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The Transition of Sleep Behaviors in Twin Infants and Their Mothers in Early Infancy

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Abbreviations: CA, corrected age

ABSTRACT

Background: The mothers of twins often suffer from sleeplessness. However, little is known about the relation of sleep behaviors between these mothers and their infants. The change of this relation with age has not been reported. The aims of this study are firstly to clarify the sleep behaviors of twin infants and their mothers by using actigraphy (four measurement periods at approximately 4- to 6-week intervals) and secondary to evaluate the relations of sleep behaviors between twin infants and their mothers. Methods: Five twin pairs and their mothers (first-time mother) were participated in this prospective longitudinal study. Their sleep behaviors were recorded for 7 consecutive days by using an actigraph, when the infants reached a corrected age (CA) of 3–6 weeks, 8–11 weeks, 13–15 weeks, and 17–20 weeks. Sleep status was classified into 3 states: both infants sleeping, only one infant sleeping, and both infants awake. Results: All infants were cobedded. The time awake during the nocturnal period decreased by almost 90 minutes from CA 3–6 weeks to CA 8–11 weeks. Sleep duration in the nocturnal period increased by almost 85 minutes, and the proportion of time with both infants sleeping rapidly increased in the same period. Maternal sleep duration during the period of both infants sleeping was positively correlated with CA. Conclusion: This research revealed the transition of sleep behaviors in twin infants and their mothers in early infancy. Cobedding may facilitate more synchronized sleep states of twin infants.

INTRODUCTION

There are approximately 20,000 twin births annually in Japan (1), meaning that roughly one in 100 pregnancies is a multiple pregnancy. It is well known that taking care of twin infants is a harder work than taking care of single infant. Previous studies have reported that mothers of twin infants demonstrate more serious fatigue (both physically and mentally) and poorer sleeping conditions in comparison to those with singletons (2-5). Multiple births are recognized as a risk factor for child maltreatment (6).

The circadian time-keeping system is the neural system that allows predictive adaption of infants to the reproducible 24-hour day/night changes of the earth. The circadian system functions in the fetus by receiving circadian signals through the mother. With the transition from fetal life, infants should move to an environment in which the main signal is the light and dark cycle. The sleep-wake circadian rhythm of infants emerges at 3–4 weeks of age (7) and usually establishes by 12–16 weeks of age (8). An irregular sleep pattern is one of the most concerns reported by mothers in early infancy periods. A population-based study reported that sleep disturbances and poor sleep quality of mothers was an important independent risk factor for postnatal depression (9).

Mothers with a singleton infant are required to respond only to two situations: sleep and awake. By contrast, in the case of twins, the mother must respond to three situations: both infants sleeping, only one infant sleeping, and both infants awake. This difference might be one of the factors that influences the extent of a twin mother’s fatigue.

While the relation of sleep behaviors between infants and mothers has been investigated in the mothers with singleton infants (4-5, 10), little is known about the relation of sleep behaviors in mothers of twins. In addition, the change of the relation depending on infants’ growth has not been reported. Therefore, a longitudinal investigation of the sleep development in twins and their mothers are critical important for not only developing a support system for mothers with twin infants but also better understanding of sleep behaviors in twins.

Actigraphy is an established method to measure sleep behaviors, and it has been utilized in many previous studies to monitor human rest/activity cycles non-invasively (11-14). Actigraphy has been widely utilized to

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assess sleep behaviors continuously with high reliability. Algorithms specifically developed for infants are available to estimate sleep status based on daily activity records (11).

The purposes of this study were to clarify the sleep behaviors of twin infants and their mothers by using longitudinal actigraph recordings (four times with approximately 4- to 6- week intervals) and to evaluate the relations of sleep behaviors between twin infants and their mothers.

METHODS

Subjects

We studied five twin pairs and their mothers who fulfilled the following inclusion criteria: no neurological or developmental problems in infants, primipara mothers, and mothers with male partners. Families were recruited through support groups for families of twins/ multiples in Hyogo prefecture, Japan. The investigations were carried out four times, when the infants reached a corrected age (CA) of 3–6 weeks, 8–11 weeks, 13–15 weeks, and 17–20 weeks.

Procedures

Infants' and mothers' sleep behaviors were recorded for seven consecutive days by using an actigraph (Micro Motionlogger, Ambulatory Monitoring Inc., Ardsley, NY). Activity counts were recorded at 1-minute intervals. The activity data were downloaded by using Watchware software (ver. 1.94.1.3, Ambulatory Monitoring Inc.), and sleep measures were analyzed by using Action-W software (ver. 2.7.1150, Ambulatory Monitoring Inc.). The algorithm "Sadeh for Infants" was used to analyze infants' data (11). Both "sleep" and "light sleep" were classified as "sleep." The "Cole-Kripke" algorithm was utilized to analyze the mothers' data (14).

The infants wore the actigraph on their ankles, while the mothers wore it on the wrist of their non-dominant arm. For infants, the band of the actigraph was changed to an adjustable elastic band in order to fit their ankles.

In order to improve the accuracy of sleep and awake determination from activity data retrieved from Actigraphy, mothers were asked to record daily diaries that included the time when the actigraph was removed, when infants went to bed and left bed (determined as "bed time"), when infants had been fed, and when infants had their diapers changed. The periods in which the actigraph was removed (mostly bath times) were recorded as "bad epochs" and regarded as time spent awake. We calculated the bed time, nocturnal awake duration, nocturnal sleep duration, number of night-awakenings, 24-hour awake duration, 24-hour sleep duration, and the proportion of nocturnal sleep each day.

At the start of the study, mothers were asked to complete the Edinburgh Postnatal Depression Scale (EPDS), which is commonly used to screen for postpartum depression in Japan. A score of 8/9 has been established as a cut-off point for depression in Japanese populations (15).

Data analysis

We analyzed sleep measures, consisting of minutes awake and minutes asleep, by using Action-W software. Mean values for each week were calculated from daily data. Statistical analysis was performed using Kruskal-Wallis one-way analysis of variance and Wilcoxon's rank test.

The data concerning the period of nocturnal sleep were classified into 3 groups: a. both infants sleeping simultaneously, b. only one infant sleeping, and c. both infants awake simultaneously. Spearman correlation coefficients were calculated between CA and the proportion of time spent in each sleep category.

All statistical procedures were carried out using SPSS software (ver. 19.0, IBM Corp., NY, USA) for Windows and Excel (2013 Microsoft, WA, USA).

Ethical consideration

This study was approved by the Ethics Committee of Kobe University Graduate School of Health Sciences in accordance with the World Medical Association Declaration of Helsinki (no. 290-1). The parents of all infants were informed of the research details and provided written informed consent to participate.

RESULTS

The characteristics of the subjects were shown in Table I. We asked 25 pairs of twin infants' families to participate in this research and obtained their consent from 5 pairs. Based on information obtained at their initial interview, the socioeconomic status of each subject was classified as upper or middle class in accordance with Japanese standards. The maternal age (mean ± SD) was 32.8 ± 4.0 years, the gestational age at birth was 35.9 ± 1.8 weeks, the infants' weight at birth was 2233.8 ± 512.8 g, and EPDS score was 7.8 ± 3.6. Two of twin mothers had EPDS scores over a cut-off point. Three pairs of twins and their mothers stayed at their home during entire periods without homecoming. Another two pairs had homecoming after the birth of twins. The periods were one month and three months respectively.

Table II showed bed time duration based on sleep diaries and actigraphic sleep measures in all infants according to CA (weeks). Infants' total bed time duration was 607.3 ± 96.8 minutes, nocturnal awake duration was 147.4 ± 75.3 minutes, and nocturnal sleep duration was 459.9 ± 89.8 minutes over the entire period. The nocturnal awake duration significantly decreased from CA 3–6 weeks to CA8–11 weeks, to CA13-15 weeks, and to CA17-20 weeks, while the nocturnal sleep duration significantly increased during the same period. The number of night-awakenings (more than 5 min.) significantly decreased from CA 3–6 weeks to CA8–11 weeks, to CA13-15 weeks, and to CA17-20 weeks. It also significantly decreased from CA 8-11 weeks to CA13-15 weeks, and to CA17-20 weeks.

All twin pairs slept in the same bed or futon (Japanese-style mattress); one pair of twins who shared a room with the parents had been cobedding with the mother throughout the study period. Two pairs of twins were shifted from cobedding with their mothers to separate beds. Another two pairs of twins were shifted from separate to cobedding during the study period.

Twenty-four-hour awake duration significantly decreased from CA 3–6 weeks to CA8–11 weeks, to CA13-15 weeks, and to CA17-20 weeks, while 24-h sleep duration significantly increased during the same period. The proportion of nocturnal sleep was significantly increased from CA 3–6 weeks to CA8–11 weeks, to CA13-15 weeks, and CA17-20 weeks. The significant increases were observed between CA 8–11 weeks and CA17-20 weeks, and between CA 13-15 weeks and CA17-20 weeks.

Furthermore, sleep behaviors relating to time in bed were classified into 3 groups: a. both infants sleeping, b. only one infant sleeping, and c. both infants awake. The changes in the proportions of time spent with only one infant sleeping (twins showing different sleep behaviors) and of both infants sleeping simultaneously during the bed time are shown in Figures 1-A and 1-B, respectively. The proportion of time with only one infant sleeping was negatively correlated with CA ($r = -0.70$, $p = 0.001$). Conversely, the proportion of time with both infants sleeping was positively correlated with CA ($r = 0.69$, $p = 0.001$).

Table III showed bed time duration recorded by diaries and actigraphic sleep measurements among the 5 mothers at each CA period (weeks). The total maternal bed time duration was 513.6 ± 104.6 minutes, nocturnal awake duration was 106.7±65.4 minutes, and nocturnal sleep duration was 406.9 ± 93.9 minutes over the entire study period. The proportion of nocturnal sleep significantly increased from CA 8–11 weeks to CA13–15 weeks and from CA 3-6 weeks to 13-15 weeks, and to 17-20 weeks.

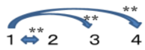
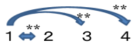
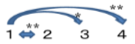
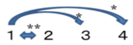
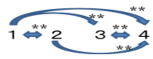
The change in maternal sleep duration during the period of both infants sleeping was shown in Figure 2. Maternal sleeping duration during the period of both infants sleeping was positively correlated with CA ($r = 0.67$, $p = 0.002$).

Table I. Characteristics of subjects

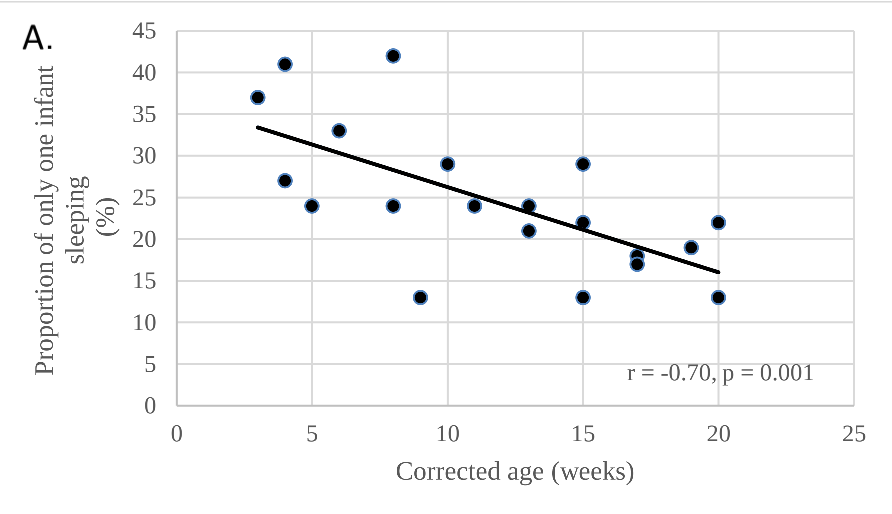
	Maternal age (y)	Gestational age (weeks)	Zygosity	Weight 1 (g)	Weight 2 (g)	Weight difference (g)	Sex	Breast-feeding	EPDS
	32	35.2	DZ	2156	1836	320	M/M	Blend	7
	28	33.3	MZ	1712	1346	366	F/F	Blend	9
	32	36	DZ	2400	2070	330	F/F	Blend	13
	39	38.1	MZ	2636	2388	248	M/M	Breast	7
	33	37.1	DZ	2792	3002	210	M/M	Blend	3
Mean ± SD	32.8 ± 4.0	35.9 ± 1.8	-	2233.8 ± 512.8		294.8 ± 63.9	-	-	7.8 ± 3.6

Note. mean ± SD, DZ : dizygotic; MZ : monozygotic

Table II. Estimated sleep measures of twin infants

	Entire period	3–6 weeks	8–11 weeks	13–15 weeks	17–20 weeks	Kruskal-Wallis	Wilcoxon
Bed time period (min)	607.3 ± 96.8	612.9 ± 88.8	609 ± 109.9	584.8 ± 85.9	622.2 ± 8.7	0.152	n.s.
Nocturnal awake duration (min)	147.4 ± 75.3	219.5 ± 60.0	130.7 ± 61.4	115 ± 70.0	123.3 ± 58.7	<0.001**	
Nocturnal sleep duration (min)	459.9 ± 89.8	393.4 ± 78.4	478.3 ± 103.3	469.8 ± 64.7	498.9 ± 70.7	<0.001**	
Number of night-awakenings (more than 5 min)	5.8 ± 3.1	8.7 ± 3.1	5.5 ± 2.8	4.2 ± 2.3	4.6 ± 1.9	<0.001**	
24-h awake duration (min)	707.4 ± 99.3	742.1 ± 92.6	683 ± 118.1	709.2 ± 85.5	696 ± 88.5	0.003**	
24-h sleep duration (min)	723.1 ± 94.4	687 ± 89.3	749.9 ± 108.6	728.9 ± 86.2	725.8 ± 81.1	0.002**	
Proportion of nocturnal sleep (%)	64.0 ± 11.7	57.5 ± 10.5	63.6 ± 10.1	65.5 ± 11.2	69.6 ± 1.7	<0.001**	

Note. n = 10. Values are mean ± SD.
p values between groups: CA 3–6 weeks (1), 8–11 weeks (2), 13–15 weeks (3), 17–20 weeks (4)
*p < 0.05, **p < 0.01



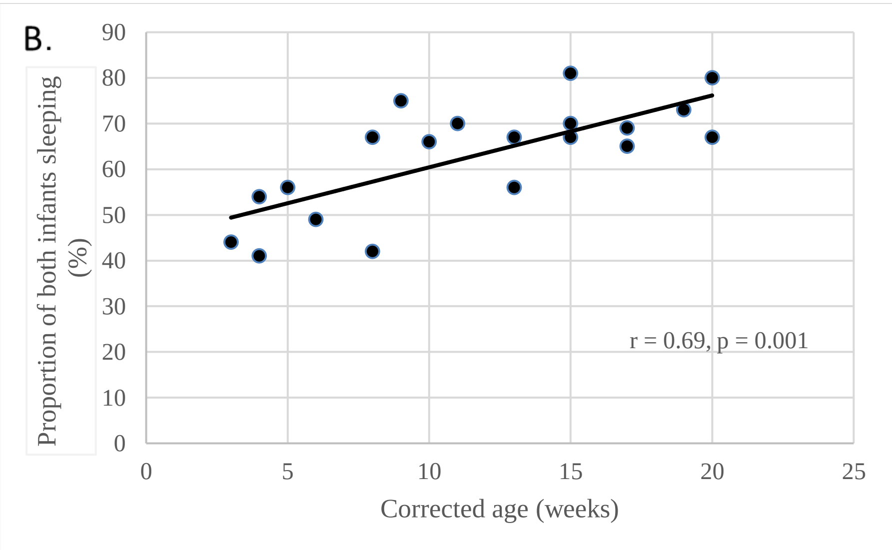
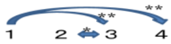


Fig. 1. A. Transition of the proportion of time with only one infant sleeping (twins showed different sleep behavior) during the bed time
B. Transition of the proportion of time with both infants sleeping simultaneously during the bed time.
(r = Spearman's coefficient)

Table III. Estimated sleep measures of mothers

	Entire period	3–6 weeks	8–11 weeks	13–15 weeks	17–20 weeks	Kruskal-Wallis	Wilcoxon
Bed time period (min)	513.6 ± 104.6	491.7 ± 101.3	535.3 ± 102.2	528.9 ± 114.6	516.3 ± 99.5	0.326	n.s.
Nocturnal awake duration (min)	106.7 ± 65.4	123.9 ± 78.3	114.5 ± 65.5	101.6 ± 52.4	79.9 ± 49.5	0.041*	n.s.
Nocturnal sleep duration (min)	406.9 ± 93.9	367.7 ± 84.9	420.8 ± 95	427.3 ± 88.3	436.3 ± 97.6	0.016*	n.s.
Number of night-awakenings (more than 5 min)	4.9 ± 3.0	5.6 ± 3.9	5.2 ± 3.0	4.3 ± 1.8	4.6 ± 2.4	0.549	n.s.
24-h awake duration (min)	904.4 ± 116.7	923.7 ± 116.8	886.6 ± 97.1	928.7 ± 115.9	883.8 ± 133.6	0.215	n.s.
24-h sleep duration (min)	524.2 ± 110.9	505.4 ± 116.1	546.2 ± 92	508.9 ± 113.7	532.8 ± 121	0.358	n.s.
Proportion of nocturnal sleep (%)	79.8 ± 15.1	73.8 ± 11.1	76.8 ± 13.0	88.2 ± 20.4	82.5 ± 12.6	< 0.001**	

Note. n = 5. Values are mean ± SD.
p values between groups: CA 3–6 weeks (1), 8–11 weeks (2), 13–15 weeks (3), 17–20 weeks (4)
*p < 0.05, **p < 0.01

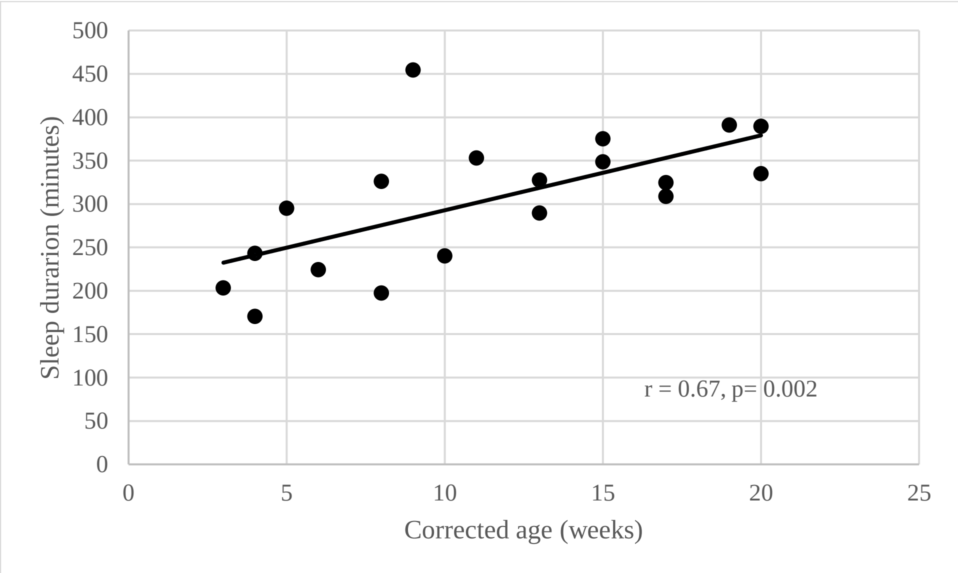


Fig. 2. Transition of maternal sleep duration during the period of both infants sleeping (r = Spearman's coefficient)

DISCUSSION

Transition of sleep behaviors of twin infants

This study investigated the developmental process of sleep behaviors in twin infants. There were very few longitudinally studies on the relation between the sleep behaviors of twin infants and their mothers during the early postnatal weeks.

The majority of twins in our study had low birthweight and preterm birth. In 2009, 73% of twins born in Japan had low birthweight, and 57% were born preterm (1). Thus, the characteristics of subjects in our study were consistent with those of typical Japanese twins. Sleep-wake cycles reflect the underlying brain functions and develop by gestational ages (16). Therefore, we assessed sleep behaviors according to the twins' CA in this study.

A lot of the previous studies, the actigraphy was utilized as a suitable method for evaluating sleep behaviors in infants (11-12). As the acitigraphy is a small, wristwatch-like device, it can be used at the usual home life. Actigraphy was recommended as a standard method for evaluating the sleep behaviors of the small children (17). Actigraphic sleep measurements have been reported to strongly correlate with polysomnographic measurements and other observation methods (11-12; 14; 17). The participants of this study were requested not only to complete actigraphic measurement but also to record their daily activity in a diary. The records of daily diary were used to confirm the accuracy of sleep measurements.

Previous studies indicated the sleep-wake circadian rhythm of singleton infants emerges at 3–4 weeks of age (7) and is usually established by 12–16 weeks of age (8). In this study, the awake duration in the nocturnal period decreased by almost 90 minutes from CA 3–6 weeks to CA 8–11 weeks and the sleep duration in the nocturnal period increased by almost 85 minutes in the same period. The proportion of time with both twin infants sleeping significantly increased in the same period. In the case of twin infants, their sleep behaviors changed dramatically from CA 3-6 weeks to CA 8-11 weeks. The period coincided with the time when infants entrain the sleep-wake circadian rhythm. Our results suggested that the sleep behaviors of twin infants changed from the scattered patterns to the similar patterns depending on the age.

Tikotzky et al. (5) performed a longitudinal study to examine development of singleton infant sleep and maternal sleep from 3 to 6 months postpartum. The methodology of their study was very similar to that of our study (actigraphy and sleep diary). In both studies, the participants were limited to only primiparous women, but the participants in the previous study were limited to full-term infants (31 girls and 26 boys). Tikotzky et al. reported that mean sleep duration in the nocturnal period was 567.5 ± 68.4 minutes, and the mean number of night-awakenings at 3 months postpartum was 2.5 ± 1.0. In comparison, the nocturnal sleep duration in our study was shorter by approximately 100 minutes, and the number of night-awakenings in our study was more frequently, occurring 4.2 ± 2.3 per night at a CA of 3 months. On the other hand, the diurnal sleep duration of twin infants in our study was longer than that of singleton infants in the previous study.

In comparison with the results of a large-scale questionnaire-based survey reported by Sadeh et al. (18), shorter nocturnal sleep duration was observed in our study, by approximately 60 minutes at CA of 3 months and approximately 30 minutes at CA of 5 months. The diurnal sleep duration of twin infants was longer than that of singleton infants. There were clear differences of sleep behaviors between singleton infants and twin infants. It was reported that neonates with typical development spend approximately 60-70% of their time for sleeping, and the ratio decreases as they grow up (15). The development of sleep-wake cycles in infants was influenced by exogenous factors such as light-dark cycle and sharing activities between the mothers and their infants (10). Our results suggested that in the case of twins interactivities might occur between not only mothers and infants but also infants and infants, and that the twin infants might wake up each other. The disturbance of nocturnal sleep duration might influence diurnal sleep behaviors until circadian rhythms are established.

All the twin infants in this study slept in the same bed or futon (Japanese traditional mattress). The twin infants typically slept next to each other on the same bed or futon. Previous studies reported that when twin infants slept in the same cot (cobedding), their sleep status were more synchronized in comparison with non-cobedding twins (19-21). Hayward et al. (19) suspected that the similarity in sleep patterns might be related to twins waking each other with their movement, resulting in similar wake/sleep cycles.

After CA 3–6 weeks, the sleep behaviors of each infant changed depending on their age. Their sleep patterns gradually became more similar as they grew older.

The sleep behaviors of mothers of twins

Tikotzky et al. (5) reported a maternal sleep duration in the nocturnal period of 387.71 minutes, and a mean number of night-awakenings of 2.61 at 3 months among mothers of singleton infants. In comparison to these previous results, nocturnal sleep duration in our study was approximately 40 minutes longer at CA 3 months, the number of awakenings was greater, and the awake duration was approximately 40 minutes longer. The maternal nocturnal wakefulness corresponded with their infants' nocturnal activities (4). In contrast to mothers of a singleton infant who must respond to only two situations related to the infant, asleep or awake, mothers of twins must respond to three situations: both infants sleeping, only one infant sleeping, and both infants awake. The increase of sleep interruptions that occurs because of mothers needing to respond to two infants affects maternal sleep quality, and might be one reason why mothers of twins required a longer total sleep duration than mothers of singleton infants.

Maternal sleep duration during both infants sleeping was significantly correlated with CA. Although mothers of twin infants demonstrated poorer sleeping conditions in comparison to those of mothers with singletons (2), maternal sleep duration increased with the synchronization of sleep behaviors between twin infants.

Since the proportion of time mothers spent in nocturnal sleep was significantly increased from CA 8–11 weeks to CA 13–15 weeks in this study, mothers might achieve better sleep in a bed separate from their infants especially before 11 weeks of CA. The proportion of time mothers spent in nocturnal sleep significantly increased from CA 3-6 weeks to CA 13-15 weeks, and CA 3-6 weeks to 17-20 weeks. Well sleeping might be the most important for mothers with young infants to recover from fatigue. Health care workers should encourage other family members of twin infants to support mothers in taking care of the infants and tell prospects of the sleep behaviors of twin mothers.

The limitation of this study was the small sample size. The number of twins has been decreasing since 2005 in Japan (1). Although actigraphy was a non-invasive small seize sensor, wearing the actigraphy and writing in a diary might be troublesome for some twin mothers. However, mothers agreed to participate in this study, their husband or their mothers were some times against the participation. Fisher et al.(22) reported that the morning wake time was more closely correlated between monozygotic twins than between dizygotic twins. They suggested that genetic factors might affect sleep behaviors together with environmental factors. Unfortunately, due to the small number of subjects in our study, the influence of genetic factors could not be examined.

Another limitation was the lack of mothers' previous medical history; preexisting mental health problems were not considered an exclusion criterion. Prino et al. (23) reported that mothers of twins were predisposed to depressive tendencies. Two of five mothers scored over 9 in our study. Poor sleep behaviors might be one of important factors which influence the mothers' emotion. In Japan, approximately 40% of women return to their parents' home and live together with their parents from around the 34th week of pregnancy until 1–2 months after birth (24). Our study included one family who had a long period of homecoming for 3 months after birth, and we were not able to exclude the influences of homecoming.

This research revealed the transition of sleep behavior in twin infants and their mothers in early infancy. Cobedding may facilitate more synchronized sleep states in twin infants. However, considering the burden on the mothers of twin, sleeping separately from the infants might be regarded as a better sleeping environment. Support from the father and other family members is also needed.

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The authors declare no conflict of interest.

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