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Longitudinal Changes and Features of Sleep Patterns of Mothers with Preterm Infants during the Early Postpartum Period

MADOKA TODA(MIYANO)[1] , HISAFUMI YASUDA[2], and SATOSHI TAKADA[2,3,*]

[1]*Department of Nursing, Kobe University Graduate School of Health Sciences, Kobe, Japan*

[2]*Department of Public Health, Kobe University Graduate School of Health Sciences, Kobe, Japan*

[3]*Kobe City Pediatric and General Rehabilitation Center for the Challenged, Kobe, Japan*

**Corresponding author*

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This study comprised 13 mothers of preterm infants and 21 mothers of term infants. Sleep assessment was conducted using an actigraph for three consecutive days. The participants were asked to record their sleep behaviors and activities over these 3 days, and complete two questionnaires (Edinburgh Postnatal Depression Scale [EPDS] and Pittsburgh Sleep Quality Index [PSQI]). As compared to the mothers of term infants, the sleep efficiency in the preterm mothers was significantly lower than that in the term mothers. The total sleep time was shorter and nighttime awakenings were more frequent in the preterm mothers at 2 weeks after childbirth, but without a significant difference.

We analyzed the changes in the sleep data of the mothers of preterm infants longitudinally, including sleep behaviors and the EPDS and PSQI scores. The total sleep time at 1 month postpartum was shorter than that at other periods, and significantly shorter than that at 2 weeks and 6 months postpartum. Our results suggested that sleep problems tended to last longer in mothers of preterm infants than in mothers of term infants, as the problems occurred twice, immediately after childbirth and immediately after discharge.

INTRODUCTION

Approximately 15 million babies every year are born preterm, i.e., before completing 37 weeks of gestation, and this number is rising. In 184 countries, the rate of preterm birth has been reported to be low with an incidence of 5%-18% (58). In Japan, the proportion of preterm infants is gradually increasing, although the total number of births is decreasing, accounting for 5.6-5.7% of the total number of births since 2005(50).

Sleep plays an important role in human life. Sleep disorders are characterized by reduced sleep volume and poor sleep quality, and they have been shown to affect the physical health, stress response, cognitive function, memory, and mood adversely (3, 13, 55). Women's sleep during the perinatal period varies significantly due to changes in the hormonal dynamics during pregnancy, delivery, and postpartum, and the childcare requirements after childbirth. Especially in the early postpartum period, mothers have to awaken at night frequently in response to the irregular life rhythm of the newborn (17, 38). The mother leads a life that matches and depends on the sleep-wake cycle of the newborn, wherein the child sleeps and awakens every few hours in the early postpartum period (19, 48). Following this, almost 80% of the term infants acquire a regulated circadian rhythm around 8-11 weeks after birth, and at the same time, the mother's night sleep stabilizes (37).

On the other hand, mothers of preterm infants are admitted to the neonatal intensive care unit (NICU) because their infants need treatment; hence, it may be assumed that the mothers do not experience sleep interruption as childcare is not required, and the effect on their sleep is limited. However, it has been reported that mothers of preterm infants in the early postpartum period are prone to sleep deprivation due to stress (35, 56). In addition, preterm infants are more likely to have more sleep disorders than full-term infants, and sleep disorders may persist throughout childhood (22), suggesting a greater impact on mothers.

Sleep problems in postpartum women are also closely related to maternity blues and subsequent postpartum depression due to changes in the hormonal balance. However, it is reported that these problems could be related to the interrupted nighttime sleep due to childcare, fatigue after labor, and postpartum depression. These reports have limited evidence because of the different evaluation methods used and the differences in the factors evaluated. Furthermore, there are only few longitudinal studies on the adaptive process of sleep behaviors for mothers with preterm infants during home care after the mother-infant separation period.

Phone: +81-78-646-5291 Fax: +81-78-646-5289 E-mail: satoshi_takada@office.city.kobe.lg.jp

In this study, we aimed to clarify the characteristics and tendencies of the sleep patterns of mothers who gave birth to preterm infants. Longitudinal investigations were conducted from the early postpartum period of separation between mothers and infants to the period after the discharge of the infants.

MATERIALS AND METHODS

Participants

The participants of this study included mothers of preterm infants and mothers of term infants. The former group comprised primiparas who gave birth before completing 34 weeks of gestation, while the latter group comprised primiparas who gave birth after 37 weeks of gestation. Additionally, those with mental illnesses, infectious diseases, hypertensive disorders of pregnancy, or other illnesses that extended the length of postpartum hospital stay were excluded.

Research methods

A survey was conducted at two perinatal medical centers, one regional perinatal medical center, and one obstetric medical institution in the Kinki area. Mothers of preterm infants were requested to participate in this study during the period from postpartum hospitalization to 2 weeks postpartum and mothers of term infants from when they visited the hospital for medical examination at 2 weeks postpartum. Regarding the participation, the midwife and nurse first explained the outline of the survey to the mothers. If the woman was interested in the study and requested more details for participation, one of the researchers directly explained the details on paper and verbally. Written informed consent was obtained from all the participants. The survey period was from February 2017 to August 2020, and the participants were assessed at 2 weeks, 1 month, 3 months, and 6 months postpartum. The mothers of preterm infants were additionally surveyed 1 month after the child was discharged.

Research procedure

Sleep assessment was conducted using an actigraph for three consecutive days. The actigraph is a reliable and valid sleep/behavior research measurement tool that has been used in sleep research at the National Aeronautics and Space Administration in the United States, and it can measure the sleep-wake rhythm and activity level (7). The activity data were downloaded using Watchware software (version 1.94.1.3, Ambulatory Monitoring Inc.).

The participants were asked to complete two questionnaires, the Edinburgh Postnatal Depression Scale (EPDS) and the Japanese version of the Pittsburgh Sleep Quality Index (PSQI), after wearing the actigraph and to maintain a sleep diary for 3 days. The actigraph was set to a measurement time of 1 minute and was worn on the non-dominant arm for 3 days. They were also asked to record their sleep behaviors and activities in the sleep diary for those 3 days.

The EPDS evaluates the depressive state of mothers quantitatively after childbirth (9). It includes assessment of the following 10 aspects: declining joy, lack of expectation from the future, self-condemnation, anxiety, fear, difficulty in coping, insomnia, depressed mood, fragility of tears, self-harm. It is configured to be measurable, with a score range of 0-30 points; higher the score, higher is the severity of depression. A Japanese version was also created by Okano et al. (8) and is now being widely used in clinical practice to evaluate postpartum depression in Japan.

The PSQI is a standardized sleep quality questionnaire developed at the University of Pittsburgh (5) and has been translated in Japanese by Doi et al. (12). Generally, this questionnaire is used for screening sleep disorders, follow-up and evaluation of therapeutic effects, examination of sleep disorder-related factors, and application in epidemiological and clinical studies. It is a self-administered questionnaire comprising 18 items under the following seven elements: sleep quality, sleep onset time, sleep time, sleep efficiency, insomnia, use of sleeping pills, and difficulty in daytime awakening. The score range is 0-21; higher the score, worse is the sleep quality.

For data analysis, the actigraph obtained data using Action-W software (version 2.7.1150, Ambulatory Monitoring Inc.) to analyze sleep measurements comprising of awakening time and sleep time. The 3-day average was calculated from the daily data collected. Statistical Product and Service Solutions softwares (version 24, IBM Corp., NY, USA) and Excel (2016 Microsoft, WA, USA) were used for statistical analysis. Data were analyzed using the Mann-Whitney U test, Friedman test, Steel-Dwass coefficient test, Wilcoxon sign rank test, and Spearman rank correlation coefficient.

Ethical considerations

This study was approved by the Institutional Review Board of the Graduate School of Health Sciences, Kobe University (approval number: 538-1). Furthermore, the survey was conducted with the approval of the ethical

review committee at each survey facility (perinatal medical centers, one regional perinatal medical center, and one obstetric medical institution).

RESULTS

Characteristics subjects the participants

Table I presents the characteristics of the participants. This study included 13 mothers of preterm infants and 21 mothers of term infants of average age 33.4 years and 31.0 years, respectively. The average gestation period at birth was 31.6 weeks for preterm infants and 39.8 weeks for term infants.

The gestational ages of 10 out of 13 preterm infants was 30-34 weeks, while that of the remaining 3 was less than 30 weeks. The average birth weight was 1558 g for all the preterm infants, of which 10 infants weighed 1000 g or more and 3 weighed less than 1000 g. The average length of hospitalization of the preterm infants and term infants was 68.9 days (range, 17-295 days) and 5.5 days (range, 5-6 days), respectively. All mothers of term infants stayed at their own parents' homes after discharge.

Table I. Characteristics of participants

	Preterm mothers (n = 13)	Term mothers (n = 21)
Maternal age (years)	33.4 ± 5.3	31.0 ± 6.0
Length of hospitalization (days)	68.9 ± 76.0	5.5 ± 0.5
Gestational age (weeks)	31.6 ± 3.0	39.8 ± 1.1
≥37 weeks gestation (number)	—	21
≤34 weeks gestation (number)	10	—
<30 weeks gestation (number)	3	—
Birth weight (g)	1558.0 ± 585.1	—※
≥2500 g (number)	—	21
≥1000 g (number)	10	—
<1000 g (number)	3	—

※ The birth weight of term infants was confirmed to be within 2,500-3,999 g, but no specific data are available.

Comparison between mothers of preterm infants and mothers of term infants

Table II shows the actigraph data and PSQI scores and EPDS scores of mothers of preterm and term infants at 2 weeks postpartum. The data was considered nonparametric data because the number of participants was small and included data were not normally distributed, and the Mann-Whitney U-test was used to compare the actigraph data and PSQI scores and EPDS scores. Although the number of participants differed, the sleep efficiency of the preterm mothers was significantly lower than that of the term mothers at 2 weeks postpartum. Moreover, the total sleep time was shorter, sleep onset latency was longer, and frequency of awakenings was higher in the preterm mothers than in the term mothers, but without significant differences. There was no significant difference in PSQI and EPDS scores between the groups. Five mothers of preterm infants and 11 mothers of term infants exceeded the PSQI cutoff value (5/6 points). Three mothers of preterm infants and 2 mothers of term infants exceeded the EPDS cutoff value (8/9 points). The proportion of EPDS high risk groups was higher in mothers of preterm infants, but no statistically significant difference was observed. At 1 month postpartum, the total sleep time was lesser and frequency of awakenings was higher in the preterm mothers than in the term mothers, but without significant differences.

Table II. Sleep-related data of mothers of preterm and full-term infants at 2 weeks postpartum

	Preterm mother Median (IQR)	Term mother Median (IQR)	P value
	(n = 13)	(n = 21)	
Total sleep times (min)	461.0 (372.6-513.0)	437.3 (398.3-527.7)	.873
Sleep efficiency (%)	97.4 (96.0-98.3)	98.6 (97.7-99.0)	.032*
Sleep onset latency (min)	12.8 (11.1-22.8)	13.8 (7.4-17.6)	.446
Number of awakenings (frequency)	2.4 (2.1-3.4)	2.2 (1.6-2.6)	.060
PSQI (score)	5.0 (4.0-6.0)	6.0 (3.5-9.0)	.371
EPDS(score)	5.0 (2.5-8.5)	4.0 (2.5-6.5)	.486

*$p < .05$, indicating significant difference

IQR, interquartile range; PSQI, Pittsburgh Sleep Quality Index; EPDS, Edinburgh Postnatal Depression Scale.

Characteristics of mothers of preterm infants

1）**Changes in sleep related data and EPDS scores in mothers of preterm infants**

Figure 1 shows the changes in the total sleep time of each participant of the preterm group. The time of the child's discharge is marked by a closed circle. Although there were individual differences in the total sleep time, 11 of the 13 preterm mothers had lower average sleep time at 1 month postpartum than that at 2 weeks postpartum. In most cases in this study, the infants were discharged from the hospital at 1-3 months postpartum.

Table III shows the average values of the sleep data, EPDS scores, and PSQI scores for each period during the postpartum. The Friedman test was performed to compare the changes over time in each item, and the Steel-Dwass coefficient test was performed for items where a significant difference was observed. The total sleep time of the preterm mothers was significantly shorter at 1 month postpartum than that at 2 weeks postpartum (.010). On the other hand, the total sleep time at 6 months postpartum (.004) was significantly longer than that at 1 month postpartum. Sleep efficiency was highest overall 2 weeks postpartum and lowest at 3 months postpartum. In addition, there were significant differences between 2 weeks postpartum and 3 months postpartum. There was no significant difference in sleep latency and number of awakenings at each time periods.

When comparing the EPDS scores for each period, the scores were significantly lower at 3 months (.005) and 6 months (.035) postpartum than those at 2 weeks postpartum. Similarly, the EPDS scores were significantly lower at 3 months (.046) postpartum than those at 1 month postpartum. Therefore, the scores were the highest at 2 weeks postpartum and decreased as time passed, such as at 1 month, 3 months, and 6 months postpartum. The changes in the score over time revealed that the score was the highest at 2 weeks postpartum, followed by 1 month postpartum. In addition, the proportion of mothers who exceeded the cutoff score in each period was 23.0% at 2 weeks postpartum, 0% at 1 month and 6 months postpartum, 7.6% at 3 months postpartum. We compared the sleeping hours of mothers with an EPDS score ≥9 as the "high risk group" and <9 as the "low risk group", and there was no significant difference between the two groups.

There were no significant differences in the changes occurring over time in the PSQI scores. The average value for each period was not in the score range indicative of sleep disorders. However, when comparing the periods, the highest values in this survey (5.3) were observed 2 weeks postpartum, 1 month postpartum.

Moreover, we compared the sleeping hours of mothers with an PSQI score of ≥6 as the " high risk of sleep disorder group" and <6 as the "low risk of sleep disorder group", there was no significant difference between the two groups.

Table IV shows the sleep data, EPDS scores, and PSQI score in mothers when infants stayed at the hospital and at 1 month after infants' discharge. Sleep efficiency at 1 month after discharge was significantly lower than that before infant discharge.

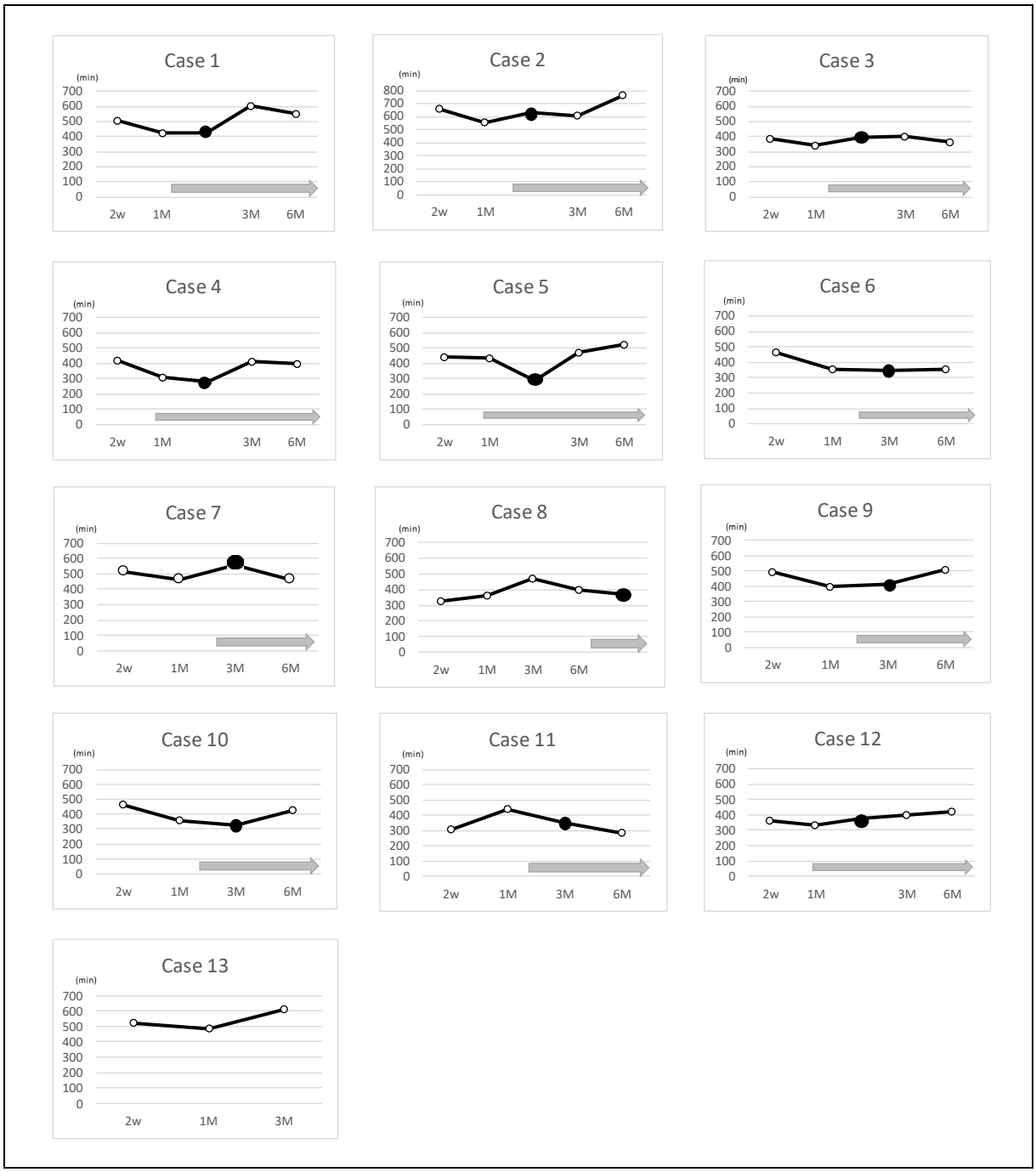

Figure 1. Changes in total sleep time of mothers of preterm infants and timing of discharge of infants

The total sleep time of mothers of preterm infants is shown over time along with the discharge time and cohabitation period of the infants. Regarding Case13 there was no data available after discharge. This figure shows the changes in the total sleep time of each participant of the preterm group. The total amount of sleep per day is marked by a white circle. The time of the infant's discharge is marked by a black circle. The time when the mothers and infants live together is indicated by a gray arrow.

Table III. Changes in the sleep data, Edinburgh Postnatal Depression Scale scores, and Pittsburgh Sleep Quality Index scores of preterm mothers over time (n = 12)

	Postpartum 2 weeks	Postpartum 1month	Postpartum 3months	Postpartum 6months
	Median (IQR)	Median (IQR)	Median (IQR)	Median (IQR)
Average sleep time (min.)	461.0 (372.6-513.0)	400.0 (349.6-450.0)	402.6 (385.1-553.6)	421.5 (400.0-497.7)
Sleep efficiency (%)	97.4 (96.0-98.3)	97.2 (96.1-99.0)	94.4 (91.8-98.1)	95.0 (93.1-97.6)
Sleep latency (min.)	12.8 (11.1-22.8)	14.3 (9.0-21.4)	13.2 (9.2-21.9)	15.5 (11.7-21.0)
Number of awakenings(frequency)	2.4 (2.1-3.4)	2.7 (2.0-4.5)	3.0 (2.2-3.8)	3.1 (2.3-4.6)
EPDS (score)	5.0 (2.5-8.5)	4.0 (2.0-8.0)	3.0 (1.5-3.5)	4.5 (1.0-5.0)
PSQI (score)	5.0 (4.0-6.0)	5.0 (4.0-5.7)	5.0 (4.0-5.7)	4.0 (3.0-6.0)

*p < .05; **p < .01, indicating significant difference
IQR, interquartile range; EPDS, Edinburgh Postnatal Depression Scale; PSQI, Pittsburgh Sleep Quality Index

Table IV. Changes in the sleep data in mothers of preterm infants at before and 1 month after infants' discharge. (n = 12)

	Pre-discharge	1 month after discharge
	Median (IQR)	Median (IQR)
Average sleep time (min.)	397.6 (356.0-439.3)	393.6 (349.0-541.9)
Sleep efficiency (%)	97.1 (95.5-98.7)	94.3 (94.0-95.4)
Sleep latency (min.)	15.2 (7.2-21.4)	12.7 (8.3-30.7)
Number of awakenings(frequency)	2.9 (2.0-4.5)	3.4 (2.8-5.4)
EPDS (score)	4.0 (2.0-4.7)	3.0 (1.2-6.7)
PSQI (score)	5.0 (4.0-6.0)	5.0 (4.2-6.0)

*p < .05; indicating significant difference
IQR, interquartile range; EPDS, Edinburgh Postnatal Depression Scale; PSQI, Pittsburgh Sleep Quality Index

2) Correlation of EPDS scores at each postpartum period

The correlation of EPDS scores at each postnatal period was investigated using Spearman's correlation coefficient. Strong positive correlations were observed in the EPDS scores between those at 2 weeks and at 1 month (.844) and 3 months (.933) postpartum. A positive correlation was found in the EPDS scores at 2 weeks postpartum and 1 month after discharge (.661).

DISCUSSION

Recently, sleep problems in parents of preterm infants have been attracting attention in Europe and the United States. However, there are very few quantitative studies conducted to date, and there is a lack of research on the long-term changes. In Japan, there are no studies focusing on the sleep behaviors of mothers of preterm

infants. Therefore, in this study, we focused on the mothers of preterm infants and investigated the long-term changes in their sleep behaviors during the early postpartum period.

Sleep behaviors in mothers of preterm infants and term infants

In our study, there were no differences between the sleep time of the mothers of preterm infants and those of term infants both at 2 weeks postpartum and at 1 month postpartum.

McMillen et al. reported that mothers of preterm infants slept lesser and woke up significantly more frequently at night than those mothers of term infants (34). These results are slightly different from our study results. In the previous study, a sleep diary was used to measure the sleep time, but an actigraph was not used. The difference in the method between the two studies might have led to different results. In previous studies on sleep involving mothers of preterm and term infants, various methods, such as interviews, questionnaires, and sleep diaries, were used, and the measurement periods differed. Moreover, the results obtained in previous studies were inconsistent with each other. Future studies on sleep behavior should apply, with uniform methods and measurement periods.

There was no significant difference in the sleep time in our study; however, the sleep efficiency at 2 weeks postpartum was significantly lower in the preterm mothers than in the term mothers. Sleep efficiency is one of the indexes showing the sleep state, and it represents the ratio of the sleep time to the bedtime. Therefore, the higher the value, the more efficiently the person sleeps. Lee et al. conducted a study on the sleep efficacy of mothers of preterm infants 5-10 days after delivery (25). They reported almost the same results as us. Additionally, there have been some Japanese studies on primiparas of term infants using actigraphs. These studies were conducted from 3 days to 2 weeks after childbirth and at 1 month postpartum (15, 52). However, none of these studies compared the sleep behaviors of preterm mothers and those of term mothers.

The measured values of sleep efficiency were higher in our study than in the previous studies. The mothers of both preterm infants and term infants showed slightly higher values of sleep efficiency in our study as compared to those in the other studies. We assessed sleep behaviors during the period when the mother of the preterm infants had been discharged and only infants remained in the hospital. The circadian rhythms of life, which include sleep/wakefulness of mothers, usually stabilize with the passage of days after delivery. The conditions of most preterm infants stabilize during these periods, and the improvement in the infant's status usually reduces the mental stress of the mothers.

Furthermore, our study only included primiparas, and all mothers of term infants stayed at their own parents' homes after discharge. The results of our study indicate that the factors that influence sleep time and sleep efficiency in the early postpartum period differed between the term mothers and preterm mothers. In the case of the mothers of term infants, the most influential factor affecting sleep was the burden of various childcare requirements. Most mothers of term infants live with their infants during hospitalization after childbirth, and they respond to requests for feeding and care of the infants (23). On the other hand, parental stress in the mothers of preterm infants caused by the status of hospitalized infants has shown an association with sleep disorders (25, 35). In our study, the mothers of preterm infants may have faced the same situation, because only the infants remained hospitalized in the early postpartum period. However, there was no significant difference between the sleep time of the term mothers and that of the preterm mothers. Nighttime awakening for feeding is observed in mothers of preterm infants. Additionally, there are several peculiar factors different from those affecting the sleep of mothers of term infants. Thus, the factors that affect the sleep of mothers in the postpartum period may be different for the mothers of preterm infants and for mothers of term infants. It is not possible to show the characteristics only based on sleep time. Therefore, it is necessary to evaluate the sleep behaviors, including other child-related factors.

Changes and characteristics of sleep behaviors of mothers of preterm infants over time

In this study, we investigated the sleep behaviors of mothers of preterm infants longitudinally. Longitudinal studies with sleep logs have already been conducted in previously; however, no definitive results have been obtained (14, 34, 57). Furthermore, although some studies have used actigraphs for the analysis of sleep behaviors in mothers of preterm infants, as done in this study, they were all cross-sectional studies (25, 27, 29, 30). Therefore, ours is the first longitudinal study to use actigraphs for mothers of preterm infants.

Average sleep times of mothers of preterm infants showed the lowest value at 1 month postpartum. This result might be related to the hormonal changes peculiar to women from pregnancy to childbirth and postpartum. Pregnancy changes the hormone secretion balance in women, which also affects sleep. The secretion of progesterone, which establishes and maintains pregnancy, increases 10-5000 times during pregnancy. Additionally, the secretion of estrogen increases approximately 1000 times in the latter half of pregnancy, and the secretion of cortisol, which is an adrenocortical hormone, also increases at that time. Moreover, the luteinizing hormone levels increase in the blood during pregnancy. The secretion pattern of these hormones

changes with pregnancy, and the sleep patterns change due to several factors other than hormones; hence, sleep problems are likely to occur (49). After childbirth, the hormones that had risen sharply start to decrease, and child-rearing behaviors begin day and night. Many child-related factors cause further changes in the mother's sleep pattern (2, 31, 40). The early postpartum child-rearing behaviors that occur in mothers of term infants are not the influential factors in the case of mothers of preterm infants, because their infants are still hospitalized. Factors, such as unstable status, various kinds of treatments, and hospital environment, which are related to the medical conditions of their infants, might influence sleep behaviors of preterm infants' mothers. Atmosphere of the NICU, privacy, noise level in the room, and attitudes of the staff also affect the sleep of the parents (56, 63), and parental stress while the infant is in the hospital is associated with sleep problems (25, 35). Therefore, the sleep behaviors, such as the sleep time in the early postpartum period are largely influenced by not only the physical postpartum changes, but also the psychological factors peculiar to mothers of preterm infants. Psychological factors are closely related to the stress caused by the hospitalization of the child.

Sleep efficiency of the preterm infants' mothers was the lowest at 3 months postpartum. In this study, most children were discharged between 1 and 3 months postpartum, and infants started to be taken care of by their mothers at around 2 or 3 months postpartum. We compared the sleep data generated from preterm infants' mothers before and at 1 month after the discharge. Sleep efficiency at 1 month after discharge was significantly lower than that observed before. The lowest value of sleep efficacy at 3months postpartum is possibly associated with the initiation of mothers' child rearing behaviors. In addition to the low sleep efficiency, the frequency of night-time awakenings was high at 1 month after the child's discharge. These factors were largely associated with child-rearing behaviors at home and were influenced by the sleep-wake pattern of the child. It is presumed that the conditions of the mothers of preterm infants were similar to those of the mothers of term infants at 1 month postpartum.

In the case of mothers of term infants, the effects of physical changes after childbirth and of child-related factors on sleep occurred at the same time as the physical changes, such as hormone secretion in the early postpartum period. On the other hand, the results of our study showed that the mothers of preterm infants were at increased risk of sleep problems during two periods. One period was when the physical changes of early postpartum and the effects of psychological factors associated with the hospitalization of the child occurred, and the other period was the time when child rearing was started after the child's discharge. This suggests that sleep problems tended to last longer in mothers of preterm infants than in mothers of term infants, as the sleep problems occurred twice, immediately after childbirth and immediately early after discharge.

Changes and characteristics of PSQI scores in mothers of preterm infants

In addition to the actigraph measurements, this study also measured sleep disorders using the PSQI. Comparing PSQI data with actigraph data, changes in sleep time, sleep efficiency, or sleep latency did not match exactly. The average value for each period was not within the score range indicative of sleep disorders. However, actigraph data showed that the longest average sleep latency was at 2 weeks postpartum and the shortest average daily sleep time was at 1 month postpartum when compared with the other periods. The average sleep efficiency was the lowest at 1 month after the child was discharged when compared to the other periods. No clear difference was found in the PSQI score results. However, when considered together with the actigraph data, it was suggested that the sleep status was more likely to change during the period of 2 weeks, 1 month postpartum, and 1 month after the child was discharged than at other times. As mentioned earlier, sleep problems during this period could add to the risk for postpartum depression; hence, it is necessary to pay attention to the degree of change.

Furthermore, sleep studies on mothers of preterm infants were conducted using various scales such as the General Sleep Disturbance Scale, Insomnia Severity Index, and Richards-Campbell Sleep Questionnaire in addition to the PSQI used in this study, and the survey methods were inconsistent. PSQI was considered a suitable scale for evaluating subjective deterioration of sleep quality due to insomnia, depression, anxiety disorder, etc. On the other hand, it was also reported that PSQI was not suitable for evaluating circadian rhythm sleep disorder, shift work, and irregular life, and it was preferable to evaluate the results in combination with other evaluation methods (32). The reason why the characteristic results were not obtained this time is that the PSQI is subjective; thus, it is appropriate for capturing clinical ones, but it was insufficient for capturing detailed indicators such as sleep efficiency. In this study as well, the characteristic was clarified by evaluating the PSQI score together with the actigraph data, indicating that the two instruments can be effectively combined.

Relationship between postpartum depression and sleep in mothers of preterm infants

Postpartum depression in Japan is known to occur in 10-15% cases (41,43). In this study, 3 out of 13 mothers exceeded the EPDS cutoff point 2 weeks postpartum, showing relatively high values. Afterward, the EPDS gradually declined, and no mother exceeded the cutoff point 6 months postpartum. From this, it seems important

for mothers of preterm infants to provide support in the early postpartum period. This could be attributed to the state of mental instability due to a marked change in the hormonal balance in the body following childbirth (1, 8, 61) and the relationship with psychosocial factors (53). Particularly, mothers who give birth to children who are admitted to the NICU, commonly preterm children, are more likely to feel guilty about the interruption of pregnancy due to unexpected childbirth and the failure to give birth normally. Additionally, mothers have a strong fear of contact with their children and are more likely to be anxious about their children's health, growth, development, and sequelae (20, 36, 59). Therefore, it can be said that mothers of preterm infants are at higher risk of developing postpartum depression than those of term infants. Generally, depression and sleep disorders are closely related. It has already been clarified that sleep disorders are a risk factor for depression (46), and sleep disorders are known precursors of depressive symptoms (33). Sleep disorders have also been reported to occur during the perinatal period prior to the onset of postpartum depression in primiparas (6, 24).

In our study, EPDS was used to examine changes over time in postpartum depression. A previous study on mothers of children admitted to the NICU reported that the average EPDS score for mothers who had been separated from their children since childbirth at the 1-month postnatal examination was 6.5(20). Another study reported a positive rate of 41.9% at 1 month postpartum and 36.0% at 3 months postpartum with the EPDS (39). Longitudinal changes in the EPDS scores in this study showed a tendency to be highest at 2 weeks postpartum and then decline by 6 months postpartum, with a temporary increase at 1 month after discharge of the infant. According to Riemann, there is a two-way relationship between mental health, including depression, and sleep, wherein mental health affects sleep and vice-versa (10). In this study, the EPDS score was the highest in the early postpartum period. As mentioned before, significant changes in the hormonal environment in the body and changes in the sleep-wake rhythms associated with childbirth are considered important influential factors. Furthermore, in the case of preterm infants, various treatments are often administered because they are in a high-risk state immediately after birth. It was thought that the accompanying mental health problems of the mother affected the sleep-wake rhythm in the early postpartum period. On the other hand, the EPDS score 1 month after the child was discharged also showed a high value. Unlike the factors in the early postpartum period, this could be related to childcare performed at home 24 hours a day. In the case of mothers of preterm infants, it was necessary to pay attention to the sleep status based on physical characteristics, as well as the mental health status in the early postpartum period. Furthermore, it is necessary to pay attention to the sleep and mental health status based on the childcare situation in the early stage after the child is discharged from the hospital.

Additionally, in this study, the higher the EPDS score in the early postpartum period, the higher the subsequent value tended to be. In existing studies, similar reports have been made in studies on mothers of term infants (45). In addition, studies on mothers of preterm infants have definitely reported characteristics of changes in EPDS scores during hospitalization and after discharge (60). However, similar findings have not been described. Therefore, in the future, it is necessary to increase the number of subjects, clarify the changes peculiar to mothers of preterm infants, and examine the relationship and effects with sleep problems.

We compared the sleep status between the high- and the low-risk groups with EPDS scores at 2 weeks after childbirth; however, no significant difference was observed. The total number of mothers of preterm infants in this study was limited (n = 13). In order to analyze the relation between the sleep status and EPDS score more accurately, further studies might be needed in the future.

Research limitations

One of the limitations of this study is small sample size and that all the participants lived in Kansai area. Unfortunately it was clinically difficult to obtain permission to investigate from the mothers of term infants at postpartum 3 and 6 months postpartum. Therefore, future studies should aim to evaluate the changes and characteristics of sleep patterns in mothers of preterm infants by increasing the target area and the number of participants. According to the results of this study, it was considered that the sleeping behavior of the mother were affected by the infant's condition after the infant was discharged, but the childcare content and the child's sleep pattern could not be evaluated. Therefore, it is necessary to conduct a survey based on these factors in the future.

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The authors declare that there are no conflicts of interest.

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