

Pediatrics and Sleep

Evaluating Night Wakings in Sleep-Disturbed Infants: A Methodological Study of Parental Reports and Actigraphy

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Summary: The aim of this study was to investigate the use of objective and subjective sleep measures in diagnostic assessment of night-waking problems during infancy. Infant sleep-wake measures obtained from parental daily logs were compared with objective sleep measures derived from activity monitoring during a week-long period in 66 referred infants. Reported sleep measures were significantly correlated with objective sleep measures and showed a significant level of day-to-day stability. Parents were accurate reporters of sleep-schedule measures (e.g. sleep onset, $r = 0.88$; sleep duration, $r = 0.74$; $p < 0.0001$). However, parents were less accurate in assessing sleep quality measures, significantly overestimating the time that their infants spent in actual sleep and underestimating the number of their night-wakings ($r = 0.41$ and $r = 0.60$, respectively; $P < 0.001$). It is suggested that subjective and objective measures should play a complementary role in the clinical assessment of night-waking problems in early childhood. **Key Words:** Infant sleep—Sleep problems—Night-waking—Actigraph—Parent—Assessment.

The maturation and consolidation of sleep-wake patterns are major developmental tasks in infancy. This course of development involves a complex matrix of biological-physiological processes as well as developmental-psychosocial processes (1). The evaluation of sleep includes two main components: 1) sleep-wake organization (i.e. timing and duration of sleep), and 2) sleep quality (i.e. continuity or fragmentation of sleep, depth of sleep). In early childhood (as well as in the elderly period) the relationships between these two components are heavily determined by rapid developmental changes. The goal of consolidated sleep during the night, also referred to as "sleeping through the night", is achieved by most infants during the first year of life (2). Nevertheless, surveys show that as many as 20-30% of infants do not succeed in achieving this goal, and their sleep continues to be fragmented. These infants suffer from multiple and prolonged night-wakings, which are the most prevalent

sleep problems during infancy and toddlerhood (3-7). Recent studies indicate that sleep difficulties in early childhood constitute not only a prevalent problem, but also a persistent one that could develop into a chronic disorder lasting well into adulthood (8-13).

A crucial issue in the evaluation of sleep disturbances in early childhood is the source of information. The reliability and validity of parental reports—the most common assessment instrument in clinical practice—have been questioned in the literature. In contrast to daytime behavior, parents might be unaware of many aspects of the sleep behavior of their infants if they occur when the parent is not observing the child or "signaled" by the child (14-18). For instance, it has been repeatedly suggested that night-wakings are more prevalent than reported by parents because most infants are able to settle back to sleep without signaling (crying, calling) to their parents (14-18).

A number of objective methods have been employed to study sleep in early childhood. These methods include polysomnographic studies, pressure-sensitive mattresses, time-lapse video recordings and direct observations. Polysomnographic sleep studies are

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usually conducted in a laboratory setting and employ electroencephalographic (EEG), electrooculographic (EOG), electromyographic (EMG), electrocardiographic (EKG) and respiratory channels to provide explicit information regarding sleep stages and physiological processes during sleep (19). However, they are limited for a short period of time and are conducted in circumstances that deviate greatly from the natural sleep context of the child. A pressure-sensitive mattress can provide useful information about sleep-wake states and respiratory patterns but requires home installation (20). Time-lapse video recording enables the monitoring of infant sleep patterns at home and provides information about sleep onset, sleep-wake states, night wakings and parental interventions. However, this method requires home installation and additional post-monitoring observer scoring (21).

Actigraphy (activity-based monitoring) has been established as a valid method of assessing sleep-wake patterns in sleep medicine [see Sadeh et al. (22) for a recent review]. Of particular relevance is its demonstrated validity in pediatric populations (18,23,24). It has also been shown that actigraphy can efficiently differentiate between normal and disturbed sleep-wake patterns of adults, young children and infants as well as monitor treatment progress (17,18,23).

Recently, a number of publications have addressed the controversy regarding the distinct value of actigraphic monitoring versus subjective daily logs in adult insomnia patients (25-27). It was argued that actigraphy has large margins of error in assessing sleep in adult insomnia patients and therefore may not be more informative than subjective daily logs despite the inherent limitations of the subjective reports. In the present study, an effort was made to explore some of these controversial issues in the pediatric context of parents completing daily sleep-logs regarding the sleep of their infants.

Despite the growing recognition of the limitations of parents as reporters of the behavior of their infants in general (28-31) and of sleep behavior in particular (15,32), clinical research in the field of infant sleep disorders is still largely based on parental reports in the form of general rating scales or daily sleep-logs (33-38). The purpose of the present study was to investigate the informative value of using parents as a source of information regarding the sleep-wake patterns of their infants. It was hypothesized that parents would be more reliable in reporting sleep schedule parameters (e.g. sleep onset, sleep duration) than in reporting sleep quality measures (e.g. number of awakenings, wake after sleep onset) that are influenced to a greater extent by whether the infant signals or not and by the ability of the parents to keep track of the behavior of their infants during the night.

METHODS

Subjects

Sixty-six healthy infants (46 boys, 20 girls), ranging in age from 7 to 26 months (mean = 14.7, standard deviation (SD) = 4.6), participated in the study. All infants were referred to a sleep disorders clinic by their parents because of reported night-waking problems. All infants came from intact middle-class families. Parents agreed to participate after they were fully informed about the study and their rights to refuse or to leave the study at any point without compromising their clinical service. The parents were interviewed by a clinical psychologist, and each infant was screened and found free of any chronic or current health problems. Neurobehavioral screening was completed using the Denver prescreening developmental questionnaire (39).

Procedure

Following the intake and screening interview with the parents and the infant (conducted by a clinical psychologist), an assessment week was initiated. During this week the parents were asked to complete daily sleep-logs documenting the sleep patterns of the child (17). The daily logs included information about the infant's sleep schedule and sleep quality (e.g. bedtime, sleep latency, night-wakings, risetime) as well as some rating scales for parental impression of the child's fatigue and mood when the child was put to bed and when the child woke up for the day. Parents were given an actigraph (AM-16, Ambulatory Monitoring Inc., Ardsley, NY) to attach to their infant's leg for nocturnal activity monitoring (17,18). Due to scheduling and technical issues the mean number of nights that were actually recorded and analyzed was 6 (ranging between 3 and 12 days).

RESULTS

Actigraphic data were analyzed using the actigraphic scoring analysis (ASA) software program for an IBM-compatible personal computer (PC) that translates the activity data into sleep-wake measures using procedures previously described in detail (18,23). Because the actigraph was attached to the infant when he or she was put to bed and removed when the infant woke up for the day, actigraphy onset and offset were used as markers of bedtime (as opposed to using parental daily logs for the same purpose in a circular manner). Actigraphic sleep measures included 1) sleep onset time, 2) sleep duration (from sleep onset time to morning awakening), 3) number of night-wakings (≥ 5

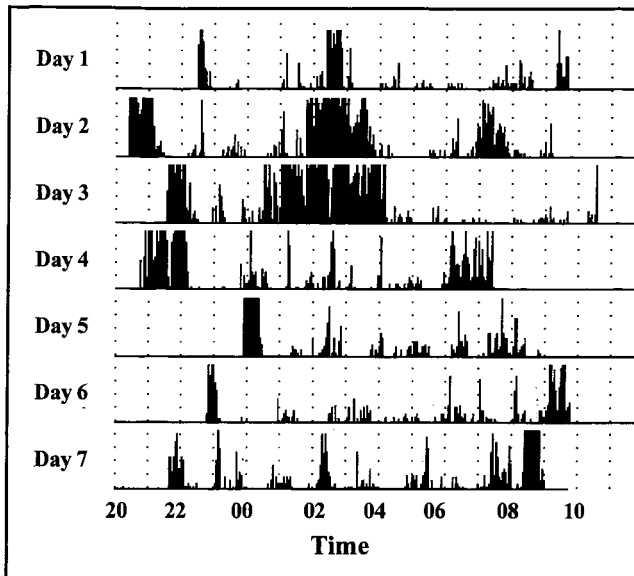


FIG. 1. A week of nocturnal raw activity data on a 16-month-old boy. Each black bar indicates the activity level at a given epoch. Bedtime starts with the first indication of activity and ends with the last indication. The rule of thumb for visual inspection is that periods in which most of the epochs are characterized by activity higher than half of the maximum activity level are periods of wakefulness. On the first night the infant was awake for >30 minutes starting at around 2:30 a.m. On the second night the infant spent >3 hours in wakefulness during the night and early morning hours. On the third night the infant spent >3.5 hours of wakefulness in the middle of night. His mother reported in her daily sleep-logs and in the following interview that she was aware that the infant was awake for only a few minutes during these nights.

minutes) and 4) sleep percentage (percentage of sleep time out of sleep duration).

Four comparable measures (sleep onset time, sleep duration, number of night-wakings and sleep percentage) were obtained from the daily sleep-logs recorded by the parents. In addition, four daily ratings (on a three-point scale) of the infant's morning mood and alertness, and evening mood and sleepiness, were obtained from the sleep-logs.

Comparison of daily logs and actigraphic sleep measures

An example of a case of notable discrepancy between a parental report and actigraphic data is illustrated in Fig. 1.

Four statistical analyses were conducted to assess the agreement and divergence of these two sets of measures. The first statistical analysis was Pearson product-moment correlations computed between the actigraphic and the daily sleep-log measures. In this first analysis, weekly averages of each sleep measure were computed for each child from the daily measures. These weekly means were then correlated to assess the extent to which these measures were in agreement re-

TABLE 1. Relationships between actigraphic and sleep-log measures (Pearson product-moment correlations; $n = 66$)

Sleep-log measures	Actigraphic measures			
	Sleep onset	Sleep duration	Sleep percentage	Number of night-wakings
Sleep onset	0.88	-0.39‡	0.13	-0.34‡
Sleep duration	-0.34†	0.74	-0.21	0.43¶
Sleep percentage	0.03	-0.11	0.41§	0.00
Number of night-wakings	-0.27*	0.04	-0.46	0.60
Morning alertness	-0.26*	0.48	-0.07	0.21
Morning mood	-0.07	0.50	0.07	0.14
Evening sleepiness	0.06	-0.05	-0.33†	0.17
Evening mood	0.17	0.00	0.16	0.05

* $p < 0.05$.

† $p < 0.01$.

‡ $p < 0.005$.

§ $p < 0.001$.

¶ $p < 0.0005$.

|| $p < 0.0001$.

garding the global infant sleep patterns (Table 1). Significant correlations were found for all four comparable measures: sleep onset time, $r = 0.88$ ($p < 0.0001$); sleep duration, $r = 0.74$ ($p < 0.0001$); number of night-wakings, $r = 0.60$ ($p < 0.0001$) (see also Fig. 2a) and sleep percent, $r = 0.41$ ($p < 0.001$) (see also Fig. 2b).

To evaluate the correspondence between the daily sleep-logs and the actigraphic measures, t tests for repeated comparisons were conducted. Actigraphic sleep onset time (21.2 ± 0.79 , military time) was significantly delayed compared to sleep onset derived from the daily logs (20.78 ± 0.69 ; $t = 9.1$, $p < 0.0001$). Actigraphic sleep duration (577 ± 46 minutes) was significantly shorter than that reported by parents (591 ± 49 minutes; $t = 3.41$, $p < 0.005$). Parents reported significantly lower rates of night-wakings (3.37 ± 1.9 wakings per night) compared to the number of actigraphically detected night-wakings (4.10 ± 1.5 ; $t = 3.83$, $p < 0.0005$). Reported sleep percentages (94.4 ± 3.9) were significantly higher than those measured by the actigraph (82.6 ± 6.2 ; $t = 16.4$, $p < 0.0001$). Non-parametric Wilcoxon tests yielded very similar results.

To assess the diagnostic implications of these discrepancies, the objective and subjective data sets were tested using two diagnostic criteria. According to these criteria a child needed to have 1) two or more night-wakings per night (on average) or 2) a sleep percentage below <90% (i.e. the infant spends $\geq 10\%$ of time in wakefulness after sleep onset) to be diagnosed with a sleep problem. These criteria are more conservative (i.e. indicate a more severe problem) than those proposed in the literature (6). The examination of the first criterion revealed that whereas 5 infants (7.6%) did not

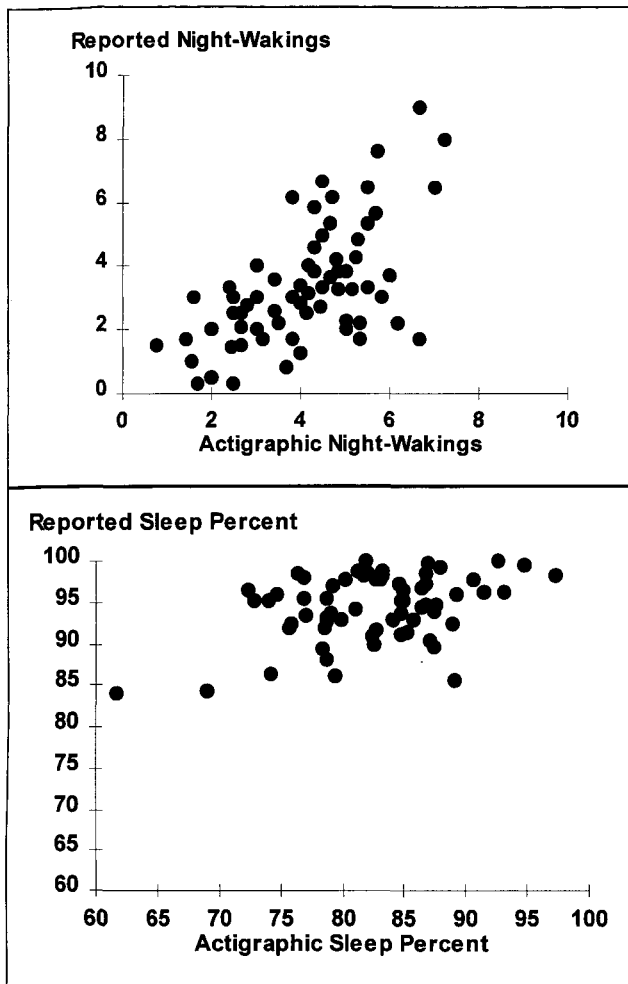


FIG. 2. Scatter plot of actigraphic and parental sleep measures for each infant: number of night-wakings (a) and sleep percentage (b).

meet this criterion using actigraphic measures, 15 infants (22.7%) did not meet this criterion using parental reports (see Fig. 2a). More divergent results were manifested with the sleep percentage criterion. Six infants (9.1%) did not meet this criterion according to the actigraphic measures, as opposed to 57 infants (86.4%) who did not meet the criterion according to the parental measures (Fig. 2b).

The potential diagnostic error of running a single diagnostic night (as in most polysomnographic studies, although they differ in many aspects from ambulatory monitoring) was also assessed with the same criteria. The first criterion (number of night-wakings) yielded, using the actigraphic data, 17 infants (25.7%) who had at least 1 night with none or only one detected night-waking, as opposed to only 5 infants (7.6%) who had an averaged measure of fewer than two episodes of night-waking over their assessment baseline period. The second criterion (sleep percentage) yielded 29 infants (39.4%) who had at least 1 night with sleep per-

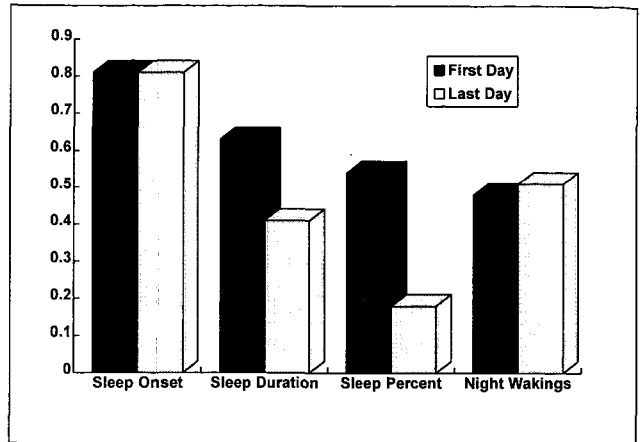


FIG. 3. First- and last-day correlation between actigraphic and reported infant sleep measures.

centage >90%, compared to 6 infants (9.1%) who had an averaged measure of >90%. The odds of having a single "good enough" night using the sleep percent criterion with the actigraphic data were 19%, whereas the odds using the night-waking criterion were 11%. Combining both criteria resulted in 9% chances of having a single "good enough" night.

For a more detailed understanding of the daily correspondence between parental daily logs and actigraphic measures, the correlation analysis was performed separately for the first and last day of the monitoring week (see Fig. 3). Sleep onset time was highly correlated on both the first and last days ($r = 0.81$ on both days; $p < 0.0001$). Similar correlations were found for the first and last day measures of night-wakings ($r = 0.48$ and $r = 0.51$, respectively; $p < 0.0001$). For two measures, the correlations on the first day were significantly higher than those of the last day (using z transformation for testing significant differences between correlations). Actigraphic and daily sleep-log measures of sleep percentage correlated on the first day ($r = 0.54$, $p < 0.0001$) significantly higher than on the last day ($r = 0.18$, not significant (ns)] ($z = 2.42$, $p < 0.001$). Similarly, the correlation of parental and actigraphic measures of sleep duration was significantly higher on the first-day ($r = 0.63$, $p < 0.0001$) than on the last day ($r = 0.41$, $p < 0.0001$) ($z = 1.72$, $p < 0.05$).

Finally, I tested the stability of the actigraphic and parental measures (Table 2). Both parental and actigraphic measures demonstrated significantly high night-to-night stability, thus suggesting that these measures are reliable in characterizing the unique sleep patterns of the infants.

DISCUSSION

Parents of sleep-disturbed infants (SDI) seek professional help on the basis of direct experiences and

TABLE 2. Night-to-night r_n measures of reliability and stability of actigraphic and sleep-log measures (all r_n measures are significant at $p < 0.0001$)

Measure	Actigraphic	Sleep logs
Sleep onset time	0.71	0.72
Sleep duration	0.50	0.67
Sleep percentage	0.76	0.50
Number of night-wakings	0.73	0.82

r_n is a statistical measure of the correspondence of several repeated measurements of the same variable, whereas simple r is used for a single repetition.

subjective perceptions of the sleep difficulties of their infants. As reporters, parents of SDI usually have the "advantage" of being needed by their infant for soothing purposes, and thus they are more likely to be aware of the behavior of their infant during the night (15,17,18). However, these parental perceptions may be biased by the chronic fatigue, anger and negative perceptions that evolve around the infant's sleep problem (7). It is conceivable that non-signaling sleep-disturbed infants remain unidentified because of parental unawareness of their disturbance, and, on the other hand, intolerant parents may overreact and seek treatment for infants who demonstrate age-appropriate sleep patterns.

The results of the present study indicate that parents have certain strengths and some limitations in their capacity to document the sleep patterns of their infants. As predicted, the parents were highly accurate in their reports with respect to schedule-related measures such as sleep onset time and sleep duration. These actigraphic and sleep-log measures were highly correlated ($r = 0.88$ and $r = 0.74$, respectively) and demonstrated reasonable night-to-night reliability and stability. On average, parents overestimated sleep duration by only 14 minutes. As predicted, when sleep quality measures are considered, parents seem less able to retain such a high level of accuracy. The correlations between actigraphic and sleep-log measures of sleep percentage and number of night-wakings were lower ($r = 0.41$ and $r = 0.60$, respectively). Parents overestimated sleep percentage by 11.8% (i.e. an average of >1 hour of unreported wakefulness during the night!) and underestimated number of night-wakings by 0.73 wakings per night. This pattern of relationships between parental and actigraphic infant sleep measures could be explained by the basic assumption that parents are more likely to be fully aware of the bedtime schedule of their infant (because of their regular involvement in bedtime routines) than of events occurring during the night (i.e. night-wakings).

Interestingly, actigraphic sleep measures were also highly correlated with the mood and alertness of the infants as perceived by the parents. A longer duration

of sleep was associated with increased alertness and better mood the following morning ($r = 0.48$ and $r = 0.50$, respectively). Increased evening sleepiness was negatively correlated with actigraphic sleep percent ($r = -0.33$). These findings require further investigation to assess whether these relationships are objective or only perceived relationships that result from parental expectations or biases.

A finding that should be of concern to those relying solely on sleep-logs for extended periods is what appears to be a time-dependent tendency for reduced accuracy on some of the measures (sleep duration and sleep percentage from the first to the last day of the monitoring week). This may reflect a trend related to a decline in motivation of the parents during continuous monitoring with daily sleep-logs. In addition, it should be considered that the parallel actigraphic monitoring conducted in the present study may have put some psychological pressure on the parents to comply with accurate reporting. One might suspect that in the absence of such measures, parental reporting could be even more compromised.

From a diagnostic perspective, the present results suggest that inaccurate parental assessment of sleep quality measures may lead to underreporting and misdiagnosis if it serves as the only source of information. Parents are less likely to overreact, exaggerate and complain when a problem does not exist (as measured objectively), but such cases could be seen in clinical settings, and, beyond providing objective feedback to the parents, special attention should be then given to possible psychosocial sources of such parental misperception. Although a significant night-to-night stability has been demonstrated for both actigraphic and parental measures, there is still considerable variability that may compromise the diagnostic validity of single-night studies. Many infants with severe night-waking problems, as documented in their actigraphic measures over an extended period, have shown single nights of "good-enough" sleep (i.e. not meeting the criteria set for night-waking problems). It is needless to say that laboratory sleep studies differ in many ways from ambulatory studies, and the findings reported here cannot be directly translated to the likelihood of misdiagnosis in single-night polysomnographic studies.

The field of infant sleep research has adopted a number of objective methods to evaluate infant sleep-wake patterns in a scientifically rigorous manner (e.g. 1,18,21). These methods, however, have not been adopted in clinical practice and research with sleep-disturbed infants. This fact may have been the result of technical and financial considerations associated with the use of these methods. Parental reports on infant sleep remain a valuable tool for obtaining parental perspective, subjective experience and patterns of bed-

time interactions that have been consistently associated with the evolution and persistence of sleep problems in early childhood (e.g. 7,40). Objective methods such as actigraphy provide additional specific and more accurate information on the sleep-wake patterns of the child that is potentially very beneficial for clinical research and practice. The integration of these ambulatory methods with clinical research and practice should be further explored and encouraged.

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