Sleeping through the night or through the nights?

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Abstract

Objective: There are substantial inter-individual differences in infants' longest consecutive sleep duration. However, intra-individual differences are rarely considered. The present study aimed to describe night-to-night variability in achieving 6 or 8 hours of consolidated sleep over a 13-night period in 6-month-old infants.
Methods: Forty-four typically developing infants were part of the study (22 girls). When infants were 6 months old, mothers were asked to complete an infant sleep diary over 13 nights to measure the longest period of uninterrupted sleep each night. Two criteria were used to determine if infants were sleeping through the night: 6 and 8 hours of uninterrupted sleep.
Results: On average, mothers reported that their infant slept 6 hours consecutively for about 5 nights out of 13. Nine infants (20.5%) never slept 6 hours consecutively, three (6.8%) met the criterion every night, but most infants (n = 32; 72.7%) showed high variability between the nights. Mothers reported that their infant slept 8 hours consecutively for about 3 nights out of 13. Half of the infants (50.0%) never slept 8 hours consecutively, one infant (2.3%) slept 8 hours consecutively every night, and twenty-one infants (47.7%) showed high variability.
Conclusions: These findings expand current knowledge by showing that there is not only high inter-individual variability, but also high intra-individual variability in infant sleep consolidation. Parents and clinicians should be aware that occasional sleeping through the night does not necessarily indicate a consolidation of this behavior.

Keywords:
Infancy, sleep consolidation, sleeping through the night, intra-individual variability

1. Introduction

In the first few weeks of life, infant sleep is fragmented into short periods with no day and night differentiation. This sleep-wake organization has profound impacts on parental sleep patterns and well-being.[1] Gradually, several characteristics of the sleep-wake cycle evolve during the first months of life, with a higher proportion of sleep during the night, a lower number of awakenings, and longer periods of sleep without interruption. To that effect, many parents wonder at what age they should expect their infant to sleep several hours consecutively, a process often called 'sleeping through the night'.[2,3] While different definitions exist within the literature, sleeping through the night is often defined as either 6 or 8 hours of uninterrupted sleep without any parental intervention.[4] Unsurprisingly, sleep-related concerns are highly prevalent among mothers.[5]

Several studies have documented considerable inter-individual variability between infants in their ability to achieve 6 or 8 consecutive hours of consolidated sleep.[6-8] Our team recently showed that when using a definition of 6 hours of uninterrupted sleep, 62.4% of mothers reported that during the last weeks their 6-month-old infant slept through the night during the past weeks; when using a definition of 8 hours of uninterrupted sleep, only 43.0% of mothers reported that their infant slept through the night during the past weeks.[9] Moreover, a review paper summarizing 11 studies reported that between 54 and 84% of infants slept through the night at 6 months of age, thus emphasizing differences in methodologies and measures, but also the great variability between infants.[4] However, most of these studies do not mention how many nights infants were achieving this ability. One older study used a sleeping through the night definition of "at least on one

occasion".[10] Another study used a criterion of meeting 80% of nights (out of 5 or 6 nights of sleep diary and videosomnography) in order for infants to be classified as sleeping through the night, using 3 different criteria (sleeping uninterrupted from 24:00 to 05:00, 8 hours of consecutive sleep, sleeping uninterrupted from 22:00 to 06:00).[11]

Not only is there variability between infants, but there is also variability within the same infant at different developmental stages. In a study by Scher using 3 nights of actigraphy and a sleep diary, the longest period of uninterrupted sleep was reported to be unstable between 8 and 14 months.[12] For instance, the rank of a specific child compared to the whole sample occasionally fluctuated between the different time points of the study. Other authors found that in some infants, there were more signaled awakenings at 12 months compared to at 6 months, contrary to the developmental trend we would expect.[13] Altogether, these studies suggest that even if an infant shows the ability to sleep through the night at one point in infancy, it does not mean that this behavior has necessarily been consolidated.

Building on the concept of variability, a few studies have also shown night-to-night fluctuations in sleep patterns using a group approach. For instance, the longest period of uninterrupted sleep in a sample of 34 healthy infants was shown to be quite variable over a period of 3 consecutive nights, with a reliability index of 0.73 at 8 months and only 0.46 at 12 months.[12] Sadeh found a stability coefficient of 0.58 over a period of 3 nights of actigraphy at 6 months old for the same sleep variable.[14] Another study using

videosomnography showed that the number of awakenings varied widely across four nights of sleep from 3 to 12 months in the same group of infants.[13]

While most of these studies described group stability for the whole sample, minimal work has focused on night-to-night fluctuations in a specific infant. Moreover, most of these studies have documented variability over a period of 3 to 6 consecutive nights. This element is important since several studies assessing infant sleep use questionnaires wherein mothers are asked to evaluate their infant's sleep patterns over a longer period, such as over the "past week", the "past two weeks", or "in general".[9,15,16] It is thus unclear how mothers take this variability into consideration when they are asked to answer one question about their infant's longest sleep duration or asked if their infant is sleeping through the night over a longer period. Therefore, the aims of the present study were to 1) describe intra-individual night-to-night variability in the ability to achieve 6 or 8 hours of consolidated sleep over a period of 13 nights in 6-month-old infants, and 2) assess associations between this variability and characteristics of the infants and parents that are known to be associated with infant sleep, such as breastfeeding and co-sleeping.

2. Material and methods

2.1 Participants

Sixty six-month-old infants were recruited through social media groups, advertisements, and word of mouth in the Greater Montreal area (Quebec, Canada). Interested mothers contacted the research team by email and were screened for eligibility. English- or French-speaking mothers 18 years of age and older were eligible for participation. Mothers and infants with serious obstetric complications, born at < 37 weeks' gestation,

or reporting a diagnosis of depression were excluded. This study was approved by the ethics committee of McGill University and Hôpital en santé mentale Rivière-des-Prairies (CIUSSS-NIM). Data were collected by two trained research assistants at the participants' homes. Written, informed consent was obtained for all mothers prior to data collection.

Given the aims of the present study, only infants with complete sleep diaries (the entire 13 nights) were included, for a total of 44 infants (22 girls, 22 boys). Most mothers (n=36) had a university diploma, 17 mothers had only one child, 20 had two children and 7 had more than two children (Table 1). The demographic characteristics of the infants who were included (complete sleep diaries) and not included in the study were found to be comparable (infant sex: Fisher exact test = .343; maternal education: Fisher exact test = .399). There was no significant difference between the mean consecutive sleep duration of participants included (340.96 ± 134.42) and not included (423.07 ± 145.31; p = .123) in the study. The coefficient of variation for consecutive duration was also similar among participants who were included (0.28 ± 0.08) and those who weren't (0.29 ± 0.10; p = .669.).

Table 1. Descriptive statistics for demographic and sleep variables

	n (%)	M ± SD	Range	N
Infant sex: female	22 (50.00)			44
Number of children				
One	17 (38.60)			44
Two	20 (45.50)			
Three or more	7 (15.90)			
Last obtained diploma				42
College	6 (14.30)			
University	36 (85.70)			
Breastfeeding				40
Never	3 (7.50)			
Non-exclusive	4 (10.00)			
Exclusive	33 (82.50)			
Co-sleeping status				
Solitary	26 (61.90)			42
Bed-sharing or co-sleeping	16 (38.10)			
Longest consecutive sleep duration		340.96 ± 134.42	156.92 – 636.92	44
Number of nocturnal awakenings		2.31 ± 1.16	0.08 – 4.62	44
Sleeping through the night				
Percent of nights 6-hr criterion met		40.38 ± 34.37	0.00 – 100.00	44
Percent of nights 8-hr criterion met		21.85 ± 31.52	0.00 – 100.00	44

2.2 Measures and procedures

When infants were 6 months old, mothers completed an adapted sleep diary for a period of 13 nights to describe their infant's sleep-wake patterns.[17] Mothers were instructed to shade in 15-minute intervals to indicate when they thought their infant was sleeping during the night, and to not shade in intervals when they believed their infant was awake during the night. Sleep parameters retrieved from the sleep diary were longest consecutive sleep duration and number of nocturnal awakenings. Longest consecutive sleep duration was defined as the longest summed time of consecutive 15-minute intervals in which the mothers indicated their infant was asleep during the nighttime sleep period. Number of nocturnal awakenings was defined as the total number of 15-minute

intervals in which the mother indicated their infant was awake during the nighttime sleep period. In this study, longest consecutive sleep duration was retrieved for every infant on each of the 13 nights. Based on prior literature, 6 and 8 hours of consecutive sleep were used as criteria for sleeping through the night.[4]

Demographic variables (infant sex, maternal education- high school and professional vs. university) were measured. Sleep-related parental practices known to be associated with infant sleep (feeding method: exclusive breastfeeding, non-exclusive breastfeeding, absence of breastfeeding; sleep location: co-sleeping or solitary sleeping) were assessed with the Sleep Practices Questionnaire (SPQ).[18,19] Mothers were asked: "Where does your baby usually sleep at night?" Solitary sleeping was defined as: "In his/her own room alone all night" or "In a bedroom shared with a sibling all night". Co-sleeping was defined as: "In my bed all night", "In a bassinet or crib next to my bed all night", "In a bassinet or crib across the room from my bed all night", "In a co-sleeper unit next to my bed all night", "Part of the night in my bed and part of the night in his/her own place (bassinet, crib, co-sleeper)".

2.3 Statistical analyses

First, the coefficient of variation for the longest consecutive sleep period (ratio of the standard deviation／mean) over the 13 nights was calculated for each infant. Then, using a 6-hour criterion and an 8-hour criterion, the number of nights each infant slept through the night (out of 13) was calculated and was subsequently transformed into percentages. Pearson's correlations and independent *t*-tests were used to assess the relationships

between the sleep variability scores (coefficient of variation of the longest consecutive sleep period and the percentage of nights infants slept through the night) and characteristics of the sample (sex of the infant, maternal education, feeding method, and sleep location). The significance level for the descriptive statistics was set at $p < 0.05$. Statistical analyses were conducted using IBM SPSS Statistics24.

3. Results

The mean longest consecutive sleep period (assessed for 13 nights) reported by mothers for the whole sample (inter-individual variability) was 340.96 ± 134.42 minutes, with a very important variability, ranging between 156.92 and 636.92 minutes. Moreover, a large inter-night variability of the longest consecutive sleep period was observed in every infant (intra-individual variability), with a coefficient of variation ranging between 0.10 and .45 between infants (mean of 0.28 ± 0.08). A higher coefficient of variation represents a higher level of dispersion around the mean. The mean total number of nocturnal awakening was 2.31 ± 1.16 (ranging between 0.08 and 4.62).

Using a definition of 6 hours of consecutive sleep, mothers reported that their infant slept through the night 40.4% (± 34.4) of the time (about 5 nights out of 13). Figure 1 shows that very different patterns were observed between infants. Nine infants (20.5%) never slept 6 hours consecutively (upper part of Figure 1), three infants (6.8%) met the criterion every night (lower part of Figure 1), and most infants (n = 32; 72.7%) showed high variability between nights. Using this criterion of 6 consecutive hours of sleep, boys slept

through the night 45.8% (± 35.8) of the time, while girls met this criterion 35.0% (± 32.8) of the nights (p = .301).

Using a definition of 8 hours, mothers reported that their infant slept through the night 21.9% (± 31.5) of the time (a little less than 3 nights out of 13). Again, Figure 2 shows great variability between infants and between nights. Half of the infants (50.0%) never slept 8 hours consecutively (upper part of Figure 2), one infant (2.3%) slept 8 hours consecutively every night (lower part of Figure 2) and twenty-one infants (47.7%) showed high variability between nights. Again, no differences were observed between boys (sleeping through the night 24.8% ± 32.6 of the nights) and girls (18.9% ± 30.8; p = .538).

No associations were observed between the coefficient of variation (of the longest period of consecutive sleep) and infant sex (t = 1.01; p = *.316*) or maternal education (t = -0.46; p = *.649*). Similarly, no associations were observed between the percentage of nights each infant slept through the night and infant sex (6-hour criterion: t = -1.05 p = *301*; 8-hour criterion: t = -0.62; p = *.538.*) or maternal education (6-hour criterion: t = 1.17; p = .250; 8-hour criterion: t = 1.12; p = .269). A higher number of awakenings was associated with a lower percentage of nights in which the 6-hour criterion of sleeping through the night was met (r = - .89; p < .001), as well as the 8-hour criterion (r = - .73; p < .001).

Most infants were exclusively breastfed (75%) and a little more than half of the sample (62%) practiced solitary sleeping (Table 1). A higher coefficient of variation (higher

level of dispersion around the mean) of the longest period of consecutive sleep was associated with a higher rate of breastfeeding (r = .40; p = .010) but was not associated with co-sleeping (r = .23; p = .144). The presence of breastfeeding was also associated with a lower percentage of nights in which the 6-hour criterion of sleeping through the night was met (r = - .49; p = .001), as well as the 8-hour criterion (r = - .50; p = .001). The presence of co-sleeping was associated with a lower percentage of nights in which the 6-hour criterion of sleeping through the night was met (r = - .44; p = .003) and was marginally associated with a lower percentage of nights in which the 8-hour criterion was met (r = - 0.30; p = .056).

4. Discussion

These results suggest that over 13 nights, the sleep patterns of 6-month-old infants have considerable variability. This was observed by relatively high coefficients of variation of the longest consecutive sleep period in individual infants, ranging between 0.10 and .45. Moreover, the results show a great variability in the percentages of infants sleeping 6 or 8 hours consecutively over a period of 13 consecutive nights. While some infants never met these criteria and others met them every night, most infants showed a wide range of night-to-night variability.

Parents are often looking for guidelines regarding various aspects of child development. Concerning sleep, parents often wonder when their infant will be able to sleep through the night and typically believe this process will occur around 6 months. While studies have reported considerable inter-infant variability,[4,6] intra-infant variability has received

less attention. In concordance with the present results, the few studies that have investigated night-to-night variability also observed high variability using various recording methods over a period of 3 to 6 nights.[11-14] However, the present results add to the literature by documenting 13 consecutive nights and by highlighting the fact that when a longer period is considered, the number of nights a specific infant meets a 6-hour criterion of consecutive sleep is quite low, with an average of 5 nights out of 13. One could also re-examine the use of the 8-hour criterion, especially at 6 months, considering that in the present sample, infants met this criterion only 3 nights out of 13.

While infant sex and maternal income were not related to night-to-night variability, some parental practices were. Indeed, the presence of breastfeeding was associated with more variability in sleep patterns. Moreover, the presence of breastfeeding and co-sleeping were associated with a lower percentage of nights in which infants slept through the night. This is consistent with many studies reporting an association with breastfeeding, co-sleeping, and sleep fragmentation.[20-22] While these practices could be associated with more sleep fragmentation, other factors could contribute to these findings. For instance, mothers who are breastfeeding and co-sleeping are more likely to observe their infant's night awakenings since they share greater proximity with their infant. Mothers are then more likely to observe the variable sleep patterns of their infant, even though these awakenings are not necessarily problematic or disturbing.[23]

With the present results, we extend the literature by documenting a considerable night-to-night variability of infant sleep in the present sample. This is of major importance for

both clinical practice and research methodology. First, since sleep is known to be a major concern for parents, it is possible that some parents expect that when their infant sleeps through one night, this behavior will be stabilized. Nevertheless, the present results suggest a lot of variability, at least at 6 months. Moreover, this variability supports the idea of sleep consolidation as a continuous and dynamic process, rather than an ability that should be achieved at some point in development. It would be beneficial to document if the same level of variability is observed at other time points, and if infants follow similar trajectories over time. Parents should be informed of the inconsistency between nights.

Moreover, most large epidemiological studies ask mothers to report their infant's sleep patterns over a one- or two-week period. While in some studies, mothers are asked to describe how many nights their child slept through the night in the past week, in other studies, they are simply asked to answer the question: "does your child sleep through the night", or to report the number of consecutive hours their infant slept in general per night in the preceding one or two weeks.[9,15,16] Mothers of infants with low night-to-night variability in sleeping through the night (e.g., never or always sleeping through the night) may find it easier to summarize their infant's sleep patterns over a long period. However, the present results show that most infants display a large inter-night variability. It is thus unclear how mothers are able to describe these inconsistent patterns when answering questionnaires used in large epidemiological studies. Therefore, the use of multiple nights should be promoted in studies documenting infant's sleep with sleep diaries. Future

studies should examine how mothers perceive and describe their infant's sleep when there is considerable night-to-night variability.

Limitations

The present study used maternal report to describe infant sleep. It is well-known that different factors can impact maternal perceptions of infant sleep and that maternal report represents a subjective impression. However, the main strength of the study is that it describes maternal perceptions in a habitual setting and over a longer period of time than what is typically done in the literature. Therefore, it reflects the perception of the mother in an ecological context. Another limitation of the present study is the small sample size that limits the generalizability of the results. It cannot be ruled out that the present sample had specific characteristics (such as high exclusive breastfeeding rates) that contributed to the present results. However, the present study did not aim to evaluate a large number of infants (which was already done in epidemiological studies), but rather aimed to document individual infant sleep patterns over a longer period to describe night-to-night patterns. Nevertheless, the number of participants was high enough to capture meaningful associations between parental practices and sleep variability. Future studies should replicate the present findings in larger samples more representative of the general population, at different time points, and by combining objective and subjective measures of infant sleep.

5. Conclusions

The sleep consolidation process, often called sleeping through the night, not only has high inter-individual variability, but also high intra-individual variability. Given the results of the present study and studies showing great inter-individual variability, parents should lower their expectations regarding infant sleep consolidation. Parents should also be aware that even if their infant sleeps through the night for one or a few nights, it does not mean that this behavior is consolidated. The present results support the concept of sleep consolidation as a developmental and dynamic process as opposed to a step that is attained at a certain point in infancy. Moreover, it is unclear how parents participating in large epidemiological studies who are asked to describe infant sleep patterns over a long period are able to do so. Finally, clinicians working with parents should also be aware of this great variability in order to nuance the information they will share when listening to and helping parents.

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Figure captions

Figure 1. Variability in 6-hour consecutive sleep duration across 13 consecutive nights in typically developing infants
White: Not sleeping 6 hours consecutively; Gray: Sleeping 6 hours consecutively

Figure 2. Variability in 8-hour consecutive sleep duration across 13 consecutive nights in typically developing infants
White: Not sleeping 8 hours consecutively; Gray: Sleeping 8 hours consecutively

Figure 1. Variability in 6-hour consecutive sleep duration across 13 consecutive nights in typically developing infants

White: Not sleeping 6 hours consecutively; Gray: Sleeping 6 hours consecutively

Participant	Night												
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Figure 2. Variability in 8-hour consecutive sleep duration across 13 consecutive nights in typically developing infants

White: Not sleeping 8 hours consecutively; Gray: Sleeping 8 hours consecutively

Participant	Night												
	1	2	3	4	5	6	7	8	9	10	11	12	13
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