Sleeping Characteristics of Children Undergoing Outpatient Elective Surgery

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Background: A significant number of children undergoing anesthesia and surgery exhibit new-onset sleep-related problems postoperatively. The aim of this longitudinal cohort study was to expand previous research in this area by using a new objective technology.

Methods: This study compared children undergoing general anesthesia and outpatient surgery (n = 92) to a community-based control group of children (n = 77). Data regarding coping, temperament, anxiety, surgical procedures, and postoperative pain were collected. Subjects underwent actigraphy sleep monitoring for at least 3 nights before surgery and 5 postoperative days (POD). Sleep assessment was performed with actigraphy sleep monitoring and the Post Hospitalization Behavioral Questionnaire (PHBQ).

Results: Forty-three children (47%) in the surgery group experienced postoperative sleeping disturbances as determined by either the actigraphy or the PHBQ. Only 13 children (14.4%), however, experienced a decrease of at least 1 SD in percentage sleep as assessed by actigraphy. Postoperative pain scores on POD 1 and POD 2 were significantly higher among children who exhibited sleep problems as diagnosed by actigraphy (F = 4.283; P = 0.047). Also, children who exhibited actigraph-based sleep problems scored lower sociability–temperament (14.1 ± 4.3 *vs.* 17.5 ± 3.4; P = 0.04) scores compared with the community group and had a higher rate of change in their perioperative anxiety levels (group × time interaction, F = 5.1; P = 0.03).

Conclusion: A significant number of children undergoing outpatient surgery experience postoperative sleep-related problems. The clinical significance of this finding, however, is unclear.

MORE than three million children undergo anesthesia and surgery in the United States every year.[1] We have previously found that 50–75% of these children develop significant behavioral stress before their surgery.[2] Also of importance is that 54% of all children undergoing general anesthesia and surgery exhibit new-onset mal-

◇ This article is featured in "This Month in Anesthesiology." Please see this issue of ANESTHESIOLOGY, page 5A.

adaptive behavioral responses as measured by the Post Hospitalization Behavioral Questionnaire (PHBQ), an instrument widely used in the medical and psychological literature.[2-5] The maladaptive postoperative responses we identified included general anxiety, nighttime crying, enuresis, separation anxiety, and temper tantrums at 2 weeks postoperatively.[2] Nightmares and waking up crying also occurred after surgery in these children; the incidence of these behaviors was as high as 20.1% at 2 weeks postoperatively.[2]

Actigraphy, a relatively new technology, is an increasingly accepted measure of human movement[6-9] that can be used to assess sleep–wake cycles and sleep quality using motion detection.[10] Actigraph technology allows the measurement of activity levels over extended periods in the home environment, a major advantage over other laboratory-based sleep measurement technologies. This increased flexibility allows for the systematic documentation of natural sleep–wake patterns in children, yet maintains objectivity free from observer bias and rater drift. Actigraphy has been used to monitor sleep patterns of adults and children with a variety of illnesses, such as insomnia, sleep apnea syndrome, hyperactivity, and chronic schedule disorders but has not been used to evaluate sleep patterns of children undergoing surgery.[10-12] Actigraphy reliably differentiates between sleep and waking states and can allow for discrimination of normal and disturbed sleeping patterns.[13-16] This methodology shows excellent validity compared with polysomnography, with validity estimates that range from 0.88 to 0.96.[9,17-20] Actigraphy also shows excellent validity compared with electroencephalograph recordings, with reported electroencephalograph correlation coefficients of 0.89,[13] 0.93,[14] and 0.98.[21] Such high estimates indicate that a fair amount of confidence can be placed in the accuracy, reliability, and validity of actigraphy as a measure of sleep.

It is important to note that although actigraphy and the PHBQ assess a child's sleep, they measure distinct aspects of the postoperative sleep domain. That is, actigraphy assesses sleep patterns, whereas the PHBQ assesses other aspects of sleep (*e.g.*, anxiety regarding sleep, trouble falling asleep, and nightmares). This issue is addressed in detail in the Methods section. Thus, these two instruments in combination may provide a more thorough profile of postoperative sleep.

The primary purpose of this investigation was to establish the sleep characteristics of children before and after outpatient surgery with the use of actigraphy and the PHBQ. A secondary purpose was to examine the

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association between anxiety before surgery and the development of postoperative sleep disturbances.

Materials and Methods

Study Design and Subjects

The study population of this longitudinal cohort controlled study consisted of 169 children aged 3–9 yr, American Society of Anesthesiology (ASA) physical status I or II. The study group consisted of 92 children undergoing standardized anesthesia and outpatient elective surgery at Yale–New Haven Hospital, and the control group consisted of 77 children who were recruited from the community.

To avoid potential confounding variables, any history of chronic illness, prematurity, or developmental delay excluded subjects from participation in this study. The Institutional Review Board approved the study protocol, and an assent (for children aged 7 yr and older) and informed consent were obtained from the children and their parents, respectively.

Primary Outcome Measures

The primary outcome, sleep characteristics of children before and after outpatient surgery, was assessed with the use of actigraphy and the PHBQ.

Actigraph

The reliability of actigraphy as a method for assessing sleep in infants, children, and adults has been established in the past decade.[10,22,23] The actigraph device used in this study (MiniMotionlogger Basic; Ambulatory Monitoring, Ardsley, NY) is a miniaturized motion detection system that collects motion activity numerically, making it available for analysis. The size of a digital wristwatch, the unit can be placed on the wrist or ankle *via* a watchband. The system is able to collect motion data for up to 16 days and is powered by a lithium cell battery. The device counts all movements (accelerations > 0.01 g) and stores cumulative counts in memory each minute. Although actigraphy does not assess rapid eye movement and slow wave sleep, as do laboratory-based assessments, it allows subjects to remain in their natural and home environments while reliably quantifying movement patterns during sleep.

The raw actigraphy data were translated to sleep measures using the Actigraphic Scoring Analysis program for IBM-compatible personal computers (Action-W, Ambulatory Monitoring, Inc., Ardsley, NY). Once downloaded, a previously developed and validated algorithm[18] was used to score the data, which was then transformed into an SPSS file for analysis. This algorithm discriminates between waking and sleeping states while accounting for natural movement during sleep. Actigraphic sleep measures calculated by this scoring program included the following: (1) total sleep period (from sleep onset time to morning awakening), (2) percentage sleep (percentage of actual sleep time during total sleep period), (3) true sleep time (total minutes actually in sleep during entire sleep period), (4) number of night awakenings (*i.e.*, how many times the child awoke during the night), and (5) number of night awakenings that lasted for at least 5 min.

Post Hospitalization Behavioral Questionnaire

This self-report questionnaire for parents is widely used in the psychological literature and is designed to evaluate maladaptive behavioral responses and developmental regression in children after surgery[2–5,24]. The original PHBQ developed by Vernon[4] consists of 27 items in six categories of anxiety, including general anxiety, separation anxiety, sleep anxiety, eating disturbances, aggression against authority, and apathy and withdrawal. For each item, parents rated the extent to which each behavior changed in frequency as compared with before surgery. Response options for each of the 27 behaviors were: *much less than before surgery* (−2), *less than before surgery* (−1), *not changed* (0), *more than before surgery* (+1), *much more than before surgery* (+2). New-onset negative postoperative behavior change was defined as any response of +1 or +2.

Previously, this instrument has been shown to demonstrate acceptable test–retest reliability, to show good agreement with interviews with parents (r = 0.47), and to predict changes as a function of preoperative interventions.[24] Parents completed a baseline PHBQ before their child's surgery and on each postoperative day (POD) 1–5.

As the focus of the present investigation was sleep patterns after surgery, we wanted to use only the PHBQ items that were shown to reliably and distinctly be related to sleep anxiety in our population. Thus, before the onset of the present study, we performed a principal components factor analysis with varimax rotation (SPSS, version 10.0; SPSS, Chicago, IL) on all 27 items of the questionnaire, using 1,492 PHBQ questionnaires that had been administered by our study group during the past 5 yr in multiple studies relating to preoperative anxiety in children.[2,3,25,26] Factor analysis is used to identify underlying conceptual similarities that explain the correlations among a set of items in a questionnaire. Its purpose is to summarize a large number of questionnaire items (n = 27) in a smaller and meaningful number of concepts (factors). Four principal components accounted for 58.59% of the questionnaire variance, with 41.05% of the variance accounted for by factor I (eigenvalue of 9.85), 7.1% of the variance accounted for by factor II (eigenvalue of 1.7), 5.6% of the variance accounted for by factor III (eigenvalue of 1.3), and 4.9% of the variance accounted for by factor IV (eigenvalue of 1.17). The items loading the highest on factor I de-

scribed the overall anxiety of the child; the items loading the highest on factor II indicated apathy; and items loading the highest on factor III represented attention-seeking behavior and separation anxiety. Items loading the highest on factor IV represented sleep difficulties. Only this fourth factor was used to analyze data in this study. Questions in the fourth factor included "Does your child have bad dreams at night or wake up and cry?," "Does your child make a fuss about going to bed at night?," "Is your child afraid of the dark?," and "Does your child have trouble getting to sleep at night?"

Baseline and Other Measures

Detailed reliability and validity data regarding the following behavioral assessment tools were reported previously by our study group.[26] Trained researchers working under a psychologist's direct supervision administered all the behavioral instruments.

- Miller Behavioral Style Scale (MBSS): This standardized instrument assesses coping style (*e.g.*, whether a person tends to "monitor" or "blunt" in stressful situations) in adults through four scenarios of stressful situations.[27] The instrument was developed specifically for patients undergoing medical procedures and identifies information seeking, information avoiding, and distraction coping styles. This is a self-report measure.
- Emotionality, Activity, Sociability, Impulsivity (EASI) instrument of child temperament: This parental report instrument assesses four temperament categories—emotionality, activity, sociability, and impulsivity—in children and is widely used in the literature.[28]
- State Trait Anxiety Inventory (STAI): This self-report anxiety instrument contains two separate 20-item subscales that measure trait (baseline) and state (situational) anxiety.[29] The STAI has been used in more than 1,000 published, peer-reviewed studies.
- Modified Yale Preoperative Anxiety Scale (mYPAS): This observational state anxiety measure for young children contains 27 items in 5 categories (Activity, Emotional expressivity, State of arousal, Vocalization, and Use of parents). The mYPAS has good-to-excellent reliability and validity for measuring children's anxiety in the preoperative holding area and during induction of anesthesia.[30,31]
- Bieri Faces Scale: This pain assessment scale uses seven line drawings of faces and is designed to measure pain intensity in children aged more than 3 yr.[32] This scale was developed from children's drawings and demonstrates strong internal consistency and agreement among children with regard to the severity of pain.

Study Protocol

A community control group of similar ages to the surgery group was recruited from the school system in New Haven and neighboring towns. This sample was recruited to provide comparative actigraphy data from a population of children who were not anticipating surgery. Once contacted, informed written consent was obtained, and demographic data, temperament of the child (EASI), baseline behavior of the child as determined by the PHBQ, and trait anxiety of the parent (STAI) was obtained. Parents received instructions about how to use the actigraph and were asked to put the actigraph on their child during 7 consecutive nights. Parents were also instructed to complete sleep diaries for their children.

The study group was recruited approximately 1 week before surgery while undergoing a preoperative preparation program. After recruitment, written consent, demographic data, and baseline measures were obtained, including child's temperament (EASI), child's baseline behavior (PHBQ), parental trait anxiety (STAI), and parental coping style (MBSS). Parents were asked to complete a sleep diary each day and to place the actigraph on their child's wrist approximately 1 h before bedtime for each of the 5 nights before surgery and the 5 nights after surgery.

Preoperative Holding Area

Children's (mYPAS) and parents' (STAI) anxiety was measured in the holding area and on separation to the operating room (OR). Sedative premedication was not offered to children in this study, and parental presence during induction of anesthesia was used only as a rescue therapy for children exhibiting extreme anxiety on entrance to the OR. Decisions to use parental presence during induction of anesthesia as rescue therapy were made solely by the attending anesthesiologist managing the case without any input from the research team.

Operating Room

Subjects were brought into the OR and placed on the OR table. Next, an oxygen saturation probe was placed on the child's hand, and a scented anesthesia mask was introduced. Anesthesia was induced using a controlled O_2-N_2O-sevoflurane technique. Once the child was induced, an intravenous cannula was inserted, and 0.1 mg/kg intravenous vecuronium was administered to facilitate the intubation. Anesthesia was maintained with O_2-N_2O and isoflurane, and intravenous fentanyl (1-5 μg/kg) was administered. Regional anesthesia was not performed with any of the subjects in the study. Children undergoing pressure-equalizing tube placement underwent a mask anesthetic with O_2-N_2O-sevoflurane. An independent observer using the mYPAS evaluated the behavior of the child at two points: on entering the OR and on introduction of the anesthesia mask.

Postanesthesia Care Unit

After surgery, incidence of adverse effects and times to discharge were recorded. All parents were present in the

postanesthesia care unit during their child's recovery period.

Postoperative Period

Parents attached the actigraph to their child 1 h before bedtime and completed a sleep diary for their child on POD 1–5. The daily sleep logs included information about children's sleep schedule (bedtime, waking time), sleep quality (night waking, sleep latency), and tiredness during the day. Parents administered the Bieri face scale to their child at bedtime and on awakening each morning for 4 days after surgery. In addition, parents were contacted by phone each day on POD 1–3. Researchers administered the PHBQ by telephone (to measure postoperative behavioral changes) and asked parents about their child's pain (Bieri's face scale). The entire interview required about 15 min. On POD 5, a researcher visited the child's home to collect the actigraph and sleep diary. Any discrepancies between the sleep diary and the actigraph data (*e.g.*, diary indicated child went to sleep at 9 PM, but actigraph data showed no movement after 8 PM) were resolved with the parents.

Statistic and Analytic Approaches

At the onset of this study, we realized that there were no published data regarding the use of actigraphy in children undergoing anesthesia and surgery. We also realized that although up to 25% of children are reported to have sleep problems after surgery, these data are based on PHBQ assessments and do not reflect actigraphic assessments. As percentage sleep is frequently cited in the actigraphy literature as an important sleep variable, we decided to base our sample size on published data for percentage sleep in healthy children at home.[15] We defined a change of 1 SD in percentage sleep (*i.e.*, 4.5)[15] as clinically significant. Given that we expected a low correlation between the SD of percentage sleep before surgery and after surgery (estimated at 0.15), with an α set at 0.05 and power of 0.90, the appropriate sample size for a two-tailed paired *t* test was 80 subjects. Because we expected some attrition, we concluded that we needed a cohort of 90 children undergoing surgery to complete this study. We also recruited a community control group (n = 77) to assure that the baseline characteristics of our study population were not significantly different compared with a community control group, and to provide a meaningful comparison group. As we expected a lower SD in percentage sleep among the group that did not undergo surgery, we decided to recruit fewer subjects in that group.

Sleep data were scored in conjunction with diary data from each patient (diaries were used to set scoring parameters for actigraphy data). Multiple nights of sleep were analyzed and averaged to provide mean sleep actigraphy measures per subject for the preoperative period and for the postoperative period. Data were appropriate for parametric analyses. Sample characteristics were analyzed using descriptive statistics. Comparisons between the children who underwent surgery and the control group were analyzed using chi-square analysis for categorical data such as gender and Student *t* test for continuous data. Changes in mYPAS were analyzed using a two-way repeated measures analysis of variance (ANOVA).

We decided *a priori* that postoperative sleeping disturbances would be determined by either actigraphy (a change of more than 1 SD in percentage sleep) or the PHBQ (negative change in sleep-related items). Associations between sleep actigraph parameters and various demographic data were analyzed using one-way ANOVA. Data are presented as mean and SD. *P* values of less than 0.05 were considered significant. Associations between categorical variables such as gender, age, and type of surgery were analyzed use chi-square analysis.

Acebo *et al.*[33] recommend that studies which intend to collect 5 nights of actigraphy data should record for at least 1 week to account for missing or unacceptable data due to illness, technical problems, and noncompliance that can affect up to 38% of actigraph recordings. This methodology is reported to ensure "adequate"[33] reliability of the measures (which was reported as at least 0.70) for calculations yielding percentage sleep, number of night awakenings, and number of night awakenings lasting at least 5 min. Analyses using the variables total sleep period and true sleep time required 7 or more nights of monitoring for adequate reliability.[33]

We asked subjects in the control group for 7 nights of data and asked subjects in the surgery group for 10 nights of data (5 nights preoperatively and 5 nights postoperatively). As predicted by Acebo *et al.*,[33] there were significant amounts of missing data. Our data collection resulted, however, in at least 5 total nights of data for the control group and 8 nights of data for the surgery group (distributed as 3 nights preoperatively and 5 nights postoperatively).

Reliability of sleep measures was calculated for this sample as per Acebo *et al.*[33] using parameters derived from a random effects ANOVA on all available data and applying the Spearman-Brown prophecy formula to estimate the effect that changes in the number of recorded nights would have on reliability. Our results showed that 3 nights of data yielded reliability estimates of at least 0.70 (defined as "adequate" by Acebo *et al.*[33]) for measures of percentage sleep, number of night awakenings, number of night awakenings lasting at least 5 min, and true sleep time. Data showed that 5 nights of data were required to ensure reliability of 0.70 or higher for the measure total sleep time.

When comparing the two groups, to account for potential accommodation to the actigraph we compared the first 3 nights with the last 2 nights of recordings in the control group with the 3 nights of preoperative recording

Table 1. Baseline Characteristics of Subjects

	Community Group (n = 77)	Surgery Group (n = 92)	P Value
Age (yr)	6.4 ± 2.5	6.7 ± 2.2	NS
Gender (%)			
Male	57.1	52.2	NS
Female	42.9	47.8	NS
Parent STAI-S	39.5 ± 9.3	35.1 ± 9.8	NS
Parent STAI-T	40.7 ± 6.3	38.2 ± 5.8	NS
Child temperament scores			
Emotionality	10.8 ± 4.2	10.0 ± 3.7	NS
Activity	14.4 ± 3.6	14.0 ± 4.5	NS
Sociability	17.4 ± 3.5	15.9 ± 3.9	NS
Impulsivity	12.0 ± 3.8	10.7 ± 3.7	NS
Parental coping			
Monitor	9.4 ± 2.8	8.8 ± 2.7	NS
Blunting	3.0 ± 2.1	3.5 ± 2.1	NS

Data are presented as mean ± SD.

NS = not significant; STAI-S = Spielberger State–Trait Anxiety Inventory, State version; STAI-T = Spielberger State–Trait Anxiety Inventory, Trait version.

and 5 nights of postoperative recording in the surgery group. Although we compared 3 nights with only 2 nights in the control group, we believe that because reliability for percentage sleep for 2 nights in the control group was 0.69, this comparison could be made with only minor caution as to reliability (0.69 *vs.* 0.70).

Results

Between June 1999 and June 2001, 169 subjects were enrolled in this longitudinal cohort investigation. The surgical group (n = 92) was similar to the community control group (n = 77) with regard to variables such as age, gender, temperament, ethnicity, parental coping styles, and parental trait anxiety (table 1). Children in the surgery group underwent the following procedures: minor general surgery, 43.5% (*e.g.*, hernia repair); pressure-equalizing tube placement, 10.9%; tonsillectomy and adenoidectomy, 6.5%; other otolaryngologic procedures, 19.6%; and other minor procedures, 19.6%. Parental presence during induction of anesthesia was used once as a rescue therapy on separation to the OR (n = 1). Ratings of children's anxiety at preoperative holding, separation, and at the two induction time points showed a significant increase in anxiety scores (F = 8.5; *P* = 0.0001).
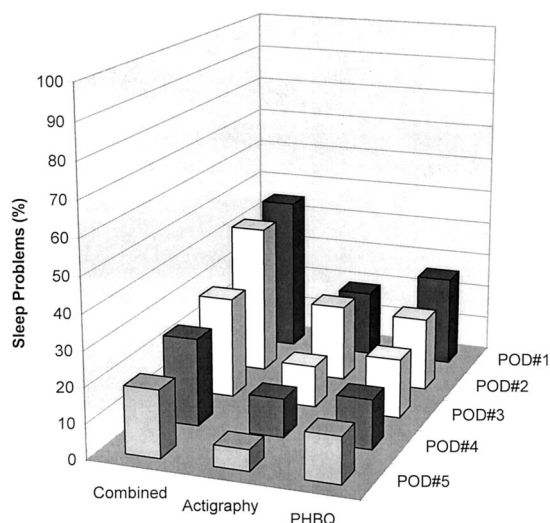
Baseline Analysis

Baseline actigraphic assessment of sleep parameters revealed no significant differences between the surgical group and community control group (table 2). Similarly, there were no baseline differences in the PHBQ between the two groups. There were also no gender differences in actigraph measures (*P* = NS) and no correlation between the actigraph measures and baseline variables such as age and parental anxiety. Children who scored high on the emotionality subscale of the EASI scored higher on percentage sleep (r = 0.46; *P* = 0.01).

Perioperative Actigraphy and PHBQ Analysis

Forty-three children (47%) in the surgery group experienced postoperative sleeping disturbances during the first 5 postoperative nights, as determined either by the actigraphy or the PHBQ (fig. 1). Thirteen children (14.4%) of the surgical group experienced actigraph-diagnosed postoperative sleep problems (*i.e.*, a percentage sleep decrease of at least 1 SD). In contrast, only four children (5.2%) of the community control group exhibited a change of 1 SD between the first 3 nights and the last 2 nights monitored (*P* = 0.04).

A repeated measures ANOVA showed that postoperative pain scores differed significantly between children in the surgical group who experienced actigraph-based postoperative sleep problems and children in the surgical group who did not experience actigraph-based postoperative sleep problems (F = 4.283; *P* = 0.047; fig. 2). Also, there was a group by time interaction (F = 3.086; *P* = 0.002) indicating change over time as a function of group membership. An inspection of mean scores showed that throughout the 5-day postoperative period, pain scores decreased more slowly for children who exhibited actigraph-based sleep problems (fig. 2). We found that anxiety in the preoperative holding area and during induction of anesthesia increased faster and became higher in children who exhibited actigraph-based sleep problems compared with children who did not exhibit actigraph-based sleep problems (group × time interaction, [F = 5.1; *P* = 0.03]; fig. 3).

To characterize the group of children who developed actigraph-based sleep problems, we compared them with the community group and with subjects who underwent surgery and did not develop actigraph-based sleep problems (table 3). There were no differences

Table 2. Baseline Actigraph Parameters

	Community Group (n = 77)	Surgery Group (n = 92)	P Value
Total sleep period (min)	556.98 ± 36.05	567.07 ± 50.02	0.14
True sleep time (min)	508.47 ± 50.99	511.49 ± 66.48	0.74
Number of night awakenings	48.50 ± 33.81	55.47 ± 42.04	0.24
Number of night awakenings > 5 min	14.63 ± 8.08	14.88 ± 7.95	0.84
Percentage sleep	91.19 ± 6.15	90.12 ± 7.48	0.32

Data are expressed as mean ± SD.

Fig. 1. Postoperative sleeping disturbances during the first 5 postoperative nights, as determined either by the actigraphy or the Post Hospitalization Behavior Questionnaire (PHBQ). POD = postoperative day.

between the three groups with regard to demographic variables such as gender and parental coping style ($P =$ NS). Also, age did not differ between the three groups ($P = 0.722$). We found, however, that children who exhibited actigraph-based sleep problems showed lower Sociability scores on the EASI compared with the other children (table 3).

On POD 1, PHBQ-based sleep problems existed in 26% of the children. These sleep problems persisted on POD 2 in 21% of the children and on POD 3 in 17% of the children. Fourteen percent of children still had sleep problems on POD 4, and 13% of children still had sleep problems on POD 5. Postoperative sleep problems were of limited magnitude for most children. For example, on POD 1, 60% of parents reported only one sleep behavior change in their child, 30% of the parents reported two sleep behavior changes, 10% of the parents reported three sleep behavioral changes, and no parents reported four sleep behavioral changes.

Finally, we found that only 21% of subjects who were identified as having PHBQ-based sleep problems were also identified as having actigraph-based sleep problems. Thus, as expected *a priori*, there was little association between PHBQ and actigraphy as these instruments assess different aspects of the sleep domain. We compared the actigraphy data of subjects who developed PHBQ-based sleep problems with subjects who did not develop PHBQ-based sleep problems. We found that on POD 1 subjects who developed PHBQ-based sleep problems exhibited shorter sleep duration (502 ± 61 min *vs.* 568 ± 61 min; $P = 0.0001$). All other actigraphic sleep variables throughout the postoperative period were not different between subjects who developed PHBQ-based sleep problems and subjects who did not develop PHBQ-based sleep problems.

Discussion

This study was undertaken to assess the effects of outpatient surgery on sleeping patterns in a cohort of children. We found that a significant number of children (47%) developed postoperative sleeping problems. The magnitude of these changes, however, was limited for most children. We found that children who developed actigraph-based sleep problems were reported by their parents to be in more pain on POD 1 and 2. Postoperative pain also decreased more slowly over time in these children. This increased and prolonged pain likely affected sleep quality in these children. Interestingly, we found that children with lower sociability (temperament) appeared to have more sleep problems as measured by actigraphy. Poor early socialization, including wariness of new persons, may be a manifestation of a predisposition to anxiety in young children. Thus, it can also be hypothesized that a subgroup of children with lower sociability responded poorly to surgery and developed increased preoperative anxiety, increased postoperative pain, and an increased incidence of postoperative sleep problems. Either way, we believe that the postoperative sleeping patterns of our sample were dependent on multiple factors, such as their temperament, perioperative psychological trauma they experienced, and their postoperative pain.

We also found that children who developed postoperative sleeping problems as diagnosed by actigraphy showed a more rapid increase in anxiety during the perioperative period and were more anxious during induction of anesthesia than those children who did not develop sleep problems.

As early as 1941, Pearson[34] described the effects of surgery on the emotional development and sleeping patterns of young children. In 1945, Levy[35] described several children who developed postoperative nightmares after tonsillectomy. It was not until the PHBQ was developed by Vernon, however, that investigators used this more systematic approach to assess postoperative behavioral changes in sleeping patterns of children.[24] Recently, two large-scale studies assessed the incidence of new-onset postoperative sleeping pattern changes in children. Using the PHBQ, Kain *et al.*[2] demonstrated that sleeping problems occurred in up to 20.2% of children 2 weeks after surgery. Similarly, Kotiniemi *et al.* reported an incidence of 18% for sleeping problems in this population.[36] It is important to note that parents complete the PHBQ. Because parental report of behavioral changes is subjective and may be influenced by the parent's anxiety, there is potential for bias. In addition, if parents perceive sleep behavior changes as related to the surgery, that is very important in itself because conception may be conveyed to the child. Further, the PHBQ assesses anxiety-related sleep behaviors rather than the quality of sleep. These two aspects are different as can

Fig. 2. Postoperative Bieri pain scores differed significantly between the two groups (F = 4.283; P = 0.047). A group by time interaction (F = 4.283; P = 0.047) indicated, as shown, that throughout the 5-day postoperative period, pain scores decreased more slowly for children who exhibited actigraph-based sleep problems. POD = postoperative day.
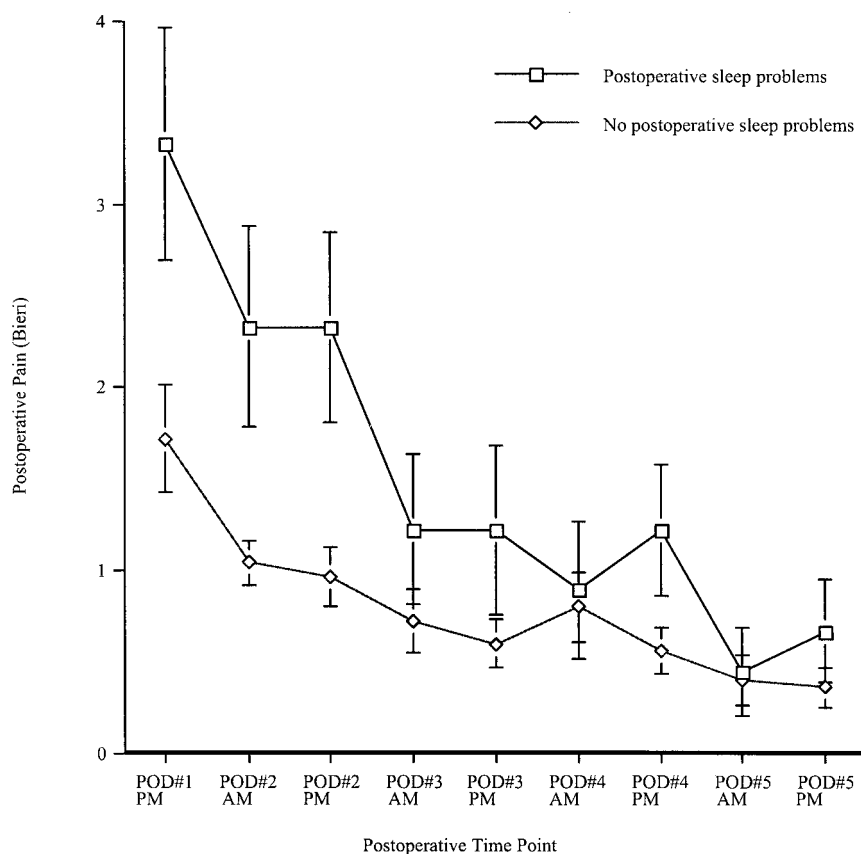
be seen from the low correlation between actigraphy and the PHBQ.

Several studies have suggested the existence of sleep disturbances in adult patients after inpatient surgery.[37–40] It should be noted, however, that there are several important differences between these adult studies and the pediatric study reported here. Because this study involved minor surgery in outpatient children, the magnitude of surgery and the hormonal stress response, hospital-related sensory stimuli (e.g., nursing assess-

ment), the amount of pain, and the administration of opioids were all minimal. We were also able to monitor sleep in the child's natural environment rather than in a laboratory setting.

Several methodologic considerations related to this study have to be addressed. First, there is no question that polysomnography is considered to be the "gold standard" method for assessing sleep, but it is not always practical for longitudinal studies in the field. Two methods are used to measure sleep in field studies because
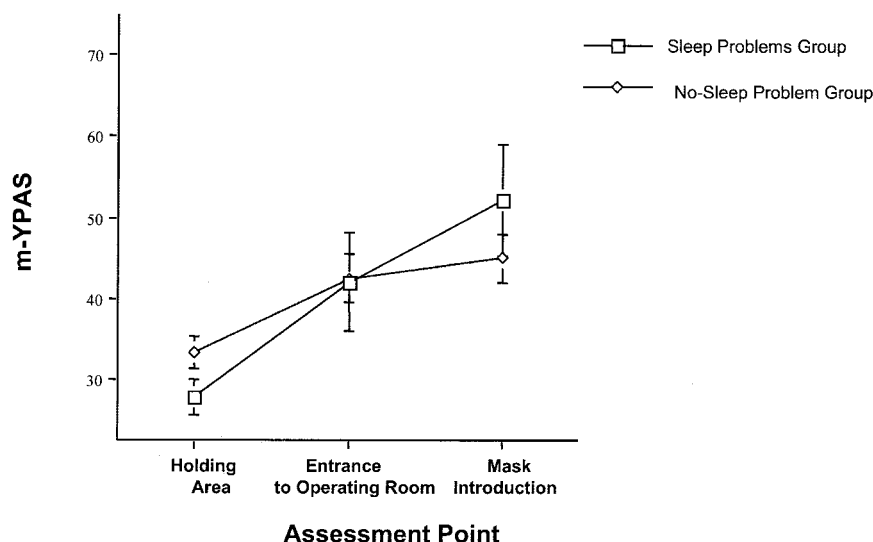
Fig. 3. Anxiety in the preoperative holding area and during induction of anesthesia increased faster and became higher in children who exhibited actigraph-based sleep problems (group × time interaction, F = 5.1; P = 0.03). m-YPAS = Modified Yale Preoperative Anxiety Scale.

Table 3. Characteristics of Various Study Groups

	Sleep Problems* Group (n = 13)	No Sleep Problems* Group (n = 35)	Community Control Group (n = 77)	P Value†
Child's characteristics				
Age	7.0 ± 2.1	6.4 ± 2.5	7.4 ± 2.5	NS
Gender (M/F; %)	61/39	43/57	58/42	NS
EASI				
Emotionality	9.2 ± 3.1	10.4 ± 3.7	10.8 ± 4.2	NS
Activity	12.6 ± 4.9	14.3 ± 4.6	14.4 ± 3.5	NS
Sociability	14.1 ± 4‡	16.5 ± 3.8	17.5 ± 3.4	0.04
Impulsivity	12.8 ± 5.9	10.1 ± 3.1	13.0 ± 3.8	NS
Type of surgery (%)				
Minor general surgery	39	35		NS
Pressure equalizing tube placement	0	11		NS
Tonsillectomy and adenoidectomy	0	23		NS
Other otolaryngologic surgery	15	3		NS
Other minor procedures	46	28		NS
Parental characteristics				
MBSS				
Monitor	8.9 ± 3.1	9.1 ± 2.7	9.4 ± 2.8	NS
Blunter	3.7 ± 2.7	3.5 ± 2.5	3.0 ± 2.1	NS
STAI-T	37 ± 4.5	39 ± 6.4	40 ± 6.3	NS
Surgical history (yes/no; %)	23/77	20/80	11/77	NS

Data are presented as mean ± SD.

* As diagnosed by actigraphy.   † Analyzed using one-way analysis of variance with Scheffe post hoc test for continuous variables; chi-square test for categorical variables.   ‡ As compared with both other groups (post hoc test).

NS = not significant; MBSS = Miller Behavioral Style Scale; STAI-T = Spielberger State–Trait Anxiety Inventory, Trait version.

they are convenient for the subject, require minimal supervision, and can easily be maintained. The first technique, subjective sleep assessment, consists of sleep diaries or logs. Alternatively, an objective measure such as actigraphy can be used. Although such monitoring does not allow assessment of rapid eye movement and slow wave sleep, it offers the significant advantage of unobtrusively studying subjects in more naturalistic environments yet shows excellent concordance with polysomnography (validity estimates range from 0.88 to 0.96)[9,17–20] and electroencephalography (validity estimates range from 0.89 to 0.98).[13,14,21] Second, we chose a difference of 1 SD to indicate clinically significant change in postoperative actigraphic sleeping patterns. We believe that this is a conservative and solid approach. Third, we recruited a large number of subjects to both study groups. Most actigraphy studies to date have reported much smaller sample sizes because of the technical and economical difficulties of large-scale actigraphic assessment. The recruitment of the community control group was particularly difficult. We decided, however, that such a group was a necessity. Fourth, it is important to emphasize that the purpose of this investigation was only to document the existence of postoperative sleeping characteristics of children undergoing surgery. This investigation did not intend to identify specific factors (*e.g.*, pain) that may be responsible for these sleeping characteristics. Future investigations with a control group that consists of children undergoing pain-free hospital-based procedures (*e.g.*, magnetic resonance imaging) may be able to answer cause–effect questions.

In conclusion, this study has documented that a significant number of children developed postoperative sleeping problems that, although generally mild and short lived, may nonetheless prolong a family's concern about their child's well being. For the small proportion of children who are preoperatively more anxious, these perioperative sleep changes may be more severe and prolonged and warrant at least more careful preparation of parents for their child's possible reaction to the surgery and more attentive postoperative follow-up evaluation.

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