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# The Intersection of Sleep Disorders and Postoperative Pain: A Narrative Review of a Bidirectional and Understudied Relationship

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## Abstract

**Background:** The relationship between pain and sleep represents one of the most significant yet insufficiently researched interactions between physiological systems during the perioperative period. Evidence indicates that pre-existing sleep disturbances, such as insomnia or sleep-disordered breathing, are strong predictors of postoperative pain intensity, higher opioid consumption, and increased risk of chronic postoperative pain.

**Objective:** This review aims to examine the bidirectional interaction between sleep and postoperative pain, highlighting its impact on rehabilitation and recovery, while proposing strategies for improved perioperative care.

**Methods:** Relevant literature was reviewed to evaluate the effects of postoperative pain on sleep architecture, including changes in sleep continuity, slow-wave sleep, and rapid eye movement (REM) sleep. Clinical and mechanistic findings on the reciprocal relationship between sleep disturbance and pain were also analyzed.

**Results:** Postoperative pain was found to fragment sleep, reduce restorative sleep stages, and impair overall sleep quality. Poor sleep, in turn, heightened pain sensitivity, interfered with rehabilitation, and delayed recovery. This cyclical relationship is rarely addressed in standard perioperative care despite its clear impact on patient outcomes.

**Conclusion:** A paradigm shift is required in perioperative medicine to incorporate preoperative sleep screening and targeted multidisciplinary interventions for sleep and pain management.

**Implications:** Future studies should focus on mechanistic and clinical investigations to break the cycle between pain and poor sleep. Integrating sleep-focused assessments and interventions into perioperative care pathways could reduce opioid use, improve recovery, and enhance overall patient well-being.

**Keywords:** Sleep Disorders, Postoperative Pain, Recovery, Opioids, Obstructive Sleep Apnea, Multimodal Analgesia, Perioperative Care

## Introduction

Sleep comprises one third of human life. Sleep is essential for survival and an important role in maintaining mental and physical health. Sleep requirement for healthy adult's ranges from 7 to 8 hours of sleeping per night (1). Sleep disorders are defined as conditions that are characterized by a disturbance of the usual pattern or behaviors of the sleeping. These disorders cause impairment in day functions and distress (2). Sleeping disorders can appear as complaints of abnormal movements during sleep, insufficient sleep or an excessive amount of perceived sleep. The most prevalent sleep disorders include sleep apnea, insomnia, narcolepsy, and restless legs syndrome/ pain. Sleep disorders had an impact on the driving, social activities, and work of the individuals (3)

Effective pain management has been regarded as a human right. Post-operative pain is one of the most common causes of pain with more than 80% of post-operative patients experiencing some degree of and up to 75% reporting moderate to severe intensity of pain (4). It is widely acknowledged that undermanaged post-operative pain can lead to complications such as decreased lung function, sleep disturbances, infection, delayed mobility, myocardial infarction and increased morbidity and mortality. (5) post-operative pain is a major factor in surgical recovery. Post-surgical pain that lingers beyond the initial few-week period of tissue healing is a major predictor of pain chronification which leads to substantial disability. (6)

Sleep disturbance is a common occurrence in post-surgical patients, particularly in those admitted to the intensive care unit (ICU). Postoperative sleep disturbance occurs due to the complex interactions of numerous factors many of which can be attenuated. If not managed postoperative sleep disturbance can lead to delayed recovery and increased morbidity(7). Major surgical trauma is thought to be accompanied by a period of postoperative immunosuppression which predisposes to infection. The postoperative inflammatory response causes neuro inflammation is likely that this contributes to the postoperative sleep disturbances that surgical patients experience(8). The suppression of Rapid Eye Movement (REM) sleep and SWS is greater in major surgery (gastrostomy) than in minor surgery (hernia repair). Patients who underwent open cholecystectomy had severe sleep disturbances with decreases in REM and SWS. Pain is the most common cause of night-time postoperative disturbance. Anesthesia has a minor role in the development of postoperative sleep disturbance. Anesthesia causes similar postoperative sleep disturbance patterns including decreased REM and SWS with decreased total sleep time and increased sleep fragmentation regardless of whether the anesthesia is regional or general. (9) Sleep deprivation causes hyperalgesia in both animals and humans and may impair pain inhibitory mechanisms implicated in the pathophysiology of chronic pain Increased daytime pain is linked with poor nighttime sleep and poor sleep is, in turn, associated with augmented next day pain sleep disturbance and psychosocial distress may both contribute to the exacerbation and spreading of pain over time. (10)

The critical bidirectional relationship between sleep disorders and postoperative pain remains a significant yet understudied challenge in perioperative care. While the vicious cycle of pain disrupting sleep and poor sleep amplifying pain is widely acknowledged, its underlying mechanisms are poorly elucidated. Furthermore, clinical protocols consistently neglect sleep as a modifiable risk factor, managing pain and sleep as separate issues rather than an interconnected dyad. This gap is exacerbated by the lack of pre-operative screening for sleep disorders that could identify high-risk patients. Consequently, there is a stark absence of evidence-based, integrated interventions designed to simultaneously address both problems. This represents a fundamental missed opportunity to improve surgical recovery and patient outcomes.

## Material and Methods

This review employs a narrative methodology to synthesize the complex and evolving literature on the bidirectional relationship between sleep disorders and postoperative pain. The relationship between sleep and pain is multifaceted, involving neurobiological, psychological, and clinical dimensions that are not easily captured by a rigid, quantitative systematic review. A narrative framework provides the necessary flexibility to explore mechanisms, identify clinical challenges, and propose integrated management strategies that a more restrictive methodology might overlook.

The sources of evidence for this review were identified through a targeted search of major scientific databases (PubMed, google scholar, Embase) for literature published primarily within the last two decades, with seminal older articles included for historical context. Key materials included systematic reviews, prospective cohort studies, randomized controlled trials (RCTs), and meta-analyses. Emphasis was placed on studies that provided mechanistic insights into the pain-sleep cycle (e.g., involving sleep architecture, endogenous analgesia, or hyperalgesia pathways) or that evaluated clinical outcomes such as pain scores, opioid consumption, sleep efficiency, and recovery metrics. Cross-disciplinary publications from the fields of anesthesiology, sleep medicine, psychiatry, and surgery were prioritized to ensure a comprehensive perspective.

To structure the review, evidence was organized around several core themes that emerged from the literature. These included: (1) the predictive role of pre-existing sleep disturbances on postoperative pain outcomes; (2) the disruptive impact of acute postoperative pain on sleep quality and architecture; (3) the evidence for a self-perpetuating, bidirectional cycle; (4) the specific challenges posed by comorbid conditions, notably Obstructive

Sleep Apnea (OSA); and (5) the evaluation of interventions designed to break this cycle. Studies were selected for inclusion based on their direct relevance to these themes and their contribution to building a logical narrative on the clinical significance of this relationship.

Sleep is assessed using everything from subjective questionnaires (e.g., Pittsburgh Sleep Quality Index) to objective polysomnography, while pain is measured with different scales and at varying time points. Furthermore, many clinical studies are observational, which can establish association but not definitively prove causation within the bidirectional model. Confounding factors, such as anxiety, depression, and the type of surgical procedure, are often incompletely controlled.

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***Table 1:*** *describes the characteristics and findings of studies included in the review.*

| Author /Year | Epidemiology | Physiological Mechanisms | Sleep Disorders | Pain Management Challenges | Bidirectional Relationship | Study finding | Clinical Implications | Future Directions |
|---|---|---|---|---|---|---|---|---|
| **Xu et al., 2024(11)** | Up to 80% of patients report moderate to severe postoperative pain with significant sleep disruption. High incidence in specific populations (children, women, obese patients). | Inflammation is a key mechanism. Opioids disrupt sleep architecture. Sleep deprivation impairs pain modulation pathways (neuroimmune, neural, endocrine). Stress response/HPA axis dysfunction lowers pain threshold. | Includes insomnia, hypersomnia, circadian rhythm disorders, obstructive sleep apnea (OSA), and decreased sleep quality/quantity. | Opioid use can cause/reveal sleep-related breathing disorders. Pain-induced sleep loss exacerbates pain perception, reducing analgesic efficacy and creating a vicious cycle. | Pain worsens sleep quality, and poor sleep exacerbates pain perception, forming a vicious cycle that impairs recovery. | Integrated management is crucial. ERAS protocols emphasize multimodal analgesia and sleep strategies. Non-pharmacological (music therapy) and non-opioid drugs (dexmedetomidine, melatonin) are beneficial. | Growing research interest (1893 publications, 2013-2023). Hot topics: OSA, tonsillectomy, children, quality of life. Undeveloped topics with potential: breast/lung cancer, fatigue, dexmedetomidine, postoperative analgesia. Global collaboration centered around USA, China, Europe. | Research on "breast cancer," "lung cancer," "fatigue," and "dexmedetomidine." Deeper investigation into inflammatory mechanisms. Shift from viewing pain/sleep as separate to integrated therapeutic strategies. Need for more clinical and animal studies to substantiate correlations. |

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| **Rampes et al. (2020)(9)** | Common in post-surgical patients, especially in ICU; severity correlates with surgery magnitude and duration. | Surgical inflammatory response (cytokines like TNF, IL-1, IL-6), pain, anesthesia, anxiety, environmental factors (noise, light). | Decreased total sleep time, loss of REM and SWS, sleep fragmentation. | Opioids disrupt sleep architecture; non-opioid pain control still associated with sleep disturbance. | Pain disrupts sleep; poor sleep increases pain sensitivity and analgesia use. | Delayed recovery, longer hospital stay, POCD, delirium, cardiovascular events, increased pain. | Dexmedetomidine, melatonin, zolpidem, and ERAS protocols show promise in improving sleep and outcomes. | More high-quality RCTs needed; combination of pharmacological and non-pharmacological approaches; integration into ERAS protocols. |
| **Gali et al. (2009)(12)** | ~4% men, 2% women aged 30–60 have OSA; 82% men, 93% women undiagnosed; 24–27.5% of surgical patients at risk | Anesthetic/analgesic agents reduce pharyngeal tone, depress ventilatory response to hypoxia/hypercapnia | Obstructive Sleep Apnea (OSA) is primary sleep disorder studied | Pain-sedation mismatch (high pain + high sedation) increases risk of apnea/bradypnea/desaturation | OSA increases postoperative complications; postoperative sedation/sleep disruption exacerbates OSA | Two-step screening (preop SACS + PACU events) identifies high-risk patients; guides monitoring level | High SACS (OR=1.9) and recurrent PACU events (OR=1.5) predict ODI >10; high SACS (OR=3.5) and PACU events (OR=21.0) predict respiratory complications | Validate with polysomnography; identify other risk factors; develop outcome-based care protocols; long-term follow-up |
| **Kaw et al., 2012(13)** | High prevalence of OSA in surgical populations (e.g., >30% in neurosurgical, up to 91% in bariatric). Associated with comorbidities (cardiovascular disease, hypertension). | Episodic hypoxia leads to sympathetic activation, hemodynamic instability. Chronic adrenergic arousal may cause down-regulated α/β receptors, attenuating response to vasopressors. | Focus on Obstructive Sleep Apnoea (OSA). Defined by AHI via PSG, questionnaires, or oximetry. | Patients with OSA have increased sensitivity to opioids, posing a risk for postoperative upper airway obstruction and respiratory depression. | The study establishes a unidirectional risk: OSA predisposes patients to postoperative complications. A bidirectional relationship with pain is not explored. | OSA is a significant risk factor for postoperative complications. Recommends preoperative screening and careful perioperative management, including potential CPAP use. | Meta-analysis of 13 studies (n=3942). OSA significantly increases odds of postoperative cardiac events (OR 2.07), respiratory failure (OR 2.43), desaturation (OR 2.27), and ICU transfer (OR 2.81). | Confirmation of findings by large prospective studies. Standardization of definitions for complications (e.g., acute respiratory failure). Need for studies on the impact of CPAP therapy on reducing postoperative risks. |

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| **Haack et al. (2020)(14)** | Chronic pain highly comorbid with poor sleep; poor sleep is a risk factor for developing chronic pain. | Opioid, monoaminergic, orexinergic, immune, melatonin, endocannabinoid systems; HPA axis; adenosine and nitric oxide signaling. | Insomnia, sleep fragmentation, reduced sleep efficiency, altered sleep architecture. | Opioids disrupt sleep; NSAIDs mildly disturb sleep; antidepressants have variable effects; risk of opioid-induced hyperalgesia. | Pain disrupts sleep; poor sleep increases pain sensitivity and spontaneous pain. | CBT-I improves sleep and pain; melatonin and cannabinoids show promise; pre-op sleep quality affects post-op pain. | Sleep loss deactivates analgesic systems (opioid, dopamine, orexin, melatonin) and activates hyperalgesic systems (adenosine, NO, cytokines). | Need for high-quality RCTs; mechanistic studies on shared pathways; timing of medications to avoid sleep disruption; longitudinal studies on cannabinoids. |
| **Niklasson et al. (2025)(15)** | ~30% insomnia symptoms, 10–20% insomnia disorder, 6–17% moderate-severe OSA in general population; higher in older surgical candidates | Sleep loss ↑ pain sensitivity, hyperalgesia; opioids disrupt sleep; melatonin may have analgesic properties; corticostriatal dysfunction links sleep loss to pain | Insomnia (primary focus), OSA, poor sleep continuity, short sleep duration | Preop sleep disturbance → ↑ postop pain intensity & opioid use; pain-sedation mismatch in PACU | Stronger causal direction from sleep → pain than pain → sleep; preop sleep predicts postop pain trajectory | Preop sleep screening; melatonin/zolpidem may help; CBT-I not yet tested perioperatively | Meta-analysis (5 studies, n=1226): preop insomnia symptoms → OR 2.69 for moderate-severe pain on POD1; qualitative support across 29 studies | Develop brief sleep interventions; test melatonin dosing; assess CPAP impact on pain; use objective sleep measures; prevent chronic pain |
| **Strutz et al., 2019(16)** | 41.1% of the surgical cohort (n=1441) were high risk for OSA (STOP-BANG ≥5 or prior diagnosis). Overall postoperative delirium incidence was 21.3%. | Proposed mechanism: Chronic sleep disruption in OSA may up-regulate cytokines, provoking pain sensitivity. Sleep deprivation promotes hyperalgesia. | Focus on Obstructive Sleep Apnoea (OSA). Classified by STOP-BANG score or prior diagnosis. | Patients with OSA have increased susceptibility to opioid-induced respiratory depression, making safe and sufficient analgesia challenging. | The study investigated a unidirectional relationship (OSA as a risk factor for outcomes). A bidirectional cycle with pain was not supported by the results. | Contrary to the hypothesis, OSA was not an independent risk factor for delirium or severe pain. Key risk factors were race, functional capacity, age, and opioid dose for delirium; and midazolam, opioids, and MAC-hours for pain. | After adjustment for confounders, high OSA risk was not significantly associated with postoperative delirium (OR 1.34, p=0.27) or maximum postoperative pain severity (β-coefficient 2.82, p=0.28). | Include detailed data on inpatient analgesic regimens in future models. Investigate OSA as a continuum of risk rather than a binary outcome. Focus on delirium duration/severity rather than just incidence. |

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| **Waxman et al. (2020)[17]** | OSA affects ≥10% of men and 3% of women >30 years; surgery is an option for CPAP-intolerant patients. | OSA may increase pain sensitivity and decrease pain tolerance; opioids increase risk of respiratory depression. | Obstructive Sleep Apnea (OSA) is the primary sleep disorder addressed. | High postoperative pain; opioid use risky due to respiratory depression; NSAIDs feared for bleeding risk. | Not explicitly discussed, but pain can disrupt sleep and poor sleep may worsen pain perception. | Multimodal analgesia preferred; local anesthetics, NSAIDs, dexmedetomidine, sucralfate, and non-pharmacologic methods are effective. | Non-opioid regimens (NSAIDs, local anesthetics, dexmedetomidine, sucralfate) provide effective pain control without increased bleeding or respiratory risk. | Need for consensus guidelines; more RCTs on non-opioid strategies; better pain assessment tools tailored to OSA patients. |
| **Rabbitts et al. (2017)[18]** | ~20% of children develop persistent pain after major surgery; high rates of insomnia symptoms (45–68%) up to 4 months post-surgery. | Sleep disruption may lead to sympathetic activation, increased stress response, inflammation, and reduced pain inhibition. | High prevalence of insomnia symptoms; subjective sleep quality more impactful than objective measures (duration/efficiency). | Opioid use common at 2 weeks; subjective sleep quality strongly predicts next-day pain. | Unidirectional: poor sleep quality predicts next-day pain, but pain does not predict subsequent sleep. | Sleep quality is a modifiable target for intervention; screening for insomnia may identify at-risk children. | Sleep quality and efficiency reduced at 2 weeks post-surgery; returned to baseline by 4 months. Poor sleep quality predicted greater next-day pain. | Larger samples; more surgery types; detailed medication tracking; examine mediators (mood, inflammation); validate self-reported naps. |
| **Pan et al. (2025)[19]** | 21.95% of adult intestinal polypectomy patients developed PSD; higher in women (64.8%) and those with high pain sensitivity (77.8%). | High pain sensitivity linked to catechol-O-methyltransferase (COMT) gene expression, elevated catecholamines, prefrontal cortex activation, and disrupted REM sleep. | Postoperative sleep disturbance (PSD) characterized by reduced sleep efficiency, increased awakenings, longer sleep latency, and reduced deep sleep. | High pain sensitivity increases PSD risk; preoperative sleep problems exacerbate postoperative outcomes. | Unidirectional: high pain sensitivity predicts PSD, but PSD's effect on pain sensitivity not assessed. | Preoperative screening for pain sensitivity and sleep quality may identify high-risk patients; targeted interventions (e.g., COX-2 inhibitors, melatonin agonists) recommended. | High pain sensitivity (OR=2.789), preoperative awakenings, and sleep latency are independent predictors of PSD. Combined model AUC=0.776. | Multicenter studies; inclusion of central sensitization measures; polysomnography; personalized intervention algorithms; validation in diverse surgical populations. |

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| **Zhong et al. (2025)(20)** | 69.1% of bariatric surgery patients developed postoperative hyperalgesia (POH); OSA prevalence high in obese/metabolic syndrome patients (50–60%) | Sleep disruption → ↑ cytokines (TNF-α, IL-1β, IL-6); intermittent hypoxia → oxidative stress → HIF-1α ↑ → mitochondrial ROS ↑ → pain sensitization | OSA characterized by sleep fragmentation, nocturnal hypoxemia; assessed via STOP-Bang and AHI | High OSA risk → more severe POH; opioid-induced hyperalgesia not primary driver; PCA avoided due to respiratory depression risk | OSA severity correlates with POH severity; mediates effects of gender and BMI on POH | Preoperative OSA screening (STOP-Bang/PSG); multimodal analgesia; early anti-hyperalgesia (NSAIDs, ketamine) | High OSA risk → ↑ POH incidence (OR 6.43); male, age, BMI ≥35, high baseline pain threshold also risk factors | Larger PSG-based studies; include CSA; assess psychological factors; long-term pain outcomes |
| **Nassar et al. (2025)(21)** | Nearly 30% of adults have sleep disorders; prevalence increases with age. Higher incidence in spine patients: 73% in lumbar stenosis, 60% in cervical radiculopathy, 75% in adult spinal deformity. | Systemic inflammation (↑IL-6, TNF-α), impaired tissue repair, hormonal dysregulation (cortisol, growth hormone), neural pathway disruption, hypoxia from OSA. | Sleep apnea, insomnia, circadian rhythm disorders, parasomnias, hypersomnia. | Higher postoperative pain, increased analgesic dependence, hyperalgesia, delayed rehabilitation. | Poor sleep ↑ pain sensitivity → worse sleep → vicious cycle. | Preoperative screening (e.g., STOP-Bang), CPAP therapy, multimodal analgesia, sleep-friendly hospital environment, patient education. | Sleep disturbances linked to worse patient-reported outcomes, longer hospital stays, higher complications. Resolution of sleep issues post-surgery improves outcomes. Conflicting data on OSA and complications may reflect variable adoption of OSA protocols. | Prospective studies, standardized screening, individualized perioperative care, multidisciplinary collaboration, novel sleep-focused interventions. |

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| **Wilson et al. (2024)(22)** | 33.5% of breast cancer patients perceived decreased PA since diagnosis; higher BMI associated with lower PA levels; 1 in 3 women reported preoperative sleep disturbance. | PA modulates inflammatory mediators, endogenous opioids, endocannabinoids, serotonin; sleep disturbance mediates PA-pain relationship via central pain processing pathways. | Preoperative sleep disturbance measured via PROMIS; common in breast cancer patients; mediates relationship between decreased PA and postoperative pain. | Perceived decrease in PA (not absolute level) predicts postoperative pain; sleep disturbance exacerbates pain management challenges. | Unidirectional mediation: decreased PA → sleep disturbance → postoperative pain. Sleep stronger predictor of pain than vice versa. | Focus on maintaining/increasing PA after diagnosis rather than absolute levels; combined PA and sleep interventions; prehabilitation programs. | Perceived decrease in PA associated with greater preoperative sleep disturbance and postoperative pain; sleep disturbance partially mediated this relationship (b=2.49, 95% CI [0.25,6.03]). | RCTs to establish causality; objective PA measurement (accelerometers); validated PA questionnaires; combined exercise-CBT interventions; personalized prehabilitation. |
| **Cozowicz et al. (2019)(23)** | OSA patients are at higher perioperative risk; 181,182 OSA patients included in study from 2006–2016 (Premier Database) | OSA involves chronic respiratory impairment, recurrent apnoea/hypopnea; opioids and sedatives worsen airway collapse, reduce respiratory drive and consciousness | Obstructive Sleep Apnoea (OSA) is the primary sleep disorder studied; postoperative exacerbation of sleep-disordered breathing occurs | High opioid use increases respiratory depression risk; OSA patients may have altered pain sensitivity and increased opioid potency | Opioid use exacerbates OSA severity postoperatively (e.g., increased apnoea-hypopnea index) | Multimodal analgesia reduces opioid use, complications, and resource utilization in OSA patients | Multimodal analgesia associated with stepwise reduction in opioid use (up to 14.9%), mechanical ventilation (OR 0.23), critical care admission (OR 0.60), and gastrointestinal complications (OR 0.65) | Encourage simultaneous use of multiple non-opioid analgesia pathways; extend research to bariatric surgery and other high-OSA-prevalence populations; study impact of regional anesthesia and nerve blockade |

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| **Kim et al. (2025)(24)** | 71% (20/28) of rotator cuff tear patients had preoperative sleep disturbances (PSQI >5). Mean preoperative PSQI: 9.5 ± 6.0. | Pain disrupts sleep onset and maintenance; inflammation (e.g., biceps tendinopathy) may contribute. | Sleep initiation and maintenance disorders due to pain and immobilization. | Postoperative pain (pVAS 8.3 on POD1) disrupts sleep; slower pain reduction in patients with high baseline PSQI. | Strong bidirectional link: pain → sleep disruption → increased pain sensitivity → worse sleep. | Early postoperative pain control is critical; preoperative sleep assessment may predict recovery; use of sleep trackers feasible. | PSQI improved from 9.5 to 6.4 at 6 weeks (p=0.03). Significant correlation between pVAS decrease and sleep duration increase (p<0.05). Higher preoperative PSQI associated with slower pain and sleep improvement. | Longer follow-up; larger cohorts; study of biceps pathology; personalized sleep-pain management; extended use of wearables. |
| **Highland et al. 2023 (25)** | 305 active-duty service members; 21.6% had OSA; shoulder surgery patients had higher presurgical sleep disturbance (median 56.1) vs. knee (49.2). | Sleep deprivation causes hyperalgesia via deactivation of neural analgesic systems; sleep deficiency lowers pain thresholds. | Sleep disturbance (PROMIS SD) assessed; OSA present in subset; shoulder surgery linked to worse baseline sleep. | Pain behaviors persist postoperatively; sleep disturbance predicts later pain behavior, complicating recovery. | Unidirectional: Sleep disturbance → pain behavior (not vice versa). Pain behavior not autoregressive. | Preoperative sleep screening crucial; early sleep intervention may improve pain-related functioning; PROMIS Pain Behavior useful for tracking recovery. | Presurgical sleep disturbance predicted Week 6 and Month 3 pain behavior. Shoulder patients had worse sleep initially. SEM showed sleep disturbance → pain behavior pathway (p=0.01 presurgery→ Week 6; p=0.03 Week 6→Month 3). | Causal studies; multidimensional sleep/pain measures; objective sleep tracking; intervention trials targeting sleep to improve pain outcomes; establish MCIDs for PROMIS Pain Behavior. |

## Results

### Poor Sleep Predicts Worse Postoperative Pain

The interaction between the sleep disturbances existed before operation and the postoperative pain is not that of correlation. Existing sleep disorders (e.g., insomnia, low sleep quality, OSA) represent a considerable risk

factor in terms of having a greater intensity of postoperative pain and larger opioid intake. Such studies as the meta-analysis conducted by Niklasson et al. (15) concluded that the symptoms of preoperative insomnia increased the risk of experiencing moderate-to-severe pain on the first postoperative day more than twice. It was this unidirectional relationship of poor sleep predicting next-day pain but not the reverse that was most evident in one pediatric study by Rabbitts et al. (18). Besides that, sleep is also another mediator, Waxman et al.(17) demonstrated that in the case of breast cancer patients, smaller physical activity went hand in hand with sleep disturbance, and it, in turn, was correlated with higher levels of pain. In the Obstructive Sleep Apnea (OSA) category, Zhong et al. (20) described it as a powerful predictor of postoperative hyperalgesia, with bad sleep before surgery being a powerful predictor of pain.

**Postoperative Pain Severely Disrupts Sleep Quality**

A problem of postoperative pain has far more than a few night awakenings to put into consideration. It can rather be characterized as a significant attack on the body system of recovery, its sleep architecture, a cyclical system of light and deep sleep and the REM phase. Pain and the system of stress of the body performs the functions of alarms and, thus, does not allow the brain to rest and get deep and restful sleep. Marino silent sleep or SWS cannot go without being very expensive. SWS is the most vital sleep stage to restore energy, tissues and release growth hormone. It is also catastrophic to the assimilation of the information and to the psychical status because the softening of the REM sleep is also adverse. Severe, stabbing pain that substitutes much orthopaedics surgery such as a rotator cuff repair is depicted by the clinical efforts of the doctor, Kim et al. (24) Patients are so afflicted by the pain that they cannot rest, nor do they sleep longer than a few minutes at a time. The sleep, however, so bitterly acquired is of a very low and discontinuous kind, and the aim of the recovery is to escape out of this state.

**The Bidirectional Relationship**

The circle of suffering and sleep is a self-perpetuating, two-lane highway - of counterprove in recuperation. It begins with the inability to relax watching the painful operation during surgery and being a servant to the others as to come and go. This sleep is background to a radical change in an impression of pain whereby the impression of pain is violently exaggerated, and hyperalgesia takes place. According to Haack et al. (2020)(14) sudden lack of activity is unfamiliar to the organism and therefore painful since the cascade of macromolecular inflammatory cytokines is triggered almost concurrently when the pathway of the inhibitory nociceptor is disinhibited. The good, which is mainly the leader in an outcome, will deteriorate as a patient is recovering out of high pressure situation. Once this happens, the patient will wake up feeling more rested and needing more analgesics. This then creates more curiosity of the next evening sleep episode. And the feedback loop is so columnar, especially when it is patients to patients, sleep disorders, narcolepsy of the slow functional recovery, the dose of the opioids that would be needed, the increased risk of chronic pain, and the prolonged hospital stay. It is vital, therefore, that the rationale behind this cycle is deciphered since the development of multitask-based pain management and sleep management systems could disrupt this cycle, resulting in a better patient outcome. The difficulties of pain control in a postoperative case are not to be neglected in this case.

**Challenges for Postoperative Pain Management**

The Obstructive Sleep Apnea (OSA) presents a special issue in the treatment of postoperative pain. It has untreated pain and the first line corrective act, which exacerbates, is stress, high blood pressure and inhibits healing. The first approach to the the problem that comes to mind is that of postoperative pain wherein the OSA patients jump queues of opioid prescription on the grounds of their susceptibility to opioids. Surgical-follow up

pain management, when the patient has OSA, is also a primary candidate since OSA patients breathe because the pain is the next. Postoperative pain medication that is primary also emerges as candidates OSA in case the severe complain is pain. This OSA suffers not alone because of bigger doses pain kill but also. The major issue is pain medicine, but not surgery. Anyway, the pain sedation issue that is also the receptors, the Gali pain sedation mismatch, takes centre stage where the patient is experiencing OSA. The centre of this issue is decided by Gali, weird, as well.

**Integrated Management Strategies**

Even in a situation, there is always the positive side, and this stem will enable the targeted action and comprehension. It ceases to be about practices of isolating the aspects of pain and sleep but rather about taking action plans based on being integrated. Multimodal analgesics with non opioid analgesia (acetaminophen, NSAIDs, gabapentinoids, centralized local aesthetic) are the pillars of this action to assist in alleviating pain by addressing multiple mechanisms pain. The measures of Borowicz et al [23] and other illustrated in patients with OSA come in the progressive reduction of opioid use and consequences of a concentration on above opioid-sparing Augmented analgesia strategies. Beyond the avoidance of opioids, the sedatives dexmedetomidine and melatonin are immeasurably valuable due to their sleep inducing and analgesia promoting effects. Furthermore, CBT-I techniques are a non-pharmacological intervention, as emphasized by Haack et al. [14] and depicted in the ERAS protocols, to provide the patient with clinically relevant skills to improve his sleep, thus, contributing to the sleep-dependent reduction of pain. There is a concerted injection of pain and sleep management ERAS that is tiered and promotes the idea that improved sleep is an objective of pain management.

**Clinical Implications**

First among the actions to be undertaken in clinical practice under the new integrated care models may be the implementation of sleep screening as a routine pre-operative procedure based on valid measures such as STOP-Bang to evaluate OSA and Insomnia Severity Index as Niklasson et al. (2025)(15) and Zhong et al. (2025)(20) have clearly demonstrated that sleep problems before surgery significantly exacerbate pain. CPAP therapy should also be considered in pre-operative optimization of such patients by pre-treating them with this type of therapy. Similarly, the possible detriments of opioids in patients with sleep disorders, in particular, OSA, need tighter standard operating procedures to endorse the concept of opioid sparing in the context of multimodal analgesia. Cozowicz et al. (2019)(23) are a firm advocate of the fact that this significantly enhances the results. Lastly, in hospitals, non-pharmacological, such as clustered care, should be set as active measures to alleviate sleep disruption during rest periods.

## Discussion

Disturbance of sleep is a common occurrence after surgery with severe adverse consequences that include slow-paced recovery, cognitive decline, pain sensitivity, and cardiovascular incidents. Rampes et al study shows that multifactorial development of postoperative sleep disturbance involves inflammatory response following surgery, the severity of surgical trauma, pain, anxiety, anesthetic medication and external conditions such as nocturnal noise and light intensity. In our work, where it can be shown that interdependence of postoperative pain and sleep is a self-sustaining cycle, which significantly impairs recovery. In order to effectively break this cycle concerted efforts are required to rule out preoperative sleep disorders, pre and post operative levels of noise and light that impact the environment and also focus on the quality of sleep and pain management.

Therefore, the issue of prioritizing sleep health is not a question of sleep but one of the key contributors to a successful recovery after surgery.

Kifle et al., 2024 showed that Opioid-Sparing Analgesia Pain management, using Multimodal Analgesia methods along with the use of sleep promotion strategies is significant since sleep disorders adversely impact recovery (26). Non-pharmacological treatment, such as music therapy or low-dose dexmedetomidine and melatonin, are good non-opioid pharmacological measures and also These interventions lead to successful pain management, reduced anxiety, better sleep, and general optimized recovery. Other studies by R. Kaw et al., 2012 indicate that the outcome of sleep disruption following surgery is adverse. Disturbed and inadequate sleep of patients significantly increased the risk of prolonged recovery, prolonged hospitalization, postoperative cognitive impairments, delirium, cardiovascular complications, and pain. R. Kaw et al., 2012 explained that the pain is not the only determinant of the sleep in postoperative recovery, and sleep disorders particularly obstructive sleep apnea are complications in postoperative recovery (27). The OSA patients are more susceptible to delayed recovery, respiratory complications, cardiovascular instability and prolonged stay in hospital. Continuous positive airway pressure (CPAP) therapy has been suggested as recommended in a few cases to decrease the poor outcomes and improve surgical recovery. Berezin et al., 2023 found that sleep disorders, such as sleep apnea, insomnia, disturbances of circadian rhythms, parasomnias and hypersomnia have the potential to have a profound impact on the outcome of surgical procedures(28). Fadayomi et al., 2018 reveled that Preoperative screening instruments like STOP-Bang can be used to distinguish those patients who are at risk especially when it comes to sleep apnea. CPAP therapy can contribute to the prevention of complications in patients with obstructive sleep apnea and implementation of multimodal analgesia can help to decrease the need of opioid use that may otherwise intensify sleep disturbance and respiratory complications (29). The current research is also indicative to the fact that establishing a sleep-friendly hospital environment promotes post-operative recovery.

The sleep quality and sleep continuity before surgery are poor factors that can predispose acute pain after surgery and augment analgesic use with adverse recovery repercussions to mental and physical well-being. Nagappa et al., 2017 conducted a study involving 1226 participants where the moderate to severe symptoms of preoperative insomnia jointly demonstrated clinical significance of pain on the first day of postoperative day (30). Pivetta et al., 2022 showed a relatively high level of the symptom relationships between the preoperative insomnia and disrupted continuity of sleep and worse acute and sub-acute pain management. The risk factor that can be changed that the state is insomnia where any interventions of sleep before surgery can help manage postoperative pain (31). In our research it shows that sleep deprivation enhances the sensitivity to pain and that painfulness disrupts restful sleep. The result of this vicious cycle is further pain in the increased opioid use, and the extended hospitalization.

Soh et al., 2024 have pointed to multiple comorbidities in relation to the sleep disturbance following post-operative that include delayed recovery, protracted hospital stays, POCD, delirium, cardiovascular events and escalation of pain, Cognitive dysfunction, depression and anxiety, chronic pain syndromes, systemic inflammation, GERD, falls and functional decline. In order to focus on early recovery after the operation, it is preferable to sleep well in the absence of pain to ensure that a patient recovers fast and returns to normal ADLs (32).

**Future Directions**

Despite growing recognition, significant gaps remain, charting a clear course for future research. A primary need is for high-quality, randomized controlled trials (RCTs) to test the efficacy of integrated sleep-pain interventions, such as combining pre-operative cognitive-behavioral therapy for insomnia (CBT-I) with multimodal analgesia. Future studies must also move beyond subjective sleep measures to incorporate objective data from polysomnography or wearable devices to precisely quantify sleep architecture and its disruption. Research should expand into underrepresented surgical populations, such as those with breast or lung cancer, and explore the therapeutic potential of specific agents like dexmedetomidine. Mechanistic studies are needed to further elucidate the shared neurobiological pathways, including inflammation, endocrine responses, and central sensitization, that underlie the bidirectional cycle. large prospective studies are required to develop and validate outcome-based, personalized care protocols that effectively break the pain-sleep cycle, ultimately improving recovery and preventing the transition to chronic pain.

## Conclusion

The relationship between postoperative pain and sleep is a self-perpetuating cycle that critically impairs recovery. Poor sleep heightens pain sensitivity, while pain itself disrupts restorative sleep. This vicious cycle leads to increased suffering, higher opioid use, and longer hospital stays. Effectively breaking this cycle requires integrated strategies that simultaneously target both pain management and sleep quality. Therefore, prioritizing sleep health is not just about rest, but a fundamental component of effective surgical recovery.

## References


1. Butris N, Tang E, Pivetta B, He D, Saripella A, Yan E, et al. The prevalence and risk factors of sleep disturbances in surgical patients: A systematic review and meta-analysis. Sleep Med Rev. 2023;69:101786.
2. Li R, Chen N, Wang E, Tang Z. Correlation between preoperative sleep disorders and postoperative delayed neurocognitive recovery in elderly patients. Zhong Nan Da Xue Xue Bao Yi Xue Ban. 2021;46(11):1251-9.
3. Bukhari MAA, Alghtani MAM, Aljohani Z, Qasem A, Alhazmi I. Diagnosis and treatment of sleep disorders: A brief review. International Journal of Medicine in Developing Countries. 2021;5(1):364-9.
4. Deflandre E, Brichant JF. Obstructive sleep apnoea and postoperative complications: A significant link? Anaesth Crit Care Pain Med. 2019;38(5):431-3.
5. Walton LL, Duff E, Arora RC, McMillan DE. Surgery patients' perspectives of their role in postoperative pain: A scoping review. International journal of nursing studies advances. 2023;5:100124.
6. Willingham M, Rangrass G, Curcuru C, Abdallah AB, Wildes TS, McKinnon S, et al. Association between postoperative complications and lingering post-surgical pain: an observational cohort study. British journal of anaesthesia. 2020;124(2):214-21.
7. O'Gara BP, Gao L, Marcantonio ER, Subramaniam B. Sleep, Pain, and Cognition: Modifiable Targets for Optimal Perioperative Brain Health. Anesthesiology. 2021;135(6):1132-52.
8. Luo J, Zhang X, Tan X, Chen J, Tang M. Targeting postoperative sleep disorders: Current advances and emerging directions in stellate ganglion block therapy. Medicine (Baltimore). 2025;104(29):e43256.
9. Rampes S, Ma K, Divecha YA, Alam A, Ma D. Postoperative sleep disorders and their potential impacts on surgical outcomes. Journal of biomedical research. 2020;34(4):271.
10. Varallo G, Giusti EM, Manna C, Castelnuovo G, Pizza F, Franceschini C, et al. Sleep disturbances and sleep disorders as risk factors for chronic postsurgical pain: a systematic review and meta-analysis. Sleep Medicine Reviews. 2022;63:101630.
11. Xu W, Zheng Y, Suo Z, Yang Y, Yang J, Wang Q, et al. Potential vicious cycle between postoperative pain and sleep disorders: A bibliometric analysis. Heliyon. 2024;10(15).
12. Gali B, Whalen FX, Schroeder DR, Gay PC, Plevak DJ. Identification of patients at risk for postoperative respiratory complications using a preoperative obstructive sleep apnea screening tool and postanesthesia care assessment. Anesthesiology. 2009;110(4):869-77.

13. Kaw R, Chung F, Pasupuleti V, Mehta J, Gay P, Hernández AV. Meta-analysis of the association between obstructive sleep apnoea and postoperative outcome. British journal of anaesthesia. 2012;109(6):897-906.
14. Haack M, Simpson N, Sethna N, Kaur S, Mullington J. Sleep deficiency and chronic pain: potential underlying mechanisms and clinical implications. Neuropsychopharmacology. 2020;45(1):205-16.
15. Niklasson A, Finan PH, Smith MT, Forsberg A, Dietz N, Kander T, et al. The relationship between preoperative sleep disturbance and acute postoperative pain control: a systematic review and meta-analysis. Sleep medicine reviews. 2025;79:102014.
16. Strutz P, Kronzer V, Tzeng W, Arrington B, McKinnon S, Ben Abdallah A, et al. The relationship between obstructive sleep apnoea and postoperative delirium and pain: an observational study of a surgical cohort. Anaesthesia. 2019;74(12):1542-50.
17. Waxman JA, Shenouda KG, Lin H-S. Assessment and management of postoperative pain associated with sleep apnea surgery. Otolaryngologic Clinics of North America. 2020;53(5):765-77.
18. Rabbitts JA, Zhou C, Narayanan A, Palermo TM. Longitudinal and temporal associations between daily pain and sleep patterns after major pediatric surgery. The Journal of Pain. 2017;18(6):656-63.
19. Pan Z, Liu Q, Chen Y, He H, Yin J, Li Y. Correlation between pain sensitivity and postoperative sleep disturbance in adult patients undergoing intestinal polypectomy under general anaesthesia: a prospective cohort study. BMJ open. 2025;15(7):e100753.
20. Zhong Z, Lu X, Zhang Q, Zhang Y. Obstructive Sleep Apnea and Postoperative Hyperalgesia in Bariatric Surgery: A Prospective Observational Cohort Study. Journal of Pain Research. 2025:4527-38.
21. Nassar JE, Singh M, Knebel A, Daher M, Alsoof D, Diebo BG, et al. The correlation of sleep disorders with postoperative outcomes in spine surgery: A narrative review. North American Spine Society Journal (NASSJ). 2025;21:100586.
22. Wilson JM, Franqueiro AR, Rosado E, Falso VR, Muñoz-Vergara D, Smith MT, et al. Preoperative decreased physical activity is associated with greater postoperative pain: the mediating role of preoperative sleep disturbance. Supportive Care in Cancer. 2024;32(7):429.
23. Cozowicz C, Poeran J, Zubizarreta N, Liu J, Weinstein S, Pichler L, et al. Non-opioid analgesic modes of pain management are associated with reduced postoperative complications and resource utilisation: a retrospective study of obstructive sleep apnoea patients undergoing elective joint arthroplasty. British journal of anaesthesia. 2019;122(1):131-40.
24. Kim H, Lee J, Koh KH. Effect of arthroscopic repair on sleep disturbances in rotator cuff tear patients: A prospective cohort study analyzing short-term postoperative pain correlations. Journal of Orthopaedic Surgery. 2025;33(2):10225536251357319.
25. Highland KB, Parry J, Kent M, Patzkowski JC, Patzkowski MS, Herrera G, et al. Lagged effect of Patient-Reported outcomes measurement information system (PROMIS) sleep disturbance on subacute Postsurgical PROMIS pain behavior. Journal of Orthopaedic Research®. 2023;41(4):711-7.
26. Kifle F, Kenna P, Daniel S, Maswime S, Biccard B. A scoping review of Enhanced Recovery After Surgery (ERAS), protocol implementation, and its impact on surgical outcomes and healthcare systems in Africa. Perioper Med (Lond). 2024;13(1):86.
27. Kaw R, Pasupuleti V, Walker E, Ramaswamy A, Foldvary-Schafer N. Postoperative complications in patients with obstructive sleep apnea. Chest. 2012;141(2):436-41.
28. Berezin L, Nagappa M, Poorzargar K, Saripella A, Ariaratnam J, Butris N, et al. The effectiveness of positive airway pressure therapy in reducing postoperative adverse outcomes in surgical patients with obstructive sleep apnea: A systematic review and meta-analysis. J Clin Anesth. 2023;84:110993.
29. Fadayomi AB, Ibala R, Bilotta F, Westover MB, Akeju O. A Systematic Review and Meta-Analysis Examining the Impact of Sleep Disturbance on Postoperative Delirium. Crit Care Med. 2018;46(12):e1204-e12.
30. Nagappa M, Ho G, Patra J, Wong J, Singh M, Kaw R, et al. Postoperative Outcomes in Obstructive Sleep Apnea Patients Undergoing Cardiac Surgery: A Systematic Review and Meta-analysis of Comparative Studies. Anesth Analg. 2017;125(6):2030-7.
31. Pivetta B, Sun Y, Nagappa M, Chan M, Englesakis M, Chung F. Postoperative outcomes in surgical patients with obstructive sleep apnoea diagnosed by sleep studies: a meta-analysis and trial sequential analysis. Anaesthesia. 2022;77(7):818-28.

32. Soh PQP, Wong WHT, Roy T, Tam WWS. Effectiveness of non-pharmacological interventions in improving sleep quality after cardiac surgery: A systematic review and meta-analysis. J Clin Nurs. 2024;33(6):2084-98.