Systematic Review and Meta-Analysis

PAIN 165 (2024) 2455–2467

PAIN®

The bidirectional relationship between sleep problems and chronic musculoskeletal pain: a systematic review with meta-analysis

Nils Runge[a,b,c,*], Ishtiaq Ahmed[a], Tobias Saueressig[d], Julya Perea[e], Celine Labie[a,b], Olivier Mairesse[c,f], Jo Nijs[a,g,h], Anneleen Malfliet[a,g,i], Sabine Verschueren[b], Dieter Van Assche[b,j], Kurt de Vlam[j,k], Tybo Van Waeyenberg[a], Jelle Van Haute[a], Liesbet De Baets[a]

Abstract

Chronic musculoskeletal pain and sleep problems/disorders exhibit a recognized bidirectional relationship; yet, systematic investigations of this claim, particularly in a prospective context, are lacking. This systematic review with meta-analysis aimed to synthesize the literature on the prospective associations between sleep problems/disorders and chronic musculoskeletal pain. A comprehensive search across 6 databases identified prospective longitudinal cohort studies in adults examining the relationship between sleep problems/disorders and chronic musculoskeletal pain. Random-effects meta-analyses, using the Hartung–Knapp adjustment for 95% confidence intervals (CIs), were conducted, and all results were presented as odds ratios (ORs). Certainty of evidence was evaluated using the Grading of Recommendations, Assessment, Development, and Evaluations approach. Including 16 articles from 11 study populations (116,746 participants), meta-analyses indicated that sleep problems at baseline may heighten the risk of chronic musculoskeletal pain in both short term (OR 1.64, 95% CI 1.01-2.65) and long term (OR 1.39, 95% CI 1.21-1.59). The evidence for different sleep problem categories was very uncertain. Chronic musculoskeletal pain at baseline may increase the risk of short-term sleep problems (OR 1.56, 95% CI 1.02-2.38), but long-term evidence was very uncertain. The impact of only local or only widespread pain on short-term sleep problems was very uncertain, whereas widespread pain may elevate the risk of long-term sleep problems (OR 2.0, 95% CI 1.81-2.21). In conclusion, this systematic review with meta-analysis suggests that sleep problems are associated with an increased risk of chronic musculoskeletal pain, but the bidirectional nature of this relationship requires further investigation.

Keywords: Musculoskeletal pain, Sleep wake disorders, Meta-analysis, Longitudinal studies, Sleep

1. Introduction

Painful chronic musculoskeletal conditions represent a major global health issue, afflicting more than 1 billion individuals worldwide.[71] Aside of the persistent pain, individuals grappling with chronic musculoskeletal pain (CMP) experience a multitude of other consequences, including a lower quality of life, elevated levels of depression, and increased disability levels when compared with those without pain.[3] The socioeconomic ramifications of CMP are substantial, presenting a significant financial burden on healthcare systems and societies worldwide.[27,68] Despite significant progress in the field of health care, the incidence of CMP is rapidly growing.[38]

Sleep problems (eg, poor sleep[40]) and sleep disorders (eg, insomnia[41] or obstructive sleep apnoea[8,26]) are other highly prevalent serious health issues. Impaired sleep has been linked to lower quality of life, poorer general health, higher levels of depression,[40] and decreased physical function.[15,19] This is a striking parallel to CMP, and, potentially not surprisingly, the

Sponsorships or competing interests that may be relevant to content are disclosed at the end of this article.

[a] *Pain in Motion Research Group (PAIN), Department of Physiotherapy, Human Physiology and Anatomy, Faculty of Physical Education & Physiotherapy, Vrije Universiteit Brussel, Brussel, Belgium,* [b] *Musculoskeletal Rehabilitation Research Group, Department of Rehabilitation Sciences, Faculty of Movement and Rehabilitation Sciences, KU Leuven, Belgium,* [c] *Brain, Body and Cognition (BBCO), Faculty of Psychology and Educational Sciences, Vrije Universiteit Brussel (VUB), Brussels, Belgium,* [d] *Physio Meets Science GmbH, Leimen, Germany,* [e] *Department of Physical Therapy, Federal University of São Carlos, São Paulo, Brazil,* [f] *Laboratoire de Psychologie Médicale et d'Addictologie (ULB312), Department of Psychiatry, Brugmann University Hospital, Université Libre de Bruxelles (ULB) and Vrije Universiteit Brussel (VUB), Brussels, Belgium,* [g] *Chronic Pain Rehabilitation, Department of Physical Medicine and Physiotherapy, University Hospital Brussels, Brussel, Belgium,* [h] *Department of Health and Rehabilitation, Unit of Physiotherapy, Institute of Neuroscience and Physiology, Sahlgrenska Academy, University of Gothenburg, Gothenburg, Sweden,* [i] *Research Foundation Flanders (FWO), Brussels, Belgium,* [j] *Division of Rheumatology, University Hospitals Leuven, Leuven, Belgium,* [k] *Skeletal Biology & Engineering Research Center, Department of Development & Regeneration, KU Leuven, Belgium*

**Corresponding author. Address. Vrije Universiteit Brussel, Pain in Motion Research Group (PAIN), Faculty of Physical Education and Physiotherapy, Department KIMA, Building F, Laarbeeklaan 103, 1090 Brussels, Belgium. E-mail address: nils.arno.andreas.runge@vub.be (N. Runge).*

Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's Web site (www.painjournalonline.com).

http://dx.doi.org/10.1097/j.pain.0000000000003279

prevalences of sleep problems and sleep disorders in people with CMP are very high with around 75%[63] and 44%,[39] respectively.

Large numbers of studies have investigated the general link between sleep problems and CMP. The prevailing consensus in the field is that there is a bidirectional relationship between the 2, with research indicating that CMP can exacerbate pre-existing sleep problems and vice versa, although both also serve as mutual risk factors for the development of the respective other condition.[21,24,54] Research on risk factors, defined here as a variable that precedes the outcome and is associated with it,[17] can be difficult to probe with predictive and causal interpretations often being mixed when it comes to relevant conclusions.[17] An enhanced understanding of the relationship between a risk factor and an outcome can be instrumental for identifying individuals at an elevated risk of developing a condition,[17,65] potentially offering them increased general support. However, it would be misguided to develop interventions targeting the risk factor based only on predictive evidence because causality cannot be implied.[17] By contrast, when a risk factor is deemed to exert a substantial causal influence on the development of a condition, it can become a potential target for direct preventive interventions in specific populations and the findings can significantly influence policies.[65]

Remarkably, despite the increased interest in the sleep-pain link in recent years, there is a paucity of comprehensive reviews regarding the prospective bidirectional relationship between sleep problems and chronic musculoskeletal pain, more specifically on their association with the development of new sleep or pain problems. Most existing reviews in this context primarily investigated general,[24] postsurgical,[67] paediatric pain populations,[4] and specific CMP populations (eg, low back pain).[66] Others focussed on the role of changes in sleep rather than the presence of a sleep problem[1] or on prognosis rather than the development of new sleep or pain problems.[56] The reviews were often narrative (or used narrative syntheses),[24,66] and only 1 systematic review with meta-analysis dedicated to the investigation of CMP has been published.[54] This sole systematic review offered support for the reciprocity between sleep problems and pain, but it had various limitations. For example, in their analyses, several studies examining the identical study populations were included, resulting in double counting of thousands of participants,[48,61,44,64] and the utilization of unadjusted values did not allow for any potential causal interpretations because of the likely unaccounted confounding.[54] Therefore, the evidence in this field remains limited. Even more, previous reviews have not explored differences between different sleep problems/disorders, although this is an important gap in the literature as people with sleep problems/disorders are not a homogenous group. The same holds for the exploration of different pain problems, with no attention towards the differences between local vs widespread pain so far. Therefore, this systematic review with meta-analysis aimed not only to overcome the limitations of the previous reviews but also to provide a more comprehensive overview of the current evidence on the following research questions:

(1) Are sleep problems/disorders at baseline associated with an increased risk of the development of chronic musculoskeletal pain?
(2) How are different categories of sleep disorders/problems at baseline associated with an increased risk of the development of chronic musculoskeletal pain?
(3) Is chronic musculoskeletal pain at baseline associated with an increased risk of the development of sleep problems/disorders?
(4) How are different chronic musculoskeletal pain problems (categorized as local vs widespread) associated with an increased risk of the development of sleep problems/disorders?

2. Methods

For this review, the PRISMA guidelines[50] and the PERSiST guidance were followed.[5] The review protocol was prospectively registered on PROSPERO (CRD42023427992).

2.1. Search strategy and screening

Six databases (PubMed [including MEDLINE], Embase, Cochrane Library, Scopus, Web of Science, and PsycINFO [through ProQuest]) were searched from inception till July 20, 2023, using relevant search terms for each of the concepts. The full search strings and results for each database can be found in supplementary file 1, http://links.lww.com/PAIN/C61. The search strategy was developed with the support of 2 experienced librarians. The records found in each database were transferred to EndNote (desktop version) for duplicate removal. The removal of duplicates was performed following a structured stepwise approach.[22] The resulting list of records was then transferred to Rayyan[49] where 2 independent researchers (N.R. and I.A.) screened titles, abstracts, and full-texts. In case of disagreements, a third reviewer made the final decision (L.D.B.). Forward and backward citation tracking was used, and the citations were also independently screened by the 2 researchers (August 23, 2023). Furthermore, 2 trial registration databases were searched for any missing registered studies (https://www.who.int/clinical-trials-registry-platform and ClinicalTrials.gov) (September 12, 2024). In a final step, 2 experts in the field were contacted and asked for any potentially missing studies. If there were doubts about study eligibility from the information provided in the study manuscript, authors of the respective studies were contacted 2 times within 2 weeks to inquire.

2.2. Eligibility criteria

Prospective longitudinal cohort studies with reports that were fully published and peer-reviewed were included in this review. Cross-sectional studies were excluded. To be included studies had to either investigate the association of sleep problems or sleep disorders at baseline with CMP at follow-up (research aims 1 and 2) or the association of CMP at baseline with sleep problems or sleep disorders at follow-up (research aims 3 and 4). This means that for aims 1 and 2, only studies investigating participants without CMP at baseline have been included, and for aims 3 and 4, only studies investigating participants without sleep problems at baseline have been included. Studies that had CMP as outcome (research aims 1 and 2) were only included if they specifically outlined that they had ensured that included participants were free of any (chronic) musculoskeletal pain at baseline even if the outcome was chronic widespread pain. Studies that provided data on mixed populations were included if it was possible to extract the data for the pain-free population at baseline.

Chronic musculoskeletal pain was defined using the International Association for the Study of Pain definition of chronic primary musculoskeletal pain and chronic secondary musculoskeletal pain with any conditions falling under these terms being included.[25] Chronic musculoskeletal pain had to be defined as having persisted for 3 months or longer. In addition, studies that

investigated people with chronic widespread pain, complex regional pain syndrome, and postsurgical or post-traumatic chronic pain (eg, after spinal surgery, arthroplasty, whiplash injury, or musculoskeletal injury) were included, if fitting all other criteria, because these are commonly seen in musculoskeletal practice.

Any sleep problems, eg, poor quality of sleep or perceived sleep disturbance, or sleep disorders (diagnosed using established diagnostic criteria), such as insomnia disorder, sleep apnoea, or narcolepsy, were included in this review.

For all research aims, the exposure and outcome had to be presented as binary variable (present or absent), or data must have been presented in a way that allowed for the creation of 2 categories (present or absent). Studies only presented as abstracts, study protocols, conference papers, unpublished data, preprints, and posters were excluded.

2.3. Outcomes

The outcome for research aims 1 and 2 was CMP. Any measurements (eg, questionnaires and clinical interviews) of CMP were allowed as long as they were fitting the criteria outlined above (ie, pain duration >3 months and presented in a way that allowed to interpret the result as present/absent). For the research aims 3 and 4, the outcome was any sleep problem/disorder. Any subjective or objective measurements were allowed to measure the outcome as long as the result was presented as present/absent (or it could be recoded as such).

2.4. Data extraction

Two independent reviewers (T.V.W. and J.V.H.) performed the data extraction of the general study summaries using a standardized extraction form. The statistical data were extracted separately by 2 other independent researchers (I.A. and N.R.). Individual extraction tables were used for each research question. In all cases, a third reviewer was available for discussion and a final decision if there were any discrepancies between the extractions. All available statistical data including adjusted and unadjusted risk ratios (RRs), odds ratios (ORs), and raw data for 2 × 2 tables were extracted where available within the primary studies. Data were separated based on follow-up durations with short term having been defined as 3 months to 3 years and long term as longer than 3 years. If studies provided outcome data on more than 1 time point within 1 follow-up duration, the time point closest to the lower boundary of each grouping was used (ie, closest to 3 months for short term and closest to 3 years for long term). If more than 1 group for exposure or outcome were presented in 1 article, best-fitting groups were created, and data were combined using the inverse variance weight method.[10] More details on the methods for combining groups are outlined in supplementary file 2, http://links.lww.com/PAIN/C61. Measures of association that were provided as RRs were transformed into ORs using established formulas if adjusted values were available or 2 × 2 tables if only raw data were available.[28] The baseline risk of the control group was calculated for each study to perform the conversion from RRs to ORs. A sensitivity analysis was performed removing studies that originally provided RRs from studies that provided ORs if more than 5 studies were included in an analysis. Authors of primary studies for which more information in context of the data extraction was required (eg, missing data or unclear presentation) were contacted 2 times through e-mail (find an overview of the contacts and received responses in supplementary file 3, http://links.lww.com/PAIN/C61).

For research aim 2, categories of sleep disorders were prespecified, although no studies investigating specific sleep disorders were included. Details on the categories can be found in the preregistered study protocol. For sleep problems, we were not able to prespecify categories. Therefore, studies were grouped together and presented if 2 or more studies investigated reasonably comparable sleep problems based on their definitions.

2.5. Risk-of-bias assessment

The risk-of-bias (RoB) assessment was performed by 2 independent researchers (N.R. and J.P.) using the ROBINS-E tool.[52] Any disagreements were resolved by discussion, but a third researcher would have been available to make the final decision (I.A.). RoB was assessed for each exposure individually, which means that different exposures within 1 study were assessed independently.

In the study protocol, a minimal set of confounders was prespecified: age, sex, body mass index, depression, and anxiety at baseline. In case, only raw data were provided in a primary study or raw data had to be used for the analyses for a different reason (eg, combination of groups was necessary through 2 × 2 table or transformation gave unreasonable results), then this study was rated as not having adjusted for the minimal set of confounders.

2.6. Data synthesis

Meta-analyses were performed if 2 or more studies were available for a research aim within 1 follow-up period. Inverse variance random-effects meta-analyses using the Paule–Mandel estimator to estimate between-study variance were performed with Hartung–Knapp adjustment (with ad-hoc adjustment) for the estimation of 95% CIs.[34,55] If available, maximally adjusted ORs from primary studies were used for the main analysis. If these were not given in primary studies, we transformed maximally adjusted RRs to ORs using the *effectsize* package in R. All ORs were log-transformed before the pooling to achieve approximate normality and back-transformed afterwards to ease interpretation. The results are presented as estimated average ORs and 95% CIs as measures of precision. Bootstrapped 95% prediction intervals (PIs) were estimated as measures of heterogeneity,[45] and for all meta-analyses, the Q-statistics testing for heterogeneity as well as proportion of between-study variability using I^2 with 95% CI is presented.[31] Absolute risk differences for each outcome were estimated based on the given ORs and 95% CIs. The baseline risk was estimated based on the control group median baseline risk in the largest meta-analyses for each direction of effect. The absolute risk difference is described for each analysis that was statistically significant. Sensitivity analyses with slightly higher and lower baseline risks were performed and can be found in the supplementary files, http://links.lww.com/PAIN/C61 for each separate analysis.

Established algorithms for the detection of outliers and influential studies were used in analyses with more than 5 studies (Supplementary file 2, http://links.lww.com/PAIN/C61).

All analyses were performed using the *meta*[6] and *metafor* packages in R.[70] The full R code can be found here https://osf.io/q6ba9/?view_only=1e4e4e5ad3074bfea43b2fbbdf7915bd.

Preplanned sensitivity analyses were performed for analyses with 5 or more included studies (see details on sensitivity and

subgroup analyses in supplementary file 4, http://links.lww.com/PAIN/C61).

2.7. Certainty of evidence

The Grading of Recommendations, Assessment, Development, and Evaluations (GRADE) approach was used to assess the certainty of evidence for each meta-analysis.[29] A detailed outline of the used approach can be found in supplementary file 5, http://links.lww.com/PAIN/C61. Publication bias was assessed using funnel plots and the Peter test if 10 or more studies were available in a meta-analysis.[62]

2.8. Changes to preregistered protocol

No significant changes to the preregistered protocol were made.

3. Results

3.1. Study selection

Nineteen thousand one hundred twenty records were retrieved from the database searches. Eight thousand one hundred ninety-two duplicates were removed, and the titles and abstracts of the remaining 11,320 records were screened. The full texts of 104 remaining records were retrieved and screened, which resulted in a final set of 16 included articles. Detailed reasons for exclusion at full-text stage can be found in supplementary file 6, http://links.lww.com/PAIN/C61. Of these 16 articles, 9 reported on the same study (HUNT study)[42,43,48,57–61,64] but on different time points resulting in 11 different study populations overall included in the meta-analyses (**Fig. 1**). Below more details on the HUNT study and how it was handled within this review are shown (see section on "Study and participant characteristics").

3.2. Study and participant characteristics

Nine of the 16 included articles reported on results of the HUNT study,[42,43,48,57–61,64] a large prospective observational study within the Nord-Trøndelag County in Norway. Details on how the overlapping populations from the HUNT articles were handled in this review are outlined in supplementary file 7, http://links.lww.com/PAIN/C61.

Approximately 116,746 participants were included in the 11 different study populations. The different study populations came from Norway (n = 6), Sweden (n = 4), and Brazil (n = 1). Nine of the 11 study populations were recruited from the general population, 1 included only teachers,[12] and 1 included university students.[37] Relevant details on all included studies can be found in supplementary file 8, http://links.lww.com/PAIN/C61. Data from 3 study populations[12,13,37] were available for short-term analyses. For the long-term follow-up, data from 9 study populations[2,32,33,37,43,47,48,57,64] were available.

3.3. Exposures and outcomes

Of the 11 different study populations, 8 reported on sleep problems as exposure and CMP as outcome,[2,13,33,37,43,47,57,64] 1 reported on CMP as exposure and sleep problems/disorders as outcome,[48] and 2 reported on associations in both directions.[12,32] All included studies provided data on sleep problems, whereas no study used established diagnostic criteria to identify people with specific sleep disorders. Sleep problems were defined in various ways with 12 studies using self-developed

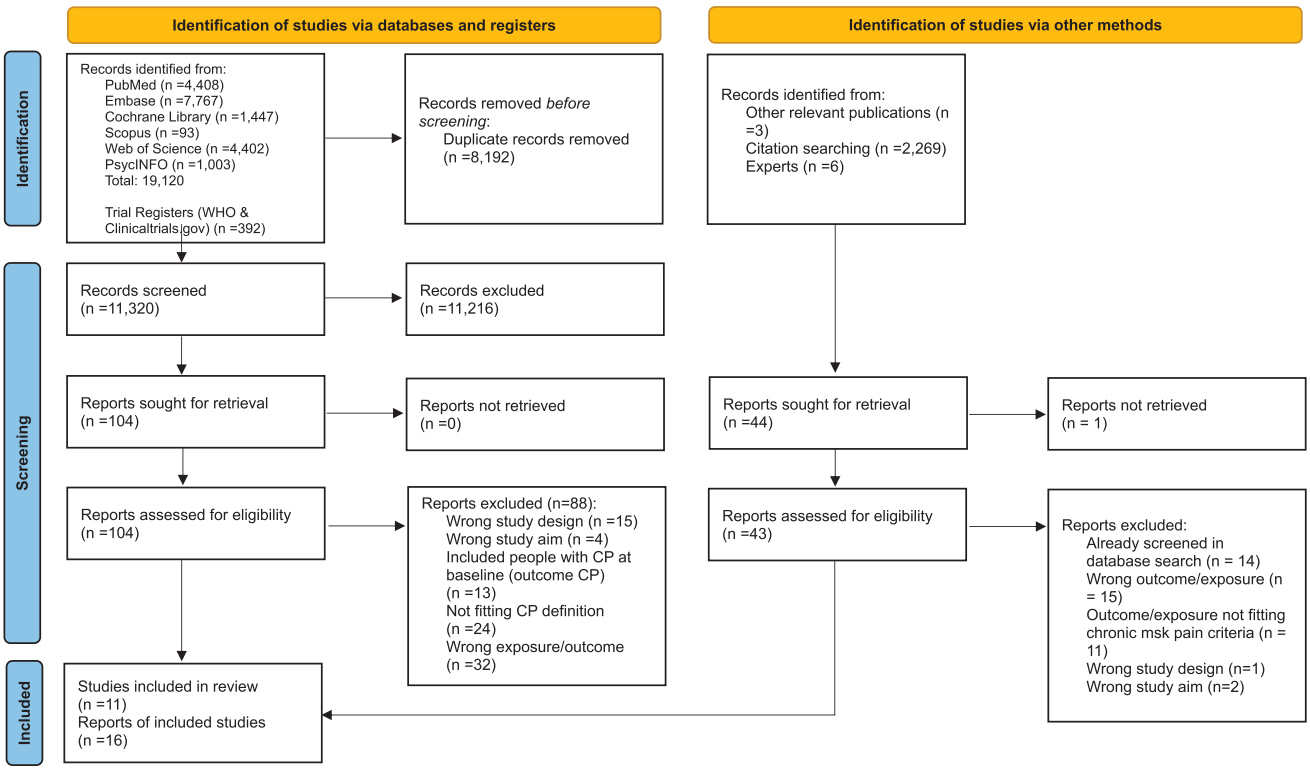

Figure 1. PRISMA flow diagram[50] showing the structure of the search and screening process.

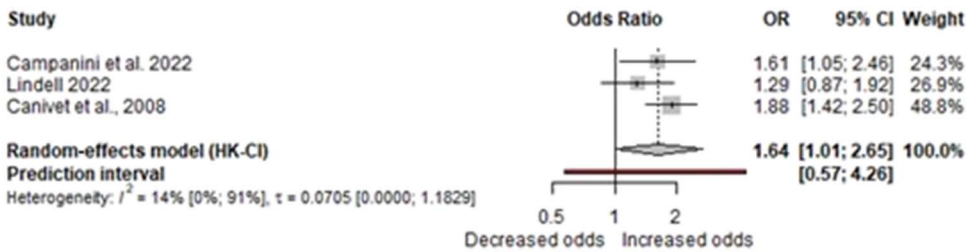

Figure 2. Forest plot showing the results of the meta-analysis for sleep problems/disorders at baseline on chronic musculoskeletal pain at short-term follow-up. CI, confidence interval; HK, Hartung–Knapp; OR, odds ratio.

questions. Only 2 included studies used existing validated questionnaires.[2,12] One study used an adapted version of a questionnaire,[32] and 1 study used a previously published sleep-wakefulness form.[37] Many studies based their questioning on established diagnostic criteria for sleep disorders but did not use the criteria in full.[32,57] As with the definition of sleep problems, questioned timeframes varied between studies with most studies asking for problems during the past 1 or 3 months.

A variety of different sleep problems were reported, in the 10 studies used in the main analyses in which sleep problems were the exposure. Only for 2 sleep problems, insomnia symptoms[37,57] (defined as problems falling asleep, staying asleep, or with early awakening) and nonrestorative sleep,[2,37,47] 2 or more studies provided data for the same follow-up duration (research question 2—long term). Regarding the outcome in these 10 studies, in 9, the outcome was local pain (including also people with possible widespread pain) and in 1 widespread pain only.[2] In 12 studies, no specific CMP problem was investigated but rather people with CMP in general. In 1 study each, investigation focussed on either chronic low back pain alone,[12] chronic low back pain and neck pain,[33] chronic low back pain and/or chronic lower limb pain,[32] or chronic low back pain, neck, and shoulder pain.[13] Of the 3 studies in which data on CMP as exposure was provided, 2 studies provided data on local pain (including also people with possible widespread pain)[12,32] and 1 study on both local and widespread pain combined and separately.[48] The outcomes in these 3 studies were insomnia symptoms in 2 studies[32,48] and poor sleep quality.[12]

All included studies assessed sleep problems and pain through self-report.

3.4. Risk of bias

Risk of bias was assessed on outcome level. Thirty different outcomes were assessed of which 20 had some concerns and 10 were of high risk of bias. The most common issues were the lack of preregistration of protocols and analysis plans. The second most common issue was lack of adjustment for covariates or that adjustment did not include all prespecified covariates. The overview of risk of bias per analysis is shown in the supplementary files, http://links.lww.com/PAIN/C61 for each outcome.

3.5. Research question 1: Are sleep problems/disorders at baseline associated with an increased risk of the development of chronic musculoskeletal pain?

3.5.1. Short term

Based on the pooled results obtained in 3 studies,[12,13,37] sleep problems at baseline may increase the risk of CMP at follow-up, but the evidence is very uncertain (OR 1.64, 95% CI 1.01-2.65, 95% PI 0.57-4.26, GRADE: very low certainty) (**Fig. 2**). Assuming a baseline risk of 20% (see Data synthesis section in the Methods), 91 more people per 1000 (95% CI 2-198) with baseline sleep problems will develop CMP in the short term compared with people without sleep problems at baseline.

3.5.2. Sensitivity analyses

The sensitivity analysis using a different adjustment model (with less variables that were in the predefined minimal adjustment set for this study) in 1 study[12] found that the 95% CI was crossing 1. The other analysis (minimally/unadjusted values) found no relevant differences to the main analysis. The results and forest plots of all sensitivity analyses can be found in supplementary file 9a (Tables 1 and 2; Figures 2 and 3, http://links.lww.com/PAIN/C61).

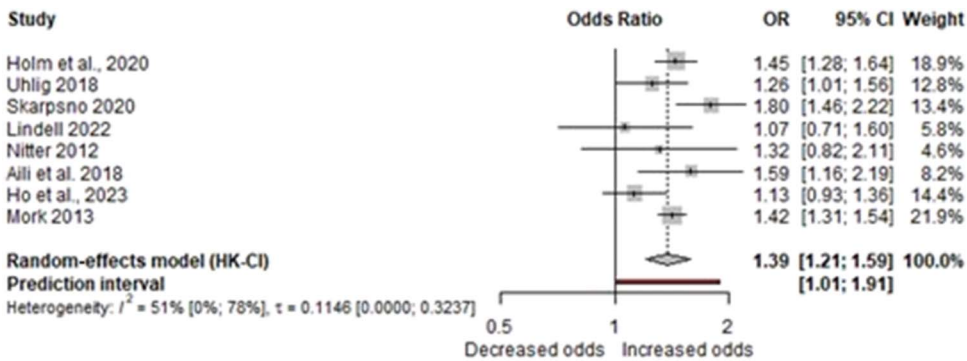

Figure 3. Forest plot showing the results of the meta-analysis for sleep problems/disorders at baseline on chronic musculoskeletal pain at long-term follow-up. CI, confidence interval; HK, Hartung–Knapp; OR, odds ratio.

3.5.3. Long term

Very low certainty evidence from 8 studies[2,32,33,37,43,47,57,64] suggests that sleep problems at baseline may result in an increase in CMP at long-term follow-up (OR 1.39, 95% CI 1.21-1.59; 95% PI: 1.01-1.91, GRADE: very low certainty) (**Fig. 3**). Assuming a baseline risk of 20%, 58 more people per 1000 (95% CI 32-84) with baseline sleep problems will develop CMP in the long term compared with people without sleep problems at baseline.

3.5.4. Sensitivity analyses

The sensitivity analysis using minimally/unadjusted values for all studies found a larger effect size (OR 1.51, 95% CI 1.22-1.87). All other sensitivity analyses found no relevant differences to the main analysis. The results and forest plots of all sensitivity analyses can be found in supplementary file 9b (Table 1; Figures 2-9, http://links.lww.com/PAIN/C61).

3.5.5. Influential studies

No study was identified as influential study. The results of the leave-one-out analysis can be found in supplementary file 9b (Figure 10, http://links.lww.com/PAIN/C61).

3.6. Research question 2: How are different categories of sleep disorders/problems at baseline associated with an increased risk of the development of chronic musculoskeletal pain?

3.6.1. Short term

For no sleep problem/disorder category, more than 1 study was available to answer this research questions.

3.6.2. Long term

3.6.2.1. Insomnia symptoms

The evidence from 2 studies[37,57] is very uncertain about the effect of insomnia symptoms at baseline on CMP at long-term follow-up (OR 1.35, 95% CI 0.02-103.32; 95% PI: 0.00-10,931.61; GRADE: very low certainty) (**Fig. 4**).

3.6.2.2. Sensitivity analyses

No sensitivity analyses found a relevant difference to the main analysis. The results and forest plots of all sensitivity analyses can be found in supplementary file 10 (Table 1, Figures 2 and 3, http://links.lww.com/PAIN/C61).

3.6.2.3. Nonrestorative sleep

The evidence from 3 studies[2,37,47] is very uncertain about the effect of nonrestorative sleep at baseline on CMP at long-term follow-up (OR 1.25, 95% CI 0.65-2.41; 95% PI: 0.31-4.65, GRADE: very low certainty) (**Fig. 5**).

3.6.2.4. Sensitivity analyses

No sensitivity analyses found a relevant difference to the main analysis. The results and forest plots of all sensitivity analyses can be found in supplementary file 10 (Table 2, Figure 5 and 6, http://links.lww.com/PAIN/C61).

3.7. Research question 3: Is chronic musculoskeletal pain at baseline associated with an increased risk of the development of sleep problems/disorders?

3.7.1. Short term

Chronic musculoskeletal pain at baseline may increase the risk of sleep problems at short-term follow-up, but the evidence from 1 study[12] is very uncertain (OR 1.56, 95% CI 1.02-2.38; GRADE: very low certainty). Assuming a baseline risk of 10% (see Data synthesis section in the Methods), 48 more people per 1000 (95% CI 2-109) with baseline CMP will develop sleep problems compared with people without CMP at baseline.

3.7.2. Sensitivity analyses

The sensitivity analysis using a different adjusted model (with less variables than were in the predefined minimal adjustment set for this study) in 1 study[12] found that the 95% CI was crossing 1. The other analysis (minimally/unadjusted values) found no relevant differences to the main analysis. The results and forest plots of all sensitivity analyses can be found in supplementary file 11a (Table 1, Figures 2 and 3, http://links.lww.com/PAIN/C61).

3.7.3. Long term

The evidence from 2 studies[32,48] is very uncertain about the effect of CMP at baseline on sleep problems in the long-term follow-up (OR 1.56, 95% CI 0.21-11.34, 95% PI: 0.02-135.44, GRADE: very low certainty) (**Fig. 6**).

3.7.4. Sensitivity analyses

No sensitivity analyses found a relevant difference to the main analysis. The results and forest plots of all sensitivity analyses can

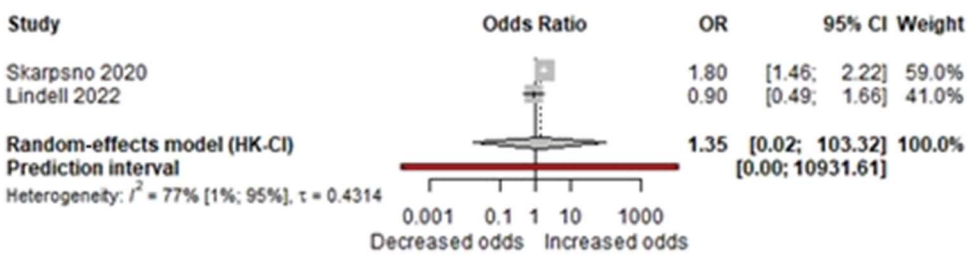

Figure 4. Forest plot showing the results of the meta-analysis for insomnia symptoms at baseline on chronic musculoskeletal pain at short-term follow-up. CI, confidence interval; HK, Hartung–Knapp; OR, odds ratio.

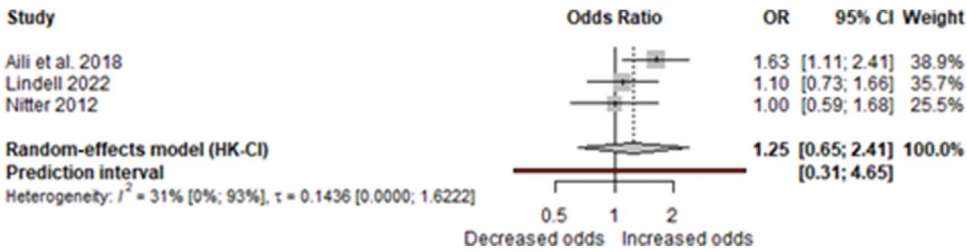

Figure 5. Forest plot showing the results of the meta-analysis for nonrestorative sleep at baseline on chronic musculoskeletal pain at short-term follow-up. CI, confidence interval; HK, Hartung–Knapp; OR, odds ratio.

be found in supplementary file 11b (Table 2, Figures 2 and 3, http://links.lww.com/PAIN/C61).

3.8. Research question 4: How are different chronic musculoskeletal pain problems (categorized as local vs widespread) associated with an increased risk of the development of problems/disorders?

3.8.1. Local pain—short term

Local CMP at baseline may increase the risk of sleep problems at short-term follow-up, but the evidence from 1 study[12] is very uncertain (OR 1.56, 95% CI 1.02-2.38; GRADE: very low certainty). Assuming a baseline risk of 10%, 48 more people per 1000 (95% CI 2-109) with baseline local CMP will develop sleep problems compared with people without CMP at baseline.

3.8.2. Sensitivity analyses

The sensitivity analysis using a different adjusted model (with less variables that were in the predefined minimal adjustment set for this study) found that the 95% CI was crossing 1. The other analysis (minimally/unadjusted values) found no relevant differences to the main analysis. The results and forest plots of all sensitivity analyses can be found in supplementary file 12a (Table 1, Figures 2 and 3, http://links.lww.com/PAIN/C61).

3.8.3. Local pain—long term

The evidence from 2 studies[32,48] is very uncertain about the effect of local CMP on sleep problems in the long term (OR 1.48, 95% CI 0.44-4.99; 95% PI: 0.08-25.54; GRADE: very low certainty) (**Fig. 7**).

3.8.4. Sensitivity analyses

No sensitivity analyses found a relevant difference to the main analysis. The results and forest plots of all sensitivity analyses can be found in supplementary file 12b (Table 2, Figure 2, http://links.lww.com/PAIN/C61).

3.8.5. Widespread pain—short term

No studies provided data on the effect of widespread pain on sleep problems in the short term.

3.8.6. Widespread pain—long term

The evidence from 1 study[48] suggests that widespread pain at baseline results in an increased risk of sleep problems at long-term follow-up (OR 2.0, 95% CI 1.81-2.21, GRADE: low certainty). Assuming a baseline risk of 10% (see Data synthesis section in the Methods), 127 more people per 1000 (95% CI 111-143) with baseline widespread pain will develop sleep problems compared with people without CMP at baseline.

3.8.7. Sensitivity analysis

The sensitivity analysis with unadjusted/minimally adjusted values found a larger effect size (OR 2.64, 95% CI 2.41-2.89). The results and forest plots of all sensitivity analyses can be found in supplementary file 12b (Table 3, Figure 4, http://links.lww.com/PAIN/C61).

3.9. Grading of Recommendations, Assessment, Development, and Evaluations

The detailed GRADE assessment for each meta-analysis can be found in supplementary file 13, http://links.lww.com/PAIN/C61.

4. Discussion

This systematic review with meta-analysis investigating the bilateral prospective associations between sleep problems/

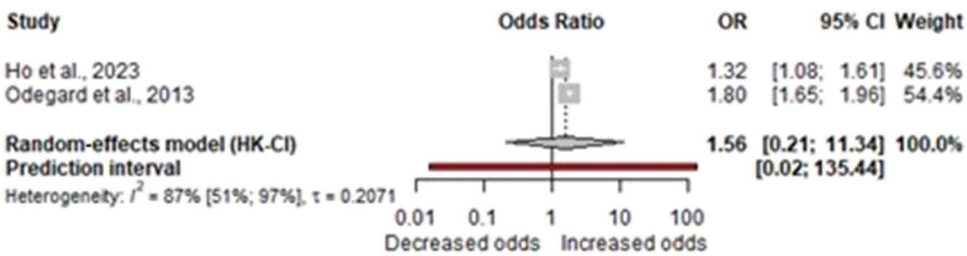

Figure 6. Forest plot showing the results of the meta-analysis for chronic musculoskeletal pain at baseline on sleep problems/disorders at long-term follow-up. CI, confidence interval; HK, Hartung–Knapp; OR, odds ratio.

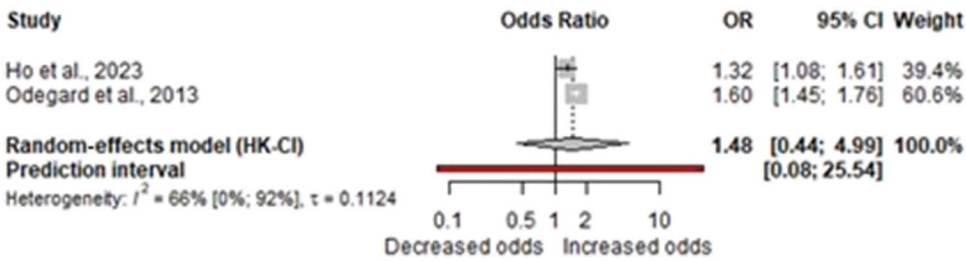

Figure 7. Forest plot showing the results of the meta-analysis for local chronic musculoskeletal pain at baseline on sleep problems/disorders at long-term follow-up. CI, confidence interval; HK, Hartung–Knapp; OR, odds ratio.

disorders and CMP included 16 reports from 11 different study populations.

Very low certainty evidence was found for sleep problems at baseline being a risk factor for CMP at the short-term and the long-term follow-up. For the short term, only 3 studies were included, and the PI was very wide, indicating that future studies could change this finding. This uncertainty was also supported by the finding of a sensitivity analysis that using a different adjustment model from one included study changed the results to not statistically significant (crossing 1). By contrast, the long-term results remained highly stable in all sensitivity analyses, and the PI also did not cross 1 giving confidence in the results. However, downgrading of the meta-analysis to very low certainty was necessary because of the observational nature of the included studies and because the 95% CI for the risk difference crossed an effect size threshold. Insomnia symptoms and nonrestorative sleep at baseline as exposures for the long-term follow-up were the only sleep problems investigated in 2 or more studies. For both, the available data were insufficient to reach any conclusions. No studies investigated specific sleep disorders at baseline as exposure.

For the association between CMP at baseline as exposure and sleep problems/disorders as outcome, very low certainty evidence found a negative effect for the short term. However, this result came from only 1 study and was not stable in sensitivity analyses. For the long term, 2 studies found very low certainty evidence for no effect. One needs to consider in this context that the 95% CI was very wide as was the PI, making it likely that future studies might change this result. This review further investigated whether dominant local pain as exposure was linked to sleep problems. For the short term, very low certainty from 1 study found an effect of local pain at baseline as exposure, although sensitivity analyses using a different adjustment model from the included study reached nonsignificant results. For the long term, very low certainty found no effect but also here one needs to consider the wide 95% CI and PI. For widespread pain at baseline as exposure, low certainty from 1 study showed it to be a risk factor for the development of sleep problems. This result was only downgraded for the observational nature of the included study.

The results of this systematic review are mostly in line with other publications in this field.[24,54,66] However, there were some relevant differences to a recent systematic review with meta-analysis by Santos et al.[54] who investigated the prospective bilateral association between sleep problems and CMP. As in this review, they also found an association between sleep problems at baseline and future CMP but also an association for the other direction. The latter is different to this review where only an association in the short term was found. Also, the effect sizes found in Santos et al.[54] were significantly larger. These differences can be explained by a number of reasons: (1) stricter inclusion criteria used in this review, especially for CMP; (2) the separation of follow-up durations in this review into short and long term vs a single analysis for all follow-up durations in Santos et al.[54]; (3) the unit of analysis error in Santos et al.[54] because of the inclusion of different HUNT studies that investigated the same study population in the same analyses; and (4) the use of unadjusted data for the analyses in Santos et al.[54] vs the use of adjusted data in this review.

4.1. Research implications

There are a number of research implications in context of this review. First, because of ethical reasons (ie, it is unethical to experimentally induce long-term sleep problems or CMP in people), it is not possible to investigate the prospective associations between sleep problems and CMP in a randomized controlled trial. This means that to be able to explore causality between sleep problems/disorders and CMP, one can only rely on prospective longitudinal cohort studies whereby strong assumptions around relevant confounders need to be made in context of their interaction with the exposure and outcome variables but also other relevant factors.[65] Although in the included primary studies, variables for adjustments were mostly described, the reasoning behind their choice was generally missing or only described in short. Future studies should use methods such as directed acyclic graphics (DAGs) to make the underlying assumptions on variable interactions transparent and to clearly outline the reasoning for covariate adjustments.[65] Ideally, DAGs and set of confounders should be specified in a protocol or analysis plan before registration. In addition, studies using experimental sleep fragmentation and deficiency paradigms can strengthen the argument for a causal link between sleep problems and CMP by identifying potential mechanisms of action. Recent reviews in this context have shown that there are a number of different potential pathways that could explain a causal influence, although the research is currently limited,[14,30] and further well-designed studies are needed to strengthen the current knowledge base.

Second, future studies should preregister their protocols and analysis plans before starting recruitment. None of the primary studies included in this review did this which means that there was a possibility for post-hoc adaptions of analyses and study protocols, a significant problem in clinical research. Third, all included primary studies in this review used complete-case analyses, mostly without providing detailed information on the missing participants, reasons for missingness, and without performing sensitivity analyses. This

makes it difficult to judge the influence of the missing data on the overall analysis. Future studies should consider established methods to deal with missing data (eg, multiple imputation) and ideally preregister a plan on how handling of missing data will be done.[35] Fourth, the sleep problems used and their definitions in the included primary studies were highly heterogeneous. There are commonly used and validated ways of assessing different aspects of sleep such as poor sleep quality (Pittsburgh Sleep Quality Index [PSQI][11]) or also insomnia (Diagnostic and Statistical Manual of Mental Disorders 5 [DSM-5] criteria[51] and insomnia severity index [ISI][7]) in research. For comparability purposes, researchers should prefer the use of these over self-developed questions, less commonly used questionnaires, or adaptions of questionnaires and diagnostic criteria. This will improve the ability to pool studies in future reviews and allow for more in-depth analyses (eg, compare different sleep disorders). Fifth, none of the included studies specifically investigated people diagnosed with sleep disorders (eg, insomnia disorder) using a full set of established criteria. Considering that people with diagnosed sleep disorders tend to have more significant symptoms compared with people with merely a sleep problem, it remains unclear whether there is a difference in risk of future CMP between the 2 groups. The hypothesis that increased sleep problems might be linked to an increased risk of CMP is supported by the findings of a number of studies included in this review that used some sort of grading within the group of people with sleep problems (eg, based on frequency or number of symptoms).[2,43,57] In these studies, people with more sleep problems had a higher risk to develop future CMP than people with less sleep problems, but this was not specifically investigated as part of this review. Considering that people with sleep problems are not a homogenous group, it is, therefore, pertinent to investigate specific groups of sleep problems/disorders in detail. Even further, subgroups of these disorders that have been found to be of higher risk of other conditions (eg, hypertension, diabetes, and depression), eg, people with insomnia and objective short sleep duration,[18,23,69] could be a specific focus. Sixth, all studies but 1 were performed in Scandinavian countries (ie, Norway and Sweden) and 9 of 16 included studies within the same study setup (The HUNT study), which may limit the generalizability of the findings. More large-scale studies in countries outside of Scandinavia and Europe need to be performed to be able to increase confidence in the transferability of the results. Seventh, for research aims 3 and 4, included studies did not present data on the percentage of people who had received musculoskeletal surgery within the group of CMP cases. Considering that sleep outcomes in patients with postsurgical CMP might differ from people with CMP of other causes, more research into these specific subgroups is required.

4.2. Clinical implications

The findings of this review have clinical implications. Sleep problems were found to be a risk factor for CMP. Although this means that an association was found, it is difficult to judge, based on the current evidence, if this link is causal (see Discussion above). However, a number of mechanisms have been proposed in the literature on how sleep problems could possibly increase the risk of CMP including increased systemic low-grade inflammation, higher levels of depression and anxiety, and increased nociceptive facilitation.[20,30,46] Although having evidence on possible mediating mechanisms can support the notion for a causal link, more research is needed to investigate causality of this link. In the meantime, one should consider screening for sleep problems/disorders in clinical practice and the general population, not only to potentially reduce cases of incident CMP (if there is a causal link) but also to help to prevent a host of other conditions linked with sleep problems/disorders (eg, depression, hypertension, and cardiovascular diseases).[36] There have been recent calls for this because compelling data show that sleep problems/disorders are highly prevalent worldwide.[36] The availability of easy-to-use assessment tools and questionnaires (Stop-Bang questionnaire,[16] ISI,[7] and PSQI[11]) means that investigating sleep issues can be performed in a time-efficient manner.

The uncertain results on the association between CMP and future sleep problems should not discourage clinicians from screening for CMP. As with sleep problems, CMP is a public health concern,[71] and screening is indicated for a variety of reasons in different settings. Importantly, when a person with CMP has been identified, pain management options and support need to be available which go beyond medication, which can in itself at times have negative impact on sleep.[9,53]

4.3. Strengths and limitations

This study has different strengths. A detailed protocol, including analysis plan, sensitivity analyses, and minimal set of confounders, was preregistered and followed as planned. The search strategy was extensive and has been developed with support of experienced librarians. Strict inclusion criteria for CMP were used to be able to make specific conclusions. Adjusted results of most primary studies (only 1 study did not provide results without adjustments) were used in the analyses, and sensitivity analyses were performed to check the robustness of the findings. The R code for the full analysis was shared on the open science framework platform to increase transparency and to allow other researchers to reuse it.

This review has also some limitations. First, the baseline risks of the absolute difference were based on the control groups of the largest meta-analyses and not prespecified. It was felt that this is most appropriate because comparable data (considering population and follow-up durations) are limited in the literature. Sensitivity analyses with higher and lower values are presented in the supplementary file, http://links.lww.com/PAIN/C61 for full transparency. Second, adjusted results from primary studies were used for the analyses, but no multivariate meta-analyses were performed because of the variable availability of data on important confounders in primary studies. Third, it was not possible to perform subgroup or meta-regression analyses because of the small numbers of included studies. This prevented further testing of potential sources of heterogeneity. Fourth, the decision on the minimal set of confounders was made based on discussions between the authors but without the use of any more formal and transparent tools (eg, DAGs).[65]

5. Conclusions

The findings of this systematic review with meta-analysis, encompassing 16 articles from 11 different study populations, indicate with very low certainty evidence that sleep problems/disorders at baseline are risk factors for CMP in both short term and long term. Further analyses on different sleep problems were inconclusive because of the limited number of available studies. Very low certainty evidence indicates an association between CMP at baseline and sleep problems/disorders in the short term but not the long term. Low certainty evidence showed that widespread pain at baseline might be a risk factor for sleep problems/disorders in the long term. The evidence for local pain was inconclusive. However, these analyses were based on a small number of studies and should be considered with caution.

Conflict of interest statement

Jo Nijs and the Vrije Universiteit Brussel received lecturing/teaching fees from various professional associations and educational organizations. The other authors have no potential conflicts of interest to report.

Acknowledgements

The authors thank Thomas Vandendriessche and Krizia Tuand, the biomedical reference librarians of the KU Leuven Libraries—2Bergen—learning Centre Désiré Collen (Leuven, Belgium), for their help in conducting the systematic literature search.

This work was funded by the Applied Biomedical Research Program, Research Foundation Flanders (Fonds voor Wetenschappelijk Onderzoek Vlaanderen), Belgium (FWO-TBM project no. TBM2021—T000521 N—54252, "Towards PREcision MEdicine for Osteoarthritis: Added value of cognitive behavioural therapy for insomnia (the PREMEO trial)"), and by Strategic Research Program SRP90 ("Pain Never Sleeps: Unravelling the Sleep-Pain Interaction in Patients with Chronic Pain") funded by the research council of the Vrije Universiteit Brussel, Brussels, Belgium. The funder had no influence on any aspect of the review process.

Supplemental digital content

Supplemental digital content associated with this article can be found online at http://links.lww.com/PAIN/C61.

Article history:
Received 1 February 2024
Received in revised form 9 April 2024
Accepted 18 April 2024
Available online 28 May 2024

References

[1] Afolalu EF, Ramlee F, Tang NKY. Effects of sleep changes on pain-related health outcomes in the general population: a systematic review of longitudinal studies with exploratory meta-analysis. Sleep Med Rev 2018;39:82–97.
[2] Aili K, Andersson M, Bremander A, Haglund E, Larsson I, Bergman S. Sleep problems and fatigue as predictors for the onset of chronic widespread pain over a 5- and 18-year perspective. BMC Musculoskelet Disord 2018;19:390.
[3] Andersen LN, Kohberg M, Juul-Kristensen B, Herborg LG, Søgaard K, Roessler KK. Psychosocial aspects of everyday life with chronic musculoskeletal pain: a systematic review. Scand J Pain 2014;5:131–48.
[4] Andreucci MSc A, Campbell P, Dunn KM. Are sleep problems a risk factor for the onset of musculoskeletal pain in children and adolescents? A systematic review. Sleep 2017;40. doi: 10.1093/sleep/zsx093.
[5] Ardern CL, Büttner F, Andrade R, Weir A, Ashe MC, Holden S, Impellizzeri FM, Delahunt E, Dijkstra HP, Mathieson S, Rathleff MS, Reurink G, Sherrington C, Stamatakis E, Vicenzino B, Whittaker JL, Wright AA, Clarke M, Moher D, Page MJ, Khan KM, Winters M. Implementing the 27 PRISMA 2020 Statement items for systematic reviews in the sport and exercise medicine, musculoskeletal rehabilitation and sports science fields: the PERSiST (implementing Prisma in Exercise, Rehabilitation, Sport medicine and SporTs science) guidance. Br J Sports Med 2022;56:175–95.
[6] Balduzzi S, Rücker G, Schwarzer G. How to perform a meta-analysis with R: a practical tutorial. Evid Based Ment Health 2019;22:153–60.
[7] Bastien C, Vallières A, Morin CM. Validation of the Insomnia Severity Index as an outcome measure for insomnia research. Sleep Med 2001;2:297–307.
[8] Benjafield AV, Ayas NT, Eastwood PR, Heinzer R, Ip MSM, Morrell MJ, Nunez CM, Patel SR, Penzel T, Pépin J-L, Peppard PE, Sinha S, Tufik S, Valentine K, Malhotra A. Estimation of the global prevalence and burden of obstructive sleep apnoea: a literature-based analysis. Lancet Respir Med 2019;7:687–98.
[9] Bohra MH, Kaushik C, Temple D, Chung SA, Shapiro CM. Weighing the balance: how analgesics used in chronic pain influence sleep? Br J Pain 2014;8:107–18.
[10] Borenstein M, Hedges LV, Higgins JPT, Rothstein HR. Introduction to meta-analysis. Hoboken, New Jersey: John Wiley & Sons, 2021.
[11] Buysse DJ, Reynolds CF, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh sleep quality index: a new instrument for psychiatric practice and research. Psychiatry Res 1989;28:193–213.
[12] Campanini MZ, González AD, Andrade SM, Girotto E, Cabrera MAS, Guidoni CM, Araujo PCA, Mesas AE. Bidirectional associations between chronic low back pain and sleep quality: a cohort study with schoolteachers. Physiol Behav 2022;254:113880.
[13] Canivet C, Östergren P-O, Choi B, Nilsson P, af Sillén U, Moghadassi M, Karasek R, Isacsson S-O. Sleeping problems as a risk factor for subsequent musculoskeletal pain and the role of job strain: results from a one-year follow-up of the Malmö shoulder neck study cohort. Int J Behav Med 2008;15:254–62.
[14] Chang JR, Fu S-N, Li X, Li SX, Wang X, Zhou Z, Pinto SM, Samartzis D, Karppinen J, Wong AY. The differential effects of sleep deprivation on pain perception in individuals with or without chronic pain: a systematic review and meta-analysis. Sleep Med Rev 2022;66:101695.
[15] Chien M-Y, Chen H-C. Poor sleep quality is independently associated with physical disability in older adults. J Clin Sleep Med 2015;11:225–32.
[16] Chung F, Abdullah HR, Liao P. STOP-bang questionnaire: a practical approach to screen for obstructive sleep apnea. Chest 2016;149:631–8.
[17] Crombez G, Veirman E, Van Ryckeghem D, Scott W, De Paepe A. The effect of psychological factors on pain outcomes: lessons learned for the next generation of research. Pain Rep 2023;8:e1112.
[18] Dai Z, Neogi T, Brown C, Nevitt M, Lewis CE, Torner J, Felson DT. Sleep quality is related to worsening knee pain in those with widespread pain: the multicenter osteoarthritis study. J Rheumatol 2020;47:1019–25.
[19] Dam T-TL, Ewing S, Ancoli-Israel S, Ensrud K, Redline S, Stone K. Association between sleep and physical function in older men: the osteoporotic fractures in men sleep study. J Am Geriatr Soc 2008;56:1665–73.
[20] De Baets L, Runge N, Labie C, Mairesse O, Malfliet A, Verschueren S, Van Assche D, De Vlam K, Luyten FP, Coppieters I, Herrero Babiloni A, Martel MO, Lavigne GJ, Nijs J. The interplay between symptoms of insomnia and pain in people with osteoarthritis: a narrative review of the current evidence. Sleep Med Rev 2023;70:101793.
[21] Duo L, Yu X, Hu R, Duan X, Zhou J, Wang K. Sleep disorders in chronic pain and its neurochemical mechanisms: a narrative review. Front Psychiatry 2023;14:1157790.
[22] Falconer J. Removing duplicates from an EndNote library. Libr Arch Open Res Serv Blog, 2018. Available at: https://blogs.lshtm.ac.uk/library/2018/12/07/removing-duplicates-from-an-endnote-library/. Accessed December 22, 2023.
[23] Fernandez-Mendoza J, Shea S, Vgontzas AN, Calhoun SL, Liao D, Bixler EO. Insomnia and incident depression: role of objective sleep duration and natural history. J Sleep Res 2015;24:390–8.
[24] Finan PH, Goodin BR, Smith MT. The association of sleep and pain: an update and a path forward. J Pain 2013;14:1539–52.
[25] Fitzcharles M-A, Cohen SP, Clauw DJ, Littlejohn G, Usui C, Häuser W. Chronic primary musculoskeletal pain: a new concept of nonstructural regional pain. Pain Rep 2022;7:e1024.
[26] Franklin KA, Lindberg E. Obstructive sleep apnea is a common disorder in the population—a review on the epidemiology of sleep apnea. J Thorac Dis 2015;7:1311–22.
[27] Gorasso V, Van der Heyden J, De Pauw R, Pelgrims I, De Clercq EM, De Ridder K, Vandevijvere S, Vansteelandt S, Vaes B, De Smedt D, Devleesschauwer B. The health and economic burden of musculoskeletal disorders in Belgium from 2013 to 2018. Popul Health Metr 2023;21:4.
[28] Grant RL. Converting an odds ratio to a range of plausible relative risks for better communication of research findings. BMJ 2014;348:f7450.
[29] Guyatt G, Oxman AD, Akl EA, Kunz R, Vist G, Brozek J, Norris S, Falck-Ytter Y, Glasziou P, deBeer H, Jaeschke R, Rind D, Meerpohl J, Dahm P, Schünemann HJ. GRADE guidelines: 1. Introduction—GRADE evidence profiles and summary of findings tables. J Clin Epidemiol 2011;64:383–94.
[30] Haack M, Simpson N, Sethna N, Kaur S, Mullington J. Sleep deficiency and chronic pain: potential underlying mechanisms and clinical implications. Neuropsychopharmacology 2020;45:205–16.
[31] Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, Welch V, editors. Cochrane handbook for systematic reviews of interventions

version 6.4 (updated August 2023). Cochrane, 2023. Available at: https://training.cochrane.org/handbook
[32] Ho KKN, Skarpsno ES, Nilsen KB, Ferreira PH, Pinheiro MB, Hopstock LA, Johnsen MB, Steingrímsdóttir ÓA, Nielsen CS, Stubhaug A, Simic M. A bidirectional study of the association between insomnia, high-sensitivity C-reactive protein, and comorbid low back pain and lower limb pain. Scand J Pain 2023;23:110–25.
[33] Holm LW, Bohman T, Lekander M, Magnusson C, Skillgate E. Risk of transition from occasional neck/back pain to long-duration activity limiting neck/back pain: a cohort study on the influence of poor work ability and sleep disturbances in the working population in Stockholm County. BMJ Open 2020;10:e033946.
[34] IntHout J, Ioannidis JP, Borm GF. The Hartung-Knapp-Sidik-Jonkman method for random effects meta-analysis is straightforward and considerably outperforms the standard DerSimonian-Laird method. BMC Med Res Methodol 2014;14:25.
[35] Lee KJ, Tilling KM, Cornish RP, Little RJA, Bell ML, Goetghebeur E, Hogan JW, Carpenter JR, STRATOS initiative. Framework for the treatment and reporting of missing data in observational studies: the Treatment and Reporting of Missing data in Observational Studies framework. J Clin Epidemiol 2021;134:79–88.
[36] Lim DC, Najafi A, Afifi L, Bassetti CL, Buysse DJ, Han F, Högl B, Melaku YA, Morin CM, Pack AI, Poyares D, Somers VK, Eastwood PR, Zee PC, Jackson CL, World Sleep Society Global Sleep Health Taskforce. The need to promote sleep health in public health agendas across the globe. Lancet Public Health 2023;8:e820–6.
[37] Lindell M, Grimby-Ekman A. Stress, non-restorative sleep, and physical inactivity as risk factors for chronic pain in young adults: a cohort study. PLoS One 2022;17:e0262601.
[38] Liu S, Wang B, Fan S, Wang Y, Zhan Y, Ye D. Global burden of musculoskeletal disorders and attributable factors in 204 countries and territories: a secondary analysis of the Global Burden of Disease 2019 study. BMJ Open 2022;12:e062183.
[39] Mathias JL, Cant ML, Burke ALJ. Sleep disturbances and sleep disorders in adults living with chronic pain: a meta-analysis. Sleep Med 2018;52:198–210.
[40] Medic G, Wille M, Hemels ME. Short- and long-term health consequences of sleep disruption. Nat Sci Sleep 2017;9:151–61.
[41] Morin CM, Jarrin DC. Epidemiology of insomnia: prevalence, course, risk factors, and public health burden. Sleep Med Clin 2022;17:173–91.
[42] Mork PJ, Nilsen TIL. Sleep problems and risk of fibromyalgia: longitudinal data on an adult female population in Norway. Arthritis Rheum 2012;64:281–4.
[43] Mork PJ, Vik KL, Moe B, Lier R, Bardal EM, Nilsen TIL. Sleep problems, exercise and obesity and risk of chronic musculoskeletal pain: the Norwegian HUNT study. Eur J Public Health 2014;24:924–9.
[44] Mundal I, Gråwe RW, Bjørngaard JH, Linaker OM, Fors EA. Psychosocial factors and risk of chronic widespread pain: an 11-year follow-up study—the HUNT study. PAIN 2014;155:1555–61.
[45] Nagashima K, Noma H, Furukawa TA. pimeta: an R package of prediction intervals for random-effects meta-analysis, 2021. doi: 10.48550/arXiv.2110.07856
[46] Nijs J, Loggia ML, Polli A, Moens M, Huysmans E, Goudman L, Meeus M, Vanderweeën L, Ickmans K, Clauw D. Sleep disturbances and severe stress as glial activators: key targets for treating central sensitization in chronic pain patients? Expert Opin Ther Targets 2017;21:817–26.
[47] Nitter AK, Pripp AH, Forseth KØ. Are sleep problems and non-specific health complaints risk factors for chronic pain? A prospective population-based study with 17 year follow-up. Scand J Pain 2012;3:210–7.
[48] Ødegård SS, Sand T, Engstrøm M, Zwart J-A, Hagen K. The impact of headache and chronic musculoskeletal complaints on the risk of insomnia: longitudinal data from the Nord-Trøndelag health study. J Headache Pain 2013;14:24.
[49] Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A. Rayyan—a web and mobile app for systematic reviews. Syst Rev 2016;5:210.
[50] Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, Shamseer L, Tetzlaff JM, Akl EA, Brennan SE, Chou R, Glanville J, Grimshaw JM, Hróbjartsson A, Lalu MM, Li T, Loder EW, Mayo-Wilson E, McDonald S, McGuinness LA, Stewart LA, Thomas J, Tricco AC, Welch VA, Whiting P, Moher D. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71.
[51] Reynolds CF, O'Hara R. DSM-5 sleep-wake disorders classification: overview for use in clinical practice. Am J Psychiatry 2013;170:1099–101.
[52] ROBINS-E Development Group. Risk of bias tools—ROBINS-E tool, Available at: https://www.riskofbias.info/welcome/robins-e-tool. Accessed December 22, 2023.
[53] Rosen IM, Aurora RN, Kirsch DB, Carden KA, Malhotra RK, Ramar K, Abbasi-Feinberg Fariha, Kristo DA, Martin JL, Olson EJ, Rosen CL, Rowley JA, Shelgikar AV, American Academy of Sleep Medicine Board of Directors. Chronic opioid therapy and sleep: an American academy of sleep medicine position statement. J Clin Sleep Med 2019;15:1671–3.
[54] Santos M, Gabani FL, de Andrade SM, Bizzozero-Peroni B, Martínez-Vizcaíno V, González AD, Mesas AE. The bidirectional association between chronic musculoskeletal pain and sleep-related problems: a systematic review and meta-analysis. Rheumatology 2023;62:2951–62.
[55] Saueressig T, Pedder H, Bowe SJ, Owen PJ, Belavy DL. Six meta-analyses on treatments for femoroacetabular impingement syndrome in a year and readers are none the wiser: methods advice for researchers planning meta-analysis of data from fewer than 5 trials. J Orthop Sports Phys Ther 2021;51:201–3.
[56] Silva S, Hayden JA, Mendes G, Verhagen A, Pinto RZ, Silva A. Sleep as a prognostic factor in low back pain: a systematic review of prospective cohort studies and secondary analyses of randomized controlled trials. Sleep 2024:zsae023.
[57] Skarpsno ES, Mork PJ, Hagen K, Nilsen TIL, Marcuzzi A. Number of chronic nighttime insomnia symptoms and risk of chronic widespread pain and pain-related disability: the HUNT study. Nat Sci Sleep 2020;12:1227–36.
[58] Skarpsno ES, Mork PJ, Marcuzzi A, Lund Nilsen TI, Meisingset I. Subtypes of insomnia and the risk of chronic spinal pain: the HUNT study. Sleep Med 2021;85:15–20.
[59] Skarpsno ES, Nilsen TIL, Hagen K, Mork PJ. Long-term changes in self-reported sleep quality and risk of chronic musculoskeletal pain: the HUNT Study. J Sleep Res 2021;30:e13354.
[60] Skarpsno ES, Nilsen TIL, Sand T, Hagen K, Mork PJ. Do physical activity and body mass index modify the association between chronic musculoskeletal pain and insomnia? Longitudinal data from the HUNT study, Norway. J Sleep Res 2018;27:32–9.
[61] Skarpsno ES, Nilsen TIL, Sand T, Hagen K, Mork PJ. Physical work exposure, chronic musculoskeletal pain and risk of insomnia: longitudinal data from the HUNT study, Norway. Occup Environ Med 2018;75:421–6.
[62] Sterne JAC, Sutton AJ, Ioannidis JPA, Terrin N, Jones DR, Lau J, Carpenter J, Rücker G, Harbord RM, Schmid CH, Tetzlaff J, Deeks JJ, Peters J, Macaskill P, Schwarzer G, Duval S, Altman DG, Moher D, Higgins JPT. Recommendations for examining and interpreting funnel plot asymmetry in meta-analyses of randomised controlled trials. BMJ 2011;343:d4002.
[63] Sun Y, Laksono I, Selvanathan J, Saripella A, Nagappa M, Pham C, Englesakis M, Peng P, Morin CM, Chung F. Prevalence of sleep disturbances in patients with chronic non-cancer pain: a systematic review and meta-analysis. Sleep Med Rev 2021;57:101467.
[64] Uhlig BL, Sand T, Nilsen TI, Mork PJ, Hagen K. Insomnia and risk of chronic musculoskeletal complaints: longitudinal data from the HUNT study, Norway. BMC Musculoskelet Disord 2018;19:128.
[65] Van Cauwenberg J, De Paepe A, Poppe L. Lost without a cause: time to embrace causal thinking using Directed Acyclic Graphs (DAGs). Int J Behav Nutr Phys Act 2023;20:145.
[66] Van Looveren E, Bilterys T, Munneke W, Cagnie B, Ickmans K, Mairesse O, Malfliet A, De Baets L, Nijs J, Goubert D, Danneels L, Moens M, Meeus M. The association between sleep and chronic spinal pain: a systematic review from the last decade. J Clin Med 2021;10:3836.
[67] Varallo G, Giusti EM, Manna C, Castelnuovo G, Pizza F, Franceschini C, Plazzi G. Sleep disturbances and sleep disorders as risk factors for chronic postsurgical pain: a systematic review and meta-analysis. Sleep Med Rev 2022;63:101630.
[68] Vargas C, Bilbeny N, Balmaceda C, Rodríguez MF, Zitko P, Rojas R, Eberhard ME, Ahumada M, Espinoza MA. Costs and consequences of chronic pain due to musculoskeletal disorders from a health system perspective in Chile. Pain Rep 2018;3:e656.
[69] Vgontzas AN, Liao D, Pejovic S, Calhoun S, Karataraki M, Bixler EO. Insomnia with objective short sleep duration is associated with type 2 diabetes: a population-based study. Diabetes Care 2009;32:1980–5.
[70] Viechtbauer W. Conducting meta-analyses in R with the metafor package. J Stat Softw 2010;36;1–48
[71] Vos T, Lim SS, Abbafati C, Abbas KM, Abbasi M, Abbasifard M, Abbasi-Kangevari M, Abbastabar H, Abd-Allah F, Abdelalim A, Abdollahi M, Abdollahpour I, Abolhassani H, Aboyans V, Abrams EM, Abreu LG, Abrigo MRM, Abu-Raddad LJ, Abushouk AI, Acebedo A, Ackerman IN, Adabi M, Adamu AA, Adebayo OM, Adekanmbi V, Adelson JD, Adetokunboh OO, Adham D, Afshari M, Afshin A, Agardh EE, Agarwal G, Agesa KM, Aghaali M, Aghamir SMK, Agrawal A, Ahmad T, Ahmadi A, Ahmadi M, Ahmadieh H, Ahmadpour E, Akalu TY, Akinyemi RO,

Akinyemiju T, Akombi B, Al-Aly Z, Alam K, Alam N, Alam S, Alam T, Alanzi TM, Albertson SB, Alcalde-Rabanal JE, Alema NM, Ali M, Ali S, Alicandro G, Alijanzadeh M, Alinia C, Alipour V, Aljunid SM, Alla F, Allebeck P, Almasi-Hashiani A, Alonso J, Al-Raddadi RM, Altirkawi KA, Alvis-Guzman N, Alvis-Zakzuk NJ, Amini S, Amini-Rarani M, Aminorroaya A, Amiri F, Amit AML, Amugsi DA, Amul GGH, Anderlini D, Andrei CL, Andrei T, Anjomshoa M, Ansari F, Ansari I, Ansari-Moghaddam A, Antonio CAT, Antony CM, Antriyandarti E, Anvari D, Anwer R, Arabloo J, Arab-Zozani M, Aravkin AY, Ariani F, Ärnlöv J, Aryal KK, Arzani A, Asadi-Aliabadi M, Asadi-Pooya AA, Asghari B, Ashbaugh C, Atnafu DD, Atre SR, Ausloos F, Ausloos M, Quintanilla BPA, Ayano G, Ayanore MA, Aynalem YA, Azari S, Azarian G, Azene ZN, Babaee E, Badawi A, Bagherzadeh M, Bakhshaei MH, Bakhtiari A, Balakrishnan S, Balalla S, Balassyano S, Banach M, Banik PC, Bannick MS, Bante AB, Baraki AG, Barboza MA, Barker-Collo SL, Barthelemy CM, Barua L, Barzegar A, Basu S, Baune BT, Bayati M, Bazmandegan G, Bedi N, Beghi E, Béjot Y, Bello AK, Bender RG, Bennett DA, Bennitt FB, Bensenor IM, Benziger CP, Berhe K, Bernabe E, Bertolacci GJ, Bhageerathy R, Bhala N, Bhandari D, Bhardwaj P, Bhattacharyya K, Bhutta ZA, Bibi S, Biehl MH, Bikbov B, Sayeed MSB, Biondi A, Birihane BM, Bisanzio D, Bisignano C, Biswas RK, Bohlouli S, Bohluli M, Bolla SRR, Boloor A, Boon-Dooley AS, Borges G, Borzì AM, Bourne R, Brady OJ, Brauer M, Brayne C, Breitborde NJK, Brenner H, Briant PS, Briggs AM, Briko NI, Britton GB, Bryazka D, Buchbinder R, Bumgarner BR, Busse R, Butt ZA, Santos FLCdos, Cámera LLA, Campos-Nonato IR, Car J, Cárdenas R, Carreras G, Carrero JJ, Carvalho F, Castaldelli-Maia JM, Castañeda-Orjuela CA, Castelpietra G, Castle CD, Castro F, Catalá-López F, Causey K, Cederroth CR, Cercy KM, Cerin E, Chandan JS, Chang AR, Charlson FJ, Chattu VK, Chaturvedi S, Chimed-Ochir O, Chin KL, Cho DY, Christensen H, Chu D-T, Chung MT, Cicuttini FM, Ciobanu LG, Cirillo M, Collins EL, Compton K, Conti S, Cortesi PA, Costa VM, Cousin E, Cowden RG, Cowie BC, Cromwell EA, Cross DH, Crowe CS, Cruz JA, Cunningham M, Dahlawi SMA, Damiani G, Dandona L, Dandona R, Darwesh AM, Daryani A, Das JK, Gupta RD, das Neves J, Dávila-Cervantes CA, Davletov K, Leo DD, Dean FE, DeCleene NK, Deen A, Degenhardt L, Dellavalle RP, Demeke FM, Demsie DG, Denova-Gutiérrez E, Dereje ND, Dervenis N, Desai R, Desalew A, Dessie GA, Dharmaratne SD, Dhungana GP, Dianatinasab M, Diaz D, Forooshani ZSD, Dingels ZV, Dirac MA, Djalalinia S, Do HT, Dokova K, Dorostkar F, Doshi CP, Doshmangir L, Douiri A, Doxey MC, Driscoll TR, Dunachie SJ, Duncan BB, Duraes AR, Eagan AW, Kalan ME, Edvardsson D, Ehrlich JR, Nahas NE, Sayed IE, Tantawi ME, Elbarazi I, Elgendy IY, Elhabashy HR, El-Jaafary SI, Elyazar IR, Emamian MH, Emmons-Bell S, Erskine HE, Eshrati B, Eskandarieh S, Esmaeilnejad S, Esmaeilzadeh F, Esteghamati A, Estep K, Etemadi A, Etisso AE, Farahmand M, Faraj A, Fareed M, Faridnia R, Farinha CSeS, Farioli A, Faro A, Faruque M, Farzadfar F, Fattahi N, Fazlzadeh M, Feigin VL, Feldman R, Fereshtehnejad S-M, Fernandes E, Ferrari AJ, Ferreira ML, Filip I, Fischer F, Fisher JL, Fitzgerald R, Flohr C, Flor LS, Foigt NA, Folayan MO, Force LM, Fornari C, Foroutan M, Fox JT, Freitas M, Fu W, Fukumoto T, Furtado JM, Gad MM, Gakidou E, Galles NC, Gallus S, Gamkrelidze A, Garcia-Basteiro AL, Gardner WM, Geberemariyam BS, Gebrehiwot AM, Gebremedhin KB, Gebreslassie AAAA, Hayoon AG, Gething PW, Ghadimi M, Ghadiri K, Ghafourifard M, Ghajar A, Ghamari F, Ghashghaee A, Ghiasvand H, Ghith N, Gholamian A, Gilani SA, Gill PS, Gitimoghaddam M, Giussani G, Goli S, Gomez RS, Gopalani SV, Gorini G, Gorman TM, Gottlich HC, Goudarzi H, Goulart AC, Goulart BNG, Grada A, Grivna M, Grosso G, Gubari MIM, Gugnani HC, Guimaraes ALS, Guimarães RA, Guled RA, Guo G, Guo Y, Gupta R, Haagsma JA, Haddock B, Hafezi-Nejad N, Hafiz A, Hagins H, Haile LM, Hall BJ, Halvaei I, Hamadeh RR, Abdullah KH, Hamilton EB, Han C, Han H, Hankey GJ, Haro JM, Harvey JD, Hasaballah AI, Hasanzadeh A, Hashemian M, Hassanipour S, Hassankhani H, Havmoeller RJ, Hay RJ, Hay SI, Hayat K, Heidari B, Heidari G, Heidari-Soureshjani R, Hendrie D, Henrikson HJ, Henry NJ, Herteliu C, Heydarpour F, Hird TR, Hoek HW, Hole MK, Holla R, Hoogar P, Hosgood HD, Hosseinzadeh M, Hostiuc M, Hostiuc S, Househ M, Hoy DG, Hsairi M, Hsieh VC, Hu G, Huda TM, Hugo FN, Huynh CK, Hwang B-F, Iannucci VC, Ibitoye SE, Ikuta KS, Ilesanmi OS, Ilic IM, Ilic MD, Inbaraj LR, Ippolito H, Irvani SSN, Islam MM, Islam M, Islam SMS, Islami F, Iso H, Ivers RQ, Iwu CCD, Iyamu IO, Jaafari J, Jacobsen KH, Jadidi-Niaragh F, Jafari H, Jafarinia M, Jahagirdar D, Jahani MA, Jahanmehr N, Jakovljevic M, Jalali A, Jalilian F, James SL, Janjani H, Janodia MD, Jayatilleke AU, Jeemon P, Jenabi E, Jha RP, Jha V, Ji JS, Jia P, John O, John-Akinola YO, Johnson CO, Johnson SC, Jonas JB, Joo T, Joshi A, Jozwiak JJ, Jürisson M, Kabir A, Kabir Z, Kalani H, Kalani R, Kalankesh LR, Kalhor R, Kamiab Z, Kanchan T, Matin BK, Karch A, Karim MA, Karimi SE, Kassa GM, Kassebaum NJ, Katikireddi SV, Kawakami N, Kayode GA, Keddie SH, Keller C, Kereselidze M, Khafaie MA, Khalid N, Khan M, Khatab K, Khater MM, Khatib MN, Khayamzadeh M, Khodayari MT, Khundkar R, Kianipour N, Kieling C, Kim D, Kim Y-E, Kim YJ, Kimokoti RW, Kisa A, Kisa S, Kissimova-Skarbek K, Kivimäki M, Kneib CJ, Knudsen AKS, Kocarnik JM, Kolola T, Kopec JA, Kosen S, Koul PA, Koyanagi A, Kravchenko MA, Krishan K, Krohn KJ, Defo BK, Bicer BK, Kumar GA, Kumar M, Kumar P, Kumar V, Kumaresh G, Kurmi OP, Kusuma D, Kyu HH, Vecchia CL, Lacey B, Lal DK, Lalloo R, Lam JO, Lami FH, Landires I, Lang JJ, Lansingh VC, Larson SL, Larsson AO, Lasrado S, Lassi ZS, Lau KM-M, Lavados PM, Lazarus JV, Ledesma JR, Lee PH, Lee SWH, LeGrand KE, Leigh J, Leonardi M, Lescinsky H, Leung J, Levi M, Lewington S, Li S, Lim L-L, Lin C, Lin R-T, Linehan C, Linn S, Liu H-C, Liu S, Liu Z, Looker KJ, Lopez AD, Lopukhov PD, Lorkowski S, Lotufo PA, Lucas TCD, Lugo A, Lunevicius R, Lyons RA, Ma J, MacLachlan JH, Maddison ER, Maddison R, Madotto F, Mahasha PW, Mai HT, Majeed A, Maled V, Maleki S, Malekzadeh R, Malta DC, Mamun AA, Manafi A, Manafi N, Manguerra H, Mansouri B, Mansournia MA, Herrera AMM, Maravilla JC, Marks A, Martins-Melo FR, Martopullo I, Masoumi SZ, Massano J, Massenburg BB, Mathur MR, Maulik PK, McAlinden C, McGrath JJ, McKee M, Mehndiratta MM, Mehri F, Mehta KM, Meitei WB, Memiah PTN, Mendoza W, Menezes RG, Mengesha EW, Mengesha MB, Mereke A, Meretoja A, Meretoja TJ, Mestrovic T, Miazgowski B, Miazgowski T, Michalek IM, Mihretie KM, Miller TR, Mills EJ, Mirica A, Mirrakhimov EM, Mirzaei H, Mirzaei M, Mirzaei-Alavijeh M, Misganaw AT, Mithra P, Moazen B, Moghadaszadeh M, Mohamadi E, Mohammad DK, Mohammad Y, Mezerji NMG, Mohammadian-Hafshejani A, Mohammadifard N, Mohammadpourhodki R, Mohammed S, Mokdad AH, Molokhia M, Momen NC, Monasta L, Mondello S, Mooney MD, Moosazadeh M, Moradi G, Moradi M, Moradi-Lakeh M, Moradzadeh R, Moraga P, Morales L, Morawska L, Velásquez IM, Morgado-da-Costa J, Morrison SD, Mosser JF, Mouodi S, Mousavi SM, Khaneghah AM, Mueller UO, Munro SB, Muriithi MK, Musa KI, Muthupandian S, Naderi M, Nagarajan AJ, Nagel G, Naghshtabrizi B, Nair S, Nandi AK, Nangia V, Nansseu JR, Nayak VC, Nazari J, Negoi I, Negoi RI, Netsere HBN, Ngunjiri JW, Nguyen CT, Nguyen J, Nguyen M, Nguyen M, Nichols E, Nigatu D, Nigatu YT, Nikbakhsh R, Nixon MR, Nnaji CA, Nomura S, Norrving B, Noubiap JJ, Nowak C, Nunez-Samudio V, Oţoiu A, Oancea B, Odell CM, Ogbo FA, Oh I-H, Okunga EW, Oladnabi M, Olagunju AT, Olusanya BO, Olusanya JO, Oluwasanu MM, Bali AO, Omer MO, Ong KL, Onwujekwe OE, Orji AU, Orpana HM, Ortiz A, Ostroff SM, Otstavnov N, Otstavnov SS, Øverland S, Owolabi MO, A MP, Padubidri JR, Pakhare AP, Palladino R, Pana A, Panda-Jonas S, Pandey A, Park E-K, Parmar PGK, Pasupula DK, Patel SK, Paternina-Caicedo AJ, Pathak A, Pathak M, Patten SB, Patton GC, Paudel D, Toroudi HP, Peden AE, Pennini A, Pepito VCF, Peprah EK, Pereira A, Pereira DM, Perico N, Pham HQ, Phillips MR, Pigott DM, Pilgrim T, Pilz TM, Pirsaheb M, Plana-Ripoll O, Plass D, Pokhrel KN, Polibin RV, Polinder S, Polkinghorne KR, Postma MJ, Pourjafar H, Pourmalek F, Kalhori RP, Pourshams A, Poznańska A, Prada SI, Prakash V, Pribadi DRA, Pupillo E, Syed ZQ, Rabiee M, Rabiee N, Radfar A, Rafiee A, Rafiei A, Raggi A, Rahimi-Movaghar A, Rahman MA, Rajabpour-Sanati A, Rajati F, Ramezanzadeh K, Ranabhat CL, Rao PC, Rao SJ, Rasella D, Rastogi P, Rathi P, Rawaf DL, Rawaf S, Rawal L, Razo C, Redford SB, Reiner RC, Reinig N, Reitsma MB, Remuzzi G, Renjith V, Renzaho AMN, Resnikoff S, Rezaei N, Rezai Msadegh, Rezapour A, Rhinehart P-A, Riahi SM, Ribeiro ALP, Ribeiro DC, Ribeiro D, Rickard J, Roberts NLS, Roberts S, Robinson SR, Roever L, Rolfe S, Ronfani L, Roshandel G, Roth GA, Rubagotti E, Rumisha SF, Sabour S, Sachdev PS, Saddik B, Sadeghi E, Sadeghi M, Saeidi S, Safi S, Safiri S, Sagar R, Sahebkar A, Sahraian MA, Sajadi SM, Salahshoor MR, Salamati P, Zahabi SS, Salem H, Salem MRR, Salimzadeh H, Salomon JA, Salz I, Samad Z, Samy AM, Sanabria J, Santomauro DF, Santos IS, Santos JV, Santric-Milicevic MM, Saraswathy SYI, Sarmiento-Suárez R, Sarrafzadegan N, Sartorius B, Sarveazad A, Sathian B, Sathish T, Sattin D, Sbarra AN, Schaeffer LE, Schiavolin S, Schmidt MI, Schutte AE, Schwebel DC, Schwendicke F, Senbeta AM, Senthilkumaran S, Sepanlou SG, Shackelford KA, Shadid J, Shahabi S, Shaheen AA, Shaikh MA, Shalash AS, Shams-Beyranvand M, Shamsizadeh M, Shannawaz M, Sharafi K, Sharara F, Sheena BS, Sheikhtaheri A, Shetty RS, Shibuya K, Shiferaw WS, Shigematsu M, Shin JI, Shiri R, Shirkoohi R, Shrime MG, Shuval K, Siabani S, Sigfusdottir ID, Sigurvinsdottir R, Silva JP, Simpson KE, Singh A, Singh JA, Skiadaresi E, Skou ST, Skryabin VY, Sobngwi E, Sokhan A, Soltani S, Sorensen RJD, Soriano JB, Sorrie MB, Soyiri IN, Sreeramareddy CT, Stanaway JD, Stark BA, Ştefan SC, Stein C, Steiner C, Steiner TJ, Stokes MA, Stovner LJ, Stubbs JL, Sudaryanto A, Sufiyan MB, Sulo G, Sultan I, Sykes BL, Sylte DO, Szócska M, Tabarés-Seisdedos R, Tabb KM, Tadakamadla SK, Taherkhani A, Tajdini M, Takahashi K, Taveira N, Teagle WL, Teame H, Tehrani-Banihashemi A, Teklehaimanot BF, Terrason S, Tessema ZT, Thankappan KR, Thomson AM, Tohidinik HR, Tonelli M, Topor-Madry R, Torre AE, Touvier M, Tovani-Palone MRR, Tran BX, Travillian R, Troeger CE, Truelsen TC, Tsai AC,

Tsatsakis A, Car LT, Tyrovolas S, Uddin R, Ullah S, Undurraga EA, Unnikrishnan B, Vacante M, Vakilian A, Valdez PR, Varughese S, Vasankari TJ, Vasseghian Y, Venketasubramanian N, Violante FS, Vlassov V, Vollset SE, Vongpradith A, Vukovic A, Vukovic R, Waheed Y, Walters MK, Wang J, Wang Y, Wang Y-P, Ward JL, Watson A, Wei J, Weintraub RG, Weiss DJ, Weiss J, Westerman R, Whisnant JL, Whiteford HA, Wiangkham T, Wiens KE, Wijeratne T, Wilner LB, Wilson S, Wojtyniak B, Wolfe CDA, Wool EE, Wu A-M, Hanson SW, Wunrow HY, Xu G, Xu R, Yadgir S, Jabbari SHY, Yamagishi K, Yaminfirooz M, Yano Y, Yaya S, Yazdi-Feyzabadi V, Yearwood JA, Yeheyis TY, Yeshitila YG, Yip P, Yonemoto N, Yoon S-J, Lebni JY, Younis MZ, Younker TP, Yousefi Z, Yousefifard M, Yousefinezhadi T, Yousuf AY, Yu C, Yusefzadeh H, Moghadam TZ, Zaki L, Zaman SB, Zamani M, Zamanian M, Zandian H, Zangeneh A, Zastrozhin MS, Zewdie KA, Zhang Y, Zhang Z-J, Zhao JT, Zhao Y, Zheng P, Zhou M, Ziapour A, Zimsen SRM, Naghavi M, Murray CJL. Global burden of 369 diseases and injuries in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. Lancet (London, England) 2020;396:1204–22.