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Improvement in Sleep Patterns After Hip and Knee Arthroplasty: A Prospective Study in 780 Patients



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ABSTRACT

Background: This study assessed change in sleep patterns before and after total hip arthroplasty (THA) and total knee arthroplasty (TKA) and its relationship to patient-reported outcome measures (PROMs). **Methods:** Between July 2016 and June 2018, surgical data and PROMs were collected on 780 subjects before and 12 months after THA or TKA. PROMs included Knee Injury and Osteoarthritis Outcome Score, Hip Disability and Osteoarthritis Outcome Score, patient satisfaction, and 2 questions from the Pittsburgh Sleep Quality Index.

Results: Before surgery, 35% (270 of 780) reported poor quality sleep. Sleep quality and duration were worse in females over males, and in THA patients (39%) over TKA patients (30%; $P = .011$). Of those reporting bad sleep, 74% (201 of 270) were improved after arthroplasty. Satisfaction was higher in subjects reporting good sleep quality (626 of 676; 93%) compared with those reporting bad sleep quality (67 of 86; 78%) ($P = .001$). Sleep was positively correlated with better Hip Disability and Osteoarthritis Outcome Score/Knee Injury and Osteoarthritis Outcome Score ($r = 0.2-0.3$).

Conclusion: Improvement in sleep quality and duration can be expected after THA and TKA and is associated with better outcome scores and satisfaction.

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Sleep quality and quantity have a great impact on quality of life (QOL). Complaints about sleep quality are very common, and during the last 30 years, there has been a rapid growth in the epidemiologic interest in sleep disorders [1]. According to the American Academy of Sleep Medicine and Research, 7–8 hours of sleep are recommended in the healthy adult population [2]. One of the most studied sleeping disorders is insomnia. Epidemiologically, insomnia can be measured and summarized into 2 categories: lack of sleep or dissatisfaction with sleep quality [3]. Lack of sleep has a prevalence rate of 20%–41% in the general population, whereas dissatisfaction with sleeping quality has a high prevalence of 30%–48% [3]. Sleeping problems are especially prevalent in older adults,

and there is a relationship between sleep efficiency and the development and maintenance of chronic pain [4,5].

Sleep disruptions are associated with multiple short-term and long-term health risks [6]. Short-term consequences include increased stress responsivity, somatic pain, reduced QOL, emotional distress, mood disorders, as well as cognitive, memory, and performance deficits [7]. Long-term consequences include hypertension, dyslipidemia, cardiovascular disease, weight-related issues, metabolic syndrome, type 2 diabetes mellitus, and colorectal cancer [6]. Sleep apnea has been shown to increase the odds of post-operative complications by a factor of 2.5 in hip arthroplasty subjects and 3.7 in knee arthroplasty subjects [8,9].

Osteoarthritis (OA) has been shown to have an adverse impact on overall sleep quality [5,10–12] and sleep duration [13] as well as increasing the risk for developing sleep disturbances [10]. A study from Park et al [13] showed a positive association between Kellgren-Lawrence grade 2 or above and shorter or longer sleep duration, with both being connected to negative health outcomes. Koken and Guclu [14] found that QOL is seriously affected by sleep disturbances and worsened by OA, especially in the preoperative period. Sleep disturbance has been associated with higher levels of

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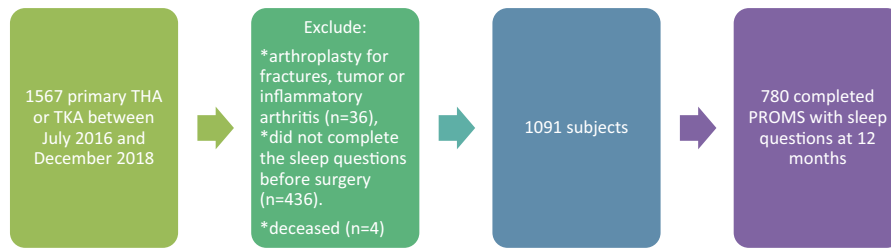


Fig. 1. Participant flow. THA, total hip arthroplasty; TKA, total knee arthroplasty; PROMs, patient-reported outcome measures.

inflammatory activity [15–17]. The inflammation caused by OA causes pain, which has been postulated as a major reason for sleep disruption in OA patients [12,18–21].

Although the relationship between OA and sleep has been examined, relatively few studies have prospectively assessed sleep before and after hip and knee arthroplasties [14,19,22–24]. Although improvement in sleep quality is consistently reported in these studies after arthroplasty, subject numbers are small, ranging from 25 to 105 subjects. Furthermore, there are conflicting reports on the relationship between sleep quality and pain scores in arthroplasty subjects [22,24–26], potentially because of inadequate sample sizes. The relationship between sleep and satisfaction with surgery has not been reported previously.

The primary outcome variable of this study was the change in patient-reported sleep patterns before and after hip arthroplasty or knee arthroplasty in a large series of 780 subjects. The secondary outcome variable was the relationship between sleep and patient-reported outcome measures (PROMs) and satisfaction after surgery.

Material and Methods

Study Design and Participants

A prospectively recorded database containing surgical data as well as preoperative and 12 months postoperative PROMs was established in June 2015. Subjects undergoing hip and knee arthroplasties who provide consent to participation are included from 5 experienced surgeons at our center. The routine data collection includes numerous demographic and operative variables. At the time of surgery, subjects are also graded according to the American Society of Anesthesiologists' (ASA) classification of

physical health [27]. The database has approval from a local hospital human research ethics committee.

Questions regarding sleep were introduced to the PROMs in July 2016. Eligible patients were all adults undergoing primary elective hip or knee arthroplasty under the care of one of the investigating surgeons between July 2016 and June 2018. Patients were required to provide written informed consent to participate. About 1567 subjects underwent total hip arthroplasty (THA) or total knee arthroplasty (TKA) between July 2016 and June 2018. Exclusion criteria were subjects who underwent arthroplasty for fractures, tumor, or inflammatory arthritis ($n = 36$), those who did not complete the sleep questions before surgery ($n = 436$), and those who died during the follow-up period ($n = 4$). Of the remaining 1091 subjects, postoperative sleep questions were completed by 780 subjects who formed the study group for analysis.

Patient-Reported Outcome Measures

PROMs were collected before and at 12 months after surgery using printed forms. PROMs included 2 questions from the Pittsburgh Sleep Quality Index (PSQI) [28], 1 about sleep duration and 1 about sleep quality. Sleep duration was classified as >7 hours; 6–7 hours; 5–6 hours; and <5 hours. Patient-reported sleep quality was classified as very good, good, bad, and very bad. The disease-specific Knee Injury and Osteoarthritis Outcome Score (KOOS) [29] and Hip Disability and Osteoarthritis Outcome Score (HOOS) [30] were collected to determine the subscores for QOL, pain, symptoms, and activities of daily living. The EuroQol 5D (EQ-5D) [31] was selected as a widely used generic measure of health status, measuring mobility, self-care, activity, pain, and anxiety [32].

Sleep Duration

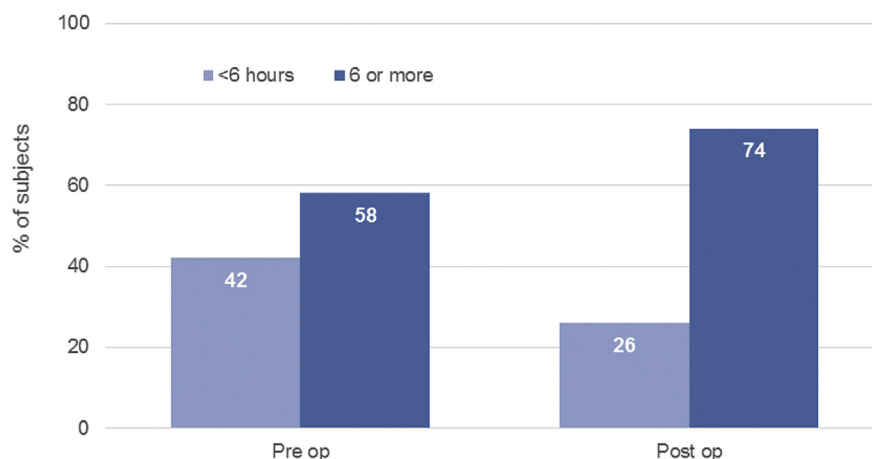


Fig. 2. Distribution of subjects reporting <6 hours or 6 hours or more sleep before and after arthroplasty.

Sleep Quality

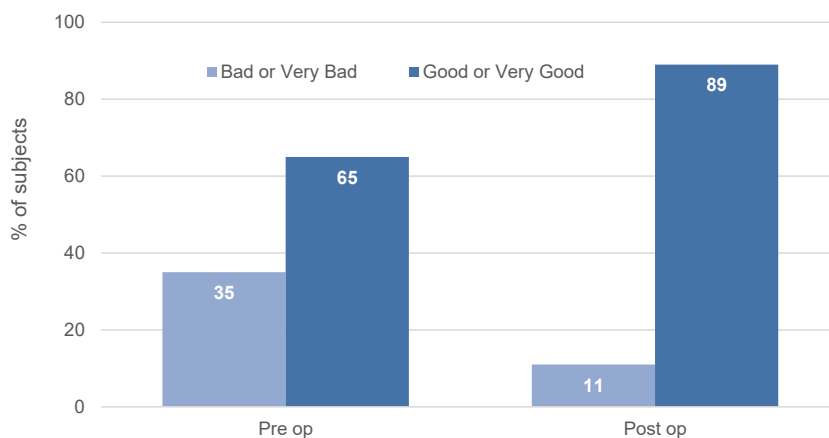


Fig. 3. Distribution of subjects reporting bad and good sleep quality before and after arthroplasty.

The satisfaction and expectation components of the Knee Society score [33] were included in the postoperative forms as well as 2 additional questions relating to satisfaction: would they have the same surgery again under the same circumstances (yes/no/unsure) and grading satisfaction with the results of surgery on 5-point Likert scale from very disappointed to very satisfied.

Statistical analysis was performed using SPSS, version 24, software (IBM, Armonk, NY). Descriptive statistics are presented as means and standard deviations for continuous variables such as mean patient-reported scores and counts and percentages for categorical variables. Means were compared between groups with independent *t* tests. Difference in proportions of patients between groups was assessed with the chi-square test. Pearson correlation was performed to assess the relationship between sleep measures and the variables of KOOS/HOOS subscores, EQ-5D scores, satisfaction, and ASA grade. Statistical significance was set at $P < .05$.

Results

Between July 2016 and June 2018, 780 subjects who underwent primary hip arthroplasty or knee arthroplasty for OA completed PROMs including sleep questions before and at 12 months after

surgery. The participant flow is shown in Figure 1. There were 402 THA procedures and 378 TKA procedures. There were 416 females (53%), and the mean age was 69 years (range, 42-99).

Sleep Duration

The reported sleep duration before and after surgery is shown in Figure 2. Before surgery, 326 (42%) patients reported less than 6 hours of sleep. This number diminished to 201 (26%) at 12 months postoperatively ($P < .001$). Of the 106 patients reporting <5 hours per night before surgery, 71 (67%) reported an increase in sleep duration. Of all 780 subjects, at 12 months postoperatively, 71 (9%) patients reported worse sleep duration, 455 (58%) were unchanged, and 254 (33%) were improved relative to their preoperative score.

Sleep Quality

The percentage of patients reporting bad or very bad sleep before surgery reduced significantly from 35% (270 of 780) preoperatively to 11% (88 of 780) postoperatively ($P < .001$) (Fig. 3). Of the 270 subjects with bad sleep preoperatively, 74% (201 of 270) reported improvement postoperatively. After 12 months, sleep

Hip vs Knee Arthroplasty

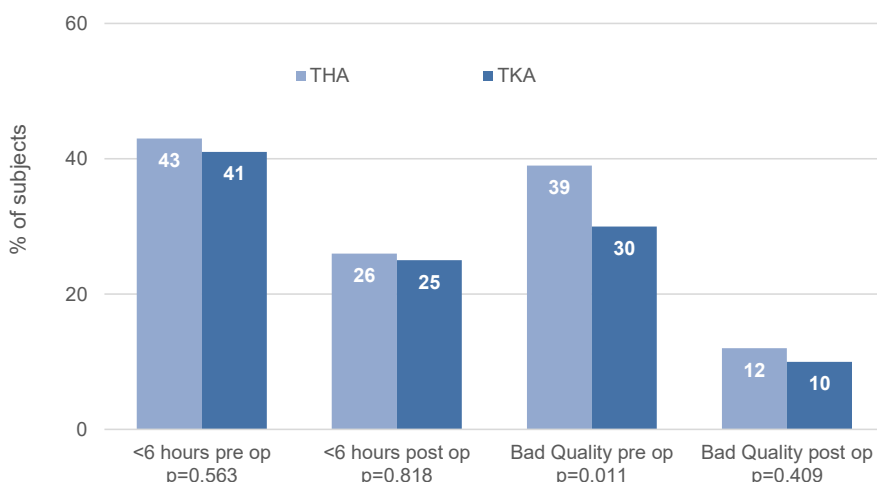


Fig. 4. Proportion of subjects reporting <6 hours of sleep duration and bad quality sleep in subjects with hip and knee arthroplasties before and after surgery.

Table 1
Improvement in Sleep Quality and Duration in Hip and Knee Arthroplasty Subjects.

N	Hip Arthroplasty		Knee Arthroplasty		P
	402		378		
Sleep quality, n (%)					
Improved	157 (39)		121 (32)		.146
Unchanged	22 (55)		233 (61)		
Worse	23 (6)		24 (6)		
Sleep duration, n (%)					
Improved	141 (35)		113 (30)		.298
Unchanged	225 (56)		230 (61)		
Worse	36 (9)		35 (9)		

quality was improved in 278 (36%), unchanged in 455 (58%), and worse in 47 (6%).

Sleep in Total Hip Vs Total Knee Arthroplasties

Sleep duration and quality before and after surgery in THA and TKA subjects is shown in Figure 4. There was no significant difference in the proportion of subjects reporting <6 hours sleep between THA and TKA subjects before surgery (P = .563) or at 1 year after surgery (P = .818). Before surgery, significantly more THA subjects (156 of 402; 39%) reported bad quality sleep compared with TKA subjects (114 of 378; 30%) (P = .011). At 1 year after surgery, there was no significant difference in the proportion reporting bad quality sleep between THA and TKA subjects (12% vs 10%, P = .409). There was no significant difference in the mean HOOS/KOOS between THA (48.2) and TKA (46.8) subjects for HOOS/KOOS pain score before arthroplasty (P = .241). The change in sleep quality and duration after arthroplasty is shown in Table 1.

Gender and Sleep

There were 416 females and 364 males. Before surgery, a greater proportion of females reported <6 hours of sleep (n = 203; 49%) compared with the male patients (n = 123; 34%) (P = .001) (Fig. 5). There were also more female patients reporting bad sleep quality preoperatively (n = 166; 40%) than male patients (n = 104; 29%) (P = .001). At 12 months postoperatively, a greater proportion of females (68; 16%) reported bad quality sleep than males (20; 6%)

(P = .001), and a greater proportion of females (128; 31%) reported <6 hours sleep than males (n = 73; 20%) (P = .001). The change in sleep quality and duration is shown in Table 2.

Satisfaction With Surgery Related to Postoperative Sleep Quality

Of the 780 subjects, satisfaction with surgery questions was completed by 762 subjects. Satisfaction with the surgery was higher in the 676 patients who reported good sleep postoperatively (n = 626; 93%) compared with the 86 patients who reported bad sleep (n = 67; 78%) (P = .001) (Fig. 6).

About 759 subjects responded whether they would have the same surgery again. Of the 674 subjects who reported good sleep postoperatively, 622 (92%) would have the same surgery again, compared with 67 of 85 (79%) who reported bad quality sleep (P = .004). The mean Knee Society Satisfaction score was 35 of 40 in those with good quality sleep and 30 in those with bad quality sleep at 12 months (P = .001).

Satisfaction with pain level while lying in bed was reported by 93% (644 of 692) of those with good quality sleep, compared with 72% (63 of 88) of those with bad quality sleep (P = .001).

Sleep and Disease-Specific Scores

Before and after surgery, sleep quality and duration was weakly positively correlated with HOOS/KOOS as shown in Table 3.

Sleep and General Health Measures

Before and after surgery, sleep quality and duration was weakly positively correlated with EQ-5D scores as shown in Table 1.

Sleep and Physical Health Status

At the time of surgery, subjects were graded according to the ASA classification of physical health [27]. The ASA grade at surgery was 1 in 110 subjects, 2 in 388 subjects, 3 in 171 subjects, and 4 in 4 subjects. ASA classification was incomplete in the remaining 107 subjects. ASA grade was not significantly correlated with preoperative sleep duration, (r[671] = -0.01; P = .897), postoperative sleep duration (r [671] = -0.06; P = .141), preoperative sleep quality (r[671] = 0.08; P = .04), or postoperative sleep quality (r[671]= -0.07; P = .058). The

Gender and Sleep

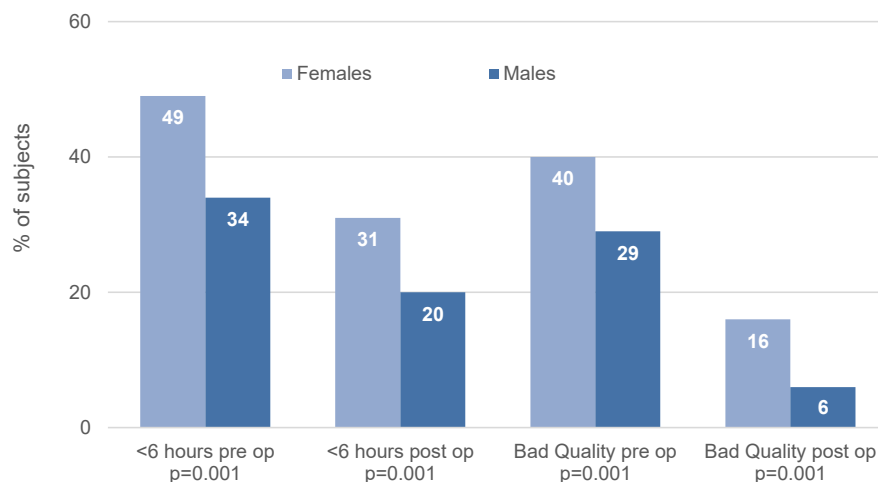


Fig. 5. Distribution of sleep quality and duration in males and females before and after arthroplasty.

Table 2
Improvement in Sleep Quality and Duration in Male and Female Subjects After Arthroplasty.

N	Females	Males	P
	416	364	
Sleep quality, n (%)			
Improved	157 (38)	121 (33)	.146
Unchanged	230 (55)	225 (62)	
Worse	29 (7)	18 (5)	
Sleep duration, n (%)			
Improved	142 (34)	112 (31)	.531
Unchanged	235 (57)	220 (60)	
Worse	39 (9)	32 (9)	

proportion of subjects that experienced improvement in sleep quality was lowest in those with an ASA of 3–4, compared with those with an ASA grade 1 or 2 (Table 4).

Discussion

In this study of 780 arthroplasty subjects, we have shown that significant improvements in sleep quality and duration can be expected after THA and TKA. Poor sleep quality and duration was common before arthroplasty, reported by nearly half the subjects. Of these, subject sleep duration and quality was improved in 7 of 10 after arthroplasty. Sleep quality and duration was positively associated with hip and knee outcome scores, patient satisfaction, and general health measures.

This study is one of the first describing a significant improvement in sleep duration after THA and TKA next to an improvement in sleep quality. A high percentage of patients reported a bad sleep quality (35%) or <6-hour duration (42%) before surgery. This is consistent with numbers found in the literature [18,19,23]. In our study, the percentage of subjects reporting bad quality sleep diminished to 11% and <6 hours to 26% at 12 months after arthroplasty. Of those with bad quality sleep before surgery, 74% reported an improvement, and of those of <5 hours of sleep duration before surgery, 67% improved. Given the established relationship between poor sleep and significant negative health risks [6,7], the positive effect of improvements in sleep should be considered an important benefit of arthroplasty.

Previous studies have shown improvement in sleep quality after joint arthroplasty [14,19,22,23,34], but few studies have examined the effect of both THA and TKA on sleep disruption 12 months after

surgery. Although the THA subjects had worse baseline sleep measures than TKA subjects, the proportion experiencing improvement was equivalent between these groups. Preoperatively, more THA patients (39%) had a poor sleep quality than TKA patients (30%), but there was no significant difference in sleep duration. A previous study reported no difference in sleep between total hip and knee OA and arthroplasties, but this may be related to a smaller sample size [19]. The preoperative difference in sleep quality was not reflected in pain scores as there was no difference between THA and TKA subjects in the mean pain scores before surgery. By 1 year after arthroplasty, the observed difference was resolved with no difference in sleep quality or duration between THA and TKA subjects. The reason for the poorer sleep observed in hip over knee arthroplasty subjects before surgery is unclear but may relate to greater difficulty finding a position of comfort in a horizontal position during sleep.

Pain has previously been reported as a main cause of sleep disturbances [10,18–21,35]. It is reasonable to expect that better HOOS/KOOS are reported in patients with a better sleep pattern. The relationship between 1-year PROMs with quality and duration of sleep has not been previously reported. We observed a weakly positive correlation between sleep quality and better HOOS/KOOS subscores (symptoms, pain, activities of daily living, and QOL) both before and after arthroplasty. We also observed that poor sleep quality and duration is associated with poorer measures of general health and well-being. In the literature, KOOS QOL has shown to be significantly lower in patients with both OA and sleeping problems [21], which our study confirms. The correlation was the strongest within the HOOS/KOOS pain subscore both preoperatively and postoperatively, which supports the current literature findings and the bidirectional connection between pain and sleeping problems [36,37]. Satisfaction with pain level while lying in bed was reported by 93% of patients with good quality of sleep compared with 72% of those with bad quality sleep. Patients with more pain have more sleeping problems with less satisfying outcomes. Focus on the sleep component in the multimodality joint arthroplasty rehabilitation could therefore help improve the final outcome and satisfaction rate, but further studies would be needed to support this.

Sleep quality was associated with greater satisfaction with surgery. Of patients reporting good sleep, 93% were satisfied with the surgery, compared with 78% of patients reporting bad sleep ($P = .001$). The mean Knee Society Satisfaction score was 35 of 40 in those with good quality sleep and 30 in those with bad quality sleep

Satisfaction and Sleep

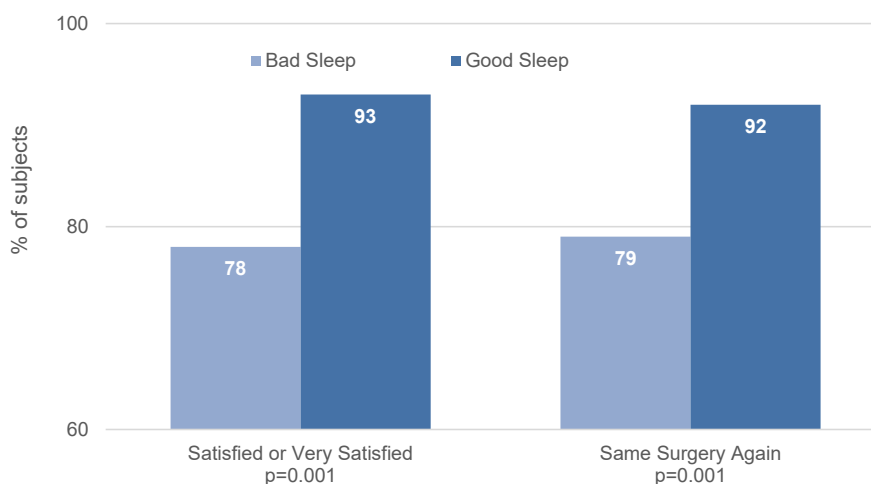


Fig. 6. Proportion of subjects reporting satisfaction with surgery in those reporting good and bad sleep.

Table 3Pearson Correlation of Sleep Quality and Sleep Duration With HOOS/KOOS Sub-scales, and EQ-5D Scores ($n = 780$).

Patient Reported Outcome Measure	Preoperative Sleep		Postoperative Sleep	
	Quality	Duration	Quality	Duration
KOOS/HOOS				
Pain	0.36 ^a	0.32 ^a	0.27 ^a	0.26 ^a
Symptom	0.27 ^a	0.20 ^a	0.15 ^a	0.17 ^a
QOL	0.25 ^a	0.25 ^a	0.21 ^a	0.20 ^a
Function	0.29 ^a	0.27 ^a	0.24 ^a	0.20 ^a
EQ-5D score				
Mobility	0.21 ^a	0.15 ^a	0.21 ^a	0.15 ^a
Self-care	0.19 ^a	0.14 ^a	0.14 ^a	0.10 ^b
Activities	0.18 ^a	0.14 ^a	0.22 ^a	0.16 ^a
Pain	0.21 ^a	0.21 ^a	0.25 ^a	0.18 ^a
Anxiety	0.16 ^a	0.09 ^c	0.23 ^a	0.16 ^a
General health	0.14 ^a	0.13 ^a	0.19 ^a	0.16 ^a

HOOS, Hip Disability and Osteoarthritis Outcome Score; KOOS, Knee Injury and Osteoarthritis Outcome Score; EQ-5D, EuroQol-5D; QOL, quality of life.

^a $P < .001$.^b $P < .01$.^c $P < .05$.

at 12 months. Higher satisfaction scores are to be expected in patients who are well rested. It has been proven that better sleep improves daytime function, physical activity, and lessens functional limitations, especially in women [38]. Randomized controlled trials have demonstrated that patients randomized to receive zolpidem, a sleep pharmacotherapeutic, had superior pain and satisfaction in the first 2 weeks after TKA [25] and 3 months after TKA [39]. Our findings confirm that the positive relationship between sleep and satisfaction with arthroplasty persists beyond the acute period to the long term.

Gender differences in sleep disorders have previously been reported in the literature. Women report more sleeping difficulties than men, especially concerning insomnia [40–43]. We observed that women reported poorer sleep quality and duration compared with men before and after arthroplasty, but the proportion experiencing improvement in sleep was equivalent between genders. Poorer sleep in women compared with men has been attributed to differences in respiratory control, sex hormones, stress response, social patterning of behaviors that affect sleep, as well as gender differences in the way women and men report symptoms [40–42]. Although others have demonstrated that women exhibit poorer sleep in the general population, we have shown that this also applies to the arthroplasty population.

General physical health and comorbidities are likely to influence sleep, especially conditions such as chronic obstructive lung disease and sleep apnea. Although we did not observe a strong correlation between ASA grade and sleep quality or duration ($r < 0.10$), we did

Table 4

Improvement in Sleep Quality and Duration According to ASA Physical Health Status.

N	ASA 1: Normal Healthy Patient	ASA 2: Mild Systemic Disease	ASA 3–4: Severe Systemic Disease
	110	388	175
Sleep quality ^a			
Improved	47 (43)	135 (35)	52 (30)
Unchanged	59 (53)	235 (61)	102 (58)
Worse	4 (4)	18 (5)	21 (12)
Sleep duration			
Improved	40 (36)	136 (35)	51 (29)
Unchanged	59 (54)	214 (55)	106 (61)
Worse	11 (10)	38 (10)	18 (10)

ASA, American Society of Anesthesiologists.

^a Significant difference between ASA grades for sleep quality ($P = .003$) but not sleep duration ($P = .673$).

find a higher proportion (12%) of with severe systemic disease (ASA grade 3 or more) experienced a deterioration in sleep quality after arthroplasty, compared with those with mild disease (4%) or those in good general health (5%). Specific medical conditions such as chronic obstructive lung disease and sleep apnea were not specifically recorded in this cohort but would be included in the classification of severe systemic disease. These chronic medical conditions are unlikely to improve with arthroplasty, and although the proportion experiencing improvement was lower than healthier cohorts, it is reassuring that 88% of those with significant systemic disease reported sleep quality was unchanged or improved after arthroplasty.

There are some noteworthy limitations to this study. Although sleep duration is easy to evaluate, it is difficult to assess sleep quality objectively in the elderly population as it is a subjective measurement. No objective sleep measurements such as polysomnography or wearable devices to measure sleep parameters were used in this study. Sleep quality can be influenced by many factors, including migraine, sleep apnea, and chronic obstructive lung disease, medical or psychiatric disorder, or OA affecting other joints, which were not controlled for in this study. However, only those with complete preoperative and postoperative sleep results were included in the analysis, which included assessing change in each subject over time, making the analysis more robust to these potentially confounding variables. From the 7 components of the PSQI, we only used the 2 components of sleep duration and sleep quality. Sleep duration is easy to assess quantitatively, and both duration and quality have the highest component correlations within the PSQI, so still represent a valid measure of sleep. The 29% of subjects who did not answer the postoperative sleep questions introduce potential selection bias to the results. These subjects were not all lost to follow-up, but rather they completed forms that did not include the questions on sleep during a transition from paper to digital-based data collection methods. We did not differentiate between different knee designs. Certain implant designs may influence range of motion with an impact on postoperative HOOS/KOOS. The implants, however, were all implanted by a group of experienced arthroplasty surgeons, and the postoperative rehabilitation protocols were the same.

Conclusion

This cohort study found that nearly 1 in 2 report poor sleep quality and sleep duration of less than 6 hours before hip and knee arthroplasty. Poorer measures of sleep were seen in females compared with males and hip over knee subjects before surgery. At 1 year after arthroplasty, significant improvements in sleep quality and duration were observed. For those with poor sleep quality or duration before surgery, 7 of 10 experienced improvement after arthroplasty. Measures of sleep were positively associated with measures of pain, symptoms, general health, well-being, and satisfaction with surgery. Improvement in sleep may be considered a realistic outcome of hip and knee arthroplasty, with important and meaningful positive effects on health and QOL.

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