Association of sleep quality with temperament among one-month-old infants in The Japan Environment and Children’s Study

Kimiyo Kikuchi1, Takehiro Michikawa2, Seiichi Morokuma1,3,*, Norio Hamada3,4, Yoshiko Suetsugu1, Kazushige Nakahara4, Kiyoko Kato3,4, Masafumi Sanefuji3,5, Eiji Shibata6,7, Mayumi Tsuji6,8, Masayuki Shimono6,9, Toshihiro Kawamoto6, Shouichi Ohga3,5, Koichi Kusuhara6,9, The Japan Environment and Children’s Study Group

1 Department of Health Sciences, Graduate School of Medical Sciences, Kyushu University, Fukuoka, Japan, 2 Department of Environmental and Occupational Health, School of Medicine, Toho University, Tokyo, Japan, 3 Research Center for Environment and Developmental Medical Sciences, Kyushu University, Fukuoka, Japan, 4 Department of Obstetrics and Gynecology, Graduate School of Medical Sciences, Kyushu University, Fukuoka, Japan, 5 Department of Pediatrics, Graduate School of Medical Sciences, Kyushu University, Fukuoka, Japan, 6 Regional Center for Japan Environment and Children’s Study, University of Occupational and Environmental Health, Kitakyushu, Japan, 7 Department of Obstetrics and Gynecology, School of Medicine, University of Occupational and Environmental Health, Kitakyushu, Fukuoka, Japan, 8 Department of Environmental Health, School of Medicine, University of Occupational and Environmental Health, Kitakyushu, Fukuoka, Japan, 9 Department of Pediatrics, School of Medicine, University of Occupational and Environmental Health, Kitakyushu, Fukuoka, Japan

☯ These authors contributed equally to this work.
¶ The Study Group members are listed at the end of this article.

* morokuma.seiichi.845@m.kyushu-u.ac.jp

Abstract

This study aimed to examine the association between infant sleep quality and temperament in one-month-old infants using a large cohort study data. We used data from the Japan Environment and Children’s Study, a cohort study which follows around 100,000 women from pregnancy until their children’s development. The mothers were asked about their infants’ sleep and temperament using a structured questionnaire. Frequent crying (adjusted odds ratio [AOR]: 1.05, 95% confidence interval [CI]: 1.00–1.10) and intense crying (AOR: 1.19, 95% CI: 1.13–1.25) were positively associated with longer sleep periods during the day than at night. Female infants with longer daytime sleep periods than that at nighttime were more likely to cry frequently (AOR: 1.17, 95% CI: 1.04–1.20). Parous women with infants who had frequent night awakening believed their infants cried more intensely (AOR: 1.19, 95% CI: 1.03–1.31). The study demonstrated a specific association between sleep quality and temperament in one-month-old infants. Based on the results of this study, further sleep intervention studies are required to improve infant temperament.
Introduction

The importance of temperament in infants has been attracting attention. Temperament is complexly affected by genetic and environmental factors [1]. Infant temperament is linked to underlying neural networks [2] and refers to the initial state of psychopathological and behavioral development [3]. A correlation between early development through temperament and attention-deficit/hyperactivity disorder at a later age has been particularly discussed [4,5].

Infant temperament may be influenced by sleep quality. Healthy sleep is defined by its appropriateness in duration, timing, quality, and absence of disturbances [6,7]. Previous studies have demonstrated various sleep qualities related to temperament during the first year of life, such as sleep duration and night awakening [8–10]. In particular, shorter nighttime sleep periods and frequent night awakenings were associated with negative or difficult infant temperament [10,11]. This may be explained by the sleep difficulties that inhibit neuropsychological functioning [12,13]. However, another study has reported weak to no association between sleep and temperament [11]. Thus, the exact nature of this relation remains ambiguous [14].

To the best of our knowledge, no study has been conducted yet to thoroughly investigate the relationship between infant sleep quality and temperament, especially in one-month-old infants. However, it is essential to elucidate this relationship in early infancy. Once this relationship is clarified, early intervention in infant sleep may help control later temperament problems, thus preventing developmental problems. Hence, this study aims to examine the association between sleep quality and temperament in one-month-old infants using data from a large cohort study.

Methods

Study design and participants

This study is a cross-sectional study conducted as part of Japan’s nationwide prospective birth cohort study, the Japan Environment and Children’s Study (JECS), which aims to elucidate the environmental factors affecting children’s health and development. The study was registered in the UMIN Clinical Trials Registry (number UMIN000030786), while the protocol and baseline profile of the participants were reported elsewhere [15,16]. JECS follows up on around 100,000 pregnant women and their children until the children reach 13 years of age. Pregnant women were recruited between January 2011 and March 2014 from 15 Regional Centres throughout Japan. In this study, we analyzed maternal and infant data, excluding data from cases of multiple participating pregnant women, miscarriages or stillbirths, missing information on maternal age at delivery, multiple births, births at <37 or >41 gestational weeks, congenital abnormality or disease in one-month-old infants, and unanswered questions on infant sleep quality or temperament (Fig 1). In this study, the definition of a “one-month-old infant” was an infant 30 or 31 days after birth.

Data collection

After registration, the pregnant women answered self-administered questionnaires in the first and second/third trimesters and the first month after birth (median: 30 (27–33) days). The medical records of the infants at birth were also transcribed and collected by physicians, midwives/nurses, and/or Research Co-ordinators.

Infant sleep. The infant’s sleep quality was identified by the awakening frequency and the length of sleep, which were indicated as predictors of children’s developmental problems [17]. Mothers ticked the infants’ sleep time on sleep/wake the day before the data collection date, marking the infant’s sleep every 30 minutes. The frequency of awakening was assessed by the
number of nocturnal awakenings between 8:00 pm and 7:59 am before the day of data collection. We set ≥5 awakenings as the points that define higher frequency because the awakening frequency ranges from 1.0 to 5.0 between 8:00 pm and 7:59 am for 2-week-old neonates [18]. Comparison of sleep duration was assessed by the length of sleep periods during nighttime (8:00 pm to 7:59 am) and that during daytime (8:00 am to 7:59 pm). We defined longer daytime sleep periods than that during nighttime as unusual.

**Infant temperament.** Infant temperament was assessed by the mothers’ responses to the questions on their infants’ mood, crying degree, and crying intensity, which related to children’s developmental disorder [17]. Infant mood was identified by the question, "Frequency of having difficulty while holding the baby due to his/her affection and/or behavior (e.g., crying, bending backwards, etc.)." Answer options included "often," "sometimes," "seldom," and "never." Often was categorized as a neonatal tendency to be in a "bad mood." The question to assess the degree of crying was "Intensity and frequency of crying (baby)" Answer options included "quite often and long," "sometimes and short," and "hardly." Quite often and long was categorized as "frequent crying, for long periods." The question to assess crying intensity was "I have trouble calming down my crying baby." The question was answerable by yes/no. "Yes" was categorized as "intense crying." All these categorizations were defined in previous studies [19,20].

**Covariates.** In addition to infant sleep and temperament data, other covariates were included in the analyses following previous studies that assessed factors associated with infant sleep [20–25]. Maternal data included maternal age at delivery, parity or any previous childbirth experience, sleep duration of the mother during pregnancy, smoking habits during pregnancy, marital status, maternal educational background, household income, and postnatal depressive symptoms (Edinburgh Postnatal Depression Scale [26,27]: a score of ≥9 out of 30 was defined as having depressive symptoms in Japan [28]). Infant data included the gestational
week at birth, birth weight (<10th percentile of birth weight standards by gestational age is categorized as small for gestational age for Japanese neonates [29]), infant sex, and feeding status.

**Statistical analyses**

First, we descriptively analyzed the data according to infant sleep quality categories and identified the cutoffs as ≥5 nighttime awakenings and longer daytime sleep periods than at nighttime. We then used the Chi-square test to examine the relationship between infant sleep quality and temperament [30]. Then, we conducted logistic regression analyses to assess the association between sleep quality and temperament [31]. We set two dependent variables, ≥5 nighttime awakenings and longer daytime sleep periods than at nighttime, and three independent variables, bad mood, frequent crying for a long period, and intense crying. The association between each dependent variable and each independent variable was examined by adjusting for covariates. We then assessed the association between infant sleep quality and temperament as stratified by sex or mother’s parity. We performed analyses in the models with only maternal age and infant and maternal covariates. We also assessed the association of infant’s sleep quality and temperament stratified by infant’s sex or mother’s parity, which have been identified as factors associated with infant temperament [19,32]. Statistical evidence of the effect modification was checked using cross-product terms of exposures and infant’s sex (or parity).

All data analyses were performed using STATA version 16.1 (StataCorp LLC. College Station, TX, USA). The dataset used for this study was the jecs-an-20180131 dataset released in March 2018.

**Ethical approval**

The JECS protocol was reviewed and approved by the Ministry of the Environment’s Institutional Review Board on Epidemiological Studies and the Ethics Committees of all participating institutions. The study has been conducted under the Declaration of Helsinki and Japan’s Ethical Guidelines for Epidemiological Research issued by the Ministry of Education, Culture, Sports, Science, and Technology and the Ministry of Health, Labor, and Welfare, Japan. Written informed consent was obtained from all participants.

**Results**

Of 103,062 pregnancies registered in the Japan Environment and Children’s Study (JECS), we analyzed 80,970 eligible maternal and infant dyad data for this study. As shown in Table 1, there were 5,158 infants (6.4%) categorized to have ≥5 nighttime awakenings and 15,616 infants (19.3%) categorized to have longer daytime sleep periods than at nighttime. Both had a median sleep duration of 15.5 hours (Interquartile range: 14.5–17.0). Regarding the temperaments, bad mood, frequent crying for a long duration, and intense crying was observed in 6.2%, 17.2%, and 19.5% of infants, respectively.

**Relationship between infant sleep quality and temperament using the Chi-square test**

Table 2 demonstrates the relationship between infant sleep quality and temperament using the Chi-square test. Significant relationships were observed between frequent nighttime awakenings and bad mood (p < 0.001) or intense crying (p = 0.001). There was a relationship between longer daytime sleep periods than at nighttime and bad mood, frequent crying, or intense crying (all, p < 0.001).
| Maternal characteristics | Total population (n = 80,970) | Five or more awakenings during the night | Sleeping longer during the day than at night |
|--------------------------|-------------------------------|----------------------------------------|------------------------------------------|
|                          | n\(^a\) (%)                  | No (n = 75,812) Yes (n = 5,158) | No (n = 65,354) Yes (n = 15,616) |
| **Age at delivery (years)** |                               |                                       |                                       |
| < 25                     | 354 (6.9)                     | 7,472 (9.9)                           | 6,073 (9.3)                             |
| 25–29                    | 1,357 (26.3)                  | 21,150 (27.9)                         | 18,215 (27.9)                           |
| 30–34                    | 1,943 (37.7)                  | 26,854 (35.4)                         | 23,400 (35.8)                           |
| ≥ 35                     | 1,504 (29.2)                  | 20,336 (26.8)                         | 17,666 (27.0)                           |
| **Parity**               |                               |                                       |                                       |
| 0                        | 1,839 (35.8)                  | 33,381 (44.2)                         | 27,112 (41.6)                           |
| ≥ 1                      | 3,293 (64.2)                  | 42,146 (55.8)                         | 37,991 (58.4)                           |
| **Smoking habits**       |                               |                                       |                                       |
| Never smoked             | 3,018 (58.8)                  | 44,256 (58.6)                         | 38,346 (58.9)                           |
| Ex-smokers who quit before pregnancy | 1,294 (25.2)                  | 17,652 (23.4)                         | 15,323 (23.5)                           |
| Smokers during early pregnancy | 824 (16.0)                  | 13,634 (18.1)                         | 11,447 (17.6)                           |
| **Marital status**       |                               |                                       |                                       |
| Married                  | 4,919 (96.4)                  | 71,653 (95.6)                         | 61,930 (95.8)                           |
| Unmarried                | 156 (3.1)                     | 2,719 (3.6)                           | 2,195 (3.4)                             |
| Divorced/widowed         | 28 (0.6)                      | 614 (0.8)                             | 518 (0.8)                               |
| **Educational background (years)** |                               |                                       |                                       |
| < 10                     | 210 (4.1)                     | 3,388 (4.5)                           | 2,824 (4.4)                             |
| 10–12                    | 1,470 (28.8)                  | 23,369 (31.2)                         | 19,924 (30.9)                           |
| 13–16                    | 3,349 (65.6)                  | 46,997 (62.8)                         | 40,791 (63.2)                           |
| ≥ 17                     | 78 (1.5)                      | 1,129 (1.5)                           | 1,012 (1.6)                             |
| **Household income (million Japanese-yen/year)** |                               |                                       |                                       |
| < 2                      | 267 (5.5)                     | 3,854 (5.5)                           | 3,251 (5.4)                             |
| 2 to < 4                 | 1,549 (32.1)                  | 24,132 (34.4)                         | 20,595 (34.0)                           |
| 4 to < 6                 | 1,673 (34.7)                  | 23,180 (33.1)                         | 20,074 (33.2)                           |
| 6 to < 8                 | 756 (15.7)                    | 11,322 (16.1)                         | 9,915 (16.4)                            |
| 8 to < 10                | 334 (6.9)                     | 4,705 (6.7)                           | 4,156 (6.9)                             |
| ≥ 10                     | 243 (5.0)                     | 2,945 (4.2)                           | 2,368 (4.2)                             |
| **Postpartum depressive symptoms at 1 month after delivery assessed by Edinburgh Postnatal Depression Scale** |                               |                                       |                                       |
| No (score < 8)           | 4,402 (86.3)                  | 64,255 (85.9)                         | 55,794 (86.5)                           |
| Depressive (score ≥ 9)   | 698 (13.7)                    | 10,554 (14.1)                         | 8,733 (13.5)                            |
| **Sleep duration during pregnancy (hours)** |                               |                                       |                                       |
| < 6                      | 245 (4.8)                     | 3,669 (4.9)                           | 2,999 (4.7)                             |
| 6 to <7                  | 765 (15.0)                    | 11,194 (15.0)                         | 9,297 (14.4)                            |
| 7 to <8                  | 1,523 (29.9)                  | 23,345 (31.2)                         | 20,025 (31.1)                           |
| 8 to <9                  | 1,441 (28.3)                  | 21,295 (28.5)                         | 18,591 (28.8)                           |
| 9 to <10                 | 801 (15.7)                    | 10,487 (14.0)                         | 9,389 (14.6)                            |
| ≥ 10                     | 324 (6.4)                     | 4,842 (6.5)                           | 4,202 (6.5)                             |
| **Infant characteristic**|                               |                                       |                                       |
| Gestational week         |                               |                                       |                                       |
| 37                       | 575 (11.2)                    | 7,213 (9.5)                           | 6,006 (9.2)                             |
| 38                       | 1,385 (26.9)                  | 17,266 (22.8)                         | 14,748 (22.6)                           |
| 39                       | 1,564 (30.3)                  | 22,372 (29.5)                         | 19,462 (29.8)                           |

(Continued)
Table 1. (Continued)

| Total population (n = 80,970) | Five or more awakenings during the night | Sleeping longer during the day than at night |
|------------------------------|----------------------------------------|---------------------------------------------|
|                              | No (n = 75,812)                        | Yes (n = 5,158)                             |
|                              | n  | (%) | n  | (%) | n  | (%) | n  | (%) |
| 40                           | 1,264 | 24.5 | 21,466 | 28.3 | 1,264 | 24.5 | 18,623 | 28.5 |
| 41                           | 370  | 7.2  | 7,495  | 9.9  | 370  | 7.2  | 6,515  | 10.0 |

Small for gestational

| No | Yes |
|----|-----|
| 4,751 | 24.5 |
| 70,062 | 92.8 |
| 4,751 | 24.5 |
| 60,465 | 92.9 |

| Yes | |
|-----|-----|
| 381  | 7.4  |
| 5,465 | 7.2  |
| 381  | 7.4  |
| 4,638 | 7.1  |

Infant sex

| Male | Female |
|------|--------|
| 2,818 | 45.4  |
| 2,340 | 45.4  |

Feeding status

| Breastfeeding | Partial breastfeeding | Formula feeding | Sleep duration (hours), median (IQR) | Sleep duration (hours) during the night (20:00 to 7:59), median (IQR) | Sleep duration (hours) during the day (8:00 to 19:59), median (IQR) |
|---------------|-----------------------|-----------------|-------------------------------------|-------------------------------------------------|-------------------------------------------------|
| 3,366 | 66.4 | 39,134 | 52.8 | 3,366 | 66.4 | 34,893 | 54.6 | 7,607 | 49.9 |
| 1,627 | 32.1 | 32,103 | 43.3 | 1,627 | 32.1 | 26,699 | 41.8 | 7,031 | 46.1 |

| Number of awakenings during the night, median (IQR) |
|---------------------------------------------------|
| 3 (2–3)                                           |

IQR: Inter quartile range; n.a: Not applicable.

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Table 2. Relationship between infant sleep quality and temperament in one-month-olds according to the Chi-square test.

| Total respondents to the temperament questions | Infants who had five or more awakenings during the night | Chi-square test P-value | Infants who slept longer during the day than at night | Chi-square test P-value |
|-----------------------------------------------|--------------------------------------------------------|------------------------|-----------------------------------------------------|------------------------|
|                                              | No | % | Yes | % | No | % | Yes | % | No | % | Yes | % |
| Bad mood                                     | n  | % | n  | % | n  | % | n  | % | n  | % | n  | % |
| No                                           | 75,817 | 93.8 | 70,941 | 93.7 | 4,876 | 94.7 | < 0.001 | 61,378 | 94.1 | 14,439 | 92.6 | < 0.001 |
| Yes                                          | 5,022 | 6.2 | 4,747 | 6.3 | 275 | 5.3 | 3,866 | 5.9 | 1,156 | 7.4 |
| Frequent crying                              | n  | % | n  | % | n  | % | n  | % | n  | % | n  | % |
| No                                           | 66,792 | 82.8 | 62,495 | 82.7 | 4,297 | 83.6 | 0.114 | 54,214 | 83.2 | 12,578 | 80.8 | < 0.001 |
| Yes                                          | 13,913 | 17.2 | 13,068 | 17.3 | 845 | 16.4 | 10,929 | 16.8 | 2,984 | 19.2 |
| Intense crying                               | n  | % | n  | % | n  | % | n  | % | n  | % | n  | % |
| No                                           | 64,982 | 80.5 | 60,745 | 80.4 | 4,237 | 82.3 | 0.001 | 53,114 | 81.5 | 11,868 | 76.3 | < 0.001 |
| Yes                                          | 15,748 | 19.5 | 14,839 | 19.6 | 909 | 17.7 | 12,053 | 18.5 | 3,695 | 23.7 |

Association of infant sleep quality with temperament by multivariate analyses

As shown in Table 3, a bad mood in infants (adjusted odds ratio [AOR]: 0.84, 95% confidence interval [CI]: 0.74–0.96) and intense crying (AOR: 0.88, 95% CI: 0.82–0.95) were negatively associated with frequent nighttime awakening when adjusted for maternal age. However, they were not associated with it after adjusting for other covariates. We also identified the adjusted

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odds ratio of having longer daytime sleep periods than at nighttime, with a bad mood in infants (AOR: 1.07, 95% CI: 0.99–1.16), frequent crying (AOR: 1.05, 95% CI: 1.00–1.10), and intense crying (AOR: 1.19, 95% CI: 1.13–1.25).

Sex-stratified association of infant sleep quality with temperament by multivariate analyses

Table 4 shows the sex-stratified association of sleep quality in infants with temperament. The analysis demonstrates effect modification by sex in the association of longer daytime sleep periods with frequent crying (p = 0.02). In conclusion, female infants with longer daytime sleep periods were more likely to cry frequently (AOR: 1.11, 95% CI: 1.04–1.20). Longer daytime sleep periods than at nighttime were associated with intense crying in both female (AOR: 1.24, 95% CI: 1.16–1.33) and male infants (AOR: 1.14, 95% CI: 1.07–1.22) and no effect modification by sex was observed (p = 0.08).

Parity-stratified association between infant sleep quality and temperament by multivariate analyses

Table 5 shows the parity-stratified association of infant sleep quality with temperament. Effect modification by parity was detected in the association of frequent awakening with intense
Table 4. Infant sex-stratified analysis of the association between infant sleep quality and temperament in one-month-olds.

| Exposure: awakening for five or more times during the night | Male infants | Female infants |
|-------------------------------------------------------------|--------------|---------------|
| Bad mood                                                    | Respondents to the sleep quality questions | Respondents to the temperament questions | Respondents to the sleep quality questions | Respondents to the temperament questions |
| Exposure: sleeping longer during the day than at night      | Respondents to the sleep quality questions | Respondents to the temperament questions | Respondents to the sleep quality questions | Respondents to the temperament questions |

| CI: Confidence interval; AOR: Adjusted odds ratio. |

\[1] \text{Adjusted for maternal age at delivery, parity, sleep duration during pregnancy, smoking habits, marital status, maternal educational background, household income, postpartum depressive symptoms, gestational age at birth, small for gestational age, infant sex, and feeding status.}

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Table 5. Parity-stratified analysis of the association between infant sleep quality and temperament in one-month-olds.

| Exposure: awakening for five or more times during the night | Nulliparae | | | Parous women | | | | P-value for effect modification by parity |
|---|---|---|---|---|---|---|---|
| Respondents to the sleep quality questions | n | % | AOR | 95% CI | AOR | 95% CI | | | Respondents to the temperament questions | n | % | AOR | 95% CI | AOR | 95% CI |
| Maternal age adjusted model | Maternal age attributes adjusted model† | Maternal age adjusted model | Maternal age attributes adjusted model† | Maternal age adjusted model | Maternal age attributes adjusted model† |
|† Adjusted for maternal age at delivery, parity, sleep duration during pregnancy, smoking habits, marital status, maternal educational background, household income, postpartum depressive symptoms, gestational age at birth, small for gestational age, infant sex, and feeding status.

Exposure: awakening for five or more times during the night

**Bad mood**

| | No | Yes | AOR | 95% CI | n | % | AOR | 95% CI |
|---|---|---|---|---|---|---|---|---|
| Maternal age adjusted model | | | | | | | | |
| Maternal age attributes adjusted model† | | | | | | | | |
| Maternal age adjusted model | | | | | | | | |
| Maternal age attributes adjusted model† | | | | | | | | |

**Frequent crying**

| | No | Yes | AOR | 95% CI | n | % | AOR | 95% CI |
|---|---|---|---|---|---|---|---|---|
| Maternal age adjusted model | | | | | | | | |
| Maternal age attributes adjusted model† | | | | | | | | |
| Maternal age adjusted model | | | | | | | | |
| Maternal age attributes adjusted model† | | | | | | | | |

**Intense crying**

| | No | Yes | AOR | 95% CI | n | % | AOR | 95% CI |
|---|---|---|---|---|---|---|---|---|
| Maternal age adjusted model | | | | | | | | |
| Maternal age attributes adjusted model† | | | | | | | | |
| Maternal age adjusted model | | | | | | | | |
| Maternal age attributes adjusted model† | | | | | | | | |

Exposure: sleeping longer during the day than at night

**Bad mood**

| | No | Yes | AOR | 95% CI | n | % | AOR | 95% CI |
|---|---|---|---|---|---|---|---|---|
| Maternal age adjusted model | | | | | | | | |
| Maternal age attributes adjusted model† | | | | | | | | |
| Maternal age adjusted model | | | | | | | | |
| Maternal age attributes adjusted model† | | | | | | | | |

**Frequent crying**

| | No | Yes | AOR | 95% CI | n | % | AOR | 95% CI |
|---|---|---|---|---|---|---|---|---|
| Maternal age adjusted model | | | | | | | | |
| Maternal age attributes adjusted model† | | | | | | | | |
| Maternal age adjusted model | | | | | | | | |
| Maternal age attributes adjusted model† | | | | | | | | |

**Intense crying**

| | No | Yes | AOR | 95% CI | n | % | AOR | 95% CI |
|---|---|---|---|---|---|---|---|---|
| Maternal age adjusted model | | | | | | | | |
| Maternal age attributes adjusted model† | | | | | | | | |
| Maternal age adjusted model | | | | | | | | |
| Maternal age attributes adjusted model† | | | | | | | | |

CI: Confidence interval; AOR: Adjusted odds ratio

*CI* < 0.05.
crying (p = 0.02). Parous women who had infants with frequent awakening felt that their infants cried more intensely (AOR: 1.17, 95% CI: 1.03–1.31). Although effect modification of parity was not identified, frequent night awakening in infants was associated with frequent crying by parous women (AOR: 1.13, 95% CI: 1.01–1.28). Longer daytime sleep periods than at nighttime were associated with bad mood by parous women (AOR: 1.20, 95% CI: 1.02–1.42) and with frequent crying by nulliparous women (AOR: 1.08, 95% CI: 1.02–1.15). Longer daytime sleep periods than at nighttime were also associated with intense crying by both nulliparous (AOR: 1.20, 95% CI: 1.13–1.27) and parous women (AOR: 1.17, 95% CI: 1.07–1.27).

Discussion

To the best of our knowledge, this study is the first to demonstrate the association between sleep quality and temperament among one-month-old infants. Our previous study showed that sleep problems in pregnant women were related to the temperament of one-month-old infants. The results of this study may add further knowledge on the possible improvement of infant temperament through the betterment of infant sleep quality.

According to the present study results, a longer daytime sleep period in infants than at night was a factor associated with infant temperament, frequent crying, and intense crying. Although the study population was not the same, a previous study reported a similar result demonstrating that infants with difficult temperaments tend to have less nighttime sleep than daytime sleep [14]. A previous study suggested that intense crying in young infants could be determined by the developmental interaction of sleep homeostatic and circadian processes and suggested that excessive crying may indicate delayed neurological maturation [33]. These results are limited because the causal relationship cannot be confirmed in this study; however, they suggest the possibility that intervening in the circadian time of infants may reduce their tendency to have negative temperaments.

In this study, frequent nighttime awakening in infants was not associated with their temperament after covariate adjustments. A previous cohort study by Hayes et al., which tracked infants from 6 weeks to 24 months of age, demonstrated statistical independence in the association between sleep-wake behavior and temperament [34]. This study showed a similar result even among one-month-old infants. The lack of association in our study might be because the frequency of infant awakening was self-reported by the mothers, which conforms to the statement by Hayes et al. in their study. Self-reporting by mothers may overlook quiet nighttime awakening in infants while the mothers are likely to be sleeping [34]. Conversely, some studies have shown that frequent awakenings or longer wake periods are associated with temperament [14,35]. Thus, no consistent results have been obtained, and further research is needed in the future.

In our study, sex differences in infants were observed in the association between longer daytime sleep than nighttime sleep periods and temperament. The associations with intense or frequent crying were significant among female infants in the logistic regression model. In particular, the rate of crying was significantly higher among female than male infants. The differences of sex in sleep duration and quality were reported in a previous study; at 6–115 months old, girls consistently slept longer (5–10 minutes) than boys. Male infants were also associated with shorter sleep periods among 14–27-month-old children [36–38]. A study suggested that difficulties in developing adaptive responses to environmental disturbances may be attributed to relatively slower development in male infants [38]. However, sex differences in temperament among one-month-old infants are still not apparent, and a biological cause likely underpins sex differences that affect sleep or temperament. Further studies are needed to elucidate the mechanism.
An association between infant sleep quality and temperament was observed among children cared for by women with or without prior childbirth experience. In particular, it was confirmed that prior childbirth experience in mothers was an effect modifier for the association between nighttime arousal and intense crying in children. This may be partly due to the differences between primiparae and multiparae delivery. Since different relationships were found depending on childbirth experience, it should be considered when considering interventions related to children’s sleep quality and temperament.

This study had some limitations. First, as JECS’s previous study mentioned, data on infant sleep and temperament were measured by maternal reports [20]. Parents often overestimated infants’ sleep time because of parental characteristics in data collection, such as education level, number of infants to care for, and level of sleep [39]. Therefore, certain infant sleep behavior may have been overlooked while the mother was unaware, and maternal characteristics can pose biases to the infant’s temperament. However, a study reported that parents’ report data agreed with polysomnography one [40]. Also, younger infants often require less intervention from parents; thus, our study parents’ reports may indicate lower levels of intervention than older infants’ parents’ reports [41]. Second, since this is a cross-sectional study, the temporal relationship between sleep and temperament in children cannot be clarified. Some inferences from previous studies can be made, but further intervention studies are needed to provide clear evidence of a relationship. Third, this was a large-scale study, and even minor differences may have been significant. Since there have been no similar studies, we believe that further research is needed. Fourth, this study may not have covered all aspects of infant temperament and sleep, such as failing to consider the “no crying” temperament. Despite these limitations, this study is the first large-scale study to investigate the association between sleep and temperament in infants in the first month of life, and is a valuable study with high generalizability.

Conclusions

In conclusion, this study demonstrated that sleep problems were associated with temperament, such as frequent or intensive crying among one-month-old infants. Therefore, it is essential to focus on sleep disorders in early infancy to identify and prevent potential future developmental problems from a clinical and public health perspective. In addition, longitudinal studies are needed to elucidate how interventions to improve sleep disorders in infants may prevent future developmental problems.

Supporting information

S1 Table. Study participants data.
(DOCX)

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The members of the Japan Environment and Children’s Study Group as of 2021 are as follows: Michihiro Kamijima (principal investigator, Nagoya City University, Nagoya, Japan, jecsen@nies.go.jp), Shin Yamazaki (National Institute for Environmental Studies, Tsukuba, Japan), Yukihiro Ohya (National Center for Child Health and Development, Tokyo, Japan), Reiko Kishi (Hokkaido University, Sapporo, Japan), Nobuo Yaegashi (Tohoku University, Sendai, Japan), Koichi Hashimoto (Fukushima Medical University, Fukushima, Japan),
Chisato Mori (Chiba University, Chiba, Japan), Shuichi Ito (Yokohama City University, Yokohama, Japan), Zentaro Yamagata (University of Yamanashi, Chuo, Japan), Hidekuni Inadera (University of Toyama, Toyama, Japan), Takeo Nakayama (Kyoto University, Kyoto, Japan), Hiroyasu Iso (Osaka University, Suita, Japan), Masayuki Shima (Hyogo College of Medicine, Nishinomiya, Japan), Hiroshige Nakamura (Tottori University, Yonago, Japan), Narufumi Suganuma (Kochi University, Nankoku, Japan), Koichi Kusuhara (University of Occupational and Environmental Health, Kitakyushu, Japan), and Takahiko Katoh (Kumamoto University, Kumamoto, Japan).

**Author Contributions**

**Conceptualization:** Seiichi Morokuma.

**Data curation:** Takehiro Michikawa.

**Writing – original draft:** Kimiyo Kikuchi, Takehiro Michikawa, Seiichi Morokuma.

**Writing – review & editing:** Takehiro Michikawa, Seiichi Morokuma, Norio Hamada, Yoshiko Suetsugu, Kazushige Nakahara, Eiji Shibata, Mayumi Tsuji, Masayuki Shimono, Toshihiro Kawamoto, Shouichi Ohga, Koichi Kusuhara.

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