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Association of Preoperative Sleep Fragmentation with Postoperative Urinary Retention Following Elective Lower-Limb Orthopedic Surgery

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ABSTRACT

Background: Postoperative urinary retention is a complication following lower-limb orthopedic surgery. Conventional risk assessment considers demographic, urological, anesthetic, and perioperative factors, whereas preoperative sleep continuity remains insufficiently investigated. Sleep fragmentation may contribute to autonomic imbalance, pain sensitivity, opioid requirements, delayed mobilization, and impaired bladder function.

Objective: To evaluate the association between preoperative sleep fragmentation and postoperative urinary retention following lower-limb orthopedic surgery.

Methods: This single-center prospective cohort study included 150 adults undergoing elective lower-limb orthopedic procedures at Al-Aleem Medical College affiliated with Gulab Devi hospital, Lahore, Pakistan, from April 2025 to April 2026. Preoperative sleep was assessed using wrist actigraphy for three nights. Participants in the highest tertile of the sleep-fragmentation index were classified as having high fragmentation. The primary outcome was urinary retention within 24 hours, defined as inability to void with a bladder volume ≥500 mL or postvoid residual volume ≥400 mL requiring catheterization. Multivariable logistic regression adjusted for demographic, urinary, anesthetic, and perioperative factors.

Results: Of 150 participants, 78 were female and 72 were male. Postoperative urinary retention occurred in 35 patients (23.3%). Incidence was higher in the high-fragmentation group than in the lower-fragmentation group (40.0% vs. 15.0%; p=0.001). High fragmentation remained independently associated with urinary retention (adjusted odds ratio, 3.21; 95% confidence interval, 1.35–7.63; p=0.008) and was associated with delayed voiding, repeated catheterization, and longer hospitalization.

Conclusion: Preoperative sleep fragmentation was associated with postoperative urinary retention in both sexes. Multicenter studies are required to validate its value for perioperative bladder-risk stratification.

Keywords: actigraphy; lower-limb orthopedic surgery; postoperative urinary retention; preoperative sleep; sleep fragmentation; urinary catheterization

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INTRODUCTION

Postoperative urinary retention is a clinically important and frequently underestimated complication following lower-limb orthopedic surgery [1,2]. It may cause painful bladder distension, repeated catheterization, urinary tract infection, delayed mobilization, prolonged hospitalization, and disruption of enhanced recovery pathways. Preoperative sleep disturbance may also adversely affect postoperative recovery by increasing pain sensitivity and analgesic requirements [3].

Established risk factors for postoperative urinary retention include advanced age, male sex, benign prostatic enlargement, lower urinary tract symptoms, increased baseline postvoid residual volume, diabetes mellitus, prolonged surgery, spinal anesthesia, and excessive intravenous fluid administration [4]. Bladder scanning and

timely catheterization procedures might help to detect it early and minimize unnecessary bladder catheterization [5,6].

Patients who are undergoing orthopedic surgery, especially those with chronic pain, limited mobility, anxiety, nocturia and worries about the surgery are likely to have poor sleep [7]. Following hip, knee, ankle or foot surgery, there may be factors that make urinary retention more likely, such as anesthesia, postoperative pain, the use of opioids, fluid therapy and temporary immobility [8,9]. Poor sleep has also been linked to increased postoperative pain and decreased recovery outcomes [10].

General anesthesia or neuraxial anesthesia can diminish bladder sensation and disrupt the coordination of voiding. Opioids can also affect the ability to empty the bladder as it causes a decrease in detrusor function, an increase in resistance to the flow of urine and a delay in the recognition of bladder fullness. These effects are part of the causes of post-operative urinary retention after TKA and other orthopedic surgeries [11,12]. Bladder-monitoring protocols based on evidence may help to limit unnecessary bladder catheters without putting patients at risk [13].

Sleep fragmentation refers to repeated awakenings or frequent transitions into lighter sleep, resulting in disrupted sleep continuity despite an apparently adequate sleep duration. Objective studies have demonstrated substantial perioperative sleep disturbance among patients undergoing total hip and knee arthroplasty [14]. Although numerous demographic, urological, anesthetic, and procedural predictors of postoperative urinary retention have been investigated, considerable variation remains in its reported incidence and associated factors [15,16].

Fragmented sleep may contribute indirectly to impaired postoperative voiding through increased pain, greater opioid exposure, fatigue, reduced alertness, and delayed mobilization. These factors may postpone independent toileting and increase the likelihood of bladder overdistension. Enhanced recovery recommendations emphasize multimodal analgesia, early mobilization, appropriate fluid management, and avoidance of unnecessary urinary catheterization [17]. Poor preoperative sleep quality has also been associated with greater postoperative pain and impaired functional recovery after joint arthroplasty [18].

Despite extensive evaluation of conventional predictors of postoperative urinary retention in fast-track orthopedic surgery [19], the role of objectively measured preoperative sleep fragmentation remains inadequately investigated. Subjective sleep questionnaires may be affected by recall bias and may not accurately capture nocturnal awakenings or disrupted sleep continuity. Wrist actigraphy provides a practical, noninvasive method for measuring total sleep time, sleep efficiency, wake after sleep onset, nocturnal awakenings, and sleep fragmentation across several nights [20].

Therefore, this study aimed to evaluate the association between objectively measured preoperative sleep fragmentation and postoperative urinary retention following elective lower-limb orthopedic surgery and to determine whether this association persisted after adjustment for established demographic, urological, anesthetic, and perioperative factors. We hypothesized that greater preoperative sleep fragmentation would be associated with postoperative urinary retention, delayed spontaneous voiding, and increased catheterization.

MATERIALS AND METHODS

This single-center prospective observational cohort study was conducted in the Departments of Orthopedic Surgery and Anesthesiology at Al-Aleem Medical College affiliated with Gulab Devi hospital, Lahore, Pakistan, from April 2025 to April 2026. Ethical approval was obtained from the Institutional Review Board of Al-Aleem Medical College before commencement of the study (IRB/AMC/2025/025). Written informed consent was obtained from every participant before enrollment. Participant data were coded and kept confidential throughout data collection and analysis.

A consecutive non-probability sampling technique was used to recruit 150 adults aged 18–80 years who were scheduled for elective lower-limb orthopedic surgery under spinal or general anesthesia. Participants were followed for at least 24 hours after surgery. Eligible procedures included total knee arthroplasty, total hip arthroplasty, anterior cruciate ligament reconstruction, corrective knee surgery, ankle arthrodesis or fixation, and elective foot surgery. The sample size was calculated using expected postoperative urinary-retention rates of 15% in patients with lower sleep fragmentation and 35% in those with high sleep fragmentation, with 95% confidence, 80% power, and an anticipated 2:1 allocation ratio. Accordingly, the final cohort comprised 100 participants in the lower-fragmentation group and 50 in the high-fragmentation group.

Adults undergoing an eligible elective procedure who could provide informed consent, complete preoperative sleep monitoring, and undergo postoperative bladder assessment were included. Patients undergoing emergency, trauma, or revision surgery were excluded. Other exclusion criteria were preoperative urinary catheterization, active urinary tract infection, neurogenic bladder, chronic urinary retention requiring catheterization, end-stage renal disease, urinary diversion, severe cognitive impairment, untreated severe obstructive sleep apnea, planned catheterization for more than 24 hours, fewer than two valid actigraphy nights, or cancellation of the scheduled procedure.

Demographic and clinical data were collected three to five days before surgery. Recorded variables included age, sex, body mass index, smoking status, American Society of Anesthesiologists physical-status class, diabetes mellitus,

hypertension, chronic kidney disease, previous urinary retention, lower urinary tract symptoms, and use of sleep-related or bladder-active medications. Male participants were assessed for benign prostatic hyperplasia, and symptomatic males completed the International Prostate Symptom Score. Female participants were assessed for previous pelvic surgery, pelvic organ prolapse, urinary incontinence, recurrent urinary tract infection, and symptoms of incomplete bladder emptying.

Baseline postvoid residual volume was assessed after voluntary voiding using a portable bladder scanner. Three measurements were obtained within 15 minutes after voiding, and the mean value was used in the analysis. The same measurement protocol was followed for all participants.

Preoperative sleep was objectively assessed using an ActiGraph wGT3X-BT device worn on the nondominant wrist for three consecutive nights. Participants maintained their usual sleep schedules and documented bedtime, waking time, nocturnal awakenings, daytime naps, device removal, evening caffeine intake, and sleep-medication use in a sleep diary. Actigraphy data were processed using ActiLife version 6.13.5. Recorded sleep parameters included total sleep time, sleep-onset latency, sleep efficiency, wake after sleep onset, number of nocturnal awakenings, and sleep-fragmentation index.

A recording night was considered valid when at least six hours of usable actigraphy data were available. At least two valid nights were required for inclusion, and mean values across all valid nights were used. Participants with fewer than two valid nights were excluded before exposure classification. Sleep diaries and device-wear records were reviewed to identify periods of device removal and distinguish nonwear time from wakefulness.

The sleep-fragmentation index was the main exposure variable. Participants in the highest tertile of the observed index were classified as having high sleep fragmentation, whereas those in the lower two tertiles were classified as having lower sleep fragmentation. The resulting groups comprised 50 and 100 participants, respectively. This tertile-based classification was derived from the study population and was not treated as an externally validated clinical cutoff. The fragmentation index was also analyzed continuously for every 10-unit increase. Subjective sleep quality was assessed using the Pittsburgh Sleep Quality Index, with a score greater than 5 indicating poor sleep quality.

The choice of anesthetic technique depended on the participant's clinical status and the procedure's needs and was determined by the anesthesiologist in attendance. Surgery was conducted under either hyperbaric bupivacaine spinal anesthesia or standard induction and maintenance agents for general anesthesia. When clinically indicated, peripheral nerve blocks and intrathecal opioids were used. Urinary Catheters were not routinely used preoperatively. Preoperatively recorded variables included anesthetic technique, use of peripheral nerve-blocks, administration of intrathecal opioids, duration of anesthetic, duration of surgery, estimated blood loss, intravenous fluid volume, vasopressor use, intraoperative hypotension and temporary catheterization. Intraoperative hypotension was defined as a mean arterial pressure below 65 mmHg and/or a decrease of ≥ 20% from baseline mean arterial pressure for ≥ 5 minutes.

Postoperative analgesia was conducted using a standardized multimodal approach, which included paracetamol, nonsteroidal anti-inflammatory drugs (NSAIDs) unless contraindicated, regional analgesia techniques and rescue opioids as required. The amount of opioids used in the first 24 hours after surgery were converted to oral morphine equivalent dose. The intensity of pain was measured at 2, 6, 12, and 24 hours using the numerical rating scale (NRS) for pain intensity (0-10). Time to first assisted standing/mobilization was documented.

Bladder function was monitored for 24 hours after surgery. Portable bladder ultrasonography was performed on arrival in the post-anesthesia care unit and every three hours thereafter until spontaneous voiding occurred. Additional scans were performed when urinary symptoms developed or when a participant was unable to void. Postvoid residual volume was measured within 15 minutes of the first spontaneous void using the mean of three bladder-scan readings. Time to first spontaneous void, maximum postoperative bladder volume, postvoid residual volume, number of catheterizations, and duration of catheter use were recorded.

Intermittent catheterization was performed when a participant was unable to void with a bladder volume of at least 500 mL or had a postvoid residual volume of at least 400 mL requiring decompression. An indwelling catheter was inserted following recurrent urinary retention, two intermittent catheterizations within eight hours, or when considered clinically necessary by the treating team.

The primary outcome was postoperative urinary retention within 24 hours, defined as inability to void with a bladder volume of at least 500 mL requiring catheterization or a postvoid residual volume of at least 400 mL requiring decompression. Secondary outcomes included time to spontaneous voiding, maximum bladder volume, repeated intermittent catheterization, indwelling catheterization for more than 24 hours, postoperative opioid consumption, pain intensity, time to mobilization, symptomatic urinary tract infection, and length of hospital stay.

Demographic, urological, surgical, anesthetic, and postoperative factors were considered potential confounders. Personnel performing postoperative bladder assessments were blinded to participants' sleep-fragmentation classification. Actigraphy data were processed and exposure groups were finalized after

postoperative follow-up to minimize any influence of sleep status on bladder-monitoring or catheterization decisions.

Data were analyzed using IBM SPSS Statistics version 27.0. Continuous variables were presented as mean±standard deviation or median with interquartile range and compared using the independent-samples t test or Mann–Whitney U test, as appropriate. Categorical variables were compared using the chi-square test or Fisher's exact test. Multivariable logistic regression was used to examine the association between sleep fragmentation and urinary retention, with clinically relevant variables and factors having univariable $p<0.20$ considered for adjustment. Crude and adjusted odds ratios with 95% confidence intervals were reported, and the interaction between sex and fragmentation was tested. Multicollinearity was assessed using variance inflation factors, calibration with the Hosmer–Lemeshow test, and discrimination using the area under the receiver-operating-characteristic curve with a 95% confidence interval. Sensitivity analyses used a 600-mL retention threshold, excluded males with benign prostatic hyperplasia, and additionally adjusted for total sleep time and Pittsburgh Sleep Quality Index score. All tests were two-sided, and $p<0.05$ was considered statistically significant.

RESULTS

The current study included 150 participants: 78 females (52.0%) and 72 males (48.0%). Fifty participants were classified as having high sleep fragmentation and 100 as having lower sleep fragmentation. Postoperative urinary retention occurred in 35 participants (23.3%).

Participants with high sleep fragmentation were older than those with lower fragmentation (61.8±10.3 vs. 57.6±10.8 years; p=0.023), while sex distribution, body mass index, comorbidities, previous urinary retention, benign prostatic hyperplasia, and previous pelvic surgery were comparable. The high-fragmentation group had a greater preoperative postvoid residual volume (69.6±35.1 vs. 51.8±29.5 mL; p=0.003), shorter total sleep time, lower sleep efficiency, longer wake after sleep onset, more nocturnal awakenings, and higher Pittsburgh Sleep Quality Index and sleep-fragmentation scores (all $p<0.001$; Table 1).

The distribution of surgical procedures, spinal anesthesia, peripheral nerve blocks, and estimated blood loss did not differ significantly between groups. However, participants with high fragmentation had longer operations (114.0±27.0 vs. 104.0±24.0 minutes; p=0.029), received more intravenous fluid (1390±390 vs. 1210±340 mL; p=0.007), required more postoperative opioids, reported higher pain scores, and mobilized later.

Postoperative urinary retention was more frequent in the high-fragmentation group than in the lower-fragmentation group (40.0% vs. 15.0%; p=0.001). The same pattern was observed among females (34.8% vs. 10.9%; p=0.021) and males (44.4% vs. 20.0%; p=0.027). High fragmentation was also associated with delayed spontaneous voiding, greater maximum bladder volume, repeated intermittent catheterization, indwelling catheterization for more than 24 hours, and longer hospital stay. The difference in symptomatic urinary tract infection was not statistically significant (Table 2).

High sleep fragmentation was associated with postoperative urinary retention on univariable analysis (crude odds ratio, 3.78; 95% confidence interval, 1.72–8.29) and remained independently associated after adjustment (adjusted odds ratio, 3.21; 95% confidence interval, 1.35–7.63; p=0.008). Baseline postvoid residual volume and postoperative opioid exposure were also independent predictors, whereas age, sex, benign prostatic hyperplasia, spinal anesthesia, operative duration, and intravenous fluid volume were not significant after adjustment (Table 3).

Table 1: Baseline clinical and preoperative sleep characteristics according to sleep-fragmentation status

Variable	Lower sleep fragmentation (n=100)	High sleep fragmentation (n=50)	p value
Age, years	57.6±10.8	61.8±10.3	0.023
Sex			0.298
Female	55 (55.0%)	23 (46.0%)	
Male	45 (45.0%)	27 (54.0%)	
Body mass index, kg/m²	28.2±4.0	29.0±4.3	0.275
American Society of Anesthesiologists physical-status class III	29 (29.0%)	18 (36.0%)	0.381
Diabetes mellitus	18 (18.0%)	13 (26.0%)	0.251
Hypertension	43 (43.0%)	25 (50.0%)	0.418
Chronic kidney disease	6 (6.0%)	5 (10.0%)	0.504
Benign prostatic hyperplasia among males	7/45 (15.6%)	6/27 (22.2%)	0.535
Previous pelvic surgery among females	7/55 (12.7%)	5/23 (21.7%)	0.315
Previous urinary retention	3 (3.0%)	4 (8.0%)	0.216
Preoperative postvoid residual volume, mL	51.8±29.5	69.6±35.1	0.003
Pittsburgh Sleep Quality Index score	6.4±2.6	10.9±3.0	<0.001
Total sleep time, minutes	381.2±47.5	342.4±50.3	<0.001
Sleep efficiency, %	85.1±6.0	73.8±7.9	<0.001
Wake after sleep onset, minutes	43.2±18.1	88.1±27.4	<0.001
Nocturnal awakenings, number	8.1±3.0	14.9±4.2	<0.001
Sleep-fragmentation index	21.7±5.1	39.2±6.4	<0.001

Table 2. Perioperative characteristics and postoperative outcomes according to sleep-fragmentation status

Variable	Lower sleep fragmentation (n=100)	High sleep fragmentation (n=50)	p value
Type of surgical procedure			0.959
Total knee arthroplasty	61 (61.0%)	30 (60.0%)	
Total hip arthroplasty	28 (28.0%)	15 (30.0%)	
Other lower-limb procedures	11 (11.0%)	5 (10.0%)	
Spinal anesthesia	64 (64.0%)	35 (70.0%)	0.583
Peripheral nerve block	56 (56.0%)	31 (62.0%)	0.599
Operative duration, minutes	104.0±24.0	114.0±27.0	0.029
Intraoperative intravenous fluid, mL	1210±340	1390±390	0.007
Estimated blood loss, mL	238±112	262±126	0.260
Postoperative opioid exposure, oral morphine equivalents, mg	24.1±8.8	30.2±9.6	<0.001
Pain score at 24 hours	3.2±1.1	3.8±1.3	0.006
Time to first mobilization, hours	6.2±2.0	7.4±2.4	0.003
Time to first spontaneous void, hours	5.1 (4.1–6.5)	7.4 (5.6–9.5)	<0.001
Maximum postoperative bladder volume, mL	398±136	512±170	<0.001
Postoperative urinary retention, overall	15 (15.0%)	20 (40.0%)	0.001
Postoperative urinary retention among females	6/55 (10.9%)	8/23 (34.8%)	0.021
Postoperative urinary retention among males	9/45 (20.0%)	12/27 (44.4%)	0.027
Repeated intermittent catheterization	4 (4.0%)	8 (16.0%)	0.021
Indwelling catheterization for more than 24 hours	2 (2.0%)	6 (12.0%)	0.017
Symptomatic urinary tract infection	1 (1.0%)	3 (6.0%)	0.108
Length of hospital stay, days	2.3±0.8	2.9±1.1	0.001

Table 3. Univariable and multivariable logistic regression analyses of postoperative urinary retention

Variable	Crude odds ratio (95% confidence interval)	Adjusted odds ratio (95% confidence interval)	p value
High sleep fragmentation	3.78 (1.72–8.29)	3.21 (1.35–7.63)	0.008
Age, per 10-year increase	1.42 (1.02–1.98)	1.31 (0.89–1.93)	0.171
Male sex	1.89 (0.88–4.04)	1.46 (0.64–3.34)	0.371
Benign prostatic hyperplasia	2.35 (0.82–6.71)	2.02 (0.64–6.40)	0.231
Baseline postvoid residual volume, per 25-mL increase	1.47 (1.17–1.84)	1.36 (1.05–1.76)	0.019
Spinal anesthesia	1.52 (0.68–3.40)	1.61 (0.67–3.86)	0.288
Operative duration, per 30-minute increase	1.48 (1.06–2.07)	1.36 (0.98–1.90)	0.067
Intravenous fluid, per 500-mL increase	1.71 (1.08–2.72)	1.43 (0.84–2.43)	0.188
Opioid exposure, per 10-mg oral morphine-equivalent increase	1.72 (1.18–2.50)	1.55 (1.03–2.33)	0.034

The multivariable model demonstrated good discrimination, with an area under the receiver-operating-characteristic curve of 0.81, and acceptable calibration according to the Hosmer–Lemeshow test (p=0.620). All variance inflation factors were below 2.0, indicating no substantial multicollinearity. When analyzed as a continuous variable, every 10-unit increase in the sleep-fragmentation index was associated with a 74% increase in the adjusted odds of postoperative urinary retention (adjusted odds ratio, 1.74; 95% confidence interval, 1.17–2.59; p=0.006). There was no significant interaction between sex and sleep fragmentation (p=0.648). In sex-stratified analyses, high fragmentation remained associated with urinary retention among females (adjusted odds ratio, 3.36; 95% confidence interval, 1.02–11.12; p=0.047) and males (adjusted odds ratio, 2.91; 95% confidence interval, 1.01–8.39; p=0.048), although the confidence intervals were wide. The association remained statistically significant after excluding males with benign prostatic hyperplasia (adjusted odds ratio, 2.89; 95% confidence interval, 1.16–7.19; p=0.023) and after additional adjustment for total sleep time and Pittsburgh Sleep Quality Index score.

DISCUSSION

This study demonstrated that preoperative sleep fragmentation was independently associated with postoperative urinary retention following elective lower-limb orthopedic surgery. Retention occurred in 23.3% of participants and was significantly more frequent in the high-fragmentation group than in the lower-fragmentation group. Tsai et al. similarly investigated the incidence and clinical predictors of urinary retention after total hip and knee arthroplasty, supporting the importance of systematic perioperative risk assessment [1]. Also, Powers et al. evaluated risk factors and postoperative outcomes of urinary retention in patients undergoing total joint arthroplasty [2].

The present study extends previous evidence and addresses the question of whether sleep fragmentation (measured objectively) may be an additional risk marker. Pre-op sleep disturbance is linked to inadequate acute post-op pain management, as reported by Niklasson et al., which may explain the connection between disturbed sleep and increased analgesic requirements, leading to delayed recovery [3]. Azarboo et al. have found some conventional

risk factors for urinary retention following hip and knee arthroplasty but objective sleep continuity was not a major determinant in their analysis [4].

Reported incidence of urinary retention after surgery may vary according to patient characteristics, the surgical procedure, anesthetic technique, opioid administration, routine for monitoring the bladder and the criteria for catheterization. The use of bladder-scanning to determine the need for catheterization may be affected by changes in postoperative bladder-scanning protocols, as demonstrated by Magnuson et al. [5] Moreover, Kołodziej et al. showed that structured nursing intervention can decrease urinary retention and need for urinary catheters for fast-track hip arthroplasty pathways [6].

Sleep fragmentation was associated with higher postoperative pain scores, higher opioid exposure and delayed mobilization. Vitale et al. reported objective sleep disturbances in patients after hip and knee arthroplasty, and reported a correlation to postoperative pain [7]. Bracey et. al. noted that urinary retention in modern rapid-recovery arthroplasty is multifactorial and can be affected by anesthesia, analgesia, mobility and bladder management techniques [8].

More than 3-fold higher adjusted odds of urinary retention were found to be associated with high sleep fragmentation. In addition, there was a graded association with a 74% increase in adjusted odds for every 10 units increase in the fragmentation index. Preoperative clinical characteristics have been suggested to identify patients at higher risk for urinary retention after a TJA [9]. Higher sleep disturbances during the peri-operative period were also associated with worse pain outcomes, increasing the general relevance of sleep quality in the peri-operative period [10].

This association between sleep fragmentation and urinary retention was seen in both sexes. Of the females, 34.8% were retained in the high fragmentation group and 10.9% in the lower fragmentation group and for males 44.4% and 20.0%, respectively. Bracey et al. found some predictors for postoperative urinary retention in TKA such as patient and perioperative factors [11]. Brouwer et al. proved that apart from bladder size, bladder filling rate and time to catheterization are also important factors to consider for postoperative retention, and may equally apply to both females and males [12].

Baseline PVR and postoperative opioid exposure were independent risk factors for urinary retention. Møller et al. demonstrated that through use of evidence-based bladder-management protocols, it is possible to decrease the number of unnecessary postoperative catheterizations and still keep patients safe [13]. A study by Wang et al. [14] found that many patients undergoing hip and knee arthroplasty in enhanced recovery pathways experienced sleep disturbance, and that sleep disturbance may exist alongside pain, anxiety, mobility impairment and other vulnerabilities during the perioperative period.

High sleep fragmentation was also related to delayed spontaneous voiding, higher maximum bladder volume, frequent intermittent catheterization, higher indwelling catheter hours and longer hospital stays. Cha et al. reported significant heterogeneity in the incidence of urinary retention and the factors associated with it in the total joint arthroplasty studies [15]. Abdul-Muhsin et al. also reported that urinary retention following nonurological operations is a multiple factor complication of clinically important consequences [16].

The results of these studies may have implications for the assessment during the perioperative period. Structured questions regarding nocturnal awakenings, sleep continuity, nocturia and poor subjective sleep might help identify patients who could benefit from more intensive bladder monitoring and may be used when multi-night actigraphy is not possible in some clinical contexts. In the setting of enhanced recovery pathways, Wainwright et al. made recommendations for early mobilisation, multimodal analgesia, appropriate fluid management and avoiding unnecessary catheterisation [17]. Luo et al. also found that decreased sleep efficiency preoperatively was correlated with increased postoperative pain and functional recovery after total joint arthroplasty [18].

The advantages of this study are prospective objective sleep assessment, inclusion of both sexes, predefined urinary-retention criteria, standardized bladder ultrasonography, blinded bladder assessors and adjustment for major confounding variables. However, the findings should be interpreted cautiously because the study was conducted at a single center and included a limited number of retention events. Scholten et al. showed that urinary-retention rates in fast-track joint arthroplasty depend substantially on institutional protocols and population characteristics [19]. Smith et al. noted that although actigraphy is useful for measuring sleep-wake patterns, it cannot accurately determine sleep stages, respiratory events, or brief electroencephalographic arousals [20].

Additional limitations include the population-derived fragmentation threshold, possible residual confounding, wide confidence intervals in sex-stratified analyses, and follow-up limited to the first 24 postoperative hours. Anxiety, chronic pain, nocturia, medication use, autonomic dysfunction, and undiagnosed sleep-disordered breathing may have influenced both sleep fragmentation and bladder function. Larger multicenter studies are therefore needed to validate these findings, establish clinically meaningful fragmentation thresholds, and determine whether sleep assessment improves existing urinary-retention prediction models [15-20].

CONCLUSION

Preoperative sleep fragmentation was independently associated with postoperative urinary retention following elective lower-limb orthopedic surgery in both females and males. There was also a significant correlation between

high fragmentation and delayed voiding, increased bladder volume, increased catheterization and hospital stay. Pre-operative sleep assessment, in conjunction with urinary assessment, opioid-sparing pain management, early mobility, vigilant fluid management, and structured bladder monitoring may aid in risk identification. Further multicenter research studies are warranted to validate these results and to evaluate if sleep optimization can decrease postoperative urinary retention.

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Data Availability: The data are available from the corresponding author upon reasonable request.

REFERENCES

1. Tsai CE, Tseng WH, Chang WS, Ho CH, Chien CS. Incidence and clinical predictors of postoperative urinary retention following total hip and total knee arthroplasty: a single-center, prospective study. *Jt Dis Relat Surg.* 2026;37(1):98-106. doi:10.52312/jdrs.2026.2429.
2. Powers MJF, Grace ZT, Torre BB, Wakefield DB, Sanzari L, Grosso MJ. Investigating postoperative urinary retention: risk factors and postsurgical outcomes in total joint arthroplasty. *Arthroplast Today.* 2025;31:101600. doi:10.1016/j.artd.2024.101600.
3. 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 Med Rev.* 2025;79:102014. doi:10.1016/j.smrv.2024.102014.
4. Azarboo A, Ghaseminejad-Raeini A, Teymoori-Masuleh M, Mousavi SM, Jamalikhah-Gaskarei N, Hoveidaei AH, et al. Risk factors of postoperative urinary retention following total hip and knee arthroplasty: a systematic review and meta-analysis. *Bone Jt Open.* 2024;5(7):601-611. doi:10.1302/2633-1462.57.BJO-2024-0003.R1.
5. Magnuson JA, Hobbs JR, Snyder V, Hozack WJ, Krueger CA, Austin MS. Routine use of bladder scans after primary total joint arthroplasty is not necessary: results of a protocol change. *J Arthroplasty.* 2023;38(6 Suppl):S52-S59. doi:10.1016/j.arth.2023.02.040.
6. Kołodziej Ł, Jurewicz A, Gębska M. Nursing interventions reduce postoperative urinary retention in fast-track total hip arthroplasty: a pilot study. *Adv Clin Exp Med.* 2023;32(4):497-500. doi:10.17219/acem/161723.
7. Vitale JA, Banfi G, Viganò M, Negrini F. How do patients sleep after orthopaedic surgery? Changes in objective sleep parameters and pain in hospitalized patients undergoing hip and knee arthroplasty. *Int Orthop.* 2023;47(8):1929-1938. doi:10.1007/s00264-023-05862-2.
8. Bracey DN, Barry K, Khanuja HS, Hegde V. Postoperative urinary retention in modern rapid recovery total joint arthroplasty. *J Am Acad Orthop Surg.* 2022;30(10):443-447. doi:10.5435/JAAOS-D-21-00963.
9. Magaldi RJ, Strecker SE, Nissen CW, Carangelo RJ, Grady-Benson J. Preoperative factors to assess risk for postoperative urinary retention in total joint arthroplasty: a retrospective analysis. *Arthroplast Today.* 2022;13:181-187. doi:10.1016/j.artd.2021.10.009.
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 Med Rev.* 2022;63:101630. doi:10.1016/j.smrv.2022.101630.
11. Bracey DN, Hegde V, Pollet AK, Johnson RM, Jennings JM, Miner TM. Incidence and predictive risk factors of postoperative urinary retention after primary total knee arthroplasty. *J Arthroplasty.* 2021;36(7 Suppl):S345-S350. doi:10.1016/j.arth.2021.02.043.
12. Brouwer TA, van Roon EN, Rosier PFWM, Kalkman CJ, Veeger N. Postoperative urinary retention: risk factors, bladder filling rate and time to catheterization: an observational study as part of a randomized controlled trial. *Perioper Med (Lond).* 2021;10(1):2. doi:10.1186/s13741-020-00167-z.
13. Møller T, Engedal MS, Plum LM, Aasvang EK. Reduced need for urinary bladder catheterization in the postanesthesia care unit after implementation of an evidence-based protocol: a prospective cohort comparison study. *Eur Urol Open Sci.* 2021;26:27-34. doi:10.1016/j.euros.2021.01.013.
14. Wang Y, Liu Y, Li X, Lv Q, Xia Q, Wang X, et al. Prospective assessment and risk factors of sleep disturbances in total hip and knee arthroplasty based on an Enhanced Recovery After Surgery concept. *Sleep Breath.* 2021;25(3):1231-1237. doi:10.1007/s11325-020-02213-y.
15. Cha YH, Lee YK, Won SH, Park JW, Ha YC, Koo KH. Urinary retention after total joint arthroplasty of hip and knee: systematic review. *J Orthop Surg (Hong Kong).* 2020;28(1):2309499020905134. doi:10.1177/2309499020905134.
16. Abdul-Muhsin HM, Jakob N, Cha S, Zhang N, Schwartz A, Navaratnam A, et al. Incidence, outcomes, and prediction of postoperative urinary retention after a nonurologic procedure. *J Am Acad Orthop Surg Glob Res Rev.* 2020;4(5):e19.00149. doi:10.5435/JAAOSGlobal-D-19-00149.
17. Wainwright TW, Gill M, McDonald DA, Middleton RG, Reed M, Sahota O, et al. Consensus statement for perioperative care in total hip replacement and total knee replacement surgery: Enhanced Recovery After Surgery Society recommendations. *Acta Orthop.* 2020;91(1):3-19. doi:10.1080/17453674.2019.1683790.
18. Luo ZY, Li LL, Wang D, Wang HY, Pei FX, Zhou ZK. Preoperative sleep quality affects postoperative pain and function after total joint arthroplasty: a prospective cohort study. *J Orthop Surg Res.* 2019;14(1):378. doi:10.1186/s13018-019-1446-9.
19. Scholten R, Kremers K, van de Groes SAW, Somford DM, Koëter S. Incidence and risk factors of postoperative urinary retention and bladder catheterization in patients undergoing fast-track total joint arthroplasty: a prospective observational study on 371 patients. *J Arthroplasty.* 2018;33(5):1546-1551. doi:10.1016/j.arth.2017.12.001.
20. Smith MT, McCrae CS, Cheung J, Martin JL, Harrod CG, Heald JL, et al. Use of actigraphy for the evaluation of sleep disorders and circadian rhythm sleep-wake disorders: an American Academy of Sleep Medicine clinical practice guideline. *J Clin Sleep Med.* 2018;14(7):1231-1237. doi:10.5664/jcsm.7230.

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