

# Prevalence and Predictors of Significant Sleep Disturbances in Children Undergoing Ambulatory Tonsillectomy and Adenoidectomy

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**Objective** To evaluate children's sleep patterns before and after ambulatory surgery and to identify predictors of sleep decrements following surgery. **Methods** Participants were 55, 6- to 12-year-old children undergoing tonsillectomy and adenoidectomy. Sleep was assessed using actigraphy for 5 nights prior to and 5 nights following surgery. Parent state and trait anxiety, and child perioperative anxiety and temperament were assessed. Data on postoperative pain and use of analgesics were collected. **Results** Children had significantly less efficient sleep following surgery than before surgery. Approximately one-third of children demonstrated clinically significant decrements in sleep efficiency. Discriminant function analysis indicated less sociable and more anxious children were more likely to experience these sleep decrements, as were children who experienced greater pain in the postoperative period. **Conclusion** Children's sleep is an important consideration in recovery from surgery and this article takes a first step toward identifying predictors of the development of clinically significant sleep disruptions following surgery.

**Key words** actigraphy; anxiety; pain; sleep; sociability; surgery.

Up to 5 million children undergo surgery in the United States each year and it is estimated that over 50% of these children display new onset maladaptive behaviors immediately following surgery (Kain, 2000; Kain, Wang, Mayes, Caramico, & Hofstadter, 1999; Thompson & Vernon, 1993). Further, when assessed at 2 weeks postoperatively, up to 25% of these children continue to evidence these behaviors (Kain et al., 1999). New onset maladaptive behaviors are most commonly assessed by parent-report measures (e.g., Post Hospitalization Behavioral Questionnaire, Vernon, 1965). Such measures are based on parent report of changes in child behavior and include new onset behaviors such as separation anxiety, enuresis, aggressive behavior, and nightmares (Lumley, Melamed, & Abeles, 1993).

In terms of postoperative behavioral changes, sleep is a particularly important behavior to consider in the surgical recovery process. It is well-documented in animal models that sleep deprivation delays wound healing (Motstaghimi, Obermeyer, Ballamudi, Martinez-Gonzalez, & Benca, 2005) and this result is consistent in human

studies in which psychological variables have also been found to impact wound healing (Kiecolt-Glaser, Marucha, Malarkey, Mercado, & Glaser, 1995).

With specific regards to recovery from surgery, adult studies have demonstrated that sleep has both a direct influence on functional limitations following surgery (Redeker & Hedges, 2002), and serves as a mediator of the relation between postoperative pain and functional limitations (Cremeans-Smith, Millington, Sledjeski, Greene, & Delahanty, 2006). Further, psychological variables such as depression and anxiety have been found to influence surgical recovery through psychoneuro-immunological pathways (Kiecolt-Glaser, Page, Marucha, MacCallum, & Glaser, 1998), and the relations between sleep and psychological variables have been strongly supported (Tsuno, Besset, & Ritchie, 2005).

Although sleep has generally been included as a component in the assessment of maladaptive behaviors in children after surgery, few studies have specifically examined children's sleep patterns. To date, only two studies directly addressed this important issue. The first

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study showed that children's sleep after surgery was significantly more disturbed than a community control cohort (Kain et al., 2002). Results of this study also demonstrated discordance between parent-reported sleep disturbances and sleep disturbances assessed using an objective measure (actigraphy). That is, parents reported significantly more sleep problems than were measured on actigraphy. The second study examined predictors of postoperative sleep in children undergoing various outpatient surgeries. This study found that, after statistically controlling for postoperative pain and preoperative sleep patterns, parents who scored higher on a measure of neuroticism (NEO-PI) had children who had lower sleep efficiency following surgery (Caldwell-Andrews & Kain, 2006). Children who were rated as more aggressive also had lower postoperative sleep efficiency. Although these two studies offer initial evidence for the prevalence of postoperative sleep decrements in children, further examination is needed. Specifically, these two studies involved large age ranges of children undergoing various surgeries and thus experiencing various degrees of pain, which are managed using various pain medications. Indeed, controlling for postoperative pain using one surgery performed by one surgeon as well as using a standardized pain management protocol is a much stronger design than post hoc statistical controls.

The current study expands on existing literature by examining sleep patterns of children before and after surgery using a protocol that is tightly controlled for surgery type, child age, and postoperative pain management. Further, this study uses actigraphy to assess children's nighttime sleep before and after surgery so that *changes* in children's sleep patterns can be assessed. Actigraphy uses a motion detection device (usually worn as a watch-like device) to provide information on children's sleep. Data on amount of time spent immobile and amount of time spent mobile can be translated into estimates of total number of minutes children spent asleep (total sleep time) and total number of minutes children spent awake. Additional variables such as number of times that the child awakes and the duration of these waking episodes can also be calculated. Sleep efficiency or percentage sleep (defined as the number of minutes spent asleep divided by number of minutes between bedtime and wake time) is a key variable often used as an indicator of children's sleep quality (Sadeh, Sharkey, & Carskadon, 1994).

This study was particularly interested in identifying the prevalence of children who show significantly less efficient sleep following surgery than they do before

surgery (i.e., significant sleep decrement). The current study evaluates *changes* in children's sleep efficiency following surgery in a sample of children undergoing homogeneous procedures [tonsillectomy and adenoidectomy (T and A)] with standardized pain protocols. This methodology provides an opportunity to determine potential screening items to specifically identify those children at risk for experiencing significant sleep decrements following surgery.

## Method

### Participants

Participants in the current study were 55 healthy, 6- to 12-year-old children undergoing ambulatory T and A and their parents. Exclusionary criteria included children with chronic illness, prematurity (<32 weeks gestation), reported developmental delay, and children with a diagnosis of obstructive sleep apnea. The Yale Institutional Review Board approved the study protocol. Informed consent and assent (for children ages 7 and older) were obtained before administration of study measures.

### Measures

#### Actigraphy

This technology reliably differentiates between sleep and waking states and can allow for discrimination of normal and disturbed sleeping patterns (Mullaney, Kripke, & Messin, 1980). This ambulatory methodology shows excellent validity when compared to polysomnography and electroencephalograph (EEG) recordings, with validity estimates that range from 0.88 to 0.98 (Cole, Kripke, Gruen, Mullaney, & Gillin, 1992; Jean-Louis et al., 1997; Sadeh, Lavie, Scher, Tirosh, & Epstein, 1991; Sadehet al., 1994). The actigraph device used in this study (Basic Motionlogger Actigraph, Ambulatory Monitoring, Inc., Ardsley, NY, USA) collects motion activity for up to 16 days and is the size of a watch that can be comfortably worn on a child's hand or ankle. Raw actigraphy data are translated to sleep measures using the Actigraphic Scoring Analysis program for IBM-compatible personal computers (ACTME, Ambulatory Monitoring, Inc; Ardsley, NY, USA). Once downloaded, a previously developed and validated algorithm was used to score the data (Sadeh et al., 1994). This algorithm discriminates between waking and sleeping states while accounting for natural movement during sleep. Actigraphic sleep measures calculated by this scoring program include the following: (a) Total sleep period (from sleep onset time to morning awakening). (b) True sleep time (total minutes actually

in sleep during total sleep period). (c) Sleep efficiency (percentage of actual sleep time during total sleep period). (d) Number of night awakenings. (e) Number of night awakenings that lasted for at least 5 min.

#### **EASI Instrument of Child Temperament**

This standardized parent-report tool assesses aspects of temperament in children. The instrument includes 20 items in four behavioral categories: Emotionality, Activity, Sociability, and Impulsivity. Given more recent data suggesting that Impulsivity may not be a homogeneous heritable trait, this scale was not used in the current analysis, and three subscale scores: Emotionality, Activity, and Sociability are reported. Each subscale contains five items rated on a 5-point scale and scores are sums ranging from 0 to 25 on each scale. Briefly, the Emotionality scale assesses distress and the ease with which the child becomes aroused. The Activity scale assesses children's preferred levels of activity and speed of action, and Sociability examines a preference for being with others rather than being alone. Test-retest reliability of the EASI temperament tool was high when mothers were rating their preschool children on adjacent months (Buss & Plomin, 1984). Matthiesen and Tambs (1999) found moderately high internal consistency (.70 when tested with 4-year olds) and high stability across time, with stability coefficients ranging from .79 between the ages of 30 and 50 months to .68 between 18 and 50 months. Parents completed this questionnaire as a measure of their child's temperament.

#### **State-Trait Anxiety Inventory (STAI)**

This widely used self-report instrument for adults assesses state and trait anxiety. The questionnaire contains two separate, self-report rating scales for measuring trait and state anxiety. Test-retest correlations for the STAI are high, range 0.73–0.86. Validity of the STAI was good as examined in two studies involving high- and low-stress conditions to large samples of students (Spielberger, 1983, 1989). Parents completed this questionnaire as a measure of their own trait anxiety and of their own state anxiety in the holding area before their child's surgery ("Anxiety in Holding").

#### **Yale Preoperative Anxiety Scale (mYPAS)**

The mYPAS is an observational measure developed and validated to assess children's anxious behavior in the perioperative setting (Kain et al., 1997). The mYPAS has been validated and widely used on children from 2 to 12 years old (for example, Vagnoli, Caprilli, Robiglio, & Messeri, 2005; Finley, Stewart, Buffett-Jerrott, Wright,

& Millington, 2006; Golden et al., 2006; Kain et al., 2000; Patel et al., 2006; Weldon, Bell, & Craddock, 2004). The mYPAS consists of 27 items falling into five categories of behavior: Activity, Emotional Expressivity, State of Arousal, and Vocalization. Using  $\kappa$ -statistics, all mYPAS categories have been demonstrated to have good to excellent inter- and intra-observer reliability (0.73–0.91), and when validated against other global behavioral measures of anxiety, the mYPAS had good validity ( $r=0.64$ ) (Kain et al., 1997). The mYPAS scores range from 22.5 to 100 with higher scores indicating greater anxiety. Research assistants who were blind to study hypotheses were trained in the administration of the mYPAS using a standardized training protocol requiring reliability coefficients of 0.8 ( $\kappa$ ).

#### **Postoperative Pain Measure for Parents (PPMP)**

The PPMP is a parent-report measure assessing children's pain following surgery (Chambers, Reid, McGrath, & Finley, 1997). Fifteen behavioral indicators of pain are rated as present or absent, providing a range on the measure of 0–15 with higher scores indicative of more pain. The measure has demonstrated good internal consistency and validity (Chambers et al., 1997) and has recently been validated down to 2 years of age (Chambers, Finley, McGrath, & Walsh, 2003).

#### **Oucher**

Children's reports of their own pain were collected using the Oucher, a self-report pain scale consisting of two scales: a photographic scale with six pictures of children's faces, and corresponding numerical scale for older children. Scores on the Oucher range from 0 to 100 with higher scores indicative of more pain. The scale was designed for use with children 3 to 12-years old. Measures of agreement in ranking the faces are adequate (Kendall's coefficient of concordance = 0.65–0.73), and convergent, discriminant and construct validity are well supported (validity estimates range from 0.69 to 0.97; Beyer & Aradine, 1986; Beyer, Denyes, Villaruel, 1992).

#### **Procedure**

Informed consent was obtained in person 5–7 days before surgery when parents and children attended a preadmissions visit at the surgery center. During this visit, parents and children met with representatives from child life and anesthesiology who presented information on the upcoming procedure and answered questions. At the completion of this visit, parents completed demographic measures, the EASI, and the STAI (trait form). Parents were also provided with a sleep diary and were

given instructions on the use of the actigraph. Parents were directed to place the actigraph on their child's wrist ~1 hr before bedtime for each of the 5 nights before surgery (PRE1–PRE5). On the day of surgery, parents' anxiety was assessed in the preoperative holding area using the state form of the STAI ("Parent Anxiety in Holding") and children's anxiety was assessed at this time point using the mYPAS ("Child Anxiety in Holding"). Child anxiety was assessed again when children were taken to the operating room ("Child Anxiety at Induction").

The intraoperative course was controlled with all children receiving the same anesthetic technique and analgesics. Following surgery, children were admitted to the postanesthesia care unit until they were stable enough to transfer to a 23 hr admission unit. While in this unit, postoperative pain was tightly controlled using a standardized protocol for all participants. This protocol required pain assessments at 15 min intervals using the Oucher scale and administration of standardized dosages of pain medication based on assessment results. That is, children's pain was managed while in the hospital with morphine through a patient controlled analgesia (PCA) pump set to deliver a bolus of 0.05 mg/kg to be followed by 0.015 mg/kg up to every 6 min upon request.

Children were discharged from the hospital on the day following surgery and parents were provided verbal and written instructions on a standardized pain management protocol at home. That is, subjects received acetaminophen 10 mg/kg + codeine 1 mg/kg every 3 hr for 3 days *if in pain*. "If in pain" was defined as an Oucher score of more than 30 (range 0–100) or if the child asked for medication. Pain was rated by the children (Oucher scale) immediately before receiving a dose of analgesics and 30 min later. The protocol for pain medication administration is included in the supplementary material (available online at [jpepsy@oxfordjournals.org](mailto:jpepsy@oxfordjournals.org)).

Children's sleep on the night of surgery was recorded using actigraphy (POST1) and children's sleep at home was recorded for four additional nights following surgery (POST2–POST5) with accompanying sleep diaries. Pain following surgery was assessed at two time points each day via the PPMP (lunchtime and bedtime). Scores reported are averages over the postoperative period.

### Statistical Analyses

Statistical analyses were carried out in a series of steps. Preliminary analyses were used to evaluate the sample for potential outliers and missing data. Once data was cleaned, paired samples *t*-tests were used to evaluate

differences in preoperative and postoperative sleep patterns across children. Of note, given that postoperative night one was spent in hospital, this night is excluded from averages of postoperative sleep at home. Hence, comparisons of preoperative and postoperative sleep include only sleep at home.

For the purposes of this study, "significant sleep decrement" is defined as a negative change in sleep efficiency that is greater than 1 *SD* of presurgery sleep efficiency. That is, children's sleep efficiency after surgery is >1 *SD* less than their sleep efficiency before surgery. This approach is consistent with that used by Caldwell-Andrews and Kain (2006), and corresponds to a change of ~10% in sleep efficiency. Although there is little data on magnitude of changes in children's sleep, immediately following painful or stressful events, the clinical significance of a 10% sleep decrement is supported by normative data on sleep efficiency in healthy children (Sadeh, Raviv, & Gruber, 2000).

The frequencies of children with significant sleep decrements are reported and independent sample *t*-tests were used to compare children with and without sleep decrements on variables of interest. Correction for multiple tests was accomplished by using a Bonferroni-corrected *p*-value. Discriminant analyses with Jackknife validation procedures (Daniel, 1989) were conducted to evaluate the predictive validity of variables found to be significant in univariate analyses. The Jackknife procedure validates the original discriminant function by removing a case and recalculating the function without that case. This procedure is then repeated with the removal of each case and the values for these functions are averaged to result in a validation function.

## Results

### Preliminary Analyses and Missing Data

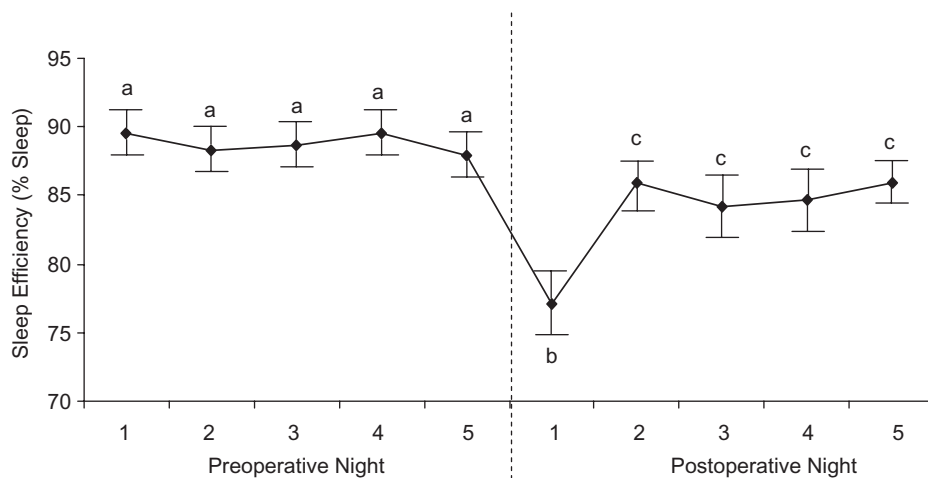
Of 73 potential participants approached for the study, 62 agreed to participate and provided informed consent. Children who did not participate did not differ significantly in age from children who did participate,  $t(66) = 0.67, p > .05$ . No other data on nonparticipants were available. Of an original 62 participants, six participants were missing all actigraphy data and were thus removed from analyses. Participants with only one missing night of actigraphy data ( $n = 5$ ) had the missing value replaced with the mean of that participants' sleep data for the corresponding time period (pre- or postsurgery). One participant was identified as an outlier based on a definition of percent sleep value >3 *SD* from the mean. This participant was removed from analysis.

**Table I.** Sleep Parameters Before and After Surgery

Sleep Parameter	Presurgery (Average of PRE1-5)	Postsurgery (Average of POST2-5)	Standard error of change	Paired <i>t</i> -test
Total sleep period (min)	598.35 (44.28)	630.84 (78.34)	27.95	2.77**
True sleep time (min)	532.16 (53.22)	532.58 (81.66)	33.64	0.04
Number of night awakenings	12.03 (5.48)	13.91 (6.11)	3.46	2.34
Number of night awakenings > 5 min	3.48 (1.81)	5.46 (2.90)	1.14	5.16**
Sleep efficiency (%)	88.79 (5.57)	83.47 (7.23)	3.52	5.64**

Note: All values are shown as Mean (SD), Standard error of change is based on a reliability coefficient of 0.8 and presurgery standard deviations.

\*\* $p < .01$



Note. Different subscripts indicate significant differences at  $p < 0.001$ ; Children spent post-operative night 1 in hospital

**Figure 1** Mean sleep efficiency before and after surgery.

The final sample consisted of 55 children, ranging in age from 6 to 12 years ( $M = 8.05$ ,  $SD = 1.78$ ). Children were primarily non-Hispanic white (87.3%), and approximately one-third were male (32.7%). One parent accompanying each child to surgery was also included in this study. Most parents in this study were mothers (98.2%) who ranged in age from 28 to 48 years ( $M = 39.44$ ,  $SD = 4.59$ ) and were married (87.3%). Average years of education of participating parents was 15.62 ( $SD = 3.13$ ) and ranged from 9 to 20 years.

### Sleep Patterns Before and After Surgery

Descriptive statistics of sleep parameters before and after surgery are shown in Table I. Although children spent, on average, the same number of minutes asleep before and after surgery (True sleep time), they spent significantly more time in bed at nighttime following surgery than they did before (Total sleep time). Further, although the total number of night awakenings did not differ from pre- to postsurgery, children experienced significantly more long awake episodes (>5 min) following surgery than they did

before (Table I). These results are reflected in sleep efficiency findings in which children had significantly lower average sleep efficiency following surgery than before surgery (Table I).

Children's sleep efficiencies by day are shown in Fig. 1. A repeated measures ANOVA of sleep efficiency over the 5 nights before surgery and 5 nights after surgery yielded significant results,  $F(9, 441) = 12.30$ ,  $p < .001$ . Follow-up paired samples *t*-tests indicated that there were no significant differences across presurgery time points (PRE1, PRE2, PRE3, PRE4, and PRE5), *t*'s ranged from 0.31 to 1.71, all  $p$ 's  $> .001$  (shown in Fig. 1 as subscript *a*). Among postsurgery time points, children had significantly lower sleep efficiency in-hospital on the night of surgery (POST1) than postsurgery nights at home, *t*'s ranged from 3.12 to 5.11, all  $p$ 's  $< .001$  (shown in Fig. 1 as subscript *b*), but there were no significant differences among the remaining four nights at home (POST2, POST3, POST4, and POST5), *t*'s ranged from 0.06 to 1.37, all  $p$ 's  $> .001$ , (shown in Fig. 1 as subscript *c*).



**Table II.** Variables of Interest for Children Displaying and not Displaying Significant Sleep Disturbances After Surgery (defined by  $>1$  SD Change in Sleep Efficiency)

	Whole sample <i>n</i> = 55	No sleep decrement <i>n</i> = 38	Sleep decrement <i>n</i> = 17	Effect size Cohen's <i>d</i>
Child age	8.05 (1.79)	7.87 (1.77)	8.47 (1.77)	
Presurgery sleep efficiency	88.79 (5.57)	88.12 (5.72)	90.29 (5.07)	
Hours spent in bed (outside nighttime)	5.21 (2.68)	5.44 (2.89)	4.69 (2.13)	
Child temperament (EAS)				
Emotionality	11.28 (3.86)	11.11 (3.42)	11.64 (4.76)	
Activity	14.02 (4.54)	13.86 (4.20)	14.35 (5.35)	
Sociability	18.85 (2.57)	19.37 (2.53)	17.71 (2.31)**	0.69
Child anxiety (m-YPAS)				
Holding	29.24 (12.01)	30.91 (13.55)	25.61 (6.70)	
Induction	33.45 (16.19)	26.96 (10.0)	36.52 (17.71)**	0.69
Parent anxiety (STAI)				
Trait	37.11 (6.51)	37.03 (6.45)	37.31 (6.88)	
State in holding	38.61 (10.09)	38.06 (10.23)	39.75 (10.02)	
Pain				
Parent-report (PPMP nights 2–5)	5.48 (2.44)	4.84 (2.01)	6.88 (2.74)**	0.87
Child report (Oucher nights 2–5)	16.68 (8.14)	16.39 (8.22)	17.32 (8.17)	
Medication administration inpatient (mg/kg morphine, night 1)	14.89 (8.67)	16.32 (9.54)	11.86 (5.59)	
Medication administration at home (mg/kg tylenol nights 2–5)	8.40 (7.51)	7.74 (7.59)	9.88 (7.36)	

Note: All values are shown as Mean (SD).

\**p* < .015; Pain values are averages over 4 days at home postsurgery, effect sizes are shown for significant effects.

m-YPAS, modified Yale Perioperative Anxiety Scale (range 22–100); STAI, State Trait Anxiety Inventory (range 20–80); PPMP, Postoperative Pain Measure for Parents (range 0–15); Oucher (range 0–100).

### Prevalence of Significant Sleep Decrements Following Surgery

Change in sleep efficiency was calculated by subtracting the average presurgery percent sleep from the average postsurgery percent sleep. Given that the night of surgery (POST1) was not representative of sleep after surgery, this night was not included in calculating the average postsurgery percent sleep. Negative change scores were indicative of sleep efficiency decrements, whereas positive change scores were indicative of sleep efficiency improvements. Change scores were normally distributed and ranged from 11.28% (positive score indicates improvement) to  $-23.32\%$  (negative score indicates decrement). Mean change in sleep was  $-3.83\%$  ( $SD = 6.50\%$ ).

### Predictors of Significant Sleep Decrements Following Surgery

In line with previously published reports in this topic (Caldwell-Andrews & Kain, 2006; Kain et al., 2002), children whose postsurgery sleep efficiency was  $>1$  SD less than their presurgery sleep efficiency were considered to display significant sleep decrements. Seventeen (30.9%) participants were categorized as having a significant sleep decrements based on this definition. Table II shows characteristics of children with and

without sleep decrements. Children who experienced significant sleep decrements did not differ from children who did not experience sleep decrements on child age, child anxiety in the holding area (mYPAS administered in holding), or parent anxiety. Child anxiety at anesthesia induction was found to differ between groups, however, with children showing significant sleep decrements displaying more anxiety at induction. In terms of temperament, children who experienced sleep decrements were rated as significantly less sociable on the EAS. There were no differences between groups on other temperament characteristics. In terms of postoperative pain at home, children with significant sleep decrements were rated as experiencing more pain by their parents (PPMP) than children without sleep decrements, but did not differ on self-report of pain or amount of pain medication administered at home or inpatient on the night of surgery. Interestingly, there were no differences in preoperative sleep efficiency between those children who experienced sleep decrements and those who did not.

The predictive validity of the three variables found to differ significantly between groups (child anxiety at induction, child sociability, and postoperative pain) was tested using discriminant function analysis. Notably, there were no significant correlations between these

**Table III.** Discriminant analysis results: Prediction of Sleep Decrement With Child Anxiety, Sociability, and Pain as Predictors

Actual group membership	Predicted group membership	
	Sleep decrement	No sleep decrement
Original sample		
Sleep decrement	24 (68.6%)	11 (31.4%)
No sleep decrement	4 (23.5%)	13 (76.5%)
Cross-validation sample		
Sleep decrement	26 (65.7%)	12 (34.3%)
No sleep decrement	4 (23.5%)	13 (76.5%)

Note: 71.2% of original groups cases correctly classified, 69.2% of cross-validated grouped cases correctly classified.

variables: anxiety and sociability,  $r=0.09$ ,  $p>.05$ ; anxiety and pain,  $r=0.107$ ,  $p>.05$ ; and sociability and pain,  $r=-0.21$ ,  $p>.05$ . A stepwise discriminant function analysis was performed to evaluate the contribution of child anxiety, child sociability, and parent report of postoperative pain in the prediction of significant sleep decrement status after surgery. Given that there was no conceptual model to suggest the order in which these predictors should be entered, an empirical stepwise analysis was used to identify those variables that were the best predictors of significant sleep decrement. To ensure that important variables were not removed from the analysis, a liberal probability to enter criterion of 0.10 was used in this analysis (Costanza & Afifi, 1979).

The final discriminant function included all three variables and was statistically significant, Wilks'  $\lambda=.75$ ,  $F(3, 48)=5.37$ ,  $p<.01$ , and accounted for ~25.1% of the variance in postoperative sleep decrement status (Table III). In terms of classification ability, 71.2% of the original cases were correctly classified into sleep decrement category by the discriminant function. The stability of this classification procedure was checked by a cross-validation run (see Statistical analysis section) in which each case is classified by the functions derived from all cases but that case. The proportion of correctly classified cases decreased only slightly (69.2%) in comparison to the original function.

Although postoperative pain contributed significantly to postoperative sleep status, we were also interested in the relative contribution of variables that could be identified before surgery (sociability and anxiety). A second discriminant analysis was conducted including forced entry of only these two variables (Table IV). This function remained significant Wilks'  $\lambda=.84$ ,  $F(2, 50)=4.65$ ,  $p<.01$ . The proportion of correctly classified cases was higher, however, with 75.5% of cases

**Table IV.** Discriminant Analysis Results: Prediction of Sleep Decrement With Child Anxiety and Sociability Predictors

Original sample Actual group membership	Predicted group membership	
	Sleep decrement	No sleep decrement
Sleep decrement	27 (75.0%)	9 (25.0%)
No sleep decrement	4 (23.5%)	13 (76.5%)

Note: 75.5% of cases correctly classified; cross-validation yielded identical results.

correctly categorized. The improvement in the classification statistic was due to a more accurate classification of the actual sleep decrement group.

## Discussion

This study evaluated changes in sleep patterns before and after T and A surgery in children. It was not surprising that children's sleep was the least efficient on the night of surgery while staying in the hospital. This was likely due to nursing checks, medication administration, and the unfamiliar environment associated with a hospital stay. The findings of children's sleep patterns upon returning home were more interesting. Results indicated that children spent more time in bed and had more long waking episodes (>5 min) following surgery. Although average time spent asleep was the same, the number of long waking episodes are reflected in overall sleep efficiency, with children experiencing less efficient sleep at home following surgery than before surgery. In terms of the duration of sleep decrements, it is most notable that sleep changes continue for at least 4 days after going home. Children's average sleep efficiency at home following surgery was still ~6% lower than their baseline sleep. Given that "poor sleep" has been defined as 10% less than perfect sleep efficiency (Sadeh et al., 2000), a value of 6% reduction suggests that this is a clinically meaningful change. Further, this change was larger than that expected by measurement error alone (as shown by standard errors of change in Table II), thus supporting the clinical significance of the findings.

It is notable that there was a significant degree of variability in children's sleep responses to surgery. Changes in sleep efficiency were normally distributed with some children showing sleep improvements, some showing relatively no change, and some showing decrements. The sample that is of most clinical relevance are children who demonstrate sleep efficiency decrements after surgery, particularly those who show sleep decrements that are considered clinically significant. As such, those were the children who were the focus of this study.

Data from this investigation indicated that slightly less than one-third of children experienced clinically significant sleep decrements following surgery. This value is higher than previous investigations, which found that only about one-fifth of children showed these decrements (Kain et al., 2002). The larger value found in this study is likely because of the variability in surgery type. Children in the current investigation underwent T and A, a procedure associated with significant distress and pain. Children in the prior investigation by Kain et al. (2002) underwent a variety of surgeries, some of which were minimally invasive and not associated with significant pain (e.g., pressure equalizing tube placement).

Findings regarding the predictors of significant sleep decrements were interesting. Results indicated that children's anxiety at anesthesia induction, children's sociability, and children's postoperative pain as assessed by their parents predicted the development of sleep difficulties following surgery. Children who were more anxious at anesthesia induction, less social, and who were rated as having more pain by their parents were more likely to experience sleep difficulties. In terms of clinical significance of effects, Cohen's *d* effect sizes fell in the medium to large range for the effects of child anxiety and sociability, and in the large range for the effect of children's pain (Cohen, 1988). Thus, it appears that these effects deserve clinical attention. Notably, this sociability finding is consistent with findings reported by Kain and colleagues (2002). The construct of sociability as assessed by the EASI indicates the degree to which the child prefers to be with others rather than by themselves. The direct link between this construct and sleep decrements is unclear at this point. In an older study of young adults, Taub and Hawkins (1979), found that college students who were less sociable also had more irregular sleep patterns. Considering that the relation between sociability and sleep has been demonstrated in two independent samples, further investigation is warranted to understand this link.

With regards to pain, it is interesting to note that although children with significant sleep decrements were rated by their parents as having more pain, medication administration did not differ between groups. In other words, although children with sleep changes following surgery were experiencing more pain, they were not medicated accordingly, thus likely perpetuating the pain-sleep cycle. Under-medication of children's postoperative pain by parents has been documented in the literature, particularly in tonsillectomy (Hamers & Abu-Saad, 2002; Wilson & Helgadottir, 2006), as has the link between

pain and sleep (Lautenbacher, Kundermann, & Krieg, 2006). It is important to note, however, that children's self-reports of pain did not differ between sleep decrement groups. Discrepancies between parent-report and child-report of pain have been previously reported. In this case, it appears that parents' decisions to medicate were based on children's report rather than their own judgments. Such administration decisions were in line with the instructions provided to parents (i.e., administer medication with Oucher score greater than 30 or on request from child), but may not have adequately managed pain. With relation to its impact on sleep, it is possible that children were underreporting their pain and thus not receiving adequate analgesics.

Although pain is undoubtedly important in children's postoperative sleep, finding variables that can be identified before surgery to classify children at risk of sleep decrements is particularly clinically relevant. In these data, children's anxiety at induction of anesthesia and their sociability were found to a priori identify those children at risk of significant sleep decrements. Thus, if replicated in future research, clinicians may use these two variables to screen for children who are at risk for sleep changes. The sociability scale of the EAS for example, can be completed very quickly (5 items), and skilled clinicians can identify those children who exhibit a high degree of anxiety at induction. Once identified, parent's of children at risk of experiencing sleep difficulties after surgery can be provided with specific instructions on managing sleep. Proper pain management for children's sleep seems an especially important consideration to be discussed with these parents. Further, given that long waking episodes appear to be especially problematic, management of these episodes should be discussed with parents and children. For example, children can be taught relaxation techniques to use to during these wake episodes in an attempt to minimize their length.

Several methodological considerations in the current study should be noted. First, it should be noted that although this study attempted to exclude children who had sleep disorders from the sample, exclusion was based on parent report of diagnosed sleep disorders rather than on polysomnographic findings. As such, it is possible that children who experience sleep apnea, but have not been diagnosed, could have been included in our sample. We should note, however, that children with positive sleep study were not enrolled in the study. An additional limitation was related to children's daytime sleep. Although this study assessed time spent in bed during the day, this assessment was based on parent report and



not on actigraphy findings. Time spent in bed did not account for sleep decrements in this sample, but it is possible that actigraphy findings may have provided more accurate information that may have been more informative. Finally, it should be noted that although child age did not differ between participants and those who were approached but did not participate in this study, without further data it is difficult to draw conclusions on the representativeness of this sample.

In conclusion, this study demonstrates that clinically significant sleep decrements are prevalent for at least 5 days following tonsillectomy in children. Given that sleep plays an important role in healing and recovery following surgery, these decrements deserve attention. Children most at risk of clinically significant sleep decrements are those who are younger and less sociable as well as those with parents who have higher trait anxiety and show more anxiety prior to their child's surgery.

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