of their infants' night-wakings, due to physical proximity to the child at night, regardless of the infant's actual sleep quality[7]. Moreover, feeding methods may account for the reported link between co-sleeping and infant night-wakings, as breastfeeding mothers are more likely to co-sleep with their infants compared to bottle-feeding mothers[4,13,14], and breastfeeding has been found to be associated with more disturbed infant and maternal sleep[15–19]. Contrary to the findings based on subjective reports, results from studies using objective sleep measures (i.e.,polysomnography, video recording) yield an inconclusive picture. Whereas some findings indicate lower sleep quality in co-sleeping infants as reflected in more brief awakenings[20,21] and lighter sleep[22], other findings demonstrate lack of difference[20,21]. For instance, Mao et al[21] found no difference in the total amount of time awake at night, and in the percent of time spent in active sleep and quiet sleep between co-sleeping and solitary sleeping infants.

It is important to note that the reported associations between co-sleeping and sleep quality may be bi-directional. Thus, co-sleeping may affect infant sleep quality, but at the same

time, parents of infants with existing sleep problems may be more likely to endorse co-sleeping (i.e. reactive co-sleeping)[7]. Hence, the phenomena may best be examined in the context of the transactional model which delineates bidirectional, ongoing dynamic influences between infant sleep development and the environment[2]. However, the lack of longitudinal studies in this field makes it difficult to infer about the direction of the links between infant sleep quality and sleeping arrangements.

One important aspect that has received little attention in the debate on co-sleeping is the role of maternal sleep quality. The few studies that have examined the links between maternal sleep and sleeping arrangement yielded inconsistent results. One study found that co-sleeping was significantly associated with less efficient maternal sleep (as assessed by one night of actigraphy)[23]. In another study[24], using laboratory polysomnography, no differences were found between co-sleeping mothers and solitary sleeping mothers in total sleep time, though the total frequency of arousals in the co-sleeping group was higher as awakenings were of shorter duration. The present study aimed at expanding the limited knowledge on this issue by examining the prospective links between maternal sleep quality and sleeping arrangements starting at pregnancy, the latter to better understand whether maternal sleep patterns, present before experiencing any influences of infant nighttime care, would predict future sleeping arrangements choices.

1.1. Study goals

The main goal of the present study was to assess comprehensively the concomitant and predictive relationships between infant/maternal sleep patterns and sleeping arrangements, using objective and subjective measures of sleep in the context of a longitudinal design. Specifically,

we aimed at examining: (a) The differences in infant/mother sleep quality and quantity between co-sleeping mother-infant dyads and solitary sleeping dyads; (b) The predictive links between maternal sleep during pregnancy and sleeping arrangement at 3 and 6 months postpartum; (c) The bi-directional prospective association between infant/maternal sleep at 3 and 6 months postpartum and sleeping arrangement.

2. Method

2.1. Participants

One hundred and fifty three married couples expecting their first child were recruited during pregnancy through childbirth preparation classes and announcements on Internet forums for expectant parents. Inclusion criteria were: (1) Two-parent families expecting their first child; (2) Singleton pregnancy. Participants were excluded if they had a chronic health condition (by self-report). Of the 153 families recruited, 16 dropped-out from the study at the 3 months assessment point, and 12 families withdrew from the study at 6 months. Three families did not participate at 3 months but were contacted again when the infant reached the age of 6 month, and agreed to participate then. The characteristics of the sample are presented in Table 1.

At the age of 3 months, most of the infants were sleeping in their parents' room (76%), while at the age of 6 months, 50% of the infants were sleeping in their parents' room. Only a small number of infants (n=7 at 3 months and n=8 at 6 months) were sharing the same bed with their parents. As there were no significant differences on any of the sleep measures between infants sleeping in the same bed with their parents and infant sharing the same room (but not the same bed), we combined these two groups together as **co-sleeping** infants without further distinction in the analyses.

2.2. Procedures

The study was approved by a hospital's Helsinki committee. All women signed informed consent before assessment of their own sleep and their infants' sleep. The study included 3 assessment points: during pregnancy, at 3 and 6 months postpartum. A research assistant visited the participants during the third trimester of pregnancy (week 34 – week 37) and instructed them about actigraphy use and questionnaires completion. Sleep was assessed for 5 nights (only on weekdays when a regular routine was maintained) with actigraphy and sleep diaries. Families were contacted again after delivery and an appointment was scheduled when the infant reached the age of 3 months. Mothers were asked to monitor their infants' and own sleep with actigraphy and diaries for 5 nights. In addition, they completed an infant background questionnaire that included questions regarding sleeping arrangements and questionnaires assessing depressive and anxiety symptoms. The same procedure was repeated at the age of 6 months. After completing the assessments, participants received a small gift (value of about 20$) and a graphic report of their actigraphic sleep.

2.3. Measures

2.3.1. Actigraphy: Actigraphy has been established as a valid and reliable method for studying and assessing sleep-wake patterns in infants, children[25], and adults[26]. The actigraph is a miniature wristwatch-like device attached to the adult's wrist or infant's ankle during the recording period. The device records movement for extended period of time with minimal disruption of ongoing sleep in the subject's natural environment. In the present study, we used the micro motion logger sleep watch (Ambulatory Monitoring Inc., Ardsley, NY) with a 1-minute epoch interval according to the standard mode for sleep-wake scoring. Data were analyzed with Sadeh's

validated scoring algorithm for infants[25] and adults[27]. Sleep diaries were used to identify possible actigraphy errors and artifacts. Mothers were asked to wear the actigraph 15 minutes before they or their infant went to sleep and to take it off 15 minutes after morning awakening. Actigraphic sleep measures included in the study: (1) WASO - minutes awake after sleep onset; (2) SMIN - sleep minutes from sleep onset to morning awakening, excluding wakefulness during the night; (3) NW - number of night-wakings lasting 5 minutes or longer; (4) LGSEP – longest sleep period without waking (of 5 minutes or longer) from sleep onset to morning awakening. Each measure was averaged across the monitoring period.

Actigraphy data was missing for 7 infants at 3 months (5 mothers refused to attach the device and 2 because of technical problems) and for 12 infants at 6 months (9 mothers refused to attach the actigraph and 3 because of technical problems). Overall, actigraphy data were available for 153 mothers during pregnancy, for 127 infants and 131 mothers at 3 months postpartum and for 114 infants and mothers at 6 months.

2.3.2. Sleep diaries: To asses sleep from a subjective perspective, mothers were asked to complete a sleep diary of their infants'[28] and own sleep patterns[29]. Derived variables included in the present study: (1) DSQ - subjective evaluation of maternal sleep quality (scale ranging from 1 = poor to 10 = excellent); (2) D-NW - number of maternal/infant night wakings; (3) NAP – Maternal/infant day-time sleep duration.

2.3.3. Infant sleeping arrangements: Were assessed with one question from the Brief Infant Sleep Questionnaire[30]. This question asks parents to choose one of the following infant sleeping arrangements options (i.e., where does the infant sleeps): (a) Infant crib in a separate room; (b) Infant crib in parent's room; (c) parents' bed. For the purposes of the present study, group b and

group c were combined into one group referred to as "co-sleeping" infants.

2.3.4. The Edinburgh Postnatal Depression Scale (EPDS)[31]: This questionnaire consists of ten short statements asking about depressive symptoms during the past week. Scores range from 0 to 30 with a higher score representing greater depressive symptom severity. In the present sample, Cronbach's alpha was 0.79 at 3 months and 0.83 at 6 months.

2.3.5. Beck Anxiety Inventory (BAI)[32]: The BAI consists of twenty-one questions rated on a four point scale ranging from 0 (not at all) to 3 (severely, I could barely stand it). Most items describe physiological symptoms of anxiety, 5 describe cognitive aspects and 3 items have a physical as well as a cognitive component[33]. In our study, Chronbach's alpha was 0.82 at 3 months and 0.77 at 6 months.

2.3.6. Background questionnaires: Questionnaires were used to collect socio-demographic data such as parental age (completed during pregnancy), and developmental data (completed at 3 and 6 months) such as infant weight, day-care (home-reared, babysitter, day-care), and health problems. Feeding method was rated on a 3-point scale: (a) exclusive breastfeeding; (b) partial breastfeeding; or (c) bottle-fed.

2.4. Plan of Analysis

ANCOVA tests (controlling for feeding method) were used to compare between sleep patterns of co-sleeping mother-infant dyads and solitary sleeping mother-infant dyads Logistic regression was used in order to examine whether maternal sleep at pregnancy predicts infant's sleep arrangement at 3 and 6 months postpartum. In addition, we used Structural Equation Modeling to further examine the bi-directional relationships between infant/maternal sleep, and sleeping arrangement at 3 and 6 months postpartum within unified multidimensional models.

3. Results

3.1. Preliminary analyses

3.1.1.. Correlations between background variables and sleep measures

Pearson or Spearman correlations were calculated to examine whether any of the background and emotional distress variables reported above were associated with the sleep measures. Maternal age was positively associated with infant's longer actigraphic sleep minutes at 3 months (r = .25, p <.01) and with more infant's (r =.29, p < .05) and maternal (r = .35, p <.001) diary night-wakings. Maternal age was also negatively associated with subjective sleep quality at 3 months (r = -.24, p <.01). Maternal higher education was correlated with higher maternal actigraphic LGSEP at 6 months (r = .20, p < .05) and infant's (r =.25, p < .05) and maternal (r =.27, p < .05) diary night-wakings. Other demographic variables were not significantly associated with any of the infant/maternal sleep measures or with sleeping arrangements. Maternal EPDS and BAI scores were not associated with any of the sleep measures. However, solitary sleeping arrangement at 3 months was associated with higher EPDS scores at 3 months (*rho* = -.20, p < .05) and with higher BAI scores at 6 months (*rho* = -26, p < .005).

Breastfeeding (a 3-level variable - exclusive; partial; none) at 3 and 6 months was associated with more fragmented sleep for both infants and mothers. For example, breastfeeding at 3 months was associated with more infant actigraphic night-wakings at 3 (*rho* = -.22, p < .05) and 6 (*rho* = -.26, p <.01) months, and with more reported infant night-wakings at 3 (*rho* = -.29, p <. 01) and 6 (*rho* = -.42, p < .01) months. Breastfeeding at 6 months was concomitantly associated with more infant actigraphic night-wakings (*rho* = -.30, p < .01) and reported night-wakings (*rho* = -.38, p < .01) at 6 months. Similar significant correlations were found for maternal objective and subjective night-wakings. Breastfeeding was also associated with lower maternal subjective

sleep quality at 3 months (*rho* =.19, $p < .05$). In addition, feeding method at 6 months was significantly associated with sleeping arrangement at 6 months ($\chi^2_{(2, N=119)} = 10$, $p < .01$, $\phi = 29$, $p < .05$). Mothers who nursed their infants were more likely to co-sleep. Feeding method was the only background variable associated with both infant/maternal sleep measures and sleeping arrangement. Thus, it was controlled for in subsequent analyses.

A one way ANOVA was conducted to explore the effect of day-care (home-reared, baby-sitter, day-care) on maternal and infant sleep. There was a statistically significant difference for 2 sleep measures: maternal actigraphic night-wakings ($F_{(2,100)} = 5.5$, $p < .01$), and infant reported night-wakings ($F_{(2,113)} = 5.1$, $p < .01$). Post-hoc comparisons using the Tukey HSD test indicated that mothers who stayed at home with their infants had significantly more night-wakings ($M = 3.3$, $SD = 1.9$) than mothers in the other 2 groups (baby-sitter: $M = 2.2$, $SD = 1.1$; day-care: $M = 2.5$, $SD = 1.1$), and home-reared infants had significantly more reported night-wakings ($M = 3.1$, SD = 1.8) than infants in the other 2 groups (baby-sitter: $M = 2.2$, $SD = 1.3$; day-care: $M = 2.2$, $SD = 1.3$). There were no significant associations between day-care and sleeping arrangements.

3.1.2. Changes in infant and maternal sleep measures

Paired-samples T tests were used to compare infants' sleep at 3 and 6 months postpartum. Repeated measures ANOVA tests were used to compare maternal sleep at pregnancy, 3 months and 6 months postpartum (Table 2). For infants, a significant decrease was found for actigraphic LGSEP, WASO and number of night-wakings, indicating an increase in sleep consolidation from 3 to 6 months. However, an increase was found in the number of reported night-wakings. Infant nap duration showed a significant decrease from 3 to 6 months. For maternal sleep, quadratic effects were found for LGSEP, WASO and number of night-wakings, indicating a statistically significant decrease in maternal actigraphic sleep quality from pregnancy to 3 months

postpartum, and an increase from 3 to 6 months postpartum. Maternal subjective evaluation of her sleep quality showed a statistically significant decrease from pregnancy to 3 months postpartum, and from 3 to 6 months postpartum.

3.2. Sleeping arrangements and infant and maternal sleep

3.2.1. Differences in infant and maternal sleep measures between co-sleeping and solitary sleeping mother-infant dyads

We used independent ANCOVA tests to examine whether there were differences in sleep quality and quantity between co-sleeping mother-infant dyads and solitary dyads while controlling for breastfeeding. Homogeneity of regression was tested for all measures prior to ANCOVA analyses. Results are presented in Table 3. For infants, significant differences were found only for diary night waking indicating more reported night-wakings among co-sleeping infants at the age of 3 and 6 months. None of the actigraphic measures was significantly different between the two groups. For mothers, significant differences were found for almost all actigraphic sleep measures (beside SMIN), and for the diary night-waking measure at 3 and 6 months, indicating significantly more disrupted actigraphic and reported sleep quality for co-sleeping mothers at both assessment points. In addition, mothers in the co-sleeping group rated their sleep as poorer than mothers in the solitary group at 3 months postpartum, and had longer daytime sleep at the age of 6 months.

3.2.2. Predictive relationship between maternal sleep at pregnancy and sleeping arrangement at 3 and 6 months

A direct logistic regression analysis was conducted using maternal sleep measures at pregnancy as predictors and sleeping arrangement (1 = solitary, 2 = co-sleeping) at *3 months* as the criterion variable. The full model containing all predictors was not statistically significant, (χ^2 (6,N = 134) = 9.3, p = .16), indicating that the model was not able to distinguish between co-sleeping and solitary sleeping arrangements at 3 months on the basis of maternal sleep at pregnancy.

A similar model was tested with sleeping arrangement (1 = solitary, 2 = co-sleeping) at 6 months postpartum as the criterion variable. The full model containing all predictors was statistically significant (χ^2(6,N = 114) = 15.5, p < .05), indicating that the model was able to distinguish between co-sleeping and solitary sleeping arrangements at 6 months on the basis of maternal sleep during pregnancy. The model as a whole explained between 12.9% (Cox and Snell E square) and 17.2% (Nagelkerke R square) of the variance in sleep arrangement, and correctly classified 63.4% of cases. As shown in Table 4, actigraphic night wakings and WASO at pregnancy, significantly predicted sleeping arrangement at 6 months postpartum; mothers who had more frequent and prolonged night wakings during pregnancy, were more likely to co-sleep with their infants at 6 months.

3.2.3. Structural Equation Modeling (SEM) of crossed-lagged associations between infant/maternal sleep and sleeping arrangement at 3 and 6 months

To examine the bi-directional predictive relationship between infant/maternal sleep and sleeping arrangement, SEM analyses were conducted with the AMOS program (Version 22) using the Maximum Likelihood Estimation method. We tested two SEM models (one for infant sleep and one for maternal sleep) that were based on a symmetrical cross-lagged model of sleeping arrangement, infant/maternal sleep and feeding method. Infant/maternal sleep was comprised as a latent variable using two manifest indicators: actigraphic and diary number of night-wakings. This latent variable enabled to represent both objective and subjective sleep while obtaining a good model fit. Four types of effects were specified: (1) stability effects (sleeping arrangement and latent infant/maternal sleep at 3 months relative to sleeping arrangement and latent infant/maternal sleep at 6 months), (2) concomitant associations (i.e., correlations between sleeping arrangement, infant sleep and feeding techniques at 3 months and correlations between the "disturbances"—the residual variances—of sleeping arrangement and infant sleep at 6 months), (3) prediction effects from feeding techniques at 3 months to sleeping arrangement and infant sleep at 6 months, and (4) most importantly, cross-lagged effects, namely, the effect of 3 months sleeping arrangement on 6 months infant sleep, and vice versa (See Shahar & Davidson[35], for more details on cross-lagged models).

Model 1 examined the relationships between ***infant night-wakings*** and sleeping arrangement (Figure 1). Prior to testing this structural model and consistent with the recommendations put forth by Anderson and Gerbing[36], we examined the measurement model underlying the latent and manifest variables. Adequate fit indices were obtained for the structural model presented in

Figure 1: $\chi 2$ [df = 6] = 7.74, p = .35; $\chi 2/df$ =1 .29; NNFI = .99, CFI = .99, RMSEA = .03. Both sleeping arrangement (β = .40, p < .001) and infant's night wakings (β = .38, p < .001) were stable over time. Infant night wakings and infant's sleeping arrangement were significantly correlated at 3 (r = .23, p = .02) but not at 6 months (r =.20, p = .07). Breastfeeding at 3 months was significantly correlated with more infant night-wakings at 3 months (r = -.32, p = .001) and predicted co-sleeping (β = -.22, p = .011) and more infant night-wakings (β = -.33, p < .001) at 6 months. There were no significant cross-lagged associations between infant night-wakings and sleeping arrangement.

Model 2 examined the relationships between ***maternal night-wakings*** and sleeping arrangement (Figure 2). Adequate fit indices were obtained for the structural model presented in Figure 2: $\chi 2$ [df = 6] = 8.23, p = .22; $\chi 2/df$ = 1.37; NNFI = .94, CFI = .99, RMSEA = .05. Both maternal night-wakings (β = .52, p < .001) and sleeping arrangement (β = .34, p < .001) were stable over time. Maternal night-wakings and sleeping arrangement were significantly correlated at 3 (β = .34, p < .001) and 6 (β =.31, p < .001) months. Breastfeeding at 3 months predicted co-sleeping (β = -.20, p = .02) and more maternal-night wakings (β = -.23, p = .03) at 6 months. As to the cross-lagged effect, more maternal night-wakings at 3 months significantly predicted co-sleeping at 6 months (β =.29, p = .04). Sleeping arrangement did not significantly predict maternal night-wakings (β =.09, p=.40).

4. Discussion

This study explored for the first time the relationships between infant and maternal sleep and sleeping arrangements in the context of a longitudinal study, while using both objective and subjective measures of sleep. Our study included only families with a first child because we wanted to focus on parents who had no prior experience with childrearing. Also, this was important to avoid the confounding effect that having more than one child may have on sleep quality and on parental sleeping arrangements choices.

Our findings demonstrated that while there were no significant differences in objective sleep measures between co-sleeping and solitary sleeping infants at both assessment points, co-sleeping mothers did report more infant night-wakings than mothers in the solitary sleeping group. These findings are consistent with previous reports of more reported sleep problems in co-sleeping infants[5,6,8–10], and they highlight the differences between subjective perception of sleep and objective assessment. Regarding maternal sleep, the present study demonstrates that co-sleeping mothers had significantly poorer sleep quality than solitary sleeping mothers at 3 and 6 months, as reflected in more objective and subjective night-wakings, longer wakefulness during the night and shorter continuous sleeping episodes. In addition, at 3 months postpartum, co-sleeping mothers evaluated their sleep quality as poorer than solitary sleeping mothers. These differences were significant even when controlling for breastfeeding.

There are several possible explanations for our findings demonstrating significant differences in objective and subjective maternal sleep quality as a function of sleeping arrangement but showing only reported (and no objective) significant differences in infant sleep quality. One possibility is that co-sleeping mothers are more likely to be awakened by the infant night-wakings because of their proximity to the infant. Thus, co-sleeping mothers may be awakened by the infants movements or by their non-distressed vocalizations (e.g., babbling) during awakenings, even if their infants do not wake-up more than solitary sleeping infants. It could also be the case that co-sleeping mothers interpret active infant sleep as awakenings. A second possibility is that co-sleeping infants do have a greater number of *short* awakenings, which are noticed and reported by the mother, but that are not detected or counted by actigraphy (i.e., the actigrahic night-waking measure relates only to awakenings of at least 5 minutes). A third possibility is that the higher rates of sleep disturbances in co-sleeping mothers are not directly

related to the infant. This possibility is supported by our findings that co-sleeping mothers show more sleep disturbances already during pregnancy. Thus, these women may suffer from continuous sleep problems, which may increase their sensitivity to the infant behavior and awakenings during the night. It should be emphasized that all of these explanations are hypothetical and should be examined in future studies using videosomnography.

Consistent with the findings based on actigraphy, co-sleeping mothers rated their sleep quality as poorer than solitary sleeping mothers at 3 months postpartum. However, at 6 months postpartum there was no significant difference in maternal subjective ratings of sleep quality. Thus, even though co-sleeping mothers had poorer objective sleep and reported more night-wakings at 6 months, they did not feel they have more sleep disturbances. This may be related to the fact that at 6 months co-sleeping mothers napped longer than solitary sleeping mother and may have compensated through daytime sleep for their loss of sleep during the night[37]. Moreover, the difference in findings regarding the quantitative measures of sleep and the subjective evaluation of sleep quality, highlight the possibility that these measures represent different aspects of sleep.

A unique finding derived from the logistic regression analysis, demonstrated that there are predictive links between maternal prenatal sleep patterns and sleeping arrangements at 6 months postpartum. Specifically, mothers who had more frequent and prolonged night-wakings during the third trimester of pregnancy were more likely to co-sleep with their infants later on. The predictive link between maternal sleep quality and sleeping arrangements was supported also by the SEM analyses, which demonstrated that maternal sleep quality at 3 months post-partum predicted the type of sleeping arrangement at 6 months, but not vice versa (i.e. sleeping arrangement did not predict sleep quality over time). These predictive links remained significant

while controlling for breastfeeding. Thus, mothers who had more fragmented sleep at 3 months were more likely to continue co-sleeping over time, even though this may contribute to the maintenance of their sleep disturbances. Whereas maternal sleep quality seems to play a role in the prediction of sleeping arrangements, infant sleep quality did not appear to be a significant predictor. The only significant predictor in the infant model was breastfeeding at 3 months, which was associated with more infant night-wakings and with co-sleeping at 6 months.

Overall, breastfeeding was found to be associated with lower infant and maternal objective and subjective sleep quality at both 3 and 6 months postpartum. Though, breastfeeding was not significantly associated with co-sleeping at 3 months, it did predict higher levels of co-sleeping at 6 months, and was concomitantly associated with co-sleeping at 6 months. However, breastfeeding does not seem to explain the relationship between co-sleeping and maternal/infant sleep quality, as these relationship remained significant even after controlling for breastfeeding. Notwithstanding the many benefits of breastfeeding for infant development, our findings are consistent with prior findings indicating that breastfeeding is associated with more disturbed sleep and with co-sleeping[14–16].

Though not the main focus of this study, our findings demonstrate significant developmental changes in maternal and infant sleep during the perinatal period. Infant nighttime sleep became more consolidated from 3 to 6 months, as reflected by a lower number of objective night-wakings, shorter wakefulness during the night, and longer continuous sleep periods. Daytime sleep showed a reduction from 3 to 6 months. These findings are in line with previous findings on the consolidation of nocturnal sleep and decrease in daytime sleep of infants in the early postpartum period[38–41]. Maternal sleep quality as measured by actigraphy and diary night-wakings deteriorated from pregnancy to 3 months postpartum and then demonstrated an

improvement from 3 to 6 months postpartum. These findings confirm similar results from other studies reporting a deterioration in maternal objective and subjective sleep quality between pregnancy and the immediate postpartum period, followed by a gradual improvement in sleep quality over time[37, 42–43].

The current study has several limitations that should be taken into account. One limitation is the cultural homogeneity of our sample, as the sample in this study represents the middle socio-economic status in Israel, which seems to hold similar attitudes regarding infant sleep and sleeping arrangements to those of parents in other Western countries[44]. Prior studies found that sleep experiences and expectations differ greatly across cultures and that the choice of co-sleeping is significantly associated with cultural orientation[2,45–47]. Thus, further research is required to generalize the present study's findings beyond cultures that have different approaches and values to sleep in general and to sleeping arrangements in particular. Another limitation of the study is that we did not evaluate the underlying reasons for co-sleeping (e.g., proactive/planned versus reactive/unplanned co-sleeping)[7], which could have contributed to a better understanding of the relationship between sleeping arrangements and sleep quality of infants and mothers. In addition, our study focused on a broad distinction between solitary sleeping mother-infants dyads and mother-infant dyads that shared the same sleeping space during the night. Most of the later dyads were room-sharers, and only 7 dyads were classified as bed-sharers. Though bed sharing and room sharing may differ on some aspect of sleep, in our study such differences were not noticeable with our small sample of bed-shares. Moreover, we did not make a distinction between partial and consistent co-sleepers, and therefore we cannot rule out the possibility that some of the room-sharing infants were taken sometimes to the parental bed. Thus, it is important for future studies to examine more specifically whether

maternal and infant sleep quality differ between room-sharing and bed-sharing mother-infant dyads, and between planned versus reactive co-sleeping families. Future studies should also assess whether sleep quality changes as a function of different intensities/features of co-sleeping. While recognizing the limitations of our study, we do believe that our findings add valuable and novel information to the literature on the relationships between sleeping arrangements and sleep quality, especially concerning maternal sleep that has received, in past research, very limited attention in the context of co-sleeping.

4.1. Conclusions

The present study afforded an opportunity to examine the objective and subjective sleep patterns of both infants and mothers in co-sleeping and solitary sleeping arrangements. Moreover, the longitudinal design enabled, for the first time, to investigate the prospective links between maternal sleep during pregnancy and sleeping arrangement and to examine the bi-directional links between infant/maternal sleep in the postpartum and sleeping arrangements.

The findings of this study may have important clinical implications because they shift the focus of the co-sleeping debate from the infants to the mothers. When parents seek professional help and consult about the implications of co-sleeping, the possibility should be discussed that the sleep of the infant is not affected by co-sleeping, but rather that co-sleeping mothers are more aware of their infant's night-wakings. In addition, the poorer sleep quality of co-sleeping mothers and the mother's motivation for co-sleeping should be taken into clinical consideration.

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Fig.1. Structural Equation Modeling for the relationships between sleeping arrangement, feeding method and infant night-waking (latent variable composed of the number of actigraphic and diary night wakings), at 3 and 6 months postpartum. Standardized coefficients are presented in the figure

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Fig2. Structural Equation Modeling for the relationships between sleeping arrangement, feeding method and maternal night-waking (latent variable composed of the number of actigraphic and diary night wakings), at 3 and 6 months postpartum. Standardized coefficients are presented in the figure.

Table 1: Characteristics of study sample (N=137 at 3 months, 128 at 6 months)

	Mean	SD	%
Maternal age*	28.97	2.9	
Maternal education	15.70	2.0	
Paternal age	30.87	3.7	
Paternal education	15.02	2.2	
Number of rooms in the house	3.25	.92	
Infant weight at delivery	3.25	.42	
Infant weight first assessment point	5.48	1.25	
Infant weight second assessment point	7.67	.95	
Infant age at first assessment point	3.10	.43	
Infant age at second assessment point	6.10	.27	
Girls			54
Day care at three months			
Home reared			88
Baby sitter			8
Day-care			4
Day care at six months			
Home reared			46
Baby sitter			23
Day-care			31
Feeding method at three months			
Fully breastfeeding			58
Partial breastfeeding			25
Bottle feeding			17
Feeding method at six months			
Fully breastfeeding			32
Partial breastfeeding			28
Bottle feeding			40

*Parental socio-demographic measures were assessed during pregnancy

Table 2: Descriptive statistics and repeated-measures T-tests / ANOVA-tests for infant and maternal sleep (pregnancy, 3 and 6 months postpartum)

Infant sleep	**Pregnancy**	**3 months**	**6 months**	**T(110)**	**Cohen's d**

	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max		
LGSEP					255.44	84.17	111	542	235.82	86.67	108	566	2.22*	.23
WASO					52.39	29.99	3.25	175	41.30	24.99	1	127	3.64***	.40
SMIN					565.17	72.8	373	749	575.65	55.81	373	677	NS	.15
NW					2.80	1.29	0	7	2.22	1.32	0	6	4.02 ***	.46
D-NW					2.16	1.24	0	6	2.64	1.62	0	7	-3.53***	.35
NAP					203.47	67.30	70	396	161.97	47.14	59.0	310	7.95***	.21
Maternal sleep	**pregnancy**				**3 months**				**6 months**				**F(112) quadratic**	**Partial η^2**
	Mean	**SD**	**Min**	**Max**	**Mean**	**SD**	**Min**	**Max**	**Mean**	**SD**	**Min**	**Max**		
LGSEP	198.79	77.13	51	415	143.74	46.29	42	304	150.33	49.16	72	366	43.02***	.35
WASO	35.93	31.73	2.40	232.60	66.33	31.06	8.20	188	48.40	23.88	4.20	127	81.09***	.43
SMIN	406.70	56.61	247	568	387.86	57.90	210	538	381.89	49.54	260	488	NS	.16
NW	2.28	1.52	0	8.30	3.06	1.38	.25	9	2.88	1.55	0	10	14.98***	.52
D-NW	2.33	1.25	0	7.2	2.73	1.37	0	8.75	2.80	1.55	0	7.35	NS	.08
DSQ	6.97	1.54	1.8	10	6.79	1.50	2	10	6.55	1.77	.52	10	#5.64*	.05
NAP	22.0	27.7	0	372	24.89	31.37	0	142	20.11	32.27	0	180	NS	.01

*P<.05, **P<.01, ***P<.001 #linear effect

Actigraphic measures: LGSEP- longest sleep period; WASO- minutes awake after sleep onset; ; SMIN- sleep minutes; NW- number of night-wakings lasting at least 5 minutes D-NW- number of night wakings according to the diary; DSQ – Diary subjective evaluation of sleep quality (1=poor; 10=excellent); NAP – Napping duration.

N=153 mothers during pregnancy, 127 infants and 131 mothers at 3 months postpartum and 114 infants and mothers at 6 months.

Table 3: ANCOVA tests (controlling for breastfeeding) comparing infant and maternal sleep measures between co-sleeping and solitary sleeping infants

		3 Months					
		Co-sleeping (N=98 infants; 101 mothers)	**Solitary sleeping (N=29 infants; 30 mothers)**				
		Mean (SD)	**Mean (SD)**	**F**	**Partial η^2**	**95% confidence interval of the difference**	
Infant	**LGSEP(min)**	249.05 (77)	278.14 (95)	NS	NS	-62.3	9.3

3M	**WASO (min)**	52.36 (31)	42.01(21)	NS	NS	-3.8	21.9
	NW (num)	2.80 (1.28)	2.39 (1.22)	NS	NS	-.20	.9
	SMIN (min)	565.74 (72)	565.32 (69)	NS	NS	-31.3	31.2
	D-NW (num)	2.37 (1.24)	1.63 (1.29)	6.81**	.05	.16	1.17
	NAP (min)	200.0 (63.18)	211.82 (75.08)	NS	NS	-37.4	18.0
Mother	**LGSEP(min)**	139.74 (41)	167.56 (69)	6.65*	.05	-48.8	-6.5
3M	**WASO (min)**	70.19 (32)	51.15 (35)	6.81**	.05	4.6	33.5
	NW (num)	3.23 (1.46)	2.55 (1.66)	4.05*	.03	.00	1.32
	SMIN (min)	391.33 (58)	381.44 (65)	NS	NS	-17.4	34.4
	D-NW (num)	3.04 (1.39)	2.07 (1.51)	9.16**	.00	.30	1.47
	DSQ (range)	6.58 (1.56)	7.20 (1.13)	3.96*	.06	-1.17	.05
	NAP (min)	27.17 (33)	16.33 (19)	NS	NS	-.84	25.5
		6 months					
		Co-sleeping (N=53 infants; 51 mothers)	**Solitary sleeping (N=52 infants, 53 mothers)**				
Infant	**LGSEP(min)**	227.47 (96)	243.67 (75)	NS	NS	-44.2	24.6
6M	**WASO (min)**	41.67 (25)	37.57 (23)	NS	NS	-7.7	12.0
	LWEP (num)	2.33 (1.42)	1.99 (1.13)	NS	NS	-.32	.68
	SMIN (min)	572.28 (53)	576.38 (59)	NS	NS	-24.6	20.7
	DWEP (num)	3.23 (1.39)	2.01(1.53)	14***	.11	-11.4	23.2
	NAP (min)	165.31 (49)	163.30 (42)	NS	NS	.47	1.53
Mother	**LGSEP(min)**	136.11 (37)	166.97 (52)	10.62**	.1	-48.7	-11.8
6M	**WASO (min)**	56.67 (21)	37.57 (20)	20.25***	.17	10.6	27.5
	NW (num)	3.38 (1.27)	2.15 (1.22)	21.79***	.18	.68	1.7
	SMIN (min)	381 (53)	381.0 (49)	NS	NS	-24.0	17.5
	D-NW (num)	3.36 (1.28)	2.31 (1.50)	10.93***	.09	.35	1.4
	DSQ (range)	6.21 (1.8)	6.94 (1.8)	NS	NS	-1.39	-.03
	NAP (min)	26.67 (40)	14.03 (21)	7.11**	.04	3.04	27.26

*p≤.05 ** p≤.01 ***p≤.001

Actigraphic measures: LGSEP- longest sleep period; WASO- minutes awake after sleep onset; ; SMIN- sleep minutes; NW- number of night-wakings lasting at least 5 minutes D-NW- number of night wakings according to the diary; DSQ – Diary subjective evaluation of sleep quality (1=poor; 10=excellent); NAP – Napping duration.

Table 4: Logistic regression analysis predicting sleeping arrangement at 6 months pospartum from maternal sleep measures during pregnancy (N=114)

Sleep measure	B	S.E	Wald	Significance (*P*)	Odds ratio	95% confidence interval

LGSEP	-.00	.00	.12	.73	.99	.99	1.00
WASO	.04	.01	7.0	.00*	1.05	1.01	1.08
NW	-.85	.31	7.6	.00*	.42	.23	.78
SMIN	-.02	.00	.16	.69	.99	.99	1.00
D-NW	.31	.19	2.8	.09	1.37	.95	1.98
DSQ	.15	.15	.90	.34	1.15	.86	1.56
NAP	-.03	.18	.03	.85	1.05	.99	1.02

*P<.05

Actigraphic measures: LGSEP- longest sleep period; WASO- minutes awake after sleep onset; SMIN- sleep minutes; NW- number of night-wakings lasting at least 5 minutes D-NW- number of night wakings according to the diary; DSQ – Diary subjective evaluation of sleep quality (1=poor; 10=excellent); NAP – Napping duration.