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The role of parental circadian preference in the onset of sleep difficulties in early childhood

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ABSTRACT

Background: Chronotype is a construct contributing to individual differences in sleep-wake timing. Previous studies with children have found that evening-types exhibit greater sleep difficulties. Infant sleep quality can be modulated by several factors, such as parental characteristics. We aimed to examine the association between parental circadian preference and sleep in early childhood.

Methods: This study was based on a longitudinal birth cohort, with several measurement points. We used information regarding parental questionnaires during pregnancy and children´s sleep measures at 3, 8, 18 and 24 months. 1220 mothers, 1116 fathers, 993 infants at 3 months, 990 infants at 8 months, 958 children at 18 months, and 777 children at 24 months were analyzed. Parental circadian preference was measured using the Horne-Östberg Morningness-Eveningness Questionnaire. Concerning children´s sleep, Brief Infant Sleep Questionnaire and Infant Sleep Questionnaire were used at each time point.

Results: Maternal circadian preference was associated with infants' circadian rhythm development at 3, 8, 18 and 24 months. Furthermore, increased maternal eveningness was also related to short sleep during daytime at 3 months, and nighttime at 3 and 8 months, to long sleep-onset latency at 3, 18 and 24 months, to late bedtime at 3, 8 and 18 months, and to sleep difficulties at 8 and 24 months. Paternal circadian preference was not associated with any sleep variable at any time point.

Conclusion: Maternal circadian preference is related to several sleep difficulties in early childhood, and it might be considered a potential risk factor for the onset of early sleeping problems.

Keywords: Circadian preference, eveningness, parental factors, early childhood, sleep, circadian rhythm

1. Introduction

Chronotype is a construct reflecting individual differences in circadian preference, and it is thought to be a relatively stable trait that contributes to individual differences in sleep-wake timing [1]. Different terms are used to describe chronotype; some authors prefer to use the term circadian typology [2], while others have labelled it as circadian preference, diurnal preference, chronotype or morningness-eveningness. However, all these terms refer to an individual’s preference for scheduling sleep and other activities with respect to the 24 h day. Some people may prefer to wake up early in the morning and are at their best in the first part of the day, whereas some others prefer to wake up later and go to bed late at night, as they usually feel better in the evening [3]. These phases reveal at what time of the day the individual is most active as well as least active.

Circadian preference is often divided into three categories: “morning”, “intermediate”, and “evening” types [4], and different questionnaires containing a different set and number of questions are used [4]. These questionnaires usually give a total summed score, and also specific cutoff scores, in order to classify the three different types of circadian preference [5]. Studies on adults and adolescents suggest that individual differences in circadian preference are linked to sleep schedule variability [6], psychosocial functioning [7], and specific properties of the circadian clock [8]. However, little is known about the development of circadian preference in early childhood. Existing studies suggest that young children show a relatively strong preference for morningness [9,10], and that toddlers exhibiting stronger morning preference have earlier bedtimes, sleep onset times, sleep midpoints, and wake times as measured with actigraphy [11]. The transition towards eveningness already starts in early childhood [12], but this shift is more significantly pronounced during adolescence [13] when the timing of sleep tends to delay [14]. At the end of the adolescence, a change towards morningness occurs [15].

In adults, circadian preference is strongly linked with sleep quality [16,17]. Eveningness is related to more sleeping difficulties, in particular insomnia and delayed sleep-wake rhythm [18]. Evening-type children (aged 4.5 years old) seem to exhibit more parent-reported sleep difficulties than morning types, and consequently it is also associated with negative social consequences [19]. Similarly, actigraph studies have also related eveningness to later bedtimes and sleep onset times compared to children with tendency for morningness [20,21]. Furthermore, eveningness, which is mediated by sleep difficulties during childhood, has been related to later problems, such as worse academic performance both at school and in university students [22].

Infant sleep quality and development can be modulated by a number of biopsychosocial factors [23]. These factors include inherited child’s characteristics, such as temperament [24] or chronotype [19], perinatal characteristics such as season of birth [25] or photoperiod [26], and environmental characteristics such as parental stress [27]. Following this line of research, our recent study reported that some maternal risk factors during pregnancy are related to infants’ sleep difficulties at three months of age [28]. More specifically, we found that symptoms of depression, Attention-Deficit Hyperactivity Disorder, and stress in mothers during pregnancy were associated with certain sleep difficulties, such as short sleep and long sleep-onset latency, and sleep practices, such as co-sleeping with parents and irregular sleep routines, in three-months-old infants. In addition, children’s sleep quality and circadian phase might also be affected by the parents’ circadian preferences. It has been reported that maternal circadian preference during pregnancy is related to maternal sleep quality during pregnancy [17], which in turn may modulate infant´s sleep quality and development. Furthermore, the circadian preference is viewed as a rather stable and reproducible quantitative behavioral trait in humans [29], regulated by a set of genes that modulate the functioning of circadian clocks and subsequently the sleep-wakefulness cycle [30,31]. Thus, such inherited factors might influence the development of infants’ sleep. In this case, infants’ diurnal preference would be reflective of their parent’s circadian preference, and thus the parent(s) and children would show a tendency towards similar diurnal preferences. However, to what extent parental circadian preference and infant sleep development are related has not been studied yet.

The aim of the study was to examine the effect of parental circadian preference on children´s sleep quality at different time points in the early childhood. To the best of our knowledge, this is the first study aiming to examine the role of parental circadian preference in the onset of sleeping difficulties in early childhood.

2. Methods

2.1. Sample

This study was based on a longitudinal birth cohort, with several measurement points [32]. The study protocol was approved by the local Ethical Committee (9.3.2011, ethical research permission code R11032). Written informed consent was obtained from all the parents.

Shortly, the recruitment and the first questionnaire occurred prenatally at 32nd week, and the following questionnaires were sent to parents at birth and at the child age of 3, 8, 18 and 24 months. For this study, we used the information regarding parental questionnaires during pregnancy (32nd week) and the sleep measures of the infants at 3, 8, 18 and 24 months. The dataset comprises 1 673 families who returned the baseline questionnaires. From this original sample, 1 427 cases were selected for the current study, which were those cases with questionnaires at 3 months. As we aimed to examine healthy infants, 207 cases with any medical illness and/or condition reported (i.e., mild and/or severe illness, including allergies, infections, use of medication for the child, virus, blood problems, and other diseases) at any time point were excluded. In total, 1 220 mothers, 1 116 fathers, 1 220 infants at 3 months, 990 infants at 8 months, 958 children at 18 months, and 777 children at 24 months were analyzed for the current study.

2.2. Measures

2.2.1. Parental circadian preference

Parents filled the Horne-Östberg Morningness-Eveningness Questionnaire (MEQ), which is a self-reported questionnaire, assessing a person's chronotype [4]. We used a shortened 6-item version of the scale to assess the individual circadian preference (consisting the items 4, 7, 9, 15, 17 and 19 from the original MEQ), as it is reported to explain 83% of the variance in the sum of the entire 19-item scale [33]. We selected the total sum score as a measure of parental circadian preference that ranges from 5 to 27, and lower scores in this scale indicates a tendency to eveningness. In addition, a cut-off of MEQ≤12 was used to detect evening-type subjects; MEQ between 13 and 17 to indicate intermediate-type individuals; and a total score of MEQ≥18 was used to classify morning-type subjects. For the purpose of this study, we only used parental circadian preference during pregnancy as the main independent variable within our statistical analysis. However, we consider circadian preference a stable parental trait that does not vary across the different time points. This assumption is based on the high correlations that we obtained between parental MEQ during pregnancy and parental MEQ at 24 months (prenatal maternal MEQ and maternal MEQ at 24 months: $r=0.759$, $p<0.001$; prenatal paternal MEQ and paternal MEQ at 24 months: $r=0.760$, $p<0.001$). Therefore, along the manuscript we will refer to the term "parental circadian preference" as a trait, and not only during the pregnancy period.

2.2.2. Sleep of the infants

Brief Infant Sleep Questionnaire [34] is targeted to characterize infant sleep quality. It comprises 13 items about duration of sleep, settling, night waking, and sleep arrangements. For this study we selected the following variables: i) number of nocturnal sleep hours; ii) number of daytime sleep hours; iii) total number of sleep hours per day; and iv) method for falling asleep (independently vs. parental support).

Infant Sleep Questionnaire is a 10-item questionnaire that assesses infant sleeping habits and parental strategies for managing infant sleep [35]. This questionnaire contains questions assessing settling, waking, and sleeping in the caregivers' bed. Parents are asked if they consider the child having a sleep problem and to report the severity of the possible problem.

In order to examine the sleeping difficulties in infants at 3, 8, 18 and 24 months, we created the following variables concerning sleep quality, which represented 25th or 75th percentile to indicate deviance from average development: i) short sleep during daytime, from the BISQ (cut off, less than 4 hours at 3 months; less than 3 hours at 8 months; less than 1.50 hours at 18 hours; and less than 1.50 hours at 24 months); ii) short sleep during night, from the BISQ (cut off, less than 8.5 hours at 3 months; less than 9.25 hours at 8 months; less than 10 hours at 18 hours; and less than 9.50 hours at 24 months; all these cut-off points represented the 25th percentile); iii) short sleep in total, from the BISQ (cut-off, less than 13 hours of total sleep in 24 hours for 3 months; less than 12.5 hours for 8 months; less than 11.75 hours for 18 months; and less than 11.33 hours for 24 months;); iv) slow development of circadian rhythm, which was calculated as the proportion of daytime sleep relative to total sleep duration per 24 hours, from the BISQ (cut-off, higher than 41.38 percent for 3 months; higher than 32.17 percent for 8 months; higher than 20.47 percent for 18 months; and higher than 20 percent for 24 months); v) long sleep-onset latency, from the ISQ (cut-off, 30 or more minutes of wake time after sleep onset for all the ages, based on previous studies [36]; vi) late bedtime (cut off, later than 22:30 for 3 months; later than 21:30 for 8 months; later than 21:00 for 18 months; and later than 21:20 for 24 months), from the BISQ; vii) high frequency of night awakening, with a cut-off of 3 or more times per night for all the time points, from the ISQ; and viii); sleeping difficulties, from the ISQ, which was obtained from an additional item concerning the parent´s opinion about the existence or not of sleep difficulties in their child (i.e., "do you think your baby has sleep problems"; 0="no sleep problem" and 1="mild, moderate or severe sleep problem).

2.2.3. Covariates

Sociodemographic factors in mothers included maternal age during pregnancy, gestational age of the time when the mother filled out the questionnaire, and gestational age at birth, and number of children in the family; sociodemographic factors in fathers examined included father´s age when the questionnaire was filled out and number of children; and sociodemographic factors in children were age (in weeks), gender, season of birth, order of birth (first born vs. others), use of pacifier and breast feeding and (this last covariate only for infants at 3 and 8 months). Seasons were defined as summer solstice (from 21st June to 21st September), autumnal equinox (from 22nd September to 20th December), winter solstice (from 21st December to 19th March) and spring equinox (from 20th March to 20th June) corresponding to the years of the infants were born (i.e., 2011 and 2012). The relevance of this variable of season of birth might be related mainly to the season of the data collection, rather than to the birth date, per se. Furthermore, we recalculated this variable into two categories: 1=Spring+Summer and 0=Other seasons, in order to examine the effects of those seasons with longer photoperiod compared to shorter photoperiods.

2.3. Statistical analyses

Statistical analyses were performed with SPSS Statistics V24.0. Descriptive statistics were conducted to obtain the means, standard deviations (SD), frequencies and percentages of the variables of interest according to maternal circadian preference.

In order to examine the potential effects of parental circadian preference during pregnancy on infant´s sleep at 3, 8, 18 and 24 months, logistic regression analysis was conducted, where infants' sleep measures were included as dependent variables and parental circadian preference as independent variables. In addition, gender, parental age during pregnancy, infant´s age at each measurement point, gestational age of the time when the mother filled out the questionnaire, gestational age at birth, number of children in the family, breast feeding, use of pacifier and season of birth were included as covariates. All these covariates were considered together within each model. Dependent variables were treated as dichotomous variables (yes vs. no), and the main explanatory variables as continuous (MEQ total score). Each outcome variable of interest, along with the covariates were conducted in different models. Parameters regarding the confounding factors are not reported within the Tables.

3. Results

Sociodemographic and sleep variables in infants at all the time points, as well as parental information during pregnancy are reported in Table 1. Furthermore, the frequency of sleep quality problems in early childhood, in terms of maternal circadian preference (i.e., morningness, intermediate or eveningness) during pregnancy, is described in Table 2.

3.1. Maternal and paternal circadian preference and sleep difficulties in early childhood

Our main results reported in Tables 3a and 3b showed that increasing maternal eveningness preference during pregnancy was associated with slower children´s circadian rhythm development, as indicated by the proportion of daytime sleep relative to the total sleep time at 3 (p<0.001), 8 (p<0.001), 18 (p=0.008), and 24 months (p=0.008). In addition, increased maternal eveningness preference was related to short sleep during daytime at 8 months (p=0.043), and to short sleep during nighttime at 3 (p<0.001) and 8 months (p=0.007), but not to total short sleep at any time point. Furthermore, higher maternal eveningness was also associated with other sleep difficulties in early childhood, such as long sleep-onset latency at 3 (p=0.048), 18 (p<0.001) and 24 months (p<0.001), late bedtime at 3 (p<0.001), 8 (p=0.003) and 18 months (p=0.001), and the prevalence of parent reported sleep difficulties at 8 (p=0.030) and 24 months (p=0.028). Finally, no significant differences were found between maternal circadian preference and high frequency of night wakening of the infant.

In contrast to these findings, paternal circadian preference was not associated with any of the sleep difficulties in the children at any time point. All the significant results are presented in Table 3a (for 3 and 8 months) and Table 3b (for 18 and 24 months).

3.2. Covariates

For this study, we were especially interested in the effect of the season as a moderator variable of our significant results. We found that at 3 months of age, longer photoperiod seasons (i.e., spring and summer) at the time of birth were related to slow circadian rhythm development (B=0.44, p=0.004); and at the age of 8 months, they were associated with short sleep during nighttime (B=-0.40, p=0.015), short sleep during daytime (B=0.30, p=0.036), and slow short total sleep (B=0.33, p=0.044).

4. Discussion

The present study provides relevant and novel information concerning the association between parental circadian preference and sleep functioning in early childhood. Our main findings indicate that maternal eveningness preference is associated with slower circadian rhythm development in infants at 3, 8, 18 and 24 months. Furthermore, maternal eveningness is also related to short sleep duration during daytime at 8 months and during nighttime at 3 and 8 months, to long sleep-onset latency at 3, 18 and 24 months, to late bedtime at 3, 8 and 18 months, as well as to the prevalence of parent reported sleep difficulties at 8 and 24 months. However, paternal circadian preference is not associated with any sleep variable at any time point. Thus, the circadian preference of the father does not seem to exert any effect on sleep functioning of the child during early childhood.

To the best of our knowledge, our study is the first to identify the relationship between parental circadian preference and sleep difficulties in early childhood. Moreover, very scarce research on the links between circadian preference and sleep has been conducted in children at early stages. Previous findings in toddlers reported that evening-type children (i.e., 30 to 36 months old) showed later bedtimes and wake times than morning-type children [11]. Similar results have been found in 4.5 years old children [19]. These authors found that evening-types had not only later bedtimes and get-up times, but also shorter nocturnal sleep time compared to morning- and intermediate-types. In our study, we found that increased maternal eveningness was related to the likelihood of increasing sleep difficulties in early childhood, such as slow circadian rhythm development, short sleep duration during daytime and night time, long sleep-onset latency and late bedtime. Therefore, our results support the notion that sleep quality in infants is influenced by circadian preference. It seems that not only infant´s circadian preference, but also parent´s circadian preference might be associated with the onset of sleep problems in early childhood.

Several potential mechanisms to explain the associations between parental circadian preference and sleep in early childhood can be considered.

First, our findings could be related to prenatal factors. This is supported by our failure to find an independent association between paternal circadian preference and sleep functioning in early childhood. Some prenatal factors, such as mood disturbances [37] and/or substance exposure [38] have been reported to associate with sleep quality in the offspring. Moreover, we recently reported that symptoms of mood disturbances, Attention Deficit Hyperactivity Disorder and stress in mothers during pregnancy were associated with certain sleep difficulties and sleep practices at the age of three-months [28]. Interestingly, in that study, infants' circadian rhythm development was not related to maternal prenatal risk factors, while the present study indicated that it is related to maternal circadian preference consistently across different time-points.

Another potential mechanism is related to genetic factors, as chronotype is considered an inherited trait with strong genetic background [39-41]. Therefore, evening-type parents would be more likely to have offspring with more tendency towards eveningness, and consequently more sleep difficulties. The sleep-wake cycle is regulated by two separate biological mechanisms, which interact together and balance each other [42]: i) the Process C (i.e., circadian rhythm), and the Process S (i.e., sleep-wake homeostasis), which are influenced to some extent by the genes of the individual [43]. However, as paternal circadian preference and child sleep were not related in our current study, this hypothesis is not supported by our findings. Clearly, further studies are needed to study the role of genetic factors and infant sleep development.

A third potential mechanism is related to the differences in lifestyle and parenting practices within the families, which, in turn, are related to the parents' circadian preferences. For instance, it has been reported that morning preference is related to earlier wake up times and earlier bedtimes of the adult [44], which can reflect the sleep-wake rhythm of the infant. It has also been reported that parenting practices within the family are related to infant sleep [45], and therefore circadian preference might be an underlying factor in preferred everyday practices.

Finally, another potential mechanism explaining our main findings relates to the potential disagreement between parents' and their children´s circadian preferences. The biological rhythm of a new mother, especially the sleep–wake rhythms, must adapt to the infant's sleep–wake rhythm [46], and thus some problems might appear when the rhythms differ. Some authors have also argued that behavioral sleep difficulties during childhood may occur because individual sleep and circadian characteristics are not matched with parental expectations (or family and school schedules) [47]. Therefore, mismatch in the circadian characteristics of the parents and the infant might increase the risk for sleep difficulties in the child, and thus infant sleep might be more often perceived as problematic.

The present study has some limitations. First, infants chronotype was not measured in this study. The associations reported here might be also related to the children´s circadian preference, and not only to the maternal circadian preference. In future studies, children chronotype would be an interesting factor to consider. Second, only subjective data of circadian preference and sleep functioning reported by the parents is provided in this study. Therefore, future studies on this topic using objective measures of chronotype and sleep would provide useful objective information to validate these initial results. Third, some other additional confounding variables have not been controlled in this study, such as electric lighting and the amount of bright light during the day. Indeed, this is a factor that could contribute to individual differences in shaping maternal and child circadian preferences and sleep difficulties [48].

Future lines for research on this topic should aim at determining how early the circadian preference manifests in infants and how stable it is during early childhood. Furthermore, previous research concerning the influence of risk factors on children's development has focused on biological or environmental risk variables, such as emotional wellbeing, parenting and/or socio-economical status, mainly in mothers [49], and maternal risk is indeed the strongest predictor of negative outcomes for children [50,51]. However, there might be several moderating factors, such as mother´s versus father´s involvement, parenting or the role of the main caregiver, which may explain the absence of paternal effects on sleep development in early childhood. Therefore, further research on paternal influence is needed.

In summary, maternal circadian preference seems to be related to several sleep difficulties in early childhood, whereas paternal circadian preference does not affect children´s sleep development at these early stages. More specifically, increased maternal eveningness seems to be associated with the likelihood of increased slow circadian rhythm development in infants from 3 months to 2 years old. In addition, other sleep quality difficulties are also related to maternal circadian preference, but not at all time points. These findings implicate that maternal and lifestyle factors, such a circadian preference, should be considered when examining the aetiology of sleeping difficulties in early childhood. In addition, further studies on the link between circadian preference and sleep functioning in early childhood should be conducted, in order to better understand the underlying factors of sleep difficulties since the earliest stages. The examination of chronotype-sleep association is of relevance in early childhood because this is a specific stage characterized by substantial inter-individual differences in the timing and duration of sleep [52]. Characterizing parental factors, such as circadian preference and other family lifestyle-related factors, having a role in the onset of sleeping difficulties in early childhood, improves our understanding on the development of problematic sleep behaviours in the infants and provides new insights for the development of new sleep interventions to support not only the child sleep but potentially also the family interactions. This way, we would be able to extend the focus of the intervention to a wider range of potential contributors.

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Conflicts of interest

The authors have no conflicts of interest to declare.

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Table 1. Descriptive variables in infants at 3, 8, 18 and 24 months; and in parents during the pregnancy period

	Infants during early childhood			
Sociodemographic variables	**3 months (N=1220)**	**8 months (N=990)**	**18 months (n=958)**	**24 months (N=777)**
	Mean (SD)	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*
Age, in weeks	14.10 (2.30)	35.38 (1.63)	80.35 (6.64)	107.37 (5.89)
	Frequency (%)	*Frequency (%)*	*Frequency (%)*	*Frequency (%)*
Sex (Male / Female)	639 (52.5) / 579 (47.5)	564 (52.5) / 516 (47.8)	498 (51.9) / 462 (48.1)	405 (52.3) / 369 (47.7)
Season of birth (Sum / Aut / Wint / Spr)				
Summer	409 (33.6)	362 (33.5)	332 (34.6)	277 (35.8)
Autumn	354 (29.1)	311 (28.8)	278 (29)	210 (27.1)
Winter	166 (13.6)	144 (13.3)	125 (13)	105 (13.6)
Spring	289 (23.7)	263 (24.4)	225 (23.4)	182 (23.5)
Breast feeding)				
Breast milk	796 (65.5)	712 (66)	-----------------	-----------------
Breast milk+substitute	262 (21.6)	225 (20.9)	-----------------	-----------------
Substitute	157 (12.9)	141 (13.1)	-----------------	-----------------
Use of pacifier (Yes / No)	858 (71.7) / 359 (28.9)	754 (70.5) / 316 (29.5)	431 (44.99) / 527 (55.01)	169 (21.75) / 608 (78.25)

	Parents during pregnancy period	
	Mothers during pregnancy (N=1220)	**Fathers during pregnancy (N=1116)**
Age when questionnaire was filled, years: Mean (SD)	30.61 (4.52)	32.58 (5.27)
Gestational age when questionnaire was filled, weeks: Mean (SD)	34.71 (2.53)	----------------------------
Gestational age when birth, weeks: Mean (SD)	40.03 (1.23)	----------------------------
MEQ total score: Mean (SD)	13.84 (2.87)	13.78 (3.03)
Evening-type (Yes / No): Frequency (%)	391 (32.0) / 829 (68.0)	393 (33.7) / 773 (66.3)

Table 2. Maternal circadian preference during pregnancy and sleep quality in early childhood

	3 months			**8 months**		
	Evening-type[a]	**Intermediate-type[b]**	**Morning-type[c]**	**Evening-type[a]**	**Intermediate-type[b]**	**Morning-type[c]**
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
Short sleep, daytime	105 (28.3%)	228 (34.5%)	43 (35.0%)	127 (41.8%)	265 (47.2%)	61 (55.5%)
Short sleep, nighttime	138 (36.3%)	194 (28.8%)	26 (20.6%)	79 (25.8%)	143 (25.1%)	19 (17.1%)
Short sleep, total	123 (32.4%)	219 (32.5%)	36 (28.6%)	70 (22.9%)	138 (24.3%)	32 (28.8%)
Slow development of circadian rhythm	132 (35.7%)	172 (26.1%)	28 (23.3%)	56 (18.4%)	81 (14.3%)	2 (1.8%)
Long sleep-onset latency (≥30 mins)	106 (28.6%)	158 (23.7%)	24 (19.0%)	33 (11.0%)	55 (10.0%)	5 (4.6%)
Late bedtime[d]	107 (27.7%)	127 (18.6%)	14 (10.7%)	60 (18.1%)	85 (14.0%)	8 (6.7%)
High frequency of night awakening (≥3 times/night)	64 (17.2%)	124 (18.5%)	27 (21.8%)	138 (45.1%)	238 42.5%)	44 (39.6%)
Sleeping difficulties	12 (3.1%)	20 (2.9%)	5 (3.8%)	19 (6.3%)	65 (11.5%)	8 (7.1%)
	18 months			**24 months**		
	Evening-type[a]	**Intermediate-type[b]**	**Morning-type[c]**	**Evening-type[a]**	**Intermediate-type[b]**	**Morning-type[c]**
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
Short sleep, daytime	74 (24.2%)	148 (27.8%)	34 (30.6%)	96 (37.9%)	163 (38.0%)	42 (47.7%)
Short sleep, nighttime	171 (55.9%)	298 (55.8%)	58 (52.3%)	86 (34.1%)	123 (28.5%)	30 (33.7%)
Short sleep, total	76 (24.8%)	143(26.8%)	33 (29.7%)	72 (28.5%)	94 (21.8%)	29 (33.0%)
Slow development of circadian rhythm	72 (23.5%)	73 (13.7%)	15 (13.5%)	37 (14.7%)	48 (11.1%)	7 (8.0%)
Long sleep-onset latency (≥30 mins)	40 (14.0%)	39 (7.8%)	10 (9.6%)	56 (22.2%)	73 (17.1%)	12 (14.3%)
Late bedtime[d]	67 (22.2%)	65 (12.5%)	11 (10.1%)	30 (12.1%)	45 (10.7%)	7 (7.9%)
High frequency of night awakening (≥3 times/night)	28 (9.8%)	51 (10.2%)	10 (9.6%)	19 (2.4%)	21 (2.8%)	6 (0.8%)
Sleeping difficulties	15 (5.2%)	13 (2.6%)	7 (6.7%)	14 (5.6%)	11 (2.6%)	2 (2.4%)

[a]Evening-type=total score in MEQ ≤12; [b]Intermediate-type= total score in MEQ between 13 and 17, included; [c]Morning-type=total score in MEQ≥18
[d]Late bedtime cut-offs: later than 23:00 for 3 months; later than 22:00 for 8 months; later than 21:30 for 18 months; and later than 22:00 for 24 months

Table 3a. Logistic regressions between parental circadian preference and infants sleep quality at 3 and 8 months

3 Months				**8 months**			
Short sleep (daytime) 25th percentile (cut-off <4h)				**Short sleep (daytime) 25th percentile (cut-off <3h)**			
	B	*p*	AOR (95% C.I.)		B	*p*	AOR (95% C.I.)
MEQ total sum Mothers	0.029	0.291	1.029 (0.976 to 1.085)	**MEQ total sum Mothers**	**0.058**	**0.043**	**1.060 (1.002 to 1.122)**
MEQ total sum Fathers	-0.020	0.456	0.980 (0.930 to 1.033)	MEQ total sum Fathers	-0.018	0.525	0.982 (0.929 to 1.038)
Short sleep (nighttime) 25th percentile (cut-off <8h)				**Short sleep (nighttime) 25th percentile (cut-off <9.25h)**			
	B	*p*	AOR (95% C.I.)		B	*p*	AOR (95% C.I.)
MEQ total sum Mothers	**-0.118**	**<0.001**	**0.889 (0.845 to 0.935)**	**MEQ total sum Mothers**	**-0.077**	**0.007**	**0.926 (0.876 to 0.979)**
MEQ total sum Fathers	-0.010	0.703	0.990 (0.943 to 1.040)	MEQ total sum Fathers	-0.023	0.406	0.977 (0.926 to 1.032)
Short sleep (total) 25th percentile (cut-off <13h)				**Short sleep (total) 25th percentile (cut-off<12.5)**			
	B	*p*	AOR (95% C.I.)		B	*p*	AOR (95% C.I.)
MEQ total sum Mothers	-0.059	0.067	0.943 (0.885 to 1.004)	MEQ total sum Mothers	0.024	0.397	1.024 (0.969 to 1.083)
MEQ total sum Fathers	-0.019	0.570	0.982 (0.921 to 1.047)	MEQ total sum Fathers	-0.002	0.945	0.998 (0.946 to 1.054)
Delayed circadian rhythm (cut-off >41; 75th percentile)				**Delayed circadian rhythm (cut-off >32.17; 75th percentile)**			
	B	*p*	AOR (95% C.I.)		B	*p*	AOR (95% C.I.)
MEQ total sum Mothers	**-0.118**	**<0.001**	**0.888 (0.841 to 0.939)**	**MEQ total sum Mothers**	**-0.143**	**<0.001**	**0.867 (0.810 to 0.928)**
MEQ total sum Fathers	0.007	0.787	1.007 (0.956 to 1.061)	MEQ total sum Fathers	-0.012	0.716	0.988 (0.926 to 1.054)
Long sleep-onset latency (cut-off >30 mins)				**Long sleep-onset latency (cut-off >30 mins)**			
	B	*p*	AOR (95% C.I.)		B	*p*	AOR (95% C.I.)
MEQ total sum Mothers	**-0.049**	**0.048**	**0.948 (0.902 to 1.009)**	MEQ total sum Mothers	-0.069	0.103	0.933 (0.859 to 1.014)
MEQ total sum Fathers	0.011	0.674	1.012 (0.959 to 1.067)	MEQ total sum Fathers	0.007	0.871	1.007 (0.927 to 1.093)
Late bedtime (90th percentile; cut-off >23:00)				**Late bedtime (90th percentile; cut-off >22:00)**			
	B	*p*	AOR (95% C.I.)		B	*p*	AOR (95% C.I.)
MEQ total sum Mothers	**-0.159**	**<0.001**	**0.853 (0.811 to 0.897)**	**MEQ total sum Mothers**	**-0.082**	**0.003**	**0.921 (0.873 to 0.972)**
MEQ total sum Fathers	-0.012	0.611	0.988 (0.942 to 1.036)	MEQ total sum Fathers	-0.051	0.057	0.950 (0.902 to 1.002)
High frequency of night awakening (cut-off >3 nights)				**High frequency of night awakening (cut-off >3)**			
	B	*p*	AOR (95% C.I.)		B	*p*	AOR (95% C.I.)
MEQ total sum Mothers	0.060	0.054	1.064 (1.001 to 1.129)	MEQ total sum Mothers	0.025	0.611	1.025 (0.931 to 1.129)
MEQ total sum Fathers	0.013	0.679	1.013 (0.954 to 1.075)	MEQ total sum Fathers	-0.077	0.127	0.926 (0.838 to 1.022)
Sleeping difficulties (Yes)				**Sleeping difficulties (Yes)**			
	B	*p*	AOR (95% C.I.)		B	*p*	AOR (95% C.I.)
MEQ total sum Mothers	0.080	0.244	1.084 (0.947 to 1.241)	**MEQ total sum Mothers**	**0.095**	**0.030**	**1.100 (1.009 to 1.199)**
MEQ total sum Fathers	0.060	0394	1.062 (0.925 to 1.220)	MEQ total sum Fathers	-0.018	0.671	0.982 (0.905 to 1.062)

*Covariates: maternal age during pregnancy, gestational age of the time when the mother filled out the questionnaire, gestational age when birth, number of children in the family, father´s age when filled out the questionnaire, children's age (in days), gender, season of birth, breast feeding and use of pacifier. B= unstandardized regression coefficient.

Table 3b. Logistic regressions between parental circadian preference and infants sleep quality at 18 and 24 months

18 Months				**24 months**			
Short sleep (daytime) 25th percentile (cut-off <1.50h)				**Short sleep (daytime) 25th percentile (cut-off <1.50h)**			
	B	*p*	AOR (95% C.I.)		B	*p*	AOR (95% C.I.)
MEQ total sum Mothers	0.027	0.356	1.027 (0.971 to 1.087)	MEQ total sum Mothers	0.020	0.487	1.020 (0.964 to 1.080)
MEQ total sum Fathers	-0.040	0.203	0.961 (0.903 to 1.022)	MEQ total sum Fathers	-0.006	0.856	0.995 (0.937 to 1.055)
Short sleep (nighttime) 25th percentile (cut-off <10h)				**Short sleep (nighttime) 25th percentile (cut-off <9.50h)**			
	B	*p*	AOR (95% C.I.)		B	*p*	AOR (95% C.I.)
MEQ total sum Mothers	-0.002	0.939	0.998 (0.949 to 1.049)	MEQ total sum Mothers	-0.042	0.177	0.959 (0.903 to 1.019)
MEQ total sum Fathers	-0.018	0.566	0.982 (0.923 to 1.045)	MEQ total sum Fathers	-0.048	0.136	0.953 (0.894 to 1.015)
Short sleep (total) 25th percentile (cut-off <11.75h)				**Short sleep (total) 25th percentile (cut-off<11.33)**			
	B	*p*	AOR (95% C.I.)		B	*p*	AOR (95% C.I.)
MEQ total sum Mothers	0.008	0.787	1.008 (0.951 to 1.069)	MEQ total sum Mothers	-0.015	0.590	0.985 (0.931 to 1.042)
MEQ total sum Fathers	0.004	0.890	1.004 (0.945 to 1.067)	MEQ total sum Fathers	-0.029	0.346	0.972 (0.916 to 1.031)
Delayed circadian rhythm (cut-off >20.47; 75th percentile)				**Delayed circadian rhythm (cut-off >20; 75th percentile)**			
	B	*p*	AOR (95% C.I.)		B	*p*	AOR (95% C.I.)
MEQ total sum Mothers	**-0.077**	**0.008**	**0.926 (0.874 to 0.980)**	**MEQ total sum Mothers**	**-0.096**	**0.008**	**0.898 (0.834 to 0.966)**
MEQ total sum Fathers	0.007	0.817	1.007 (0.950 to 1.067)	MEQ total sum Fathers	-0.019	0.556	0.981 (0.920 to 1.046)
Long sleep-onset latency (cut-off >30 mins)				**Long sleep-onset latency (cut-off >30 mins)**			
	B	*p*	AOR (95% C.I.)		B	*p*	AOR (95% C.I.)
MEQ total sum Mothers	**-0.171**	**<0.001**	**0.843 (0.776 to 0.916)**	**MEQ total sum Mothers**	**-0.108**	**0.004**	**0.901 (0.840 to 0.966)**
MEQ total sum Fathers	0.019	0.685	1.019 (0.929 to 1.118)	MEQ total sum Fathers	-0.068	0.069	0.934 (0.868 to 1.005)
Late bedtime (90th percentile; cut-off >21:30)				**Late bedtime (90th percentile; cut-off >22:00)**			
	B	*p*	AOR (95% C.I.)		B	*p*	AOR (95% C.I.)
MEQ total sum Mothers	**-0.099**	**<0.001**	**0.906 (0.859 to 0.955)**	MEQ total sum Mothers	-0.097	0.064	0.901 (0.844 to 1.006)
MEQ total sum Fathers	-0.020	0.458	0.980 (0.928 to 1.034)	MEQ total sum Fathers	-0.022	0.534	0.979 (0.915 to 1.047)
High frequency of night awakening (cut-off >3 nights)				**High frequency of night awakening (cut-off >3)**			
	B	*p*	AOR (95% C.I.)		B	*p*	AOR (95% C.I.)
MEQ total sum Mothers	-0.012	0.777	0.988 (0.910 to 1.073)	MEQ total sum Mothers	-0.032	0.284	0.834 (0.756 to 1.001)
MEQ total sum Fathers	-0.084	0.131	0.919 (0.824 to 1.025)	MEQ total sum Fathers	-0.162	0.160	0.835 (0.721 to 0.977)
Sleeping difficulties (Yes)				**Sleeping difficulties (Yes)**			
	B	*p*	AOR (95% C.I.)		B	*p*	AOR (95% C.I.)
MEQ total sum Mothers	-0.067	0.293	0.935 (0.825 to 1.060)	**MEQ total sum Mothers**	**-0.160**	**0.028**	**0.852 (0.739 to 0.983)**
MEQ total sum Fathers	0.017	0.719	1.017 (0.929 to 1.113)	MEQ total sum Fathers	-0.032	0.698	0.969 (0.825 to 1.137)

*Covariates: maternal age during pregnancy, gestational age of the time when the mother filled out the questionnaire, gestational age when birth, number of children in the family, father´s age when filled out the questionnaire, children's age (in days), gender, season of birth, breast feeding and use of pacifier.

B= unstandardized regression coefficient.