ORIGINAL ARTICLE

Interrelationship between sleep quality of 1-month old infants and their mothers' corresponding activities

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Abstract

The aim was to examine the interrelationship between sleep quality of 1-month infants and mothers, mothers' corresponding activities to infant's night sleep, and mother's mental health. A cross-sectional survey with self-reported questionnaire was conducted among 437 healthy mother–infant pairs at 1-month postpartum delivered at a maternal hospital in Tokyo. The main measurements were the presence of mother's sleep problem, the presence of infant's unstable sleep quality (hereinafter, unstable sleep), mother's stimulating activities, such as responding to active sleep immediately, and four indices of mothers' mental health. After comparing statistically, the basic characteristics and above main measurements with and without infant unstable sleep, a covariance structure analysis was conducted to investigate the association among four main measurements according to the hypotheses made based on previous studies. The infants' unstable sleep affected the mothers' sleep problem ($\beta = 0.12$), the mothers' sleep problem affected the stimulating activities ($\beta = 0.11$) and the stimulating activities affected the infants' unstable sleep ($\beta = 0.11$). The infants' unstable sleep and mothers' sleep problem affected the mothers' mental health directly ($\beta = 0.20$, $\beta = 0.15$). The values of GFI (0.993, AGFI (0) and RMSEA (0.032) showed a high fitness of the model. The inter-relationships between the infants' unstable sleep, mothers' sleep problem, mothers' stimulating activities, and mothers' mental health were verified in just 1 month post birth. It is significant that those relationships were obtained in the neonatal periods. The result that mothers' stimulating activities affect infants' unstable sleep is important with implications on sleep health education.

Keywords Infant–mother relationship · Parenting behavior · Circadian rhythms · Sleep difficulty · Mental health · Postpartum

Introduction

It is well known that sleep is significantly inhibited during postpartum due to the rapid changing of hormones and infant care [1]. Some studies have showed that mother's

sleep disorder and infant's sleep problem at this time are both an independent risk of postpartum depression [2–5]. There are several studies on the relationship between infant's sleep and mother's sleep or mental health [4–8]. Dennis and Ross indicated that infant's sleep patterns affect maternal fatigue [6], and Kurth et al. reviewed that the amount of infant crying during the first 3 months is associated with tiredness and fatigue [7]. Tikotzky also reported the negative implications of maternally disturbed sleep problems on the mother–infant relationship of eighty postpartum mothers from 3 to 18 months [8]. However, the studies which focus on the relationship between child's sleep and mother's sleep or mental health are limited, because sleep is difficult to study during the few months of postpartum period even when using actograms or questionnaires [1, 6]. As a result, the details of postpartum sleep disorders and its effects on maternal role or mother–child relationship are not well understood [1].

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In general, in the first month of childbirth, the mother's sleep is unstable [9, 10]. In addition, the condition is complex for many reasons, and sleep difficulties in 1-month-old infants are recognized as a normal developmental process [7]. There is a universal belief that maternal disturbed sleep in the early postpartum is an unavoidable part of motherhood. Perhaps that part of the reason, the interventions to improve postpartum maternal sleep are few and consensus regarding effective modalities is also lacking [1].

On the other hand, the circadian rhythm acquisition of a newborn begins soon after birth and usually established by 3 months [11]. A report shows that postpartum educational interventions may promote maternal and infant sleep [12]. Furthermore, there were some reports that behavioral parental education at pregnancy was effective for prevention of sleep problem in the child [13, 14]. Given these facts [11–14] and considering that the early postpartum mother's mental health is important for good care and growth of her infant, the period of 1 month after birth could be a critical period for both the infant's acquisition of circadian rhythm and formation of the mother's caregiving skills.

We have already reported that 1-month postpartum sleep is related to the subjective mental health, such as depressive mood, anxiety, low motivation, or irritability, of the 457 women from the questionnaire survey [15]. Before that we had reported that the sleep difficulty of a 4-month-old infant was affected by the mother's undesirable caregiving activities which inhibited the infant's sleep [16], and that a parental educational intervention with a pamphlet had reduced the mothers' undesirable caregiving activities and prevented infants' sleep problems' worsening at 7 months [17]. The undesirable activities in these studies [16, 17] were defined as follows: "Hold up an infant and soothe immediately", "Feed or check diaper promptly" when infant wakes and cries during midnight (0:00–6:00 am) and "Be present at bedtime to help infant go to sleep (Co-sleeping)" based on several literature reports [18–21]. The previous survey [15] had covered not only mothers' sleep and mental health, but also infants' sleep state and mothers' caregiving activities.

The mother's sleep for the first month after birth is thought to be more unstable and easily inhibited by infant's nighttime lactation compared to a mother of a 4-month-old infant [9, 10]. Even so, the mother's rearing activities may also affect the infant's sleep quality and mother's mental health even in this period for the above facts [11–14]. Although there are several trials of parental education in pregnancy [22–24] or immediately postpartum to 4 months postnatal [25], these studies do not yet indicate significant effects on infant's sleep and maternal mental health.

According to the hypotheses that the inter-relationships are present in 1-month infant's sleep, the mother's sleep, mother's caregiving activities, we analyzed the sleep environments of 1-month-old infants, including their mothers'

activities, sleep and subjective mental health. The purpose was to examine the comprehensive interrelationship between sleep quality of children and mothers, mother's infant rearing activities and subjective mental health of mothers.
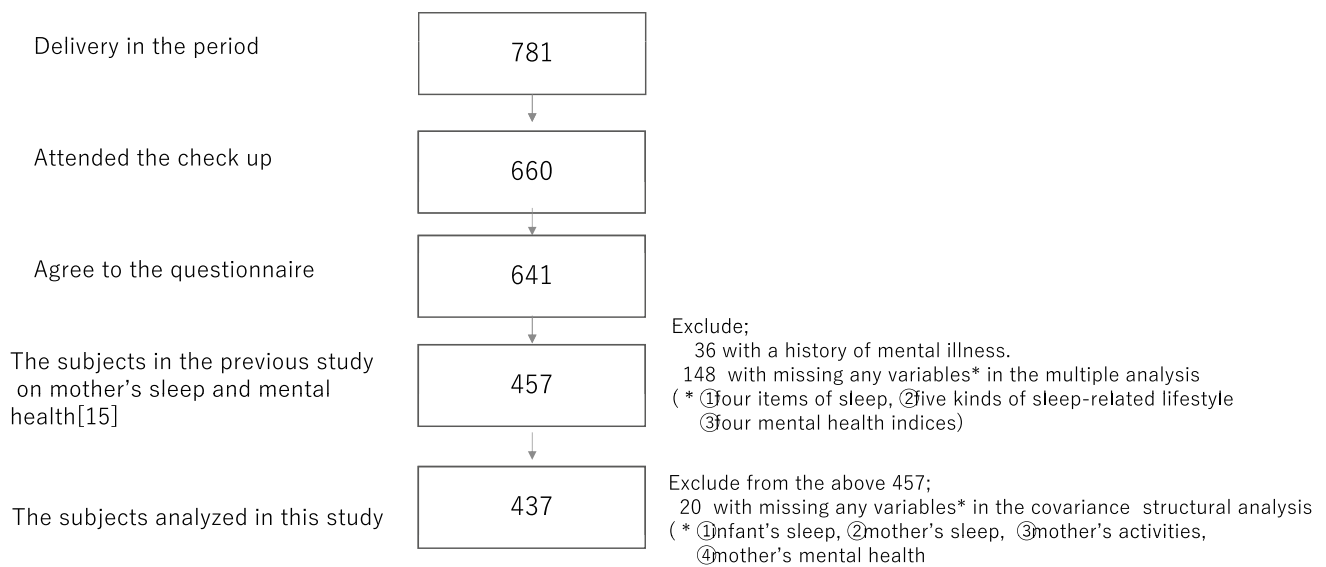
Materials and methods

Subject

The subjects were 437 mother–infant pairs at 1-month postpartum delivered at a maternal hospital in Tokyo from July 2009 to November 2010. The mothers were included in the 457 subjects of the previous report [15]. Out of the total 781 who had delivered in the above period, 660 had attended the 1-month health check-up and 641 had agreed to the questionnaire survey. We excluded 168 with missing variables in the covariance structural analysis and 36 with a history of mental illness (Fig. 1). The hospital had recommended spontaneous labor and introduced high-risk pregnant mothers to the higher functional hospitals. The inclusion criteria of the subjects to be analyzed were that they had no history of psychiatric disorders, and all four kinds of variables used for a covariance structural analysis were obtained. The variables were the presence of mother's sleep problems, the presence of infant's unstable sleep, three kinds of stimulating activities that may interfere with infant's good sleep, and four indices of mothers' mental health.

Variables and evaluation

The questionnaire was prepared as a baseline survey of "The childcare support for mothers by lifestyle habits improvement and parent skill education from pregnancy to postpartum" [26] (hereinafter, program), which was carried out as a grant project by Welfare Medical Organization of Independent Administrative Institutions. The question items concerned characteristics of the subjects (age, BMI before pregnancy, birth history, work, feeding and supporters), mother's sleep, infant's sleep, stimulating activities, and mother's subjective mental health. Supporters had been selected up to three from husbands, parents, parents-in-law, sisters, relatives, and friends.

The sleep status of mothers was evaluated by sleep indices, sleep satisfaction, and sleep problem. Sleep indices were "sleep onset latency" (time from going to bed until falling asleep), "sleep efficiency" (total sleep time/time in bed %), and "Number of night awakenings". Sleep satisfaction was measured on a five-point scale, from "satisfied" (1) to "very dissatisfied" (5). Sleep problems were defined as "Difficulty falling asleep", "Nonrestorative sleep or poor in quality", "Difficulty maintaining sleep", and "Waking up too early". Infant's unstable sleep qualities were defined in accordance

Delivery in the period	781
Attended the check up	660
Agree to the questionnaire	641
The subjects in the previous study on mother's sleep and mental health[15]	457
The subjects analyzed in this study	437

Exclude;
  36 with a history of mental illness.
 148 with missing any variables* in the multiple analysis
(* ①four items of sleep, ②five kinds of sleep-related lifestyle
   ③four mental health indices)

Exclude from the above 457;
 20 with missing any variables* in the covariance structural analysis
(* ①infant's sleep, ②mother's sleep, ③mother's activities,
  ④mother's mental health

Fig. 1 Participants' flow

with the sleep difficulties in the previous studies [16, 17]. These were "Difficulty in falling asleep and light sleep", "Crying at night often", "Day and night reversal", and "Difficulty in falling asleep when waking up at night" which the mothers responded to as applicable to their children's sleep. The mother's stimulating activities were similarly specified: "Feeding or diaper checking immediately", "Hold up the infant immediately" and "Be present until falling asleep". These were defined as "undesirable behaviors" in the previous studies [16, 17] and were based on theoretical background of behavioral issues as discussed later in the discussion [20, 21]. The subjective mental health of the mother was evaluated by the visual analog scale (VAS) method on four aspects, which were depressive mood, anxiety, low motivation, and irritability. The score was valued from 0 (good) to 10 (bad), digitized to one decimal place. Depressive mood was from "pleasant" to "depressed". Anxiety was from "relief" to "very anxious". Low motivation was from "motivated enough" to "no motivation", and irritability was from "none" to "always".

The variables used for the covariance structure analysis were "the existence of infant's unstable sleep qualities (hereinafter, infant's unstable sleep) "the existence of mother's sleep problems (hereinafter, mother's sleep problem)", "the number of stimulating corresponding activities that may interfere with infant's sleep (hereinafter, "stimulating activities"), and "four indices of mental health by VAS".

Development of the hypothesis model

To analyze the relationship among "infant's unstable sleep", "mother's sleep problem", "stimulating activities" and

"mother's mental health indices", we hypothesized a model as shown in Fig. 2. We hypothesized two main paths: one is the direct path from "infant's unstable sleep" and "mother's sleep problem" to "mother's mental health indices" and the other is the path from "mother's sleep problem" to "infant's unstable sleep" via "stimulating activities" acting as a mediating factor.

These paths were hypothesized based on previous studies which indicated a relationship between maternal nursing and infant sleep [16] and the relationship between mother's sleep problem and mother's mental health [15].

Analyses

First, we compared the group with any infant's sleep difficulty (Infant Unstable sleep Group; IUSG, $n = 180$) and the group without difficulty (Control Group; CG, $n = 257$) regarding the basic characteristics, mothers' sleep, infants' sleep, stimulating activities and mothers' mental health. Because the distribution had no normality, the numerical values were compared by Mann–Whitney's U test using median values. Comparison of discrete variables was done by χ^2 test.

Next, a covariance structure analysis was conducted to investigate the association among mother's sleep, infant's sleep, stimulating activities, and four mental health indices (latent variable) by MLR (Robust Maximum Likelihood). MLR is recommended for the structural equation modeling analysis of abnormal data or small sample size [27].

To evaluate the reliability of mental health, Cronbach's α coefficient was investigated. Goodness-of-Fit Index (GFI), Adjusted Goodness-of-Fit Index (AGFI) and Root Mean
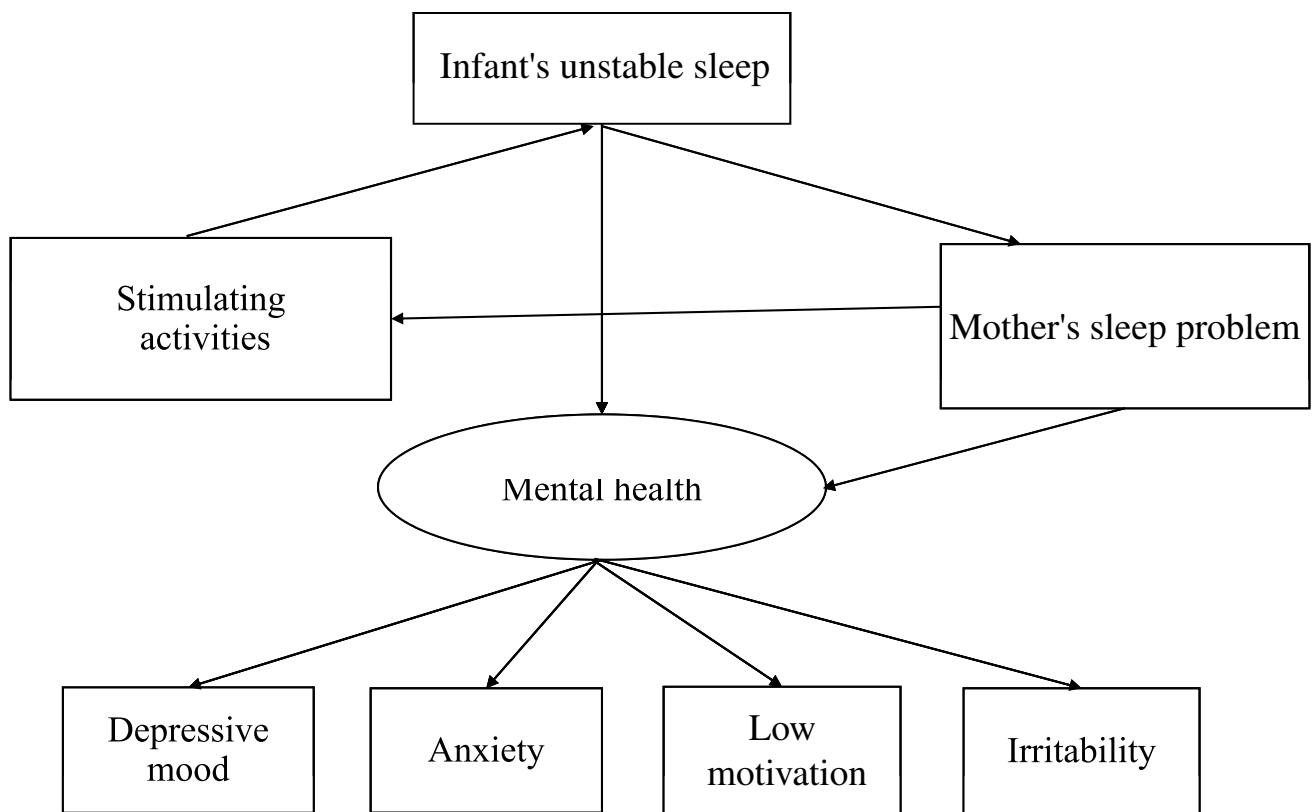
Fig. 2 Hypothetical model. Two main paths were hypothesized (1) The first path from "Infant's unstable sleep" and "Mother's sleep problem" to "Mother's mental health" (2) The second path from "Mother's sleep problem" to "Infant's unstable sleep" via "Inadequate activities"

Square Error of Approximation (RMSEA) were used to evaluate model goodness-of-fit. The adoption of the model was conditional on the fact that the goodness-of-fit indices were the best and that all the path coefficients were significant in the Wald test. The covariance structure analysis was conducted by MPULUS. SPSS-Statistics version 22 and MPULUS version 7 were used for date analysis, and the significance level is set to 5%. Both GIF and AGFI take values between 0 and 1, and the closer the value is to 1, the more powerful the model is. RMSEA is judged to be a better model as it is closer to 0, and models are adopted at 0.05 or less.

Ethical considerations

Prior to the start of this study, we submitted our research plan to the Ethics Committee of the Japan Medical Association for Preventive Medicine of Japan and received approval (No 210626). The hospital midwives had told the subjects in person the purpose of the study verbally and via a document. We stated in the document that the aggregated data are used only for research purposes, individuals are not specified, privacy is strictly observed and there is no disadvantage for not answering. Those who signed the consent form for the

research were designated as the subjects of this research. In addition, the hospital individually informs everyone in writing that there is a case where research and utilization of data are made at the time of the first visit.

Results

The basic characteristics

As shown in Table 1, In IUSG, the rate of breast-feeding was smaller, the rate of mixed-feeding was larger, and the rate of support from husband was smaller than in CG significantly. For the other items, the difference between the two groups was not significant.

Mother's sleep state, sleep problems

Table 2 shows mother's sleep. In IUSG's mothers, the sleep time was shorter (5.0 vs 6.0 h), the sleep efficiency was lower (88.3 vs 91.4%), the numbers of night awaking were higher (3.0 vs 2.5 time) and the sleep satisfaction was poorer (4.0 vs 3.0 score) than in CG's mothers significantly. Furthermore, the rate of having sleep problems was higher (37.3

Table 1 Participants' characteristics (from questionnaire)

	Total (n=437)			Control group (n=257)			Infants unstable sleep group (n=180)			z/t	p
	n	Median	(IQR)	n	Median	(IQR)	n	Median	(IQR)		
Attributes of mothers											
Age (years)	437	32.0	(29.0, 35.0)	257	33.0	(29.0, 35.0)	180	32.0	(28.0, 35.0)	− 1.426	0.144
BMI before pregnancy (kg/m²)[a]	437	20.3	(19.0, 22.3)	257	20.5	(19.0, 22.4)	180	20.0	(19.0, 22.3)	− 0.550	0.582
Numbers of feeding (time/day)	306	9.0	(8.0, 10.0)	175	9.0	(8.0, 10.0)	131	9.3	(8.0, 10.0)	− 0.544	0.586
Numbers of supporters	427	2	(2, 3)	249	2	(2, 3)	178	2	(2, 3)	− 1.909	0.056
	n	(%)		n	(%)		n	(%)		χ^2	p
Birth history											
Primipara	234	(53.5)		131	(51.0)		103	(57.2)		1.662	0.197
Multipara	203	(46.5)		126	(49.0)		77	(42.8)			
Work											
No working	307	(70.3)		182	(70.8)		125	(69.4)		0.845	0.839[b]
During engaged	3	(0.7)		1	(0.4)		2	(1.1)			
Maternity leave	100	(22.9)		59	(23.0)		41	(22.8)			
Child care leave	26	(5.9)		15	(5.8)		11	(6.1)			
Feeding											
Breastfeeding	146	(33.4)		95	(37.0)		51	(28.3)		9.957	0.007
Formula	14	(3.2)		10	(3.9)		4	(2.2)			
Mixed	146	(33.4)		70	(27.2)		76	(42.2)			
Supporters (up to 3)											
Husband	402	(92.0)		243	(94.6)		159	(88.3)		12.862	<0.001
Parents	322	(73.7)		182	(70.8)		140	(77.8)		1.730	0.188
Parents in law	105	(24.0)		67	(26.1)		38	(21.1)		1.730	0.188
Sisters	66	(15.1)		36	(14.0)		30	(16.7)		0.572	0.450
Relatives	11	(2.5)		8	(3.1)		3	(1.7)		0.965	0.326[b]
Friends	34	(7.8)		35	(13.6)		9	(5.0)		3.518	0.061
Others	8	(1.8)		5	(1.9)		3	(1.7)		0.059	0.808[b]

IQR inter-quantile range

[a]From medical record data

[b]Fisher's exact test

vs 26.4%) in IUSG. As regards four kinds of sleep problems among two groups, only the difference of "Nonrestorative sleep or poor in quality (31.1 vs 16.3%)" was significant.

Mothers' stimulating activities and infants unstable sleep

Table 3 shows mothers' activities and infants' unstable sleep. In IUSG' mothers, the numbers of stimulating activities were more (2.0 vs 1.0), the rate of "Hold up an infant immediately" (36.1 vs 20.6%) and "Be present until falling asleep" (52.2 vs 42.8%) were higher than in CG. Regarding IUSG' infants' sleep difficulties, "Day and night reversal (46.1%)" was the most, and then "Difficulty in falling asleep when waking up at night" (37.8%), "Crying at night

often" (31.4%), "Difficulty in falling asleep and light sleep" (27.7%) had followed.

Mother's subjective mental health

Table 4 shows mother's subjective mental health. In total, the irritability score was the highest, then the anxiety, the depressed mood, and the low motivation followed. In IUSG's mothers, all four indices of mental health were significantly higher than those of CG's mothers.

The results of covariance structural analysis

The Cronbach's α was 0.848, and high internal consistency was shown regarding the reliability of mental health. Applied to the hypothesis model, the model goodness-of-fit

Table 2 Mothers' sleep

	Total (n=437)			Control group (n=257)			Infants unstable sleep group (n=180)			z/χ²	p
	n	Median	(IQR)	n	Median	(IQR)	n	Median	(IQR)		
Bed time [o'clock]	284	23.0	(22.0, 24.0)	184	23.0	(22.0, 24.0)	100	23.0	(22.0, 24.0)	−0.617	0.537
Falling asleep time [o'clock]	196	24.0	(23.0, 24.5)	126	24.0	(23.0, 24.5)	70	24.0	(23.0, 24.5)	−0.619	0.536
Awakening time [o'clock]	277	6.5	(6.0, 7.0)	176	6.5	(6.0, 7.0)	101	7.0	(6.0, 7.0)	−1.685	0.092
Arising time [o'clock]	248	7.0	(6.0, 7.5)	163	7.0	(6.0, 7.0)	85	7.0	(6.2, 7.5)	−1.036	0.300
Total sleep time [h]	437	6.0	(5.0, 6.0)	257	6.0	(5.0, 6.0)	180	5.0	(4.5, 6.0)	−4.441	<0.001
Time in bed [h]	206	8.0	(6.6, 9.0)	140	8.0	(6.5, 9.0)	66	8.0	(6.9, 9.2)	−0.497	0.619
Sleep onset latency [h]	188	0.5	(0.2, 1.0)	121	0.5	(0.2, 1.0)	67	0.5	(0.3, 1.0)	−1.798	0.072
Sleep efficiency [%]	156	90.3	(82.9, 94.1)	105	91.4	(83.3, 95.6)	51	88.3	(76.9, 92.3)	−2.159	0.031
Numbers of night awaking [time]	340	2.5	(2.0, 3.0)	206	2.5	(2.0, 3.0)	134	3.0	(2.0, 3.0)	−2.491	0.013
Sleep satisfaction [score][a]	437	3	(2, 4)	257	3	(2, 4)	180	4	(3, 4)	−6.079	<0.001
Having sleep problems [n, (%)] [n=437]	134	(30.9)		66	(23.6)		68	(35.2)		7.286	0.007
Sleep problem (Multiple answers) [n, (%)] [n=437]											
Difficulty falling asleep	40	(9.2)		21	(8.2)		19	(10.6)		0.724	0.395
Difficulty maintaining sleep	25	(5.7)		12	(4.7)		13	(7.2)		1.279	0.258
Waking up too early	8	(1.8)		3	(1.2)		5	(2.8)		1.528	0.216[b]
Nonrestorative sleep or poor in quality	98	(22.4)		42	(16.3)		56	(31.1)		13.272	<0.001
Taking a nap or snooze [n, (%)]											
Always	188	(43.0)		108	(42.0)		80	(44.4)		1.140	0.566
Sometimes	204	(46.7)		121	(47.1)		83	(46.1)			
None	39	(8.4)		26	(10.1)		13	(7.2)			

IQR inter-quantile range

[a] High score is bad

[b] Fisher's exact test

Table 3 Mothers' stimulating activities and unstable sleep in infants

	Total (n=437)			Control group (n=257)			Infants unstable sleep group (n=180)			z	p
	n	Median	(IQR)	n	Median	(IQR)	n	Median	(IQR)		
Numbers of stimulating activities	437	1.0	(1.0, 2.0)	257	1.0	(1.0, 2.0)	180	2.0	(1.0, 2.0)	− 2.612	0.009
		n	(%)		n	(%)		n	(%)	χ^2	p
Stimulating activities*											
Feeding or diaper checking immediately		335	(75.9)		201	(78.2)		134	(74.4)	0.839	0.360
Hold up a infant and soothe		118	(27.3)		53	(20.6)		65	(36.1)	12.884	<0.001
Be around until falling asleep		204	(46.5)		110	(42.8)		94	(52.2)	3.775	0.052
Unstable Sleep in infants (Multiple answers)**											
Difficulty in falling asleep and light sleep		50	(11.4)		0	(0.0)		50	(27.7)	80.612	<0.001
Crying at night often		55	(12.6)		0	(0.0)		55	(31.4)	89.834	<0.001
Day and night reversal		83	(19.0)		0	(0.0)		83	(46.1)	146.309	<0.001
Difficulty in falling sleep when waking up at night		68	(15.6)		0	(0.0)		68	(37.8)	114.981	<0.001

IQR inter-quantile range

*Same as undesirable behaviors defined in our previous reserches [16, 17] on 4 months' infants which had significantly affected to infants' sleep difficulties

Those are considered to reinforce or maintain infant's sleep problem in behavioral perspectives

**Mother's answer to the question that was "Does your baby fit in with the following sleep issues"

Table 4 Mother's subjective mental health

|	Total (n=437)		Control group (n=257)		Infants poor sleep group (n=180)		z	p
	Median	(IQR)	Median	(IQR)	Median	(IQR)		
Mental health								
Depressive mood[a]	2.4	(1.1, 4.5)	2.0	(0.8, 4.0)	2.8	(1.4, 4.8)	− 3.765	<0.001
Anxiety[a]	2.5	(1.0, 4.8)	2.1	(0.8, 4.5)	3.3	(1.5, 5.0)	− 3.515	<0.001
Low motivation[a]	2.3	(0.8, 4.4)	1.9	(0.6, 3.9)	2.9	(1.2, 4.8)	− 3.396	0.001
Irritability[a]	4.6	(1.8, 6.1)	3.6	(1.3, 5.8)	5.1	(2.9, 6.6)	− 3.755	<0.001

IQR inter-quantile range

[a]High score is bad

was GFI = 0.993, AGFI = 0.987, RMSEA = 0.032. The covariance structural analysis showed a significant association between all paths. That is," Infant' unstable sleep" and "Mothers' sleep problem" directly affected "Mental health" ($\beta = 0.20$, $\beta = 0.15$). "Infant's unstable sleep" affected "Mother's sleep problem" ($\beta = 0.12$) and "Mother's sleep problem" affected "Stimulating activities" ($\beta = 0.11$), "Stimulating activities" affected "infant's unstable sleep" ($\beta = 0.11$) (Fig. 3).

Discussion

We conducted a cross-sectional questionnaire survey on 1-month postpartum mothers and their infants. The results showed that the sleep of about 40% of 1-month infants is still unstable and about 30% of mothers have any sleep difficulties. Dennis reported that 70.9% mothers at 4 weeks postpartum thought that their baby slept from well to very well, and 82.8% stated that their baby's sleep pattern allowed them to get a reasonable amount of sleep [6]. Of course, since the infant's circadian rhythm has not yet been established, sleep instability cannot be considered abnormal. Even so, the results mean that there are significant within-person differences in sleep of mother and infant at just 1 month. Furthermore, there is a possibility that not only biological conditions (intrinsic factors [28]), but behavioral or environmental factors (extrinsic factors [28]) may be involved in the difference during 1 month after birth from the reasons mentioned in the introduction [11–14]. Behavioral interventions for infant and toddler sleep disturbance (ITSD) were developed on the hypothesis that ITSD is maintained or reinforced by

GFI=0.993 AGFI=0.987 RMSEA=0.032
*p<0.05 **p<0.01   ***p<0.001
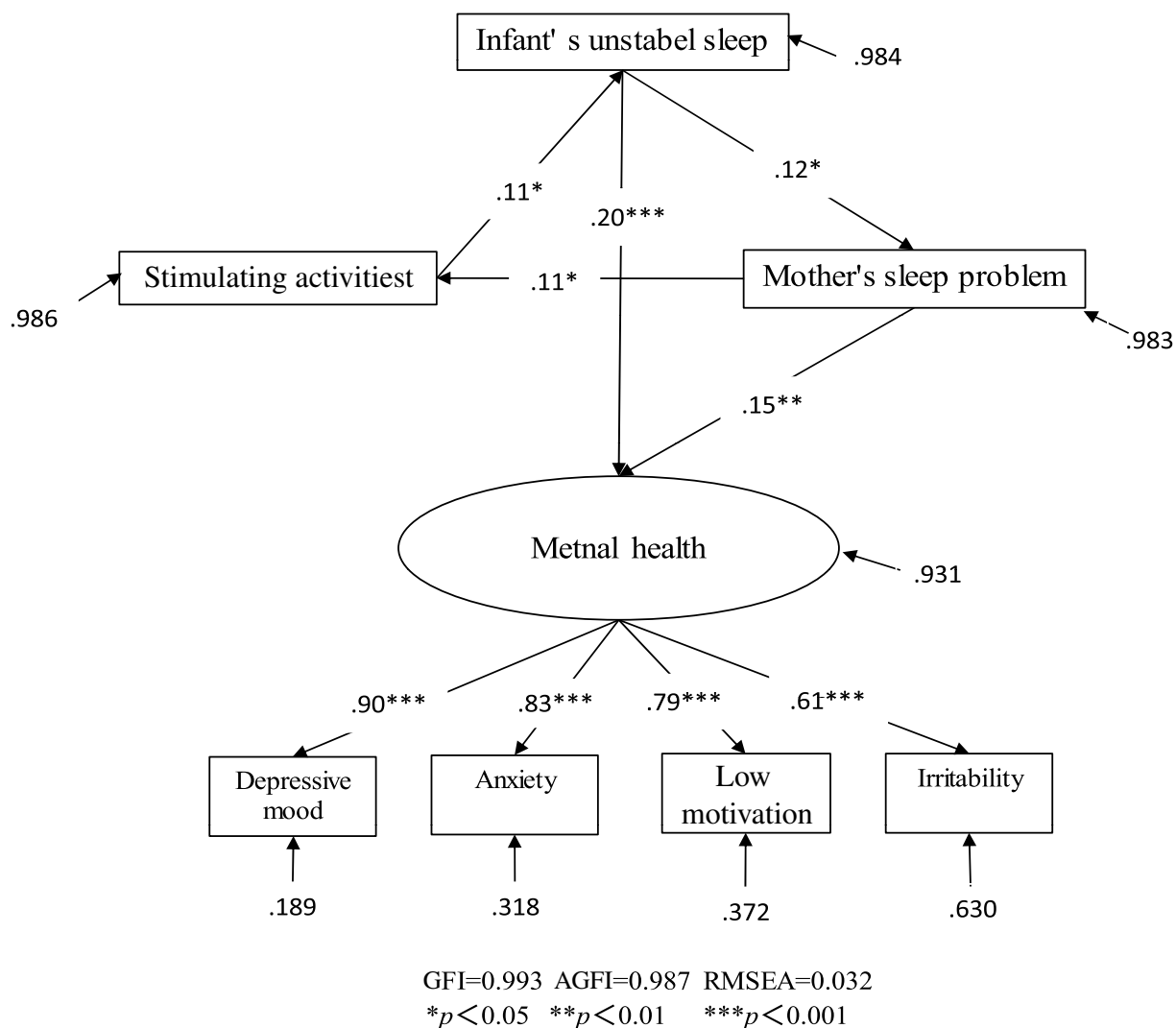
Fig. 3 The final model. The covariance structural analysis showed "Infant's unstable sleep" and "Mother's sleep problem" affected "Mental health" ($\beta=0.20$, $\beta=0.15$), "Infant's unstable sleep" affected "Mother's sleep problem" ($\beta=0.12$), "Mother's sleep problem" affected "Stimulating activities" ($\beta=0.11$), "Stimulating activities" affected "Infant's unstable sleep" ($\beta=0.11$)

prompt parental behaviors in response to infant night waking, such as feeding, holding, and soothing [29]. Mindell reviewed 41 studies and concluded that extinction and parental education were well-established methods for ITSD [18]. After that, American Academy of Sleep Medicine reviewed 52 behavioral treatment studies and concluded that empirical evidence provides strong support for unmodified extinction and preventive parent education [30]. As newborn's sleep, American Academy of Pediatrics recommends that reducing the discomfort of sleeping in any way helps to maximize the time and quality of baby's sleep during the first weeks of life, and infants are better to learn sleep alone when drowsy but awake [31],"When you put him down to sleep, try to avoid letting him cry. Instead, respond to these tears, and do whatever you can to soothe your baby. Pick him up if necessary, putting him down again five to ten minutes later" [31]. Mindell et al. suggest that avoidance of parental reinforcement (e.g., with attention, night feeding) may prevent a small, temporary sleep problem from becoming a large and chronic one [32].

Perhaps, the mother in this period would be sensitive to childcare and may easily act excessively in response to nocturnal lactation or faint signs of infant's movements and voices during active sleep, and may stimulate the infant to

promote the above-mentioned nighttime awakening. Thus, the mother's stimulating activity in the present study may have interfered with the neonate's good sleep. In addition, daytime napping and inactivity are usual among Japanese postpartum women in this period, stemming from the idea that rest is necessary [15, 32]. Ueda et al. reported that 1-month postpartum women who engaged in daily activities had favorable mental health by the multiple regression analysis [33]. Lillis et al. reported that even small changes in daily exercise and napping behaviors could lead to reliable improvement in postpartum maternal sleep [34]. Adachi et al. showed that poor sleep hygiene of a nap and getting up after awakening relate to poor mental health in 1-month postpartum [15].

The comparison between the two groups showed that the mothers in IUSG with infant's sleep difficulty had significantly more sleep problem, poorer sleep quality and poorer mental health than the mothers in CG. Additionally, the results of covariance structural analysis showed that our hypothesis model is appropriate. That is, the inter-relationships among the following four factors, infant's unstable sleep, mothers sleep problem, mother's stimulating activities, and mother's mental health, were verified in just 1 month post birth.

The limitations of this study are as follows: First, data were collected from mothers' self-reports and, therefore, the results are subjective. Second, the subjects were recruited from only one hospital in an urban area in Tokyo and, therefore, they are not representative of all Japanese women. Third, measurements for mental health and sleep state lack objective data.

Despite these limitations, we consider the result is reliable because the values of GFI, AGFI and RMSEA show a high fitness of the model. Furthermore, the subjects were low-risk healthy women and have little selection bias from high response rate of 97%. These relationships have already been suggested in our previous study at 4 months after birth [16]. In this study, a similar relationship was confirmed in 1 month after birth. Especially, the result that mother's stimulating activities affect infant's unstable sleep is important. The results can be considered reasonable from the mechanism of new born infants' circadian rhythm acquisition [11, 12] and the result of previous studies showing the effect of educational intervention from pregnancy [13, 14].

The result suggests that proper parenting behaviors may help infant's healthy sleep formation immediately after birth. Unfortunately, in Japan, the knowledge of baby's sleep and sleep difficulty is unknown among not only pregnant women but also perinatal health professionals. Many parents give up on stopping their infant's crying at night, and even if they consult a doctor or other health professionals, they may scarcely get adequate advice. Therefore, we think that the "behavioral parent training of newborn infant sleep" from pre-delivery or after birth will be useful for infant's healthy sleep development and mother's mental health.

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