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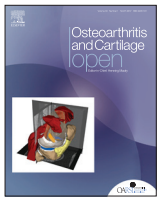

Review

Measures of sleep are not routinely captured in trials assessing treatment outcomes in knee osteoarthritis - A scoping systematic review and call to action

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ABSTRACT

Objective: To identify and map the extent to which trials for pain interventions in individuals with knee osteoarthritis (OA) track measures of sleep, characterize the type of sleep measure assessed, and assess their influence on pain-related effect sizes.
Design: A scoping review was conducted, searching seven bibliometric databases from 2000 to 2022. We included all randomized controlled trials with a primary purpose of assessing non-surgical pain management interventions for adults with knee OA. All non-surgical interventions and any comparator or control were included. Demographic data were pooled from all trials.
Results: 926 trials conducted in 61 countries met eligibility. Nineteen trials (2.1%) recorded some form of sleep assessment. Eleven trials (1.2%) assessed a formal index of sleep disturbance collected at multiple time points. No trials formally assessed the influence of sleep on the primary pain outcome (e.g., as a potential mediator), nor met the most recent guidelines for core data element recommendations regarding sleep assessment.
Conclusion: This review highlights the paucity of sleep data captured and reported in randomized controlled trials for knee OA. The vast majority of trials addressing symptomatic knee OA do not capture sleep measures, significantly limiting the ability to accurately determine an intervention's effect on pain. Future research should include formal sleep-centric assessments measured at multiple time points to analyze sleep dysfunction and its relationship on treatment effects.

1. Introduction

Osteoarthritis (OA) was historically considered an age-related, degenerative condition with little consideration for other predisposing contributors [1], but is now recognized as a complex diagnosis influenced by biopsychosocial factors and behaviors affecting pain and disability [2]. Sleep is a primary domain recommended for further investigation and inclusion in pain research studies due to its psychosocial and physiologic effects on pain [3–7]. Sleep disruption and pain appear to have a weighted bidirectional relationship in which disrupted sleep is not only a consequence of pain, it is also an integral factor in pain expression [8]. A growing body of research has further illuminated the potential relationship between sleep quality and symptoms of knee OA [9–12]. Subjects with knee OA demonstrate greater pain intensity in response to upper body mechanical stimuli compared to controls, suggestive of central hyperalgesia [13]. Heightened levels of pro-inflammatory cytokines in patients with knee OA are linked to cartilage, synovial and subchondral bone dysfunction and correlate with heightened pain manifestation [14–16]. Existing literature supports the additive effect that sleep disturbance has on augmented central pain processing and increased basal systemic inflammatory biomarkers [8,17]. Reduced sleep duration affects up to 70% of individuals with symptomatic knee OA [12] and has been associated with increased pain [9], metabolic syndrome, and mental health conditions [10].

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Calls to assess the role of sleep disturbance in knee OA intervention trials began as early as 2000 [7]. In 2003, the European Alliance of Associations for Rheumatology established the need for uniform reporting of knee OA clinical trials [18]. By 2005, the Initiative on Methods, Measurement, and Pain Assessment in Clinical Trials (IMMPACT) built upon the Consolidated Standards of Reporting Trials (CONSORT) guidelines to establish a set of six core outcomes for all chronic non-cancer pain clinical studies. Their guidelines included sleep assessment as a core outcome due to the influence of sleep on pain [4]. A decade later, the Osteoarthritis Research Society International (OARSI) disseminated recommendations for the design, conduct, and reporting of clinical trials for knee OA recommending a multidimensional pain assessment inclusive of sleep quality [6]. In 2018, the National Institutes of Health (NIH) created the Helping to End Addiction Long-term (HEAL) initiative as a rigorous and progressive research effort to mitigate the opioid crisis and improve pain management, and subsequently published required common data elements to ensure standardized, comparable, and valid data collection within pain research inclusive of sleep assessment [19].

It is unclear how well trials for knee OA have consistently adhered to recommendations for collecting measures of sleep assessment [20]. Accounting for sleep disturbance in intervention trials targeting symptomatic knee OA may improve our current understanding of treatment effects. Thus, the primary objective of this scoping review was to determine what proportion of trials for knee OA-related pain collected and reported any measure of sleep assessment. A second objective was to determine which sleep measurement tools were most commonly collected and reported.

2. Method

This review followed the Preferred Reporting Items for Systematic reviews and Meta-Analysis extension for Scoping Reviews (PRISMA-ScR) guidelines [21] and was registered with Open Science Framework [22]. We performed a scoping review to systematically map the literature, identify and analyze knowledge gaps, and examine how well sleep measures are captured in pain-focused interventional trials for knee OA. This will help determine if future meta-analysis of the effect of sleep disturbance on knee osteoarthritis interventions is feasible based on available trials and if data from these trials will allow for assessment of mediating effects of sleep on pain-related treatments [23–25].

2.1. Information sources and search strategy

With the help of an academic librarian, literature search strategies were developed for PubMed (Ebsco interface), CINAHL, Cochrane Central, Scopus, SPORTDiscus, EMBASE, and PsycINFO databases.

For PubMed, medical subject headings (MeSH) and keyword searches were used to identify trials related to knee OA and queried results were combined using Boolean operators (AND, OR and NOT) [26]. In order to identify randomized controlled trials, study type filters were used and specific keyword searches of the titles and abstracts were conducted using the terms "random," "trial," "randomized controlled trial," and "controlled clinical trial." Search filters for date range January 1, 2000 to May 15, 2022 were applied (Supplementary Appendix A). Limiting our search to this date range aligned with the recent focus on the sleep-pain relationship and published guideline recommendations for the inclusion of a measure of sleep disturbance in persistent pain research [4,5,7,19,27–29]. We used each database's controlled vocabulary to determine equivalent terms within databases not indexed by MeSH headings (Scopus, Embase, and SPORTDiscus). For example, in EMBASE, we searched the Emtree for equivalent terms corresponding to each of our MeSH headings.

2.2. Eligibility criteria

The population of interest for this review was individuals with knee OA. All non-surgical interventions primarily intended to treat pain from knee OA were considered. Any comparator or control could be used, with the goal of characterizing measures of sleep disturbance as a baseline, mediating, or outcome variable.

To be included in the review, studies had to: (1) be a randomized controlled trial, (2) include adults (18+ years of age) with a diagnosis of knee OA [30], use the American College of Rheumatology, Kellgren-Lawrence Criteria, radiographic criteria or medical practitioner diagnosis to establish a diagnosis of knee OA, (3) examine a non-surgical intervention addressing pain as a primary outcome measure, and (4) be published between January 1, 2000 and May 15, 2022.

2.3. Protocol amendment

After a vast body of literature was identified on the initial review of search results, amendments were made to the inclusion criteria to further focus the initial research question by excluding non-peer reviewed or predatory journals, trials focused on surgical interventions for knee OA, and trials assessing an acute pain response (primary endpoints $\leq$ two weeks). We clarified inclusion of pain as the primary outcome rather than a secondary or unspecified outcome.

2.4. Data management

Covidence, a web-based software, was used for study screening and data extraction [31]. Two independent reviewers (JF and TM) performed title and abstract screening, full text screening and full text review. A third reviewer assisted with data extraction (JO) and a fourth reviewer resolved any disagreements (DR). The three reviewers independently performed data extraction initially with iterations of the same 20 studies. After each iteration of 20 studies, reliability and agreement was assessed. Once initial agreement reached >80%, the rest of the studies were divided among the reviewers for extraction. Initial agreement between reviewers for the same 20 trials was 100%. The reason for each exclusion is summarized in Fig. 1.

2.5. Data extraction

Data extracted included general study information (year of initial subject enrollment and the country or countries in which data collection was performed), characteristics of participants (total participants, age, and sex), and characteristics of the studies (outcome measures, intervention type, and sleep measure reported). As manuscripts are often published several years after study initiation, we captured the year of initial enrollment, whenever possible, as well as the year of publication in order to best assess the timing between research guidelines and adherence to sleep assessment recommendations.

2.6. Data synthesis and analysis

The primary outcome of interest was any measure of sleep reported as a baseline measure, confounder, or outcome variable. A JADAD-like adherence tool [32] was adapted to categorize the quality of sleep measure assessment, from 0 (no sleep measure) to 4 (formal sleep measure reporting) (Supplemental Appendix B). The sleep assessment quality scores for all trials were reported. Rates of sleep inclusion in controlled trials annually were assessed to compare with the timing of research guideline publication. Descriptive statistics were reported for all extracted data. A risk of bias assessment was not included since the methodological quality of the trials would likely not influence choices to capture sleep measures.

3. Results

3.1. Description of included trials

The initial search identified 22,436 trials. After removing duplicates, screening, and full text review, 926 trials met inclusion criteria and

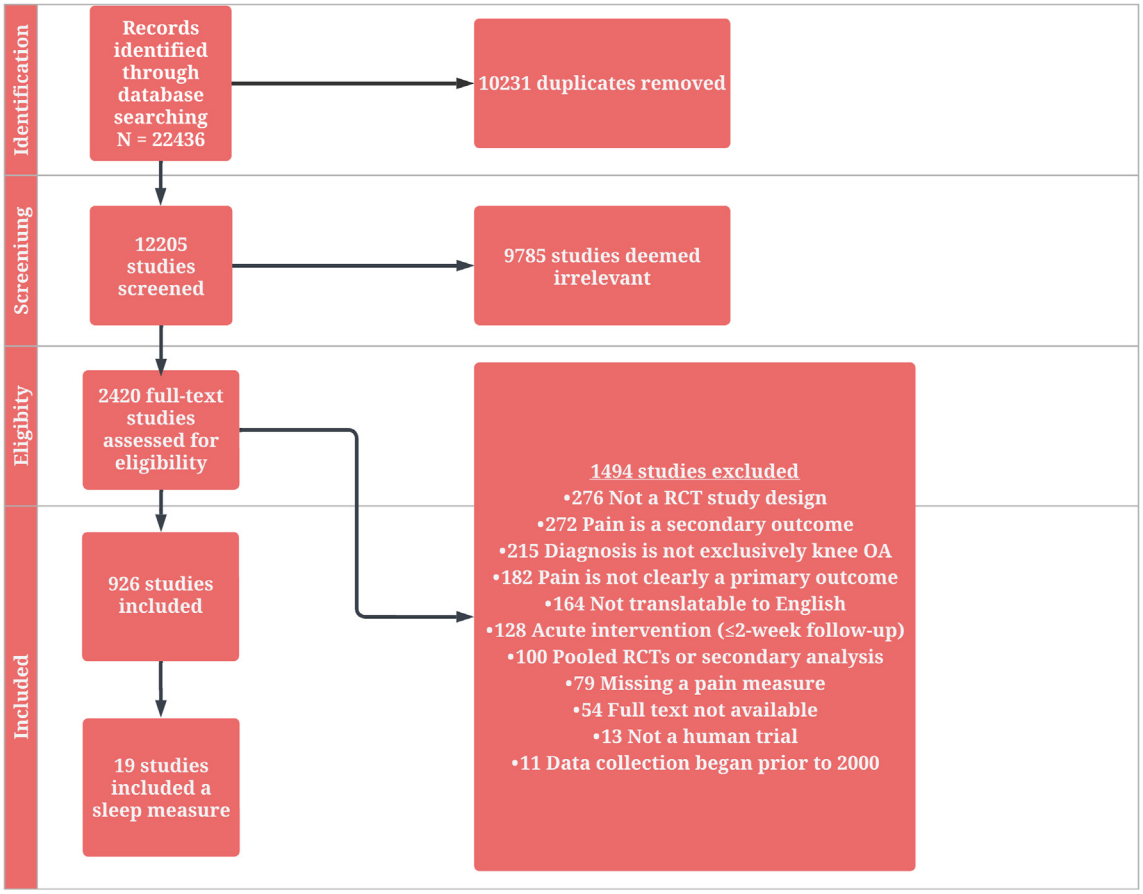

Fig. 1. Flowchart of search process Selection process for RCTs.

were included in the final review (Fig. 1). Nineteen (2.1%) trials published in 18 journals assessed at least one sleep measure (Table 1) [33–51]. Three trials (0.3%) included general sleep questions as a baseline descriptive variable [34,35,52]. Five trials (0.5%) collected an informal sleep measure at multiple time points [36–40]. Eleven trials (1.2%) collected a formal measure of sleep disturbance at multiple time points [41–51]. Initial reporting of sleep-related data was noted in one study published in 2004 [41]. The rate of knee OA intervention trials published each year that included a sleep assessment was relatively consistent over the next 18 years averaging 0.0%–0.5% annually (Fig. 2). 2018 had the largest number of knee OA trials published with at least one sleep measure (N = 4). Two trials included formal proxy measures of sleep quality evaluations: wearable actigraphy and polysomnography [43,48]. The 19 trials that included at least one sleep assessment were scored according to the sleep outcome reporting checklist (Supplementary Appendix B). An overview of each of these 19 trials is provided in Table 2.

3.2. *Participant and trial characteristics*

Participant characteristics are summarized in Table 3. Among the 19 trials that reported sleep measures, interventions were conducted in diverse healthcare and community settings spanning 17 countries, with 31.6% of these trials taking place in the United States (Fig. 3).

The treatments included within these 19 trials were pharmacologic management (n = 5), complementary/alternative therapies (n = 4), physical therapy (n = 1), injections/nerve blocks (n = 1), modalities (n = 2), nutritional supplementation (n = 3), and psychotherapies (n = 3). The year of initial subject enrollment was reported in 59.9% of all trials (n = 555 of 926). The median year (range) of initial enrollment was 2012

Table 1
Classification characteristics of knee OA-related pain trials inclusive of sleep assessment.

Classification	Classification Criteria	Trials Meeting Criteria (#)	Trial Sleep Measures
1	Any sleep measure collected at baseline only or unclear time point	3	Informal sleep-related questions (baseline data)
2	Any sleep measure collected at a single time point and controlled for within the statistical analysis	0	
3	Any informal sleep measure collected at multiple time points (pre-/post intervention)	5	Nottingham Health Profile (3) Brief Pain Inventory (2)
4	Formal sleep measure collected at multiple time points (pre-/post intervention)	11	Pittsburgh Sleep Quality Index (6) Insomnia Severity Scale (2) Wearable Actigraphy (2) Chronic Pain Sleep Inventory (1) PROMIS-29 (1) Polysomnography (1)

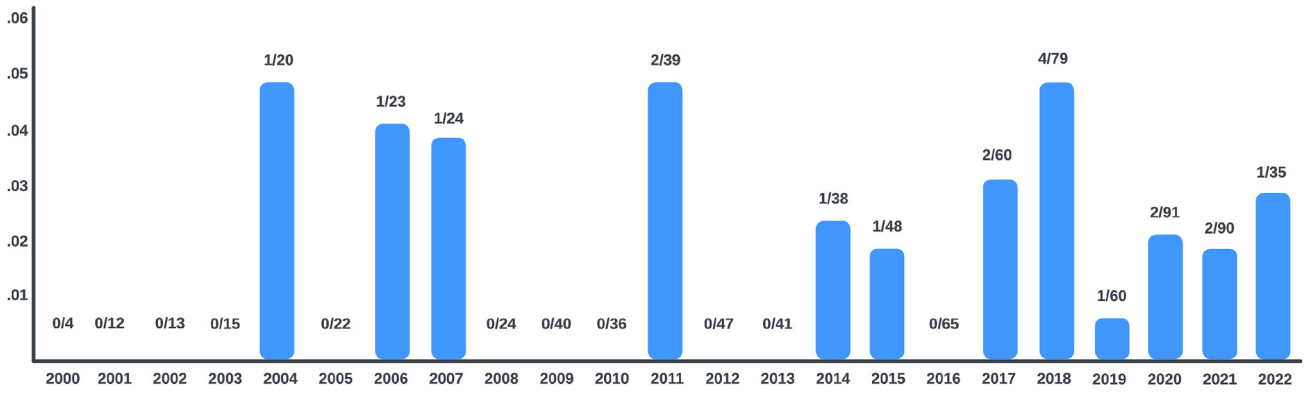

Fig. 2. Rate of trial adherence based on sleep assessment research recommendations. The Y axis represents the rate of knee OA trials published assessing sleep. Trials inclusive of any form of sleep assessment were not published in 2000–2003, 2005, 2008–2010, 2012–2013, and 2016.

Table 2
Characteristics of included trials with any form of sleep measure reported.

Primary Author	Year Data Collection Started	Country	Participants	Intervention	Follow-up Time Period	Sleep Measure	Sleep Measure Collection Point	Quality Score
Deyle 2020 [33]	2012	United States	156	Physical Therapy versus glucocorticoid injection	52 weeks	Sleep questions (not a formal measure)	Baseline	1
Kessler 2018 [34]	2010	Germany	151	Alternative	52 weeks	Sleep questions (not a formal measure)	Baseline	1
Serrie 2017 [35]	2007	12 European Countries	990	Pharmacologic	12 weeks	Sleep question diary and Patient Global Impression Score (not a formal measure)	Baseline	1
Aciksoz 2017 [36]	2011	Turkey	96	Superficial hot and cold application	6 weeks	Nottingham Health Profile	Multiple	3
Cankurtaran 2020 [37]	2019	Turkey	23	Genicular nerve block (GNB)	12 weeks	Nottingham Health Profile	Multiple	3
Frakes 2011 [38]	2009	United States & Puerto Rico	524	Pharmacologic	10 weeks	Brief Pain Inventory	Multiple	3
Uchio 2018 [39]	2014	Japan	354	Pharmacologic	14 weeks	Brief Pain Inventory	Multiple	3
Yurtkuran 2006 [40]	Not reported	Turkey	56	Alternative - Balneotherapy	12 weeks	Nottingham Health Profile	Multiple	3
Babul 2004 [41]	Not reported	United States	146	Pharmacologic	12 weeks	Chronic Pain Sleep Inventory	Multiple	4
Cheung 2014 [42]	2011	United States	36	Yoga	20 weeks	Pittsburgh Sleep Quality Index	Multiple	4
Fary 2011 [43]	2007	Australia	70	Pulsed Electrical Stimulation	26 weeks	Wearable Actigraphy	Multiple	4
Heffner 2018 [44]	Not reported	United States	30	Cognitive Behavioral Therapy	8 weeks	Insomnia Severity Scale	Multiple	4
Illeez 2022 [45]	2016	Turkey	66	Pharmacologic	12 weeks	Pittsburgh Sleep Quality Index	Multiple	4
Innes 2018 [46]	2015	United States	22	Meditation versus Music Listening	10 weeks	Pittsburgh Sleep Quality Index	Multiple	4
Lopresti 2021 [47]	2020	Australia	101	Nutritional - Supplemental	8 weeks	Patient Reported Outcomes Measurement Information System (PROMIS-29)	Multiple	4
Smith 2015 [48]	2008	United States	100	Cognitive Behavioral Therapy	24 weeks	Polysomnography, Actigraphy, Insomnia Severity Index	Multiple	4
Steels 2019 [49]	2016	Australia	111	Nutritional – Supplemental	8 weeks	Pittsburgh Sleep Quality Index	Multiple	4
Wang 2021 [50]	2012	Taiwan	97	Nutritional – Supplemental	8 weeks	Pittsburgh Sleep Quality Index	Multiple	4
Weiner 2007 [51]	Not reported	United States	88	Periosteal Stimulation Therapy	6 weeks	Pittsburgh Sleep Quality Index	Multiple	4

Table 3
Baseline participant characteristics.

Pooled Participants (n)		Age in Years (Mean ± SD)		Sex (n, % Female)	
Sleep Measure	No Sleep Measure	Sleep Measure	No Sleep Measure	Sleep Measure	No Sleep Measure
3217	135,159	61.9 ± 5.2	61.3 ± 5.5	67.9%	68.8%

*Trials differentiated by inclusion of a sleep measure.

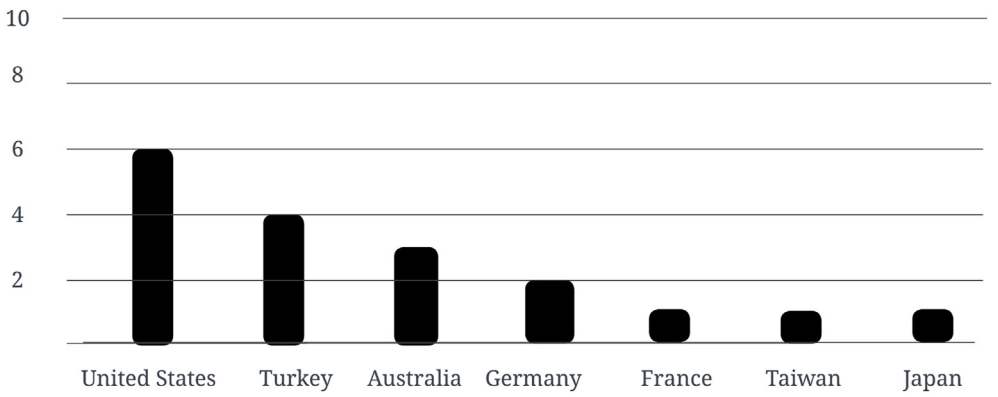

Fig. 3. Distribution of sleep assessment inclusion by country. Countries of origin were determined by the location(s) for subject recruitment. Serrie (2017) reported subject recruitment in Germany, France, and 10 other unidentified European countries.

(2007–2020) for those trials that included a sleep measure (n = 15), similar to 2013 (2000–2021) for trials that did not report sleep measures (n = 540). The majority of trials were initiated in 2016 (n = 52 trials; Fig. 4). Mean sample sizes were comparable in trials without a sleep measure (n = 149 ± 196 participants) and trials which included a form of sleep assessment (n = 169 ± 233 participants).

4. Discussion

This is the first scoping review to map the literature capturing and reporting sleep assessments in knee OA trials [19]. Out of the 926 trials reviewed, only 19 captured any measure of sleep and only 11 of these captured a measure of sleep disturbance at multiple time points over the course of the trial. There was not a single trial which included sleep assessment as a primary outcome or effect modifier influencing treatment intervention. Only one trial used the PROMIS instrument, consistent with the most recent and robust research recommendations; however, the additional sleep duration question from the Pittsburgh Sleep Quality Index (PSQI) was not included. It appears that recommendations for the optimal conduct of pain research are not being followed in studies of knee OA. We discuss our findings here with reference to research recommendation timelines, gaps in the literature and potential areas for future work.

4.1. Overall summary of findings

There is converging evidence from numerous studies highlighting the importance of sleep assessment and benefits of targeted treatment in reducing pain and improving function [5,8,53,54]. Research recommendations have substantiated the need to capture and report assessments of sleep disturbance as a core outcome due to its important interaction with pain as an often overlooked, yet primary confounding variable. As an effect modifier, sleep disturbance can alter intervention effects, confounding the ability to accurately assess intervention efficacy. Controlled trials that examine unimodal interventions do not provide the granularity of information needed to address the inherently multi-dimensional aspects of pain.

Despite the publication of multiple guidelines for enhanced persistent pain research and recommendations specific to knee OA intervention trials over the past two decades, this review highlights the paucity of

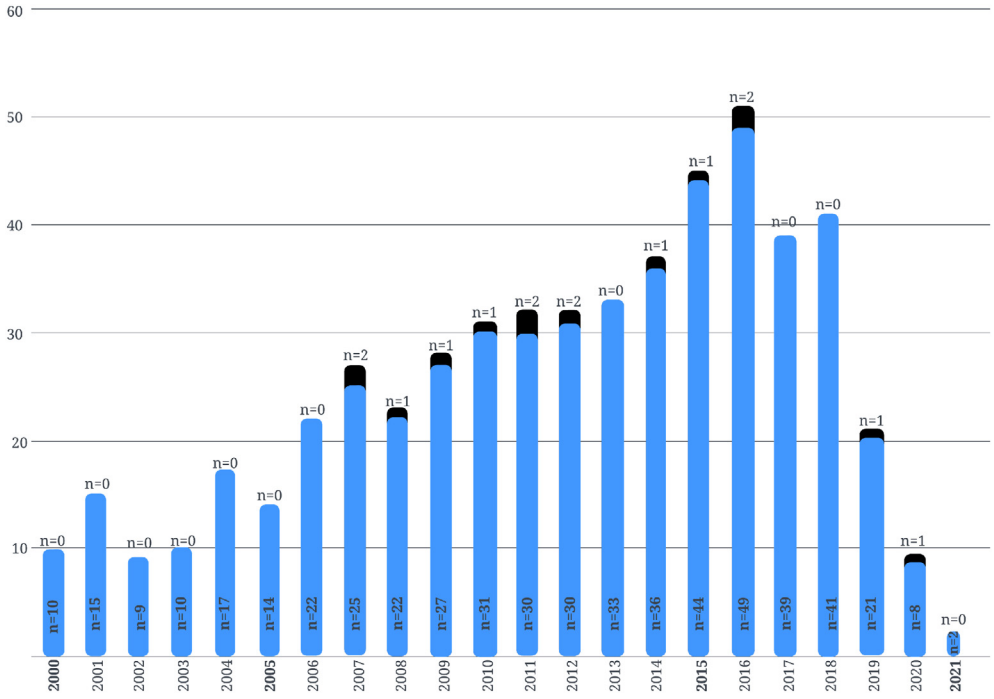

Fig. 4. Distribution of enrollment initiation by year for all included trials (n = 926) The blue bar represents the number of knee OA studies published that year without a sleep measurement. The black bar represents the number of knee OA studies published that year with a sleep measurement. Years in bold correspond with the date of publication of research guidelines recommending sleep assessment. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

research trials inclusive of sleep disturbance with only 1.2% of all trials (11 of 926) using a reliable and valid sleep outcome tool longitudinally over the course of the trial [4,6,19]. The first trial to initiate sleep-related data collection was not published until 2004 [41], four years after the first recommendation was available [7], and rates of adherence to research guidelines inclusive of sleep measures consistently average 0.0%–0.5% of all relevant trials annually (n = 19).

Patterns of exclusion of sleep measures in knee OA trials were not limited to a single country or region, suggesting it is a global problem (n = 926, 61 countries in which data was collected). The reasons for omitting sleep assessment in these trials is unknown. It is possible early recommendations were too vague or non-descript, negating consistent application of sleep outcome tools [4,7]. A majority of trials (96%; n = 893) included a measure of disability or function, such as the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), which includes one question related to sleep. However, these trials did not extract or report on the specific sleep question, suggesting there was not an intent to align with recommendations to report on sleep disturbance. Additional reasons for poor guideline adherence could be a lack of awareness or understanding of the extensive relationship between sleep and persistent pain, inclusive of arthritic conditions.

Additionally, we extracted the year of subject enrollment for each randomized controlled trial as we were interested in comparing the initiation of trials which included sleep assessment to the publication of research guidelines recommending sleep inclusion. Compliance with research guidelines and inclusion of sleep disruption assessment did not change over time. The initial call for inclusion of sleep assessments in knee osteoarthritis trials was published in 2000 and the first trial to report on sleep assessment was published in 2004 [41]. In 2005 and 2015 the IMMPACT and OARSI guidelines were published respectively, without a subsequent noted change in the inclusion of sleep measures in those trials initiated between 2005 and 2021; each year demonstrating four or fewer trials inclusive of some form of sleep assessment.

4.2. Clinical impact

Although measures of sleep are recommended as a core outcome in chronic pain trials [19], sleep considerations do not appear to carry over to patient management. Many current knee OA clinical practice guidelines fail to adequately consider the association between knee OA symptoms and sleep quality [55–57]. The lack of clinical assessment directly relates to the lack of sleep inclusion in randomized controlled trials. Consistent with the results of this scoping review, only one systematic review has assessed the relationship between sleep disruption and pain response in individuals with OA noting a total of seven identified trials, four focusing on knee OA [58]. Although nearly 70% of patients with knee OA experience sleep dysfunction [12], the relative absence of sleep assessment in controlled trials limits our understanding of the impact of sleep on clinically relevant treatments.

Several examples highlight the effect modification of sleep disturbance on pain-related outcomes and the importance of collecting these variables. The Strategies for Prescribing Analgesics Comparative Effectiveness (SPACE) trial randomized subjects with moderate to severe chronic back pain, hip or knee osteoarthritis to either an opioid therapy (N = 120) or non-opioid therapy (N = 120) to assess their effect on pain and function [59]. Primary outcomes included the Brief Pain Inventory (BPI) interference and severity subscales. The PROMIS Sleep Disturbance assessment reported on eight items related to sleep quality and nighttime sleep concerns collected at baseline, six months and twelve months. A high percentage of patients included within the study suffered from sleep disturbance (34%) [60]. Baseline sleep disturbance scores predicted diminished improvement in both BPI interference ($\beta = 0.06$, $P = <0.001$) and severity ($\beta = 0.03$, $P = 0.02$) subscales as an effect modifier. For example, a 10-point higher baseline PROMIS score predicted 0.58 points less improvement on the BPI interference subscale and likewise 0.26 points less improvement on the BPI severity subscale [60]. Similarly, the PACE trial randomized 1246 subjects with acute low back pain to either a treatment group evaluating paracetamol versus a placebo-control to assess recovery [61]. Sleep quality was assessed using the PSQI sleep quality question modified to reflect sleep patterns over the previous seven days. Findings included a statistically significant association between sleep quality and pain intensity ($p < 0.001$), noting sleep quality predicted diminished improvement in pain rating scores. For every one-point decrease in sleep quality (based on a 0–3 Likert scale), pain intensity (based on a 0–10 point numerical rating scale) increased by 2.08 points (95% CI 1.99–2.16) [62]. Sleep disruption as a covariate or effect modifier enhances the ability to assess pain interventions accurately. As trials consistently incorporate sleep assessment, clinicians will likely benefit from better ways to address sleep as a means to enhance clinical outcomes.

4.3. Opportunities for research advancement and a call to action

Based on current research recommendations [4,6,7,19], in combination with the findings from this systematic scoping review, researchers are missing sleep assessment as a crucial variable within their methodology, resulting in a missed opportunity to better understand the role of sleep in the pain experience. If researchers are not considering sleep disturbance as an important treatment effect modifier, researchers and clinicians may have an unclear picture of the value of our interventions.

There appears to be minimal adherence with collecting sleep measures in trials for knee OA. However, consensus has historically been lacking in regard to the optimal outcome measures to assess sleep disruption [4,6,7,19]. The recent HEAL Initiative provides clear direction recommending optimal outcome measures for sleep assessment in pain research with a standardized common data element set [63], consisting of the PROMIS Sleep Disturbance questionnaire with the addition of one question from the PSQI, the sleep duration question, to assess sleep within prospective research studies [19]. Consistent with the NIH HEAL Initiative, we strongly recommend researchers investigating interventions for knee OA, design trials inclusive of the PROMIS Sleep Disturbance questionnaire and the PSQI sleep duration question.

4.4. Strengths and limitations

This is the first scoping review to map the literature identifying the use of sleep assessment within randomized controlled trials addressing non-surgical interventions for knee OA. This review presents a broad overview of trials over the past two decades offering a comprehensive picture of the available evidence, and more importantly highlights the opportunity to improve research efforts inclusive of sleep assessment. Secondly, this review identified the heterogeneity of sleep assessment in trials when measured, identifying a lack of consistency. Use of consistent, standardized variables can improve comparison of treatment effects across studies.

There are inherent limitations to consider. As this is a scoping review, no definitive conclusions can be made with regard to the relative effectiveness of the various interventions. This review focuses on knee OA treatment based on non-surgical interventions and therefore cannot be generalized to trials assessing surgical treatments for knee OA or in other persistent pain populations.

The relationship between sleep disturbance and knee OA is well-documented. Sleep disturbance is strongly associated with increased pain [9–11]. Only 11 trials (1.2%) considered the effects of sleep disturbance on their primary outcome. The paucity of sleep data present in randomized controlled trials for knee OA significantly limits clinicians' and researchers' understanding of how sleep may influence treatment effects in this patient population, potentially downplaying the importance of sleep's impact. Clinicians should recognize the influence of sleep has not been accounted for in most clinical trials for knee OA. Future controlled intervention trials should include formal longitudinal sleep-centric assessments to enhance our understanding of the relationship between sleep and pain to better inform clinical practice.

Registration

Open Science Framework https://osf.io/6wqve/?view_only=7193fa10502c481bb22a176a414109cb.

Disclaimer

The view(s) expressed herein are those of the author(s) and do not reflect the official policy or position of the Uniformed Services University, U.S. Department of Defense, or the U.S. Government.

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Brett Neilson: Conceptualization; Methodology; Formal analysis; Writing - review & editing; Supervision.

Jody L Young: Conceptualization; Formal analysis; Writing - review & editing; Supervision.

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Declaration of competing interest

All authors have no competing interests to declare.

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Appendix A. Search strategy example

Database	Search Strategy
PubMed	(((((“Knee" [Mesh]) OR (“Knee Joint” [Mesh])) OR (Knee [Title/Abstract])) AND (((((“Osteoarthritis” [Mesh]) OR (“Joint Diseases” [Mesh])) OR (degenerative arthr*[Title/Abstract])) OR (gonarthr* [Title/Abstract])) OR (osteoarthr* [Title/Abstract]))) AND ((((((“Randomized Controlled Trial” [Publication Type]) OR (“Controlled Clinical Trial” [Publication Type])) OR (“Random Allocation” [Mesh])) OR (“Clinical Trial” [Publication Type] OR “Controlled Clinical Trial” [Publication Type] OR “Pragmatic Clinical Trial” [Publication Type] OR “Clinical Trial, Phase IV” [Publication Type] OR “Clinical Trial, Phase III” [Publication Type] OR “Clinical Trial, Phase II” [Publication Type] OR “Clinical Trial, Phase I” [Publication Type] OR “Clinical Trial Protocol” [Publication Type] OR “Adaptive Clinical Trial” [Publication Type])) OR (random* AND control* AND trial*[Title/Abstract])) OR (clinic*[Title/Abstract] AND trial*[Title/Abstract]))) NOT (meta-analysis [Title] OR systematic review [Title]) AND (2000:2022 [pdat])) NOT (animal*)

Appendix B. Sleep outcome reporting checklist

Sleep Outcome Reporting Checklist	Scoring System
No reporting of any sleep measures	0
Any sleep measure reported at baseline only (descriptive)	1
Any sleep measure collected at a single time point and controlled for in the analysis (covariate)	2
Any sleep measure as an outcome at multiple time points (change due to intervention)	3
Sleep disturbance measured at multiple time points (change due to intervention)	4

*No trial met the NIH HEAL Initiative minimal data set elements for sleep assessment.

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