HHS Public Access

Author manuscript

J Pain Symptom Manage. Author manuscript; available in PMC 2015 May 15.

Published in final edited form as:

J Pain Symptom Manage. 2009 March ; 37(3): 352–362. doi:10.1016/j.jpainsymman.2008.03.010.

Disrupted Sleep the Night Before Breast Surgery Is Associated with Increased Postoperative Pain

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Abstract

Despite the best available clinical care, pain following surgery is a virtually universal patient experience that can have pervasive negative consequences. Given the large variability among patients in postoperative pain levels, research on novel modifiable risk factors is needed. One such factor suggested by recent experimental studies indicates that disruption of even a single night's sleep can increase subsequent pain in healthy volunteers. In this preliminary clinical study, we tested the hypothesis that poor sleep the night before surgery would predict heightened postoperative pain. Patients (n=24) scheduled for routine breast conserving surgical procedures for the diagnosis or treatment of cancer were recruited and wore an actigraphy device providing objective, validated measures of sleep duration and disruption (low sleep efficiency). Pain severity and interference with daily activities for the week after surgery was assessed with the Brief Pain Inventory. As hypothesized, multiple regression analyses revealed that lower sleep efficiency was a significant predictor of greater pain severity and interference, controlling for age, race, and perioperative analgesics as appropriate. Sleep efficiency was not significantly related to measures of depressed mood, emotional upset, or relaxation assessed on the morning of surgery. Patients with sleep efficiency in the lowest tertile had clinically higher levels of pain (>2 points), compared to patients in the highest sleep efficiency tertile. Sleep duration had no significant effects. This preliminary clinical study supports the possibility that sleep disruption on the night before surgery may increase patients' experience of pain following surgery. Research to investigate the mechanisms underlying these effects and to explore the possible clinical benefits of interventions to improve patients' sleep prior to surgery is now warranted.

Keywords

Pain; postoperative; sleep; sleep disruption; sleep efficiency; surgery

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Introduction

Despite continuing improvements in surgical procedures, postoperative pain continues to be a virtually universal patient experience following even minimally invasive surgery, such as breast conserving surgery for cancer treatment or diagnosis. Moreover, while pain at rest is generally well controlled by opioids, the more severe and longer lasting pain associated with movement and daily activities is less responsive to pharmacological management.[1] Pain following breast conserving surgery can have pervasive negative consequences; including exacerbation of other side-effects (notably, nausea and fatigue), increased risk of complications, unplanned readmission, delayed convalescence, development of chronic pain, poor physical and mental functioning, and lower quality of life.[2] Given the sometimes prolonged, negative impact of postoperative pain, and the large variability across patients, investigation of possible modifiable presurgery risk factors is needed. One such factor that has yet to receive much clinical research attention is sleep.

A relationship between sleep and pain has long been recognized, but mostly in the context of chronic pain, where determination of causal relationships is problematic since it is difficult to disentangle effects of poor sleep on pain from the effects of pain on sleep.[3] Emerging experimental research with healthy animal and human samples has shown that manipulations of sleep including overall/partial sleep deprivation, selective sleep stage deprivation (e.g., slow wave sleep), and disruption of sleep continuity (e.g., forced awakenings) can have effects on acute pain responses.[4–6] Recent experimental findings suggest that sleep disruption may have more profound effects on pain than sleep deprivation.[7] Not yet investigated is the possible impact of poor sleep prior to surgery on postoperative pain. The purpose of the present preliminary study was to examine the possibility that poor sleep (duration and disruption) the night before surgery may be predictive of heightened pain during postoperative recovery. Positive findings would have important health care implications, as interventions to improve sleep could be applied in this clinical setting to improve postoperative outcomes.

To provide an assessment of sleep in the clinical setting, actigraphy monitoring methodologies that distinguish sleeping from waking periods based on night time movement levels, are useful.[8] These wrist-watch style devices provide data that are less susceptible to self-report biases and “first night effects,” which reflect disrupted sleep due to discomfort associated with monitoring and assessment.[8] Actigraphy provides objective measures of sleep duration and disruption comparable to that obtained with polysomnography, which is considered the “gold standard” in sleep research.

Based on the experimental research described above, we hypothesized in this preliminary prospective study that poor sleep the night before surgery, as indicated by actigraphy-derived data on sleep duration and efficiency levels, would predict greater pain over the week following surgery.

Methods

Participants

The study was approved by the Mount Sinai School of Medicine Institutional Review Board; all patients provided written informed consent. Twenty-four women scheduled for their first breast cancer surgery (lumpectomy or excisional [surgical] biopsy; not fine needle biopsy or core needle biopsy) were recruited from three Mount Sinai surgical practices. The surgical procedures differ in that a greater surgical margin is taken with lumpectomy to ensure full resection of malignant tissue. Perioperative analgesic amount and postoperative pain did not differ by surgery type ($P>0.05$). Eligible patients were aged 18+, living in the New York area, able to speak/write English, with no neuromuscular/movement disorders (for actigraphy purposes), no uncontrolled medical, sleep, endocrine or psychiatric illness, no ongoing use of hypnotic or sedative medication and no prior treatment for cancer, as determined by semi-structured interview at the time of recruitment (and confirmed by chart review).

Procedure

Demographic and health information were collected from patients prior to surgery using questionnaires that patients completed at home. Data obtained included age, race, education, use of medications and marital status. In the clinical waiting area prior to surgery, participants completed three single item visual analog scales (VAS) assessing levels of emotional upset, relaxation and depressed mood. Patients also reported the time they went to bed and when they woke up for the previous night. All patients underwent similar surgical procedures, with breast conserving approaches (excisional biopsy or lumpectomy) without axillary node dissection, following standard clinical protocols. Anesthetic procedures also followed standard institutional guidelines. All surgeries were performed under local anesthetic (e.g., lidocaine 2% with 1:100,000 epinephrine). Local anesthetic was supplemented with an intravenous sedation regimen to achieve an Observer's Assessment of Alertness Sedation (OAA/S) score between 2 and 4.[9] Sedation was achieved with combinations of short acting narcotic agents (fentanyl 0.5–2 μg/kg bolus or infusion at 0.01–0.05 μg/kg/min) and sedative hypnotic agents (midazolam 0.01–0.1 mg/kg and/or propofol 10–50 μg/kg/min). All procedures were conducted on an outpatient basis, with patients discharged from the hospital on the same day as surgery. At the end of the study period, apposite clinical data, including pathology reports (to determine postsurgery cancer diagnosis, height and weight), anesthesia data (to determine anesthesia duration and analgesic drugs) and operative data (to determine surgeon, presurgery needle localization procedures, surgery start time and surgery duration) were abstracted from medical charts. Also abstracted were the timing, dose, and routes of administration of analgesics used during surgery and during the postoperative period before discharge. Subsequent postoperative pain therapy followed standard Mount Sinai Hospital guidelines. Patients were prescribed acetaminophen/codeine (300mg/30mg) oral medication at discharge to be taken on an "as needed" basis. The use of this postoperative pain medication was self-reported by participants. As part of the study protocol, patients wore a wristwatch-sized actigraphy (Actiwatch-64, Mini Mitter, Bend, OR) device for seven consecutive nights (beginning the night before surgery), and on day 7 (post-surgery) completed the Brief Pain Inventory

(BPI),[10,11] as well as three single-item VASs assessing emotional upset, relaxation and depressed mood.

Sleep Measurement

The Actiwatch, which has been used previously with surgery patients,[12] monitors gross motor activity with an omnidirectional accelerometer capable of sensing motion with a minimal resultant force of 0.01 g and a sampling rate of 32 Hz recorded in continuous one minute epochs. Activity counts (A) in each epoch are calculated using a standard algorithm, which uses the activity level in the adjacent two minute period (±2 epochs (En); A = E-2(1/25) + E-1(1/5) + E + E+1(1/5) + E+2(1/25). The Actiwatch is water resistant and designed to tolerate normal daily activities. During sleep a small amount of movement normally occurs, so wakefulness is operationally defined (Actiware Sleep Activity Monitoring Software, Version 3.3, Mini Mitter, Bend, OR) as > 40 activity counts per epoch (immobility count = 0), a cut point found to be optimal for identifying sleep/wake periods during the night in clinical and healthy populations.[8] Comparison of actigraphy and polysomnography results in previous studies has typically yielded agreement (validity) rates above 90 %[13] and the proportion of PSG and actigraphy-registered sleep epochs (sensitivity), and wake epochs (specificity) are comparable.[14] The Actiwatch also demonstrates good night-to-night reliability, no first night effect (unlike polysomnography) and high comparability (93% to 99%) for participants wearing two watches at the same time[15]. To reduce the possibility of artifacts related to inconsistent wearing of the device, participants were instructed not to remove the Actiwatch for bathing or other activities. Actigraph data was analyzed using Actiware Sleep Activity Monitoring Software (Version 3.3, Mini Mitter, Bend, OR). Actigraph output (actograms) was examined visually to confirm that there were no inconsistent values that might indicate defects in the device or procedures. Following standard procedures,[8] bedtime for sleep and rise time were determined in the actigraphy data, with the aid of bed and wake times reported by patients on the morning of surgery by a blinded investigator based on a precipitous dip/rise in evening/morning activity. Standard sleep variables (occurring between bed and rise time) are outlined and defined in Table 1. The primary actigraphy determined predictors were: sleep duration (total sleep time) and sleep efficiency (the ratio of total time asleep to the total time in bed multiplied by 100), as determined by the Actiware software.

Pain Measurement

The Brief Pain Inventory (Short-Form) (BPI), a classic self-report measure, was used to assess patients' experience of pain retrospectively over the week after surgery.[10,11] The inventory was completed by patients once, on day 7 after surgery. The two subscales of the BPI assess pain severity and the extent to which pain interferes with daily activities. Pain severity determination was based on three items rating pain: "at its worst," "on average" (over the last week), and "at that moment."[16] Mean scores of these three items were calculated and scores could range from 0 (no pain) to 10 (pain as bad as you can imagine). The pain interference determination was based on seven items assessing how much their pain interfered with patients' daily activities (e.g., walking ability, normal work) over the week after surgery. Mean scores of these seven items were calculated and scores could range from 0 (no interference) to 10 (completely interferes). Clinically significant differences in

pain using an 11-point scale have previously been established as +/− 2 points.[17] The BPI has previously demonstrated strong reliability and validity,[18,19] has been widely used with several surgical patient populations,[20–22] and has been recommended for use as a clinical and research tool by the Agency for Health Care Policy and Research.[23]

Psychological Variable Measurement

Participants' mood was assessed using three single-item visual analog scales (VAS). For each question, participants were asked to indicate on a 100 mm line how "emotionally upset," "relaxed," and "depressed" they were feeling "right now." The VAS scores could range from 0 ('not at all upset/relaxed/depressed') to 100 ('as upset/relaxed/depressed as I could be'). VAS measures, first developed in the 1920s, have been widely used to provide quick quantitative assessments of a wide variety of subjective phenomena in non-patients and clinical contexts, and have a strong record of reliability and validity, as has previously been reviewed extensively.[24,25]

Statistical Analyses

Descriptive data in the present study are presented as means ± standard deviation or percentages. The associations between postoperative pain severity/interference and age, body mass index (BMI), anesthesia duration, surgery duration, surgery start time, perioperative analgesics, sleep efficiency, total time in bed, total sleep time, sleep onset time, sleep end time were examined using Pearson's r correlations. Univariate analyses of variance were used to assess the relationships between education, race, marital status, post surgery diagnosis, presurgery needle localization, surgeon and postoperative pain severity/interference. The independent associations between sleep efficiency measured the night before surgery and mean postoperative pain severity and mean pain interference scores were analyzed using multiple linear regression, adjusting for covariates. Demographic, medical and operative factors which were associated ($P<0.10$) with postoperative pain severity or interfere in preliminary analyses were used as covariates. Results of the regression analyses are presented with standardized Beta (B) coefficients and 95% confidence intervals (CI), with variance explained (R^2) expressed as percentages. To illustrate the relationship between sleep and pain, levels of sleep efficiency the night before surgery were split into tertiles (defined as the upper, middle and lower 33.3 % of the sample). Group differences between the highest and lowest tertiles were performed with analyses of covariance planned contrasts. Significance levels were $P\leq0.05$.

Results

Women in the sample were, on average, 45 years old, had normal body mass indices, and were demographically diverse (Table 1). None of the patients reported taking hypnotic or sedative medication to help them sleep or to reduce anxiety during the study period. Mean sleep onset time, sleep end time, total sleep time and sleep efficiency levels (Table 1), as determined by actigraphy, were similar to those reported for other patients undergoing surgery.[12] Self-reported time in bed the night before surgery was highly comparable and significantly correlated, with actigraphy measured total time in bed the night before surgery

(mean difference=7.8 min; r=0.82, *P*=0.0001). No participants withdrew from the study after enrollment; results are presented for 24 patients.

The mean pain severity was 2.96 (± 2.55) and the mean pain interference with daily activities was 2.48 (± 2.48) during the week after surgery, with individual scores ranging from 0 to 8.33/8.43 (out of a possible 10). Clinical cutoff points have been established for one BPI item: "pain at its worst over the last week," with a score of 0–4 classified as mild pain and 5–10 classified as moderate to severe pain. According to these clinical cutoffs, 13 (54.2%) patients in this study experienced mild pain and 11 (45.8%) patients experienced moderate to severe pain at some point in the week following surgery. Of the demographic, medical and surgical variables shown in Table 1, only age and race were significantly associated with postoperative pain; younger patients had greater pain severity and pain interference levels compared with older patients, while African American patients (*n*=6) experienced greater pain interference levels compared with Caucasian patients (*n*=18). There was also a trend for a significant positive correlation (*P*<0.10) between pain severity and perioperative levels of midazolam and propofol. In the week following surgery, 14 (58.0%) women took analgesic medication (acetaminophen/codeine). Participants who took postoperative pain medication (*n*=14) had similar sleep efficiency levels the night before surgery than those who took no medication over the week following surgery (*P*>0.41). Pre-surgery sleep efficiency was also not related to emotional upset, relaxation or depressed mood assessed on the morning of surgery (*P*>0.50).

The relationships between sleep variables and postoperative pain are shown in Table 1. Self-reported total time in bed and actigraphy-determined total time in bed, sleep onset time, sleep end time, and total sleep time (sleep duration) the night prior to surgery were not associated with postoperative pain (severity or interference). As hypothesized, significant negative relationships between sleep efficiency the night before surgery and postoperative pain severity and interference were found.

To explore possible confounding factors, multiple regression analyses were performed (Table 2). The first regression model examined postoperative mean pain severity scores and the second model examined mean pain interference scores as the outcome variables. Sleep efficiency the night before surgery was the predictor variable, and appropriate (demographic, medical or operative) factors based on associations that showed a trend (*P*<0.10) with the respective postoperative pain measures in bivariate analyses were covariates. The first regression analysis revealed that sleep efficiency the night before surgery remained a significant independent predictor of mean postoperative pain severity scores after controlling for age, midazolam and propofol (B = −0.39, CI: −0.19, −0.003, *P*=0.045). In this model age, midazolam and propofol accounted for a total of 29.9 % of the variance in postoperative pain severity scores, and sleep efficiency the night before surgery explained an additional 13.7 % of the unique variance. The second regression model revealed that sleep efficiency the night before surgery was a significant independent predictor of mean postoperative pain interference scores after controlling for age and race (B = −0.55, CI: −0.21, −0.06, *P*=0.001). In this model, age and race accounted for a total of 27.0% of the variance in postoperative pain interference scores, while sleep efficiency the night before surgery explained an additional 31.0% of the unique variance. Confirming the

temporal specificity of these relationships between presurgery sleep and the two postoperative pain measures, sleep efficiency averaged over the week after surgery (84.5 (± 7.4) was not related to postoperative pain severity (r=−0.08, *P*=0.75) or pain interference (r= −0.05, *P*=0.86). Previous literature indicates that mood at the time of questionnaire completion may influence retrospective pain reports.[26] In the present study, levels of current emotional upset and relaxation assessed at the time patients completed the BPI were not correlated with either pain outcome (*P*s >0.13). Depressed mood also was not correlated with pain severity (*P*>0.24), but was significantly associated with pain interference (r=0.46, *P*=0.024). However, multiple regression analyses revealed that sleep efficiency remained a significant independent predictor of pain interference (B = −0.54, CI: −0.26, −0.004, *P*=0.044) when controlling for current depressed mood on day 7 after surgery.

To illustrate the relationships between presurgery sleep and postoperative pain, the sample was divided into tertiles based on sleep efficiency levels the night before surgery. Figure 1 (left-hand panel) shows that participants in the lowest sleep efficiency tertile had 59% higher mean pain severity scores than participants in the highest sleep efficiency tertile (*P*=0.025). Similarly, Figure 1 (right-hand panel) shows that participants in the lowest sleep efficiency tertile had 64% higher mean pain interference scores than participants in the highest sleep efficiency tertile (*P*=0.008). Consistent with guidelines for clinically significant differences in pain,[17] patients with sleep efficiency in the highest tertile showed a greater than two point difference in both pain severity (2.70 points) and pain interference (2.81 points) scores, than patients with sleep efficiency in the lowest tertile.

Discussion

Results of the present preliminary study indicate that patients with lower sleep efficiency the night before breast-conserving surgery have significantly heightened levels of postoperative pain over the week after surgery. No relationship was found between sleep duration and postoperative pain. These findings are consistent with emerging experimental evidence that sleep duration has less of an impact on the experience of pain than disruptions in sleep continuity.[7] Extending this experimental research, the present study is the first to document significant adverse effects of sleep disruption (lower sleep efficiency) on subsequent acute pain in a clinical context.

No evidence was found to support the possibility that the relationship between presurgery sleep efficiency and postoperative pain was attributable to differences in surgery/anesthesia duration, postsurgery cancer diagnosis, perioperative analgesics, preoperative emotional upset, relaxation, depressed mood or postoperative sleep efficiency, although a larger sample and more extensive assessments would be necessary to have the power for formal evaluation of possible mediational factors. While the findings should be interpreted with caution given the small sample size, participants who were younger and/or African American were found to have higher levels of postoperative pain consistent with the literature;[27,28] however, statistically controlling for these factors did not eliminate sleep efficiency as a significant independent predictor of pain severity and pain interference over the week following surgery.

The mechanisms responsible for the effects of sleep disruption on pain have yet to be elucidated. Researchers in the experimental literature demonstrating effects of sleep disruption on subsequent pain sensitivitiy[7] have suggested that disruption of sleep continuity may influence brainstem opioidergic pathways, which are known to be involved in descending modulation of pain.[29] The involvement of a more peripheral pathway is also possible. Sleep disruption could affect the acute stress response to surgery, which is characterized by complex interactions among the neuroendocrine, metabolic, and immune systems.[30] In particular, since sleep and pain are influenced by common neurobiological (e.g., serotonergic and glucocorticoid) pathways, it is possible that these mechanisms may be involved.[5] Evidence suggests that glucocorticoid administration to patients undergoing surgery reduces post surgery pain,[31] perhaps as a result of suppressed inflammatory processes.[32] Healthy individuals with lower cortisol responses to laboratory stressors have also been shown to have increased pain sensitivity to standardized challenges following the stressor.[33,34] A separate line of experimental research has demonstrated that poor sleep prior to physical[35] and psychological challenges results in reduced acute cortisol responses,[36,37] which appears to be selective for sleep the night immediately before the challenge.[36] Together, these studies raise the possibility that the physiological response to surgery stress may be important in the relationship between sleep and postoperative pain; although additional research on these mechanisms is clearly needed.

The present preliminary study was designed as a first step to explore the impact of presurgery sleep on postoperative pain; as such there are strengths and limitations which must be considered. First, although significant results were found with a relatively small sample size, results should be interpreted with caution. Future research should replicate the study in larger samples with greater diversity (e.g., including male surgery patients). It is also possible that the small sample size may have resulted in a relatively small number of individuals from certain age or racial groups influencing the findings. Second, although the level of pain reported by patients in this study was comparable to previously published data from women undergoing ambulatory breast surgery,[20] the impact of sleep on postoperative pain in patients receiving more extensive/invasive procedures would be important to examine. Third, although levels of presurgery sleep duration and sleep efficiency found in the present study was comparable to presurgery sleep recorded in other samples undergoing ambulatory surgery[12] the impact on pain that might be found in patients with more severely disrupted sleep would be important to examine. Fourth, although self-report and medical records indicated that none of the patients in the present study had a sleep-related disorder, it is not known whether the relationship between poor sleep recorded the night before surgery and postoperative pain in the current sample was due to a cumulative sleep deficit or was specific to the night before surgery. Future research should examine patients' sleep patterns for a longer preoperative period to better characterize the temporal relationship. In addition, although the present study excluded patients with known psychiatric illness, longer-term subclinical psychological problems, which may affect sleep and pain around the time of surgery, were not investigated in this preliminary study. Based on these initial findings of an association between poor preoperative sleep and increased postoperative pain, larger studies would now be warranted to investigate the effects of longer-term psychological factors (e.g., anxiety and depressed mood) that could contribute to increased sleep disruption before

surgery and greater postoperative pain. Fifth, the present study used the Brief Pain Inventory as the primary outcome variable to assess pain over the week following surgery. Although the scale is validated and less burdensome to patients than some measures, it relies on retrospective, self-reported ratings which could be influenced by mood at the time of questionnaire completion.[26] To address this issue the present study controlled for depressed mood reported at the time of BPI completion; however, future studies should employ more frequent pain assessments to better understand the variation in pain ratings over the week after surgery. Interestingly, the present study did not find a relationship between preoperative sleep and postoperative analgesic use, considered by some to be a more objective indicator of postoperative pain.[38] However, it is important not to over interpret these negative findings. Since the study was a preliminary investigation, and we were cognizant of the potential for overburdening patients around the time of surgery, the measure used to assess postoperative medication was rather crude. As a result, postoperative analgesic usage was not considered a major outcome variable in the present study. Future research should employ more detailed diary methods which assess daily postoperative analgesic medication dosage in order to determine whether poorer sleep the night before surgery is associated with increased postoperative medication use. Sixth, one strength of the present study was the objective assessment of sleep. However, while actigraphy is a validated against polysomnography[13] and is generally more reliable than self-report data particularly for the assessment of sleep disruption,[39] actigraphy does not detect wake time in which no movement occurs, so overestimation of total sleep time is possible.[39,40] In addition, actigraphy is unable to detect more subtle changes in sleep architecture. Experimental research has suggested that selective deprivation of particular stages of sleep (e.g., slow wave sleep) can modify pain responses,[4,7] but actigraphy is not able to assess sleep stages. Concurrent investigation of sleep stage and sleep efficiency in relation to pain would be of interest. It must also be noted that the accuracy of actigraphy is diminished in evaluating disordered sleep. Although its role in clinical diagnosis is limited, actigraphy has proven to be a useful methodology for investigating the effects of clinical interventions for insomnia.[41] Finally, although a strong relationship was found between presurgery sleep efficiency and pain over the week after surgery, it is important to emphasize that attribution of causality to this relationship must await additional research, including randomized studies in which sleep efficiency is manipulated (improved) in this clinical context.

Pain following ambulatory surgical procedures, such as breast conserving surgery can have a substantial impact on physical functioning and quality of life following surgery, despite analgesic medication and good medical care.[2] The significant relationship between presurgery sleep efficiency and pain interference with daily activities, such as walking and housework in the present study, highlights the potential pervasive impact of poor sleep on patients' recovery of normal functioning following surgery. These preliminary findings may, therefore, have important implications for the clinical care of surgery patients. For example, it would be of interest to examine the clinical utility of pharmacological (e.g., prescription of sleeping pills) or psychological (e.g., cognitive behavioral therapy) interventions to improve patients' sleep the night before surgery, to explore the possibility of ameliorative effects on postoperative pain that may complement the benefits of routine postoperative opioid medications.

In summary, emerging evidence from experimental studies suggests that poor sleep adversely affects pain responses.[3,5] The present preliminary investigation represents an important first step in identifying poor sleep as a possible modifiable risk factor that may adversely affect postoperative pain. Specifically, it was found that disrupted sleep the night before surgery (low sleep efficiency) was related to significantly greater pain severity, and to pain interference with daily activities over the week following surgery. While these initial findings need to be replicated in larger more diverse samples, the results may have important implications for the clinical care of patients about to undergo surgery. Additional research regarding the mechanisms responsible for these effects and the impact of interventions to improve sleep prior to surgery would also appear warranted.

Acknowledgments

This research was supported by grants from the National Cancer Institute (CA105222; CA81137-05), the American Cancer Society (CRTG 00-312-01; PF-05-098-01-CPPB), and the Department of Defense (DAMD17-99-1-9303). The content of the information contained in this report does not necessarily reflect the position or policy of the Department of Defense.

The authors would like to acknowledge the contributions of Alexis Kowalski, BA, as study coordinator and Suzy Blumenthal, MPH, for her assistance with the actigraphy data. We would also like to thank the study participants for their contribution of time and effort to the research.

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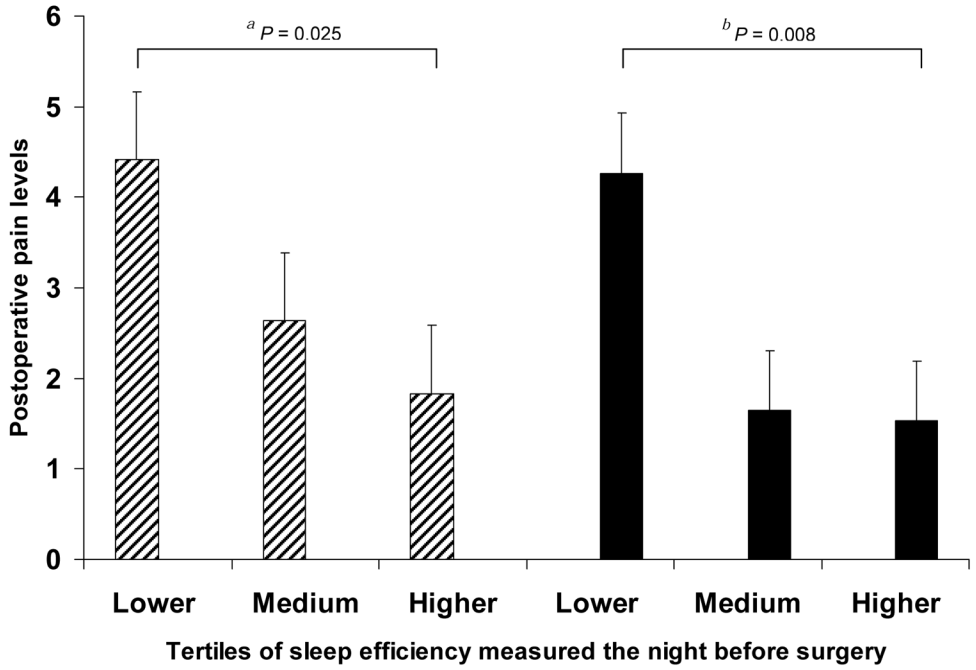

Figure 1.

Mean Brief Pain Inventory (BPI) pain severity (0–10) scores (hatched bars) adjusted for age, midazolam and propofol, and mean BPI pain interference (0–10) scores (solid bars) adjusted for age and race over the week following surgery in lower, middle and higher sleep efficiency tertiles. Error bars are standard error of the mean. Significance values ($^{a}P<0.05$; $^{b}P<0.01$) are analyses of covariance planned contrasts.

Table 1

Demographic, Medical, Surgical and Sleep Characteristics and the Relationship with Postoperative Pain Severity and Interference with Daily Activities

	Mean (± SD) or number (% sample)	Association with postoperative pain severity	Association with postoperative pain interference
Age (yrs)	45.2 (± 2.2)	r = −0.52, *P* = 0.010 [a]	r = −0.47, *P* = 0.019 [b]
Body mass index (kg/cm^2)	23.9 (± 1.43)	r = −0.09, *P* = 0.65	r = 0.03, *P* = 0.88
University degree or higher	15 (62.5 %)	F = 0.31, *P* = 0.58	F = 0.13, *P* = 0.72
Race: Caucasian	18 (75.0 %)	F = 1.51, *P* = 0.23	F = 5.23, *P* = 0.032 [b]
Married	9 (37.5 %)	F = 1.31, *P* = 0.27	F = 2.18, *P* = 0.16
Cancer positive diagnosis	8 (33.3 %)	F = 1.44, *P* = 0.24	F = 0.84, *P* = 0.37
Needle localization procedure	12 (50.0 %)	F = 0.69, *P* = 0.42	F = 0.77, *P* = 0.37
Anesthesia duration (min)	81.9 (± 43.3)	r = 0.17, *P* = 0.43	r = 0.13, *P* = 0.56
Surgery duration (min)	43.2 (± 41.0)	r = 0.001, *P* = 0.99	r = 0.03, *P* = 0.88
Surgery start time (24 hour clock)	12:04 (± 1:57)	r = 0.28, *P* = 0.18	r = 0.30, *P* = 0.16
Surgeon:			
CW	14 (58.3 %)	F = 0.36, *P* = 0.78	F = 0.66, *P* = 0.59
AG	7 (29.3 %)		
BP	3 (12.5 %)		
Perioperative analgesics: [c]			
Fentanyl (μg)	4.25 (± 20.4)	r = 0.24, *P* = 0.27	r = −0.06, *P* = 0.77
Midazolam (mg)	1.87 (± 1.36)	r = 0.38, *P* = 0.064	r = 0.21, *P* = 0.34
Propofol (mg)	86.5 (± 142.9)	r = 0.36, *P* = 0.083	r = 0.21, *P* = 0.32
Lidocaine (ml)	18.4 (± 12.9)	r = −0.17, *P* = 0.43	r = −0.07, *P* = 0.74
Self-reported sleep variables:			
Total time in bed [d] (mins)	396.1 (± 81.2)	r = 0.24, *P* = 0.26	r = 0.19, *P* = 0.39
Actigraphy determined variables:			
Presurgery sleep efficiency[e] (%)	85.4 (± 10.1)	r = −0.44, *P* = 0.034 [b]	r = −0.49, *P* = 0.015 [b]
Total time in bed [f] (min)	403.9 (± 88.1)	r = 0.08, *P* = 0.73	r = 0.06, *P* = 0.77
Total sleep time [g] (min)	343.9 (± 86.7)	r = −0.16, *P* = 0.46	r = −0.23, *P* = 0.28
Sleep onset time [h] (24 hour clock)	23:54 (± 1:12)	r = −0.09, *P* = 0.65	r = −0.05, *P* = 0.81
Sleep end time[i] (24 hour clock)	6:19 (± 0:55)	r = −0.22, *P* = 0.30	r = −0.27, *P* = 0.19

[a] Significant at *P*<0.01.

[b] Significant at *P*<0.05.

[c] Intravenous analgesic medications administered during the surgical procedure and in the PACU/recovery room before discharge.

[d] Minutes between self-reported bed and wake time for the night before surgery.

[e] The ratio of total sleep time to the total time in bed multiplied by 100, measured by actigraphy the night before surgery.

[f] Minutes between time of getting into bed and rising the next morning, measured by actigraphy the night before surgery.

[g] Minutes between sleep onset and sleep end time, measured by actigraphy the night before surgery.

[h] First 10-minute period in which no activity occurred after getting into bed, measured by actigraphy the night before surgery.

[i] Last 10-minute period before rising in which no activity occurred, measured by actigraphy on the morning of surgery.

Table 2

Factors Predictive of Pain Severity (Model 1) and Pain Interference with Daily Activities (Model 2) Over the Week Following Surgery

Model 1 (Pain severity)	Standardized Coefficients (*B*)	95% Confidence Interval	Significance (*P*)	Model 2 (Pain interference)	Standardized Coefficients (*B*)	95% Confidence Interval	Significance (*P*)
Age	−0.41	−0.18 to −0.01	0.032[b]	Age	−0.28	−0.18 to 0.007	0.075
Midazolam	0.30	−0.13 to 1.26	0.11	Race	0.34	0.16 to 3.70	0.034[b]
Propofol	−0.06	−0.01 to 0.01	0.75	Presurgery Sleep Efficiency[a]	−0.55	−0.21 to −0.06	0.001[c]
Presurgery Sleep Efficiency[a]	−0.39	−0.19 to −003	0.045[b]				

AU: SHOULD THIS BE -0.003?

[a] The ratio of total sleep time to the total time in bed multiplied by 100, measured by actigraphy the night before surgery.

[b] Significant at $P<0.05$.

[c] Significant at $P<0.001$.