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Sleep quality and its association with recovery in patients undergoing total knee arthroplasty: A systematic review

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☐
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Ethical approval was not required, as the data was sourced from an open-access archive.
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Abstract

Background/Aim: Sleep disturbances are a prevalent but often overlooked issue among patients undergoing total knee arthroplasty (TKA). These disruptions significantly contribute to increased pain, delayed functional recovery, and reduced quality of life. This systematic review examines the association between sleep quality and postoperative recovery outcomes after TKA.

Methods: The review utilized five databases: PubMed, Embase, Ovid/MEDLINE, CINAHL, and Scopus. We identified studies that evaluated sleep quality and recovery outcomes in adult TKA patients. Eligible studies used validated tools such as the Pittsburgh Sleep Quality Index (PSQI), Insomnia Severity Index (ISI), and actigraphy to examine recovery metrics, including pain, mobility, and overall recovery trajectories. A narrative synthesis was conducted to identify patterns and variations across the included studies.

Results: Seven studies, involving a total of 902 patients, were included in this review. Poor sleep quality is consistently correlated with adverse recovery outcomes, such as higher pain levels, slower functional recovery, and diminished quality of life. Quantitative data underscored the association between elevated PSQI scores and delayed recovery metrics. Patients with higher PSQI scores reported elevated pain levels (VAS: 3.8 vs. 1.6) and poorer functional outcomes, as indicated by significantly higher WOMAC-Physical Function scores several weeks after TKA compared to groups with less prominent insomnia ($P<0.05$).

Conclusion: Interventions targeting sleep disturbances, such as behavioral therapies, showed promising benefits. However, methodological variability limited the generalizability of findings. This review emphasizes the critical importance of sleep quality as a modifiable factor in optimizing recovery after TKA. Integrating sleep assessments and targeted interventions, such as cognitive-behavioral therapy for insomnia (CBT-I), into perioperative care can significantly enhance recovery trajectories and patient outcomes. Future research should prioritize standardizing methodologies and investigating the effectiveness of sleep-focused strategies across diverse patient populations.

Keywords: total knee arthroplasty, sleep quality, recovery, Pittsburgh Sleep Quality Index, actigraphy

Introduction

Total knee arthroplasty (TKA) ranks among the most frequently performed orthopedic procedures, primarily aimed at alleviating pain and restoring mobility in individuals with advanced knee osteoarthritis [1,2]. Globally, over a million TKA procedures are conducted annually [3], with this figure expected to rise due to aging populations and increasing rates of osteoarthritis [4]. Success in TKA is conventionally assessed through improvements in pain relief, range of motion, and functional recovery. However, these metrics often neglect other critical factors influencing outcomes, such as sleep quality.

Sleep disturbances are a common yet underrecognized issue in patients undergoing TKA. Poor sleep quality is associated with slower tissue healing, heightened pain sensitivity, and delays in rehabilitation [5,6]. Contributing factors include postoperative pain, restricted mobility, anxiety, and the disruptive nature of hospital environments. Although the relationship between sleep and recovery has been studied in other surgical contexts, its specific impact on TKA recovery remains insufficiently explored [7,8].

Recent research employing validated tools such as the Pittsburgh Sleep Quality Index (PSQI) and Insomnia Severity Index (ISI) has initiated efforts to map the connection between sleep quality and recovery outcomes [9]. Studies demonstrate that sleep quality is linked not only with pain levels but also as a modifiable factor that can significantly enhance physical rehabilitation and overall quality of life [10,11]. Furthermore, interventions like cognitive-behavioral therapy and pharmacological treatments show promise in addressing sleep disturbances and improving outcomes in comparable patient groups [12,13].

Research in this area is expanding, yet there is still a need for a comprehensive review to synthesize current literature, identify emerging knowledge gaps, and offer up-to-date, evidence-based recommendations for clinical practice. This systematic review aims to assess existing evidence on the role of sleep quality in postoperative recovery for patients undergoing TKA. By analyzing the available literature, we intend to evaluate the significance of incorporating sleep-focused interventions into perioperative care plans to optimize recovery outcomes.

Objectives

This systematic review aims to investigate the associations between sleep quality and postoperative pain, functional recovery, and recovery objectives in patients undergoing TKA.

Population, Intervention, Comparator, and Outcomes (PICO)

This review examines adult patients undergoing TKA to determine whether interventions enhancing sleep quality can lead to a measurable reduction in postoperative pain. It compares outcomes for individuals who receive sleep interventions with those experiencing poor sleep or no intervention. In addition to pain management, the review investigates the role of improved sleep in promoting functional recovery, contrasting these outcomes with those in patients whose sleep is not addressed. Finally, it evaluates the broader impact of sleep optimization on overall recovery, including physical rehabilitation, psychosocial adjustment, and quality of life, in comparison to conditions of suboptimal sleep.

Materials and methods

Study design and search strategy

This study adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines. The search strategy targeted five databases: PubMed, Embase, Ovid/MEDLINE, CINAHL, and Scopus. Initial searches commenced on September 13, 2024, and to ensure comprehensive coverage by including recent articles, a secondary search was conducted on November 15, 2024, using the same methodology. The search string "total knee" AND "sleep" was consistently applied across all databases and was developed in consultation with an experienced librarian. In Scopus, the prefix "TITLE-ABS-KEY" was included to restrict searches to titles, abstracts, and keywords. Filters were set to include only English-language primary literature published from 1999 to the search date.

Selection process and study inclusion criteria

The article selection was facilitated by Rayyan software (Rayyan, Qatar Computing Research Institute, Ar-Rayyan, Qatar), which managed duplicate removal and conducted screening at the title, abstract, and full-text levels. Studies were included if they focused on adult patients (18 years or older) who had undergone TKA and assessed sleep quality using validated tools, such as the PSQI, Epworth Sleepiness Scale (ESS), ISI, actigraphy, or structured sleep diaries. Studies were excluded if they did not include recovery outcomes related to pain, mobility, or functional improvement. Additionally, studies without validated sleep measures, those lacking TKA-specific recovery data, and non-primary literature – such as editorials, opinion pieces, surveys, or case reports – were excluded. Screening was conducted by two independent reviewers, with disagreements resolved through consultation with a third reviewer. A PRISMA diagram illustrating the search process is provided in Figure 1.

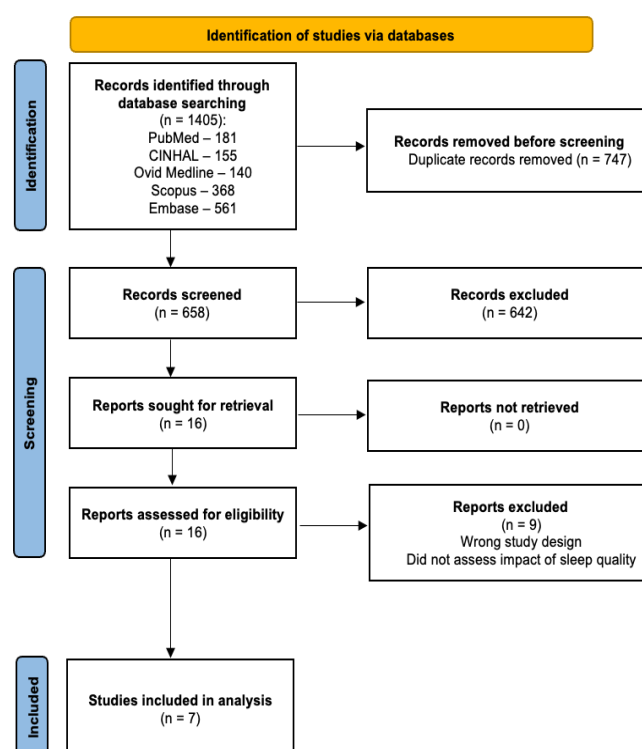Figure 1: PRISMA flow diagram of included studies in systematic review.

Table 1: Study features, methodology, and sleep quality assessments.

Study (year)	Study design	Criteria Inclusion	Exclusion	Validated sleep quality measure	Additional measure	Risk of bias
Gibian et al. (2023)	Prospective observational cohort study	Age ≥18, BMI<45, smartphone ownership	Revision/bilateral TKA, pregnancy, narcotic dependence, neurological disorders, peripheral vascular disease, prisoners	PSQI	Fitbit Inspire HR wearable device	Low
Hamilton et al. (2023)	Prospective observational cohort study	Age ≥45, fluent in English, and meeting American College of Rheumatology criteria for KOA	Cognitive disorders, autoimmune disorders, recent MI, severe Raynaud symptoms, moderate-to-severe peripheral neuropathy	ISI	–	Medium
Mukartihal et al. (2022)	Prospective observational cohort study	Patients undergoing elective primary TKA, consenting to participate and complete outcome surveys	Revision/complex TKA, history of sleep disorders, psychiatric disorders, and prior knee surgeries	PSQI	–	Low
Owens et al. (2023)	Prospective observational cohort study	Age ≥45, KOA diagnosis, scheduled for unilateral TKA, proficient in English, stable medication use for one month prior	Cognitive disorders, cardiovascular conditions, peripheral neuropathy, pregnancy, and systemic inflammatory conditions (e.g., rheumatoid arthritis)	ISI	2-item Sleep and Pain Behavior Scale (SP2) developed for this study	Medium
Hamai et al. (2023)	Retrospective cohort study	Primary TKA performed ≥18 months prior to the study with patient-reported outcomes data	None explicitly mentioned, but focus was on patients with adequate follow-up and data	PSQI	–	High
Herrero-Sánchez et al. (2014)	Cross-sectional observational study	Elderly patients with TKA performed within one month of the study	Previous TKA, lower extremity or cervical surgery, radiculopathy, myelopathy, fibromyalgia, cognitive impairment, or rehabilitation within 6 months	PSQI	–	Medium
Hughes et al. (2018)	Prospective observational cohort study	Adults scheduled for primary TKA	Not explicitly listed	ISI	3-item Sleep-Pain Behaviors Survey (SPBS); actigraphy	Medium

Dashes (–) indicate not reported. BMI: Body Mass Index, TKA: Total Knee Arthroplasty, PSQI: Pittsburgh Sleep Quality Index, ISI: Insomnia Severity Index.

Risk of bias and quality of evidence

The ROBINS-I V2 tool (Risk of Bias in Non-randomized Studies of Interventions Version 2) was used to assess the quality of the studies. This approach facilitated a comprehensive evaluation of the studies

Risk of bias and quality assessment: Observational studies inherently carry a higher risk of bias compared to randomized controlled trials due to the absence of randomization and control groups. This limitation increases their vulnerability to confounding and selection bias, as the included populations may not accurately represent the broader patient population. Furthermore, observational studies often face information and measurement biases because of the lack of standardized outcome measures or blinding. Publication bias is also a concern, with studies reporting positive or significant findings being more likely to be published. Despite these challenges, observational studies, such as case-control and cohort studies, provide valuable insights, especially for conditions difficult to investigate through randomized trials. However, their findings tend to be associative rather than causal, and their generalizability is limited. These factors highlight the need for a cautious interpretation of their results.

Level of evidence and grade of recommendation: This systematic review encompasses studies including RCTs, cohort, observational, and retrospective studies. The evidence's overall level is categorized as Level 2, indicative of observational data frequently employed to report rare conditions or unique clinical outcomes. Observational studies, comprising well-designed cohorts, case-control, or large case series, generally fall under Level 2 evidence. While these studies deliver moderate-quality evidence, they may entail some bias risk due to confounding variables, lack of randomization, or incomplete data. These studies are valuable for identifying associations and generating hypotheses, yet they might lack the rigor associated with randomized controlled trials. Consequently, a Grade B recommendation is assigned based on this evidence level. This grade denotes consistent or moderately strong evidence suggesting that an intervention or finding is likely to enhance outcomes. Nonetheless, further validation through higher-level studies may be necessary to confirm its efficacy and generalizability.

Data extraction and statistical analysis

Data collection from all five databases was conducted by two independent authors (VMVJ, MN). They systematically extracted data into a customized spreadsheet to ensure consistency and accuracy across the studies. The variables gathered included patient demographics, sample sizes, sleep quality assessment tools, recovery metrics, and key findings. Numerical data, such as means and standard deviations, were recorded, while ranges were noted to account for study heterogeneity. A narrative synthesis approach was employed, focusing on trends, commonalities, and variations in the findings. Results were organized thematically to explore the influence of sleep quality on postoperative outcomes, including pain, mobility, and overall recovery trajectories. Adverse events were also documented. Discrepancies, if any, were resolved through consultation with a third reviewer.

Results

Overview of included studies

A search across five databases initially identified 1,405 studies. After removing duplicates and conducting abstract screenings and full-text reviews based on inclusion and exclusion criteria, seven articles were selected for inclusion in our systematic review. This entire process is detailed in the PRISMA flowsheet (Figure 1). All included studies had received the necessary ethical approval before publication. The studies were all observational in design; specifically, there were five prospective observational cohort studies, one retrospective cohort study, and one cross-sectional observational study. No randomized controlled trials met the inclusion criteria. Table 1 provides further details on the study characteristics, methodologies, and tools used to assess sleep quality. Four studies exclusively employed a single validated sleep measure, either the PSQI or the ISI, while three studies used at least one additional measure, such as self-created surveys, actigraphy, or other methods.

Impact of sleep quality on pain outcomes

Four studies investigated the impact of sleep quality on pain outcomes following TKA. Gibian et al. [14] found that patients who reported "very bad" sleep at 30 days postoperatively had significantly higher pain scores, with average VAS scores of 3.8 compared to 1.6 in those reporting "bad" sleep (P=0.010). Moreover, device-measured sleep duration remained stable postoperatively and did not show a significant correlation with pain outcomes (preoperative: 5.9 h; 60 days post-TKA: 5.6 h; 90 days post-TKA: 5.8 h). Hamilton et al. [15] reported that persistent perioperative insomnia was associated with higher pain scores at all postoperative time points. Participants with persistent insomnia showed a slower decline in WOMAC-Pain scores compared to those with improved insomnia, new insomnia, or no insomnia. Although all groups' WOMAC-Pain scores fell below the clinical threshold (≤ 30) at 12 months post-TKA, the persistent insomnia group had a less pronounced reduction, decreasing from 47.74 at baseline to 15.14 (P<0.05). Similarly, Mukartihal et al. [16] found that PSQI scores increased significantly during the first six postoperative weeks (mean 13.48 vs. preoperative mean 1.98, P<0.001); as sleep quality returned to near-baseline levels by 1 year (mean PSQI 2.10, P=0.15), Knee Society Scores (KSS) – which include pain measures – improved from a preoperative mean of 52.00 (9.98) to 71.67 (6.58) at 6 weeks and 85.49 (4.67) at 1 year postoperatively (P<0.001). Owens et al. [17] found that insomnia symptoms at 6 weeks postoperatively, indicated by peak ISI scores of 12.42, mediated the relationship between maladaptive presurgical sleep behaviors and long-term pain outcomes.

Impact of sleep quality on functional recovery

Four studies were included that assessed sleep quality and functional recovery. A retrospective review/observational study by Hamilton et al. [15] found that participants with persistent perioperative insomnia had significantly worse physical function at 6 weeks postoperatively, with WOMAC-Physical Function scores above the clinical threshold of ≤ 30 (M=36.80) and significantly higher than all other trajectories (P<0.05). Participants in the new insomnia group also had elevated scores (M=28.13) compared to the Improved Insomnia and No Insomnia groups (P<0.05). However, by 12 months, there were no statistically significant differences in physical function among groups. A similar review/observational study by Mukartihal et al. [16] reported that early postoperative sleep disturbances, reflected in elevated PSQI scores (mean 13.48 at 1 week postoperatively), were linked to delayed functional recovery, as measured by KSS. As sleep quality improved over time, functional outcomes also improved, with KSS rising from 71.67 at 6 weeks to 85.49 at 1 year. Owens et al. [17] identified maladaptive presurgical sleep behaviors as facilitators of poorer functional outcomes, as seen in WOMAC-Physical Function scores at 6 weeks (b=7.026, P=0.007). Hamai et al. [18] observed a significant association between better functional capability, indicated by a mean Knee Society Score of 62 (22), and fewer sleep disturbances at midterm follow-up.

Relationship between sleep quality and overall recovery trajectory

Herrero-Sánchez et al. [19] found that patients with poor sleep quality (mean PSQI score of 11.2) experienced significantly reduced physical function, as evidenced by lower SF-36 scores (40.8 [22.9] compared to 68.3 [19.9] in controls, P<0.001), and greater disability, indicated by higher WOMAC scores (35.0 [19.2] versus 23.71 [15.04], P=0.036). These findings underscore the detrimental impact of inadequate sleep on health-related quality of life, hindering engagement in daily activities during recovery. Additionally, Hughes et al. [20] demonstrated the longitudinal impact of maladaptive sleep-pain behaviors on recovery. Persistent insomnia symptoms, assessed with the ISI, were linked to heightened pain severity (B=0.32, P<0.001) and poorer physical function (WOMAC, B=1.71, P<0.01) over the first postoperative year.

Discussion

Our systematic review highlights the significant relationship between sleep quality and critical components of postoperative recovery following TKA. Multiple studies indicate that poor sleep, particularly persistent perioperative insomnia, is closely associated with increased pain levels, slower pain resolution, and delayed functional improvement. Patients with poor sleep consistently reported greater pain intensity at various postoperative stages, and those with similar sleep disturbances experienced prolonged impairments in physical function. For instance, Hamilton et al. [15] found that patients with persistent insomnia exhibited significantly worse physical function during early recovery. Notably, these differences are mostly diminished by the 12-month post-TKA mark, suggesting that while insomnia may initially hinder functional recovery, its long-term impact may be limited or requires further investigation. Furthermore, our findings show that inadequate sleep correlates with worse overall recovery trajectories, including diminished health-related quality of life and increased debilitation. Collectively, our observations suggest that proactively addressing sleep disturbances in the perioperative phase may be essential for optimizing pain management and functional recovery following TKA in adult patients.

A study by Nuñez et al. [21] also found that restorative sleep and regular physical activity were linked to improved physical function and reduced pain in individuals with long-term knee osteoarthritis. Patients who experienced better sleep quality and participated in physical activity showed enhanced functional capacity and an improved overall quality of life. These findings emphasize the interconnected role of sleep, aligning with previous research indicating that sleep disruptions can intensify pain perception [22,23]. This suggests that optimizing sleep quality may be crucial for rehabilitation and functional recovery following TKA.

Unlike previous studies that have demonstrated a notable connection between sleep quality and functional recovery, Van Meirhaeghe et al. [8] found a different pattern. Their study revealed that although sleep quality improved following total knee and hip arthroplasty, it was more closely linked to patient satisfaction than to functional outcomes. Despite a significant number of patients reporting better sleep postoperatively, the association between improved sleep and enhanced physical function remained weak according to their findings. This suggests that factors other than sleep might more significantly influence postoperative functional recovery. Although other studies have

documented that this relationship may be mediated by inflammatory pathways and psychosocial stressors [24,25], the existing discrepancies highlight the need for further investigation into the specific mechanisms by which sleep contributes to rehabilitation outcomes in arthroplasty patients.

Given the variability in findings about the relationship between sleep quality and functional recovery, a targeted clinical approach to perioperative sleep management could optimize postoperative outcomes for TKA patients. Identifying sleep disturbances pre-surgery allows for early interventions, such as cognitive-behavioral therapy for insomnia (CBT-I) or pharmacologic treatment, when appropriate. Incorporating sleep-focused education into rehabilitation programs may also improve patient adherence to recovery protocols, potentially enhancing pain control and mobility. Although optimizing sleep is crucial in postoperative care, it should be integrated with other essential rehabilitation strategies – such as structured physical therapy and multimodal pain management – to ensure a comprehensive and individualized recovery plan.

Future directions and recommendations

We offer several recommendations. First, this review identified a significant correlation between sleep and both pain and functional recovery. Future research should explore interventions aimed at optimizing both perceived and objective sleep quality. Additionally, our search did not identify any randomized controlled trials (RCTs). To clarify the impact of sleep quality on postoperative pain and functional outcomes, we recommend that researchers employ a robust RCT design. Lastly, tailored interventions, such as cognitive-behavioral therapy for insomnia (CBT-I) and pharmacological treatments, warrant further investigation in diverse TKA populations. These interventions may help reduce sleep disturbances and enhance recovery.

Limitations

This study presents several limitations. First, although there is literature on the association of sleep with postoperative outcomes, most studies are observational or retrospective. Additionally, methodological heterogeneity, especially regarding the recovery metrics employed, underscores the need for standardized protocols in future research. Such standardization would facilitate future meta-analyses. Despite these limitations, we consider this article important as it provides up-to-date information, identifies gaps in the literature, and offers recommendations and future considerations for researchers. These contributions are crucial for improving sleep and postoperative outcomes in patients undergoing TKA.

Conclusion

This systematic review assesses the relationship between sleep quality and recovery outcomes in patients undergoing TKA. Poor sleep quality consistently correlates with increased postoperative pain, slower functional recovery, and diminished overall recovery trajectories. This dynamic between sleep disturbances and recovery emphasizes the need to integrate sleep-focused interventions into perioperative care. However, the variability in methodologies and reliance on subjective measures limit the broader applicability of current findings, highlighting the need for standardized protocols and comprehensive longitudinal studies.

Future research should assess the effectiveness of interventions like cognitive-behavioral therapy for insomnia and utilize objective tools such as actigraphy in diverse TKA populations. Prioritizing sleep quality in postoperative care enables clinicians to address modifiable factors, thereby enhancing recovery and ultimately improving the quality of life for patients undergoing TKA.

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