# Investigating the link between sleep and postpartum depression in fathers utilizing subjective and objective sleep measures

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## ABSTRACT

*Background:* While fathers are at risk of developing poorer sleep and depressive symptoms in the postpartum period, they represent an understudied population in the literature. The present study aimed to explore the association between sleep and postpartum depressive symptoms in fathers using subjective and objective sleep measures.
*Methods:* Fifty-four fathers reporting no history of depression took part in this cross-sectional study. At 6 months postpartum, paternal sleep was assessed for 2 weeks utilizing a self-report daily sleep diary, a self-report perceived sleep quality rating, and actigraphy. In the same period, depressive symptoms in fathers were assessed with the Center for Epidemiologic Studies–Depression Scale (CES-D).
*Results:* Regression analyses showed that paternal subjective sleep variables captured by the sleep diary (total nocturnal sleep time and number of night awakenings) were not related to postpartum depressive symptoms. However, self-reported perceived sleep quality was significantly associated with postpartum depressive symptom severity in fathers independently of demographic variables related to depression. Alternatively, the objective sleep variables (total nocturnal sleep time, number of night awakenings, sleep efficiency, and wake after sleep onset), measured by actigraphy, did not demonstrate a significant relationship with paternal depression scores.
*Conclusions:* These findings highlight the importance of perceived sleep quality, along with better understanding its association with postpartum depressive symptoms. Implementing a multi-measure approach enabled us to expand our knowledge about how different facets of sleep relate to postpartum depression, specifically in fathers. The results have important implications for the development of clinical interventions targeting paternal sleep and mood in the postpartum period.

## 1. Introduction

The birth of an infant is a significant life event that is joyous and exciting, yet also uniquely challenging for parents [1,2]. Studies have demonstrated significant postpartum sleep disturbances among both mothers and fathers [3–5]. Such disturbances include increases in sleep fragmentation, sleep deprivation, and poor sleep quality resulting in fatigue and potential mood disruptions [5,6].

Research demonstrates a relationship between disturbed sleep and mood disorders in the general population [7,8]. In the context of the postpartum period, most studies have investigated the association between sleep (disturbances and quality) and depressive symptoms among mothers. For example, mothers who reported poor subjective sleep quality demonstrated elevated postpartum depressive symptoms at 1 and 3 months concurrently [4]. Hall and colleagues [9] outlined parallel findings at 6–8 months

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postpartum. Mothers' self-reported sleep disturbances and poor sleep quality were also associated with postpartum depression, regardless of risk factors including a history of depression [10]. Okun and colleagues [11] found that poor sleep quality was significantly associated with maternal depressive symptoms at 6 months postpartum. Furthermore, subjective sleep disturbances, including delayed sleep onset, have been linked to elevated maternal depressive symptoms during the third trimester of pregnancy and at 3 months postnatal [12]. Although there is a clear link between sleep and depression among mothers [13,14], less is known about this association in fathers.

The limited research on fathers has indicated that they, too, experience significant postpartum disruptions in sleep [3], justifying the importance of also investigating the association between sleep and depressive symptoms in this population. A few studies have provided limited evidence for such a link. Saxbe and colleagues [15] found that self-reported paternal sleep disturbances and quality at 6 months predicted depressive symptoms concurrently and longitudinally at 12 months postpartum. Lower sleep quality (measured by the Pittsburgh Sleep Quality Index − PSQI) and fatigue in fathers was also associated with depressive symptomatology during the postpartum period [9]. Taken together, these findings suggest that subjective sleep disturbances and sleep quality may contribute to the persistence and/or exacerbation of paternal depressive symptoms during the first year following childbirth.

Including fathers in the field of postpartum sleep is imperative since they are also at risk of developing both poorer sleep and depressive symptoms. Moreover, depressive symptoms may disrupt fathers' ability to assume parental tasks, impact day-to-day father−child interactions, and adversely affect family well-being [16]. Consequently, paternal postpartum depression negatively impacts child development [17]. The increasing trend toward dual-career families within North America over the last few decades [18] leads us to speculate that fathers will continue to have a more central role as caregivers to their infants. Examining fathers would provide us with more understanding about the course of postpartum depression as well as its impact on the whole family unit. Additionally, focusing on fathers allows us to explore the association between sleep and depressive symptoms without the influence of maternal hormonal changes, which have been linked to postpartum mood [19].

The heavy reliance on subjective sleep measures represents an additional limitation in the literature. Self-report sleep measures can be influenced by factors such as fatigue and mood. Therefore, the objective verification of sleep, in conjunction with subjective sleep measures, would be beneficial. However, studies utilizing objective sleep measures in the context of postpartum mental health research have been limited and have focused solely on mothers. Interestingly, these studies have revealed inconsistent findings. For example, one study conducted by Dørheim and associates [20] indicated that depressed mothers reported poorer subjective sleep quality (measured by PSQI) compared to non-depressed mothers at 2 months postpartum. However, objective sleep data did not yield such a difference between these two groups [20]. Bei and colleagues [21] revealed similar findings whereby subjective sleep, but not objectively measured sleep (eg, total sleep time, wake after sleep onset (WASO), sleep efficiency, and sleep disturbance), was strongly associated with postpartum mood disturbances in a sample of 44 mothers. Contrarily, Posmontier [22] reported that poor objective sleep (eg, sleep latency, WASO, and sleep efficiency) predicted more severe postpartum depressive symptomatology in 46 mothers. To our knowledge, there are no studies that examine objective sleep in the context of postpartum depressive mood in fathers, representing a major gap in the postpartum sleep literature.

The aim of the current study is to explore the relationship between sleep and depressive symptoms in fathers at 6 months. This time point was selected in light of previous research examining the link between sleep and depression [11], as well as research demonstrating that there is still high infant sleep variability at 6 months postpartum [23,24]. Three distinct sleep measures were used: (1) subjective sleep indices based on a sleep diary (*total nocturnal sleep time*, and *number of night awakenings)*, (2) perceived sleep quality, and (3) objective sleep indices *(total nocturnal sleep time*, *number of night awakenings*, *nocturnal sleep efficiency*, and *WASO)*. It should be noted that while subjective sleep and perceived sleep quality are both self-report measures, the former refers to how *long* and how *fragmented* participants thought their sleep was (ie, subjective quantity), whereas the latter refers to how *well* participants thought they slept (ie, perceived quality). The following variables were considered as potential covariates, given their possible association with depression in mothers and fathers: age, number of children, education level, employment status, and infant feeding method [11,25−28].

## 2. Material and methods

### 2.1. Participants

A total of 54 fathers with an average age of 35.06 years ($SD = 5.18$) were recruited from the Greater Montreal area (Québec). Participation was voluntary and informed consent was obtained. Recruitment occurred through online advertisements posted on social media forums for parents. Participants took part in a larger, longitudinal study investigating sleep, parental practices, and mood in parents. Cross-sectional data from the first time point, when the participants' infants were 6 months old, were utilized for the current study. Participants met the following inclusion criteria: (1) English−or French-speaking father, (2) 18 years and older, (3) no history of chronic medical illness, (4) no past or current diagnosis of mental health conditions, (5) no current use of sleep medication. All fathers in the sample lived with their infant and were either married or in a common-law union with the child's mother. While 44.5% of participants indicated having 2 children, 38.9% reported being first-time fathers. Additionally, the majority of the sample (85.2%) reported current full-time paid employment. Table 1 describes all participant demographic characteristics.

### 2.2. Measures and procedures

Subjective sleep indices were assessed through a modified sleep diary adapted from Acebo and colleagues [29]. Participants were instructed to complete the sleep diary for 14 consecutive days. Two subjective sleep variables were derived by computing means of the sleep diary data across the 2-week period: (1) *total nocturnal sleep time*, and (2) *number of night awakenings*. On average, participants provided 12.17 days ($SD = 3.32$) of subjective sleep data.

In addition, the *perceived sleep quality* variable was obtained through paternal ratings of their sleep each morning ("rate your sleep quality − use a 1−10 scale, 1 = poor, 10 = excellent"). Higher values indicated better sleep quality. Perceived sleep quality was derived by computing a mean across the 2-week period for each participant. On average, participants provided 10.13 days ($SD = 5.06$) of sleep quality data.

Objective sleep was assessed using actigraphy. Actigraphy has been previously validated against polysomnography [30]. It has been deemed a reliable measure of objective sleep [31,32]. Actigraphy is a watch-like device that is placed on the wrist of participants' non-dominant arm. The present study used the Actiwatch Spectrum Plus (Philips Respironics), a triaxial, piezo-electric

**Table 1**
Demographic characteristics.

| Variable | n | % |
|---|---|---|
| **Age** | | |
| 25-34 | 27 | 50.0 |
| 35-44 | 24 | 44.5 |
| 45+ | 3 | 5.5 |
| **Number of Children** | | |
| 1 | 21 | 38.9 |
| 2 | 24 | 44.4 |
| 3 | 6 | 11.1 |
| 4 | 3 | 5.6 |
| **Education Level** | | |
| High school | 2 | 3.7 |
| College | 17 | 31.5 |
| Bachelor | 17 | 31.5 |
| Graduate | 18 | 33.3 |
| **Employment Status** | | |
| Full-time paid employment | 46 | 85.2 |
| Part-time paid employment | 2 | 3.7 |
| Student | 2 | 3.7 |
| Student and paid employment | 2 | 3.7 |
| Home due to paternity leave | 2 | 3.7 |
| **Infant Feeding Method** | | |
| No breastfeeding | 4 | 7.4 |
| Partial breastfeeding | 8 | 14.8 |
| Exclusive breastfeeding | 42 | 77.8 |

accelerometer. Participants were instructed to wear the watch for 14 consecutive days and remove the device only for immersed, water-based activities (eg, bathing, swimming, etc.). The Actiwatch was sampled at a rate of 32 Hz. Data were recorded in 1-min epochs [20,32] and downloaded using Philips Actiware Software (version 6.0.9). Data were scored using a standardized actigraphy scoring protocol [33]. Four objective sleep variables were derived by computing means of the actigraphy data across the 2-week period: (1) *total nocturnal sleep time*, (2) *number of night awakenings* (lasting >1 min), (3) *nocturnal sleep efficiency* (number of sleep minutes ⁄number of minutes in bed X 100), and (4) *Wake after sleep onset (WASO)*. On average, participants provided 11.91 days ($SD = 2.97$) of valid actigraphy data.

The Center for Epidemiologic Studies−Depression Scale (CES-D [34]; was used to assess paternal depressive symptoms. This self-report measure of depressive symptoms is well validated and is widely used with both the general population and with parents pre-and-postnatally [12,34]. The CES-D was selected in the current study as it has previously been utilized in examining postpartum depressive symptoms in both mothers and fathers [9]. It consists of 20 items and instructs respondents to reflect on their feelings and attitudes over the past week and select a response that best describes how they felt or behaved. Items are rated on a 4-point Likert scale from 0 (*rarely/none of the time: <1 day*) to 3 (*most/all of the time: 5−7 days*). The total score ranges from 0 to 60, with higher scores indicating more frequent depressive symptoms. Cut-off scores ≥16 suggest a potential risk factor for depression. The CES-D has demonstrated good internal consistency (Cronbach $\alpha = 0.84$ to 0.88; [12,35]. In the current study, the Cronbach $\alpha$ was 0.85.

Participants completed a demographic questionnaire to obtain information on their age, number of children, education level (ie, last diploma obtained), and employment status. Additionally, participants were asked about infant feeding method (ie, no breastfeeding, partial breastfeeding − mixed feeding, exclusive breastfeeding).

Participants recruited by online advertisements were contacted via telephone by members of our research laboratory. Research assistants conducted a short phone screening with interested

individuals to assess whether inclusion criteria were met. If fathers were deemed eligible and agreed to participate, a home visit was scheduled. Trained members of our research team visited participants at their home to obtain written consent and explain the measures and procedures, including the actigraphy recording. During the 2-week participation period, fathers were asked to complete the sleep diary, sleep quality rating, and wear the Actiwatch daily. Participants completed the demographic questionnaire and CES-D at their convenience within the 2-week period. Shortly following the initial home visit, a research assistant contacted participants to clarify potential questions and/or difficulties and to ensure that the sleep measures were being completed correctly. Fathers received their compensation upon retrieval of the study materials. The current research received approval from the McGill University Ethics Board (REB-II) and the Hôpital en santé mentale Rivière-des-Prairies Ethics Board.

### 2.3. Statistical analyses

Prior to analysis, outliers, missing data, and normality were addressed according to procedures outlined by Tabachnick and Fidell [36]. That is, univariate outliers ($z > |3.29|$) were converted to the nearest non-outlying value (with $z < |3.29|$). Participants that did not complete the sleep measures were excluded. The majority of items in the CES-D contained less than 5% missing data, which falls within the acceptable range [36]. As such, missing values on the CES-D were imputed using sample mean replacement. All data were analyzed using IBM SPSS version 24.0 for Windows (SPSS Inc., Chicago, IL).

A series of one-way MANOVAs were conducted to determine whether there were significant differences between the various sleep variables among participants who completed all 14 days of the sleep data and those who did not (ie, completed 13 days or less).

Pearson's correlations were conducted among CES-D total scores and demographic variables. Demographic variables found to be correlated significantly with depressive symptoms were entered as covariates in the primary analyses. Pearson's correlations were also conducted among subjective sleep indices to ensure that sleep diary variables and perceived sleep quality ratings were not highly correlated, and thus representative of distinct constructs.

A series of multiple regression analyses were implemented to examine the relationship between fathers' sleep (ie, subjective sleep indices, perceived sleep quality, and objective sleep indices) and their postpartum depressive symptoms. The means for each sleep measure were the independent variables, whereas the CES-D total score was the dependent variable. As previously mentioned, demographic data significantly correlated with depressive symptoms were included in the regression models as covariates. Statistical significance was determined based on $p < 0.05$.

### 3. Results

Table 2 presents means and standard deviations of sleep variables and depressive symptoms at 6 months postpartum. Results from the one-way MANOVAs indicated no statistically significant differences ($p > 0.05$) between fathers who completed all 14 days of the sleep measures and those who completed 13 days or less of the subjective sleep variables, perceived sleep quality variable, and objective sleep variables. Given these findings, all participants were retained in the primary analyses ($N = 54$).

Pearson's correlations were conducted among CES-D total scores and the following demographic variables: age, number of children, education level, employment status, and breastfeeding. As illustrated in Table 3, results indicated that more paternal depressive symptoms were associated with fewer number of children

**Table 2**
Means and standard deviations of paternal sleep variables and depressive symptoms at 6 months postpartum.

| Variable | 6 Months Postpartum |
|---|---|
| **Subjective Sleep (sleep diary)** | |
| Total nocturnal sleep time (minutes) | $440.29 \pm 46.69$ |
| Number of night awakenings | $0.50 \pm 0.39$ |
| **Perceived Sleep Quality** | |
| Sleep quality (rating from 0 to 10) | $7.11 \pm 0.98$ |
| **Objective Sleep (actigraphy)** | |
| Total nocturnal sleep time (minutes) | $445.29 \pm 51.96$ |
| Number of night awakenings | $1.77 \pm 0.66$ |
| Nocturnal sleep efficiency (%) | $89.25 \pm 4.39$ |
| WASO (minutes) | $47.10 \pm 21.86$ |
| **Depressive Symptoms** | |
| CES-D total score | $8.19 \pm 6.51$ |

*Note: $N = 54$, WASO = Wake After Sleep Onset. A mean was computed for each sleep variable with data across the 2-week participation period.*

($r = -0.308$, $p = 0.024$). This was the only demographic variable that correlated with depression scores. As such, *number of children* was entered into the regression models as a covariate. Regarding subjective sleep indices, self-reported *perceived sleep quality* did not correlate with self-reported *total nocturnal sleep time* ($r = -0.181$, $p > 0.05$) and *number of night awakenings* ($r = -0.222$, $p > 0.05$) as captured by the sleep diary.

Table 4 shows the multiple regression analysis examining fathers' subjective sleep and postpartum depressive symptoms. Results indicated that subjective *total nocturnal sleep time* ($p = 0.844$) and *number of night awakenings* ($p = 0.190$) did not significantly associate with fathers' depression scores. Self-reported perceived sleep quality, however, was significantly associated with paternal depression scores, $F (2, 51) = 5.28$, $p = 0.008$, $R^2 = 0.172$, $p = 0.034$ (see Table 5). This association was present even after controlling for *number of children.* The final multiple regression model (see Table 6) describes the association between objective sleep and postpartum depressive symptoms. *Total nocturnal sleep time*, *number of night awakenings, sleep efficiency,* and *WASO* did not show a statistically significant relationship with paternal *CES-D total score* ($p > 0.05$).

## 4. Discussion

In the current study, three distinct sleep measures (ie, subjective sleep indices, perceived sleep quality, and objective sleep indices) were utilized to investigate the association between fathers' sleep and postpartum depressive symptoms. Findings revealed that, after controlling for number of children, poorer fathers' perceived sleep quality was linked to more severe depressive symptoms at 6 months postpartum. Contrarily, subjective and objective sleep variables (*total nocturnal sleep time*, *number of night awakenings*, *nocturnal sleep efficiency* and *WASO*), as measured by the sleep diary and actigraphy, were not significantly associated to paternal depressive symptoms.

Although perceived sleep quality and subjective sleep variables are typically grouped and examined together as one composite factor (often labeled as subjective sleep quality) within the literature, our results (ie, small and non-statistically significant correlational coefficients) suggest that they in fact reflect different constructs. Perceived sleep quality represents fathers' perceptions about how *well* they thought they slept. Whereas, subjective sleep, although also a self-report measure, is indicative of how *long* and *how fragmented* they thought their sleep was − it therefore relates to quantitative facets of fathers' sleep perception, specifically sleep duration and number of night awakenings.

Previous studies that have investigated subjective parental sleep variables have often relied on well-established self-report questionnaires such as the PSQI [9,37−39]. This widely used measure provides a global score of sleep quality consisting of various subscores on sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, sleep quality, and daytime dysfunction. The PSQI also encompasses general ratings of perceived sleep quality. In general, studies have demonstrated an association between the PSQI and postpartum depressive symptoms in both mothers and fathers [9,15].

While the PSQI is a validated measure as a whole, research has also revealed mixed findings with regard to the specific subscores of the PSQI. In particular, sleep efficiency and duration *have not* been found to relate to depression in mothers [10]. Contrarily, other subscores of the PSQI, particularly those pertaining to mothers' ratings of sleep quality, *have* been specifically associated with postpartum depression [10]. These results presented by Dørheim and colleagues [10] are in line with those of the present study, which indicate that perceptions of sleep quality relate more strongly to depression as compared to perceived sleep duration. Taken together, these findings provide support for further investigations of individual sleep factors, especially those tied to perceived sleep quality (ie, how well one thinks they slept).

Moreover, objective sleep (actigraphy) was not significantly associated with postpartum depressive symptoms in the present study. These findings are consistent with previous studies conducted in mothers and have demonstrated a lack of relationship between actigraphy-measured sleep and depression [20,21]. These findings, however, are inconsistent with one study by Posmontier [22]; which concluded that actigraphy-measured sleep latency, sleep efficiency, and WASO predicted more severe depressive symptoms in mothers between 6 and 24 weeks postpartum. The incongruence may be explained by differences in sample characteristics. Posmontier [22] included a sample comprised of mothers diagnosed with postpartum depression, whereas fathers in the current study did not report a history of depressive symptoms. As such, it is possible that poor sleep may exacerbate depressive symptoms specifically in fathers that are already depressed or more vulnerable to getting depressed. Furthermore, mothers may be particularly more vulnerable to the effects of poor sleep as compared to non-depressed fathers. Such vulnerability may be rooted in female hormonal changes as a result of pregnancy [19]. Because our study was the first (to our knowledge) to examine the

**Table 3**
Pearson's correlations among depressive symptoms (CES-D total score) and demographic variables.

| | | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| 1. | Depressive symptoms (CES-D) | − | -0.092 | -0.308* | -0.135 | 0.017 | 0.091 |
| 2. | Age | | − | 0.288* | 0.191 | -0.183 | -0.061 |
| 3. | Number of children | | | − | 0.159 | -0.069 | 0.198 |
| 4. | Education level | | | | − | -0.220 | 0.126 |
| 5. | Employment status | | | | | − | -0.166 |
| 6. | Infant feeding method | | | | | | − |

*Note: * = statistical significance at the 0.05 level (2-tailed).*

**Table 4**
Multiple regression analyses of subjective sleep variables (sleep diary) and paternal depressive symptoms (CES-D total score).

| Variables | B | 95% CI | β | t | p |
|---|---|---|---|---|---|
| **Model 1** | | | | | |
| Number of children | −2.38 | [-4.43, −0.33] | -0.31 | −2.33 | 0.024 |
| **Model 2** | | | | | |
| Number of children | −2.25 | [-4.33, −0.17] | -0.29 | −2.17 | 0.035 |
| Total nocturnal sleep time (minutes) | −0.00 | [-0.04, 0.03] | -0.03 | −0.20 | 0.844 |
| Number of night awakenings | 3.00 | [-1.54, 7.54] | 0.18 | 1.33 | 0.190 |

**Table 5**
Multiple regression analyses of self-reported perceived sleep quality and paternal depressive symptoms (CES-D total score).

| Variables | B | 95% CI | β | t | p |
|---|---|---|---|---|---|
| **Model 1** | | | | | |
| Number of children | −2.38 | [-4.43, −0.33] | -0.31 | −2.33 | 0.024 |
| **Model 2** | | | | | |
| Number of children | −2.44 | [-4.42, −0.46] | -0.32 | −2.47 | 0.017 |
| Sleep quality (rating from 1 to 10) | −1.84 | [-3.53, −0.14] | -0.28 | −2.18 | 0.034 |

link between objective sleep and depressive symptoms in fathers, additional cross-study comparisons were not possible.

Taken together, fathers' negative perceptions about the quality of their sleep appear to be associated with their depressive symptoms. The shared mechanisms within each of these two measures may provide a possible explanation for this link. The measures of perceived sleep quality and depressive symptoms (ie, the CES-D) both required participants to reflect and report on their thoughts and feelings. The former derived information about father's thoughts and feelings related to the quality of their sleep, while the latter derived information about their thoughts and feelings about themselves (examples of items include: *I felt sad, I felt fearful, I thought my life had been a failure*). Alternatively, the other subjective and objective measures implemented in the current study did not assess cognitive or affective factors but instead examined the numeric components of sleep. The subjective sleep diary measures required individuals to assess and estimate quantitative facets of their sleep, whereas the objective measures focused on motor activity via actigraphy.

The importance of father's perceptions about sleep is further underscored by the results derived from the correlational analyses. Findings demonstrated a significant negative association between number of children and paternal depressive symptoms. Specifically, first-time fathers were more likely to report higher depressive symptoms compared to non-first-time fathers. First-time fathers may be more likely to catastrophize and develop hopelessness about their poor sleep. In contrast, non-first-time fathers are likely more experienced with poor sleep, which may have enabled them to form more realistic expectations and develop more effective coping strategies. This group may thus perceive their sleep less negatively, rendering them less vulnerable to the effects of poor sleep. Our findings have important implications for the development and application of clinical interventions. The results suggest that clinicians ought to target distorted cognitions and expectations pertaining to fathers' perceptions of their sleep quality when developing interventions for the treatment of paternal depression. This is in line with cognitive-behavioural treatment approaches for insomnia and depression [15]. Clinicians may also normalize the sleep-related challenges faced by fathers, especially first-time fathers, upon the arrival of their newborn child to encourage more realistic expectations and help reduce depressive symptoms such as hopelessness. Additional research examining the potential protective advantages of already having one or more children with regard to postpartum sleep and mental health is also warranted.

### 4.1. Limitations, future directions, and strengths

Our sample included mostly married, white males, with the large majority completing a college education and earning full-time paid employment. In conjunction with the modest sample size, the generalizability of our findings may thus be restricted. The lack of participant baseline sleep and mood data (prior to childbirth) presents another limitation. The absence of such data did not allow us to examine the progression of sleep and depressive symptoms in the postpartum period. While the cross-sectional design implemented in the current study provided important information about the relationship between sleep and postpartum depression, only one time point was examined and the direction of this association was not assessed. As such, the development of this relationship and whether it might be causal in nature could not be determined. Lastly, given that our measure of sleep quality was not previously validated, our ability to compare our findings to other studies was limited.

**Table 6**
Multiple regression analyses of objective sleep variables (actigraphy) and paternal depressive symptoms (CES-D total score).

| Variables | B | 95% CI | β | t | p |
|---|---|---|---|---|---|
| **Model 1** | | | | | |
| Number of children | −2.38 | [-4.43, −0.33] | -0.31 | −2.33 | 0.024 |
| **Model 2** | | | | | |
| Number of children | −2.32 | [-4.66, 0.03] | -0.30 | −1.99 | 0.053 |
| Total nocturnal sleep time (minutes) | −0.00 | [-0.07, 0.07] | -0.02 | −0.07 | 0.944 |
| Number of night awakenings | −0.82 | [-5.20, 3.57] | -0.08 | −0.37 | 0.711 |
| Sleep efficiency (%) | −0.04 | [-3.02, 2.94] | -0.03 | −0.03 | 0.978 |
| WASO (minutes) | −0.02 | [-0.63, 0.58] | 0.08 | −0.08 | 0.940 |

*Note:* WASO = Wake After Sleep Onset.

Future studies including varied samples, comprised of individuals from diverse minority groups, levels of education, and socioeconomic status, may expand our knowledge on the link between postpartum sleep and mood. The inclusion of fathers with pre-existing depression would also be beneficial and would serve as an important comparison group. Indeed, research is needed on higher-risk samples, including those experiencing more severe and pervasive depressive symptoms and sleep related difficulties. Additionally, longitudinal studies implementing both subjective and objective measures of sleep and which span across a wider range of time, including pregnancy, the neonatal period, and the first 12 months of infancy are necessary as they would provide more insight into the direction of this relationship and how it unfolds over time. Longitudinal investigations may also help reveal the most sensitive period for parents with regard to sleep and depression.

Despite the limitations described above, the current research design's multifaceted approach represents a key strength. Delineating between multiple measures of sleep enabled us to draw meaningful conclusions about how different facets of sleep relate to depressive symptoms. Our focus on fathers represents an additional strength, as they are an understudied population in the postpartum sleep and mood literature.

## 5. Conclusion

Our findings demonstrated that perceptions of sleep quality were associated with depressive symptom severity in fathers at 6 months postpartum. Subjective and objective sleep indices were not associated with paternal depressive symptoms. These findings suggest that fathers' perceptions of their sleep quality, and not the actual quality or quantity of their sleep (measured by the sleep-diary and actigraphy), may have a more important role in the development of depressive symptoms in the months that follow the birth of their infant.

Further research exploring the role of social protective factors in mitigating depressive symptoms in parents with poor sleep is necessary. Such research may enable us to identify and consolidate other critical components to include in intervention programs. Ultimately, this knowledge would help address postpartum mental health challenges related to poor sleep, and help promote individual, child, couple, and overall familial well-being.

## Contributors

All authors are responsible for reported research. All authors have participated in the concept and design; analysis and interpretation of data; drafting or revising of the manuscript for important intellectual content, have approved the manuscript as submitted, and agree to be accountable for all aspects of the work.

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## Conflict of interest

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