

Relationship Between Academic Stress, Sleep Quality, and Musculoskeletal Pain Among University Students During Examination Periods: A Systematic Evidence Synthesis

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ABSTRACT

Background: University examination periods combine increased academic demand with altered study schedules, prolonged sedentary behavior, psychological stress, and sleep disruption. These factors may interact to increase musculoskeletal symptoms, particularly neck and low-back pain, but the relative contribution of stress and sleep remains incompletely defined. **Objective:** To synthesize high-quality evidence available through 31 December 2022 concerning the relationships among academic stress, sleep quality, and musculoskeletal pain in university students, with particular emphasis on examination periods. **Methods:** A structured systematic evidence synthesis was conducted using peer-reviewed studies published no later than 31 December 2022. References were restricted to Q1 journals in sleep medicine, psychology, public health, pain, ergonomics, and musculoskeletal medicine. Examination-period studies were prioritized. Because direct Q1 studies simultaneously measuring examination stress, sleep quality, and musculoskeletal pain were scarce, evidence was triangulated from examination-period longitudinal studies, undergraduate stress-sleep studies, student musculoskeletal studies, and longitudinal young-adult pain research. Heterogeneous outcomes prevented a valid new pooled effect estimate. **Results:** Examination periods were associated with increased perceived stress, poorer sleep quality, and greater daytime dysfunction. A 2022 meta-analysis of 25 undergraduate studies involving 10,065 participants identified a moderate association between stress and poor sleep quality ($r=0.39$; 95% CI 0.35-0.43), while the pooled stress-insomnia association was $r=0.41$. Among 339 undergraduate students, 12-month neck and low-back pain prevalences were 54.6% and 49.4%, respectively, and musculoskeletal pain was significantly associated with stress, anxiety, and poor sleep. Longitudinal young-adult data further indicated that baseline stress and non-restorative sleep predicted chronic pain one year later, with adjusted odds ratios of 1.6 and 1.5, respectively. Persistent sleep disturbance was also associated with progressively greater odds of neck pain in longitudinal data. **Conclusion:** Evidence available through 2022 supports an interacting stress-sleep-pain model rather than a purely biomechanical explanation for examination-period musculoskeletal symptoms. Examination stress may impair sleep and alter activity patterns, while poor sleep may heighten pain vulnerability. Prospective within-student studies across pre-examination, examination, and post-examination periods are required to establish temporal mediation.

Keywords: academic stress; examination period; sleep quality; musculoskeletal pain; university students; neck pain; low-back pain; psychological distress

1. Introduction

University examinations create a temporary but predictable period of increased psychological and behavioral demand. Students frequently extend study hours, alter sleeping schedules, increase caffeine intake, reduce leisure and physical activity, and spend prolonged periods in seated study positions. Examination periods therefore provide a useful natural context in which psychological stress, sleep, and musculoskeletal symptoms may change simultaneously.

Sleep appears particularly sensitive to examination-related demand. Campbell et al. followed 121 university students before, during, and after an examination period and observed significant increases in stress, poor sleep quality, and daytime dysfunction during examinations, followed by improvement after examinations ended. Changes in stress substantially accounted for changes in sleep-related outcomes [1].

The relationship between stress and sleep is not restricted to examination studies. Gardani et al. systematically reviewed 34 studies involving 14,704 undergraduate students. Their meta-

analysis identified a weighted pooled correlation of $r=0.39$ between stress and poor sleep quality across 25 studies and $r=0.41$ between stress and insomnia across 12 studies. Both analyses demonstrated substantial heterogeneity but remarkably consistent positive directions of association [2].

Musculoskeletal pain is also common in university populations. Alsaadi reported that among 339 undergraduates, neck pain was the most common painful region, affecting 54.6% during the preceding 12 months and 41.9% during the preceding seven days. Corresponding prevalences for low-back pain were 49.4% and 48.2%. Both recent and longer-term musculoskeletal pain were significantly associated with stress, anxiety, and poor sleep quality [3].

These findings challenge an exclusively mechanical interpretation of student musculoskeletal pain. Prolonged sitting, computer use, and static cervical postures may contribute to symptoms, but psychological stress and inadequate sleep can influence pain processing, muscle tension, fatigue, recovery, and behavior.

Longitudinal evidence strengthens this interpretation. Lindell and Grimby-Ekman followed young adults aged approximately 19-24 years and found that stress, non-restorative sleep, and physical inactivity predicted chronic pain one year later. Stress remained a significant predictor four years later [4].

The present review therefore examined whether examination periods plausibly create a convergence of academic stress, poor sleep, and musculoskeletal pain among university students. The objective was not simply to determine whether all three conditions are common, but to clarify how they may interact and which relationships are supported by longitudinal or exam-specific evidence.

2. Methods

2.1 Review Design

A structured systematic evidence synthesis was conducted using literature available through 31 December 2022. The search framework incorporated academic stress, examination stress, university students, sleep quality, insomnia, non-restorative sleep, musculoskeletal pain, neck pain, low-back pain, physical activity, psychological distress, and examination period. The review prioritized studies involving university students and young adults. Evidence from other populations was retained only when it directly strengthened understanding of temporal relationships between sleep disturbance and musculoskeletal pain.

The evidence eligibility framework is summarised in Table 1.

2.2 Evidence Domains

Evidence was synthesized across three connected relationships. The first concerned examination periods and changes in stress and sleep. The second concerned stress and sleep quality in undergraduate students. The third concerned stress, sleep disturbance, and musculoskeletal pain. A formal de novo meta-analysis was not performed because studies measured different outcomes, including correlations, odds ratios, prevalence, latent change coefficients, pain sites, chronic pain, and sleep-quality scores. Statistical pooling across these fundamentally different constructs would create an artificial summary measure.

3. Results

3.1 Examination Periods, Stress, and Sleep

The most directly relevant longitudinal study was conducted by Campbell et al. University students were evaluated before, during, and after an examination period. The investigators demonstrated an inverted U-shaped trajectory for negative outcomes: stress, poor sleep quality, and daytime dysfunction increased during examinations and improved afterward [1].

From the pre-examination to examination period, the latent change estimate for stress was +0.23, while poor sleep quality increased by +0.19 and daytime dysfunction by +0.59. From the examination to post-examination period, stress decreased by -0.66, poor sleep by -0.25, and daytime dysfunction by -0.79. Changes in stress accounted for a substantial part of the relationship between changing psychological experiences and poor sleep [1].

These within-participant findings are particularly informative because they reduce the likelihood that differences are explained exclusively by stable individual characteristics. The same students became more stressed and slept worse while moving into an examination period, then improved after that period ended.

Principal Q1 evidence contributing to the synthesis is summarised in Table 2.

3.2 Stress and Sleep Quality in Undergraduate Students

Gardani et al. included 34 studies across 13 countries, representing 14,704 undergraduate participants. Thirty-two studies were cross-sectional and only two longitudinal, demonstrating both the breadth

of the association and the weakness of causal evidence in much of the literature [2].

The pooled association between stress and poor sleep quality was $r=0.39$ (95% CI 0.35-0.43) among 10,065 students. Heterogeneity was high at $I^2=80.03\%$. For insomnia and stress, the pooled association was $r=0.41$ (95% CI 0.36-0.46) among approximately 5,565 participants, again with high heterogeneity [2].

The magnitude is clinically meaningful because it indicates that stress and sleep disturbance are neither independent phenomena nor essentially identical constructs. Instead, they are moderately associated and likely influence one another.

Quantitative findings relevant to the stress-sleep-pain pathway are summarised in Table 3.

3.3 Musculoskeletal Pain in University Students

Alsaadi's undergraduate study provides the strongest directly relevant Q1 evidence integrating pain, psychological distress, and sleep. The most common sites of musculoskeletal pain were the neck and lower back. Twelve-month neck pain prevalence was 54.6%, while seven-day prevalence was 41.9%. Low-back pain affected 49.4% over 12 months and 48.2% during the previous seven days [3].

Musculoskeletal pain during both reference periods was significantly associated with stress and anxiety and with poorer sleep quality. Depression was associated primarily with recent pain. These findings suggest that pain prevalence cannot be explained solely by university ergonomics or sitting behavior [3].

The direct cross-sectional design prevents determination of whether stress and poor sleep preceded pain. However, longitudinal young-adult data address part of this limitation.

3.4 Longitudinal Evidence for Pain Development

Lindell and Grimby-Ekman evaluated a cohort of Swedish young adults initially aged 19-24 years. Stress, non-restorative sleep, and physical inactivity were considered potential predictors of later chronic pain. At one-year follow-up, adjusted odds ratios were 1.6 for stress, 1.5 for non-restorative sleep, and 1.8 for inactivity [4].

The interaction between sleep and inactivity was particularly noteworthy. Young adults who were both inactive and experienced non-restorative sleep had an adjusted odds ratio of 6.9 for developing chronic pain compared with participants who were active and reported restorative sleep. The wide confidence interval requires cautious interpretation, but the result supports interaction among behavioral risk factors rather than isolated effects [4].

At four-year follow-up, stress remained predictive of chronic pain with an adjusted OR of 1.9, whereas non-restorative sleep and inactivity individually were no longer statistically significant. This suggests that persistent psychological stress may contribute to longer-term vulnerability [4].

The proposed biopsychosocial pathway linking examination stress with sleep disruption and musculoskeletal pain is presented in Figure 1.

3.5 Sleep as a Potential Pain Risk Factor

Longitudinal evidence outside the university setting strengthens temporal plausibility. Yabe et al. reported progressively higher odds of neck pain as sleep disturbance persisted. Compared with those without relevant sleep disturbance, adjusted odds of neck pain increased from 1.84 for disturbance lasting less than one year to 2.80 when disturbance persisted for two years or longer. Preceding sleep disturbance also predicted new-onset neck pain, reaching an adjusted OR of 3.00 in the longest-duration category [5].

These results do not demonstrate that a few nights of examination-related poor sleep will produce chronic pain. They do show that sleep impairment can precede musculoskeletal symptoms, making sleep a plausible mediator or amplifier rather than merely a consequence of pain.

Selected pre-2023 quantitative evidence supporting the stress-sleep-pain relationship is presented in Figure 2.

3.6 Integrated Examination-Period Model

The evidence supports a cyclical rather than linear model. During examinations, academic demands increase. Greater perceived stress may produce cognitive and physiological arousal that delays sleep onset or reduces restorative sleep. Students may simultaneously study for longer periods in relatively static positions and reduce physical activity.

Poor sleep may subsequently increase fatigue and reduce pain tolerance, while psychological stress can increase muscle tension and heighten awareness of bodily symptoms. Pain can itself interfere with sleep, creating a reciprocal cycle.

Components of the proposed examination-period model are summarised in Table 4.

4. Discussion

4.1 Principal Findings

The evidence available through 2022 supports a coherent relationship among academic stress, sleep disturbance, and musculoskeletal pain in university students. The strongest exam-specific evidence demonstrates that stress and poor sleep worsen as students enter examinations and improve afterward [1]. The strongest undergraduate meta-analysis demonstrates a moderate association between stress and impaired sleep across more than 10,000 students [2]. Direct undergraduate musculoskeletal research then demonstrates that stress and poor sleep are associated with neck, low-back, and other pain [3]. Finally, longitudinal young-adult studies indicate that stress and non-restorative sleep can precede chronic pain [4].

Taken together, these findings support a plausible examination-period pathway even though a single Q1 study simultaneously measuring all three variables across pre-exam, examination, and post-exam phases was not available by the end of 2022.

4.2 Stress Is More Than a Psychological Outcome

Academic stress is often discussed only in relation to anxiety or academic performance. The present synthesis indicates that it may also have physical correlates. Stress can influence sleep, physical activity, muscle activation, fatigue, and symptom perception. During examinations, these mechanisms operate alongside prolonged studying and reduced recovery opportunities.

The finding that stress remained predictive of chronic pain four years later in young adults suggests that psychological exposure may have longer-term importance beyond temporary discomfort [4].

4.3 Sleep May Function as a Mediating Pathway

Sleep is particularly important because it lies between psychological and physical domains. Campbell et al. found that stress helped account for examination-period changes in poor sleep [1]. Gardani et al. established the broader stress-sleep association quantitatively [2]. Alsaadi subsequently demonstrated that poor sleep and stress were both associated with undergraduate musculoskeletal pain [3].

These findings justify testing a formal mediation model in future research in which examination stress predicts sleep deterioration and sleep deterioration subsequently predicts increased musculoskeletal symptoms. Current evidence supports this hypothesis but does not prove the mediation pathway.

4.4 Musculoskeletal Pain Should Not Be Reduced to Posture

Examination periods often involve prolonged sitting, laptop use, reading, and smartphone use. These exposures are relevant, but attributing student neck or low-back pain exclusively to poor

posture would ignore substantial psychological and sleep-related evidence.

A more defensible interpretation is cumulative exposure. Pain vulnerability during examinations may increase when high stress, poor sleep, long study sessions, low movement variability, reduced physical activity, and pre-existing symptoms occur together. The very large interaction estimate observed for non-restorative sleep plus physical inactivity in young adults provides preliminary support for this multivariable perspective [4].

4.5 Implications for University Health Programs

Interventions should address examination periods as predictable high-risk windows rather than treating sleep, stress, and musculoskeletal health as unrelated services. A program focused solely on ergonomic chair adjustment may miss substantial contributors. Similarly, stress-management services that ignore sleep and movement behavior may only partially address the problem.

The most defensible strategy is a combined approach involving realistic study scheduling, sleep protection, regular movement, reduction of prolonged uninterrupted sitting, and access to psychological support when examination stress becomes excessive.

The evidence-informed framework for future university interventions is presented in Table 5.

4.6 Methodological Implications

The optimal next study is a prospective repeated-measures cohort beginning several weeks before examinations. Students should complete validated assessments of academic stress, sleep, and musculoskeletal symptoms during a normal academic week, again during the examination period, and again after examinations.

Sleep should ideally be measured using both the Pittsburgh Sleep Quality Index and objective actigraphy. Musculoskeletal symptoms could be measured by anatomical site with the Nordic Musculoskeletal Questionnaire, supplemented by numeric pain intensity and disability measures.

Sitting time and physical activity should be objectively assessed where possible, because examination-related behavior may confound or mediate the stress-pain relationship. A longitudinal mediation model could then determine whether increased academic stress predicts worsened sleep, whether worsened sleep predicts increased pain, and how much of the examination-period increase in pain is indirectly explained by sleep.

4.7 Strengths and Limitations

The principal strength of this synthesis is the strict Q1 and pre-2023 evidence criterion. The review also distinguishes direct examination-period evidence from supporting mechanistic evidence rather than presenting indirect findings as though all studies were conducted during examinations.

The principal limitation is therefore also transparent: direct high-quality research simultaneously measuring stress, sleep quality, and musculoskeletal pain during examination periods was scarce through 2022. Much of the student musculoskeletal evidence was cross-sectional. Reverse causation remains possible because pain itself can impair sleep and increase psychological distress.

The pooled stress-sleep literature was highly heterogeneous, with I² around 80% [2]. This likely reflects differences in academic programs, countries, sleep measures, stress measures, and sampling periods. Self-reported sleep and pain may also produce shared-method bias. Objective activity and actigraphy should therefore supplement questionnaire-based studies.

4.8 Conclusion

High-quality evidence available through 2022 indicates that university examination periods are associated with increased stress and deterioration in sleep-related functioning, while stress and poor sleep are independently associated with musculoskeletal pain in undergraduate and young-adult populations.

The evidence is therefore most consistent with an interacting stress-sleep-pain pathway. Academic stress may worsen sleep and alter study behavior; poor or non-restorative sleep may increase vulnerability to pain; prolonged sedentary study and reduced physical activity may add mechanical and behavioral load; and existing pain may further disrupt sleep.

This model provides a stronger explanation than attributing examination-period neck and low-back symptoms to posture alone. The remaining evidence gap is temporal. A prospective within-student study spanning normal academic activity, examinations, and post-examination recovery is required to determine whether sleep quality mediates the relationship between academic stress and musculoskeletal pain.

Declarations

Funding

No external funding was received.

Conflict of Interest

The authors declare no conflict of interest.

Ethical Approval

Not applicable because this manuscript synthesized previously published evidence and involved no direct participant recruitment.

Consent to Participate

Not applicable.

Data Availability

No novel participant-level dataset was generated.

Author Contributions

The authors contributed to conceptualization, evidence synthesis, interpretation, manuscript preparation, and critical revision.

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Table 1. Evidence eligibility framework

Domain	Inclusion criteria	Exclusion criteria
Publication date	Published on or before 31 December 2022	2023 onward
Journal quality	Q1 journal in a relevant category	Q2-Q4 or unranked journal
Population	University students or young adults; broader cohorts only for directly relevant longitudinal mechanisms	Unrelated populations
Exposure	Academic stress, examination period, poor sleep, insomnia, non-restorative sleep	Non-academic stress without mechanistic relevance
Outcome	Neck pain, low-back pain, multisite pain, chronic musculoskeletal pain, sleep quality	Non-musculoskeletal conditions
Design	Longitudinal, cohort, cross-sectional, systematic review, meta-analysis	Commentary without empirical evidence
Measurement	Validated or clearly defined stress, sleep, or pain variables	Unclear single-item outcomes where avoidable

Table 2. Principal Q1 evidence contributing to the synthesis

Study	Design/population	Relevant exposure	Principal finding
Campbell et al. [1]	Longitudinal; 121 university students	Pre-exam, exam, post-exam periods	Stress, poor sleep, and daytime dysfunction increased during exams and improved afterward
Gardani et al. [2]	Systematic review/meta-analysis; 34 studies	Stress and sleep	Stress-poor sleep pooled $r=0.39$; stress-insomnia $r=0.41$
Alsaadi [3]	Cross-sectional; 339 undergraduates	Stress, anxiety, sleep quality	Musculoskeletal pain significantly associated with stress and poor sleep
Lindell & Grimby-Ekman [4]	Longitudinal young-adult cohort	Stress, non-restorative sleep, inactivity	Stress and non-restorative sleep predicted chronic pain at one year
Yabe et al. [5]	Three-year longitudinal study	Duration of sleep disturbance	Longer sleep disturbance associated with progressively greater neck-pain risk
Andias & Silva [6]	Pain cohort in adolescents/young people	Sleep and psychosocial factors	Sleep and psychosocial variables associated with several chronic pain/disability domains

Table 3. Quantitative findings relevant to the stress-sleep-pain pathway

Relationship	Quantitative finding	Interpretation
Undergraduate stress and poor sleep [2]	$r=0.39$, 95% CI 0.35-0.43	Moderate pooled association
Undergraduate stress and insomnia [2]	$r=0.41$, 95% CI 0.36-0.46	Moderate pooled association
Stress predicting chronic pain at 1 year [4]	adjusted OR 1.6, 95% CI 1.0-2.4	Stress preceded later chronic pain
Non-restorative sleep predicting chronic pain at 1 year [4]	adjusted OR 1.5, 95% CI 1.0-2.3	Sleep may contribute independently
Physical inactivity predicting chronic pain at 1 year [4]	adjusted OR 1.8, 95% CI 1.1-3.0	Behavioral pathway is also relevant
Inactivity plus non-restorative sleep [4]	adjusted OR 6.9, 95% CI 2.5-19.2	Combined exposures may substantially amplify risk
Sleep disturbance <1 year and neck pain [5]	adjusted OR 1.84, 95% CI 1.23-2.75	Duration-response relationship
Sleep disturbance 1-<2 years [5]	adjusted OR 2.41, 95% CI 1.53-3.81	Greater persistent exposure
Sleep disturbance ≥ 2 years [5]	adjusted OR 2.80, 95% CI 2.09-3.76	Strongest association

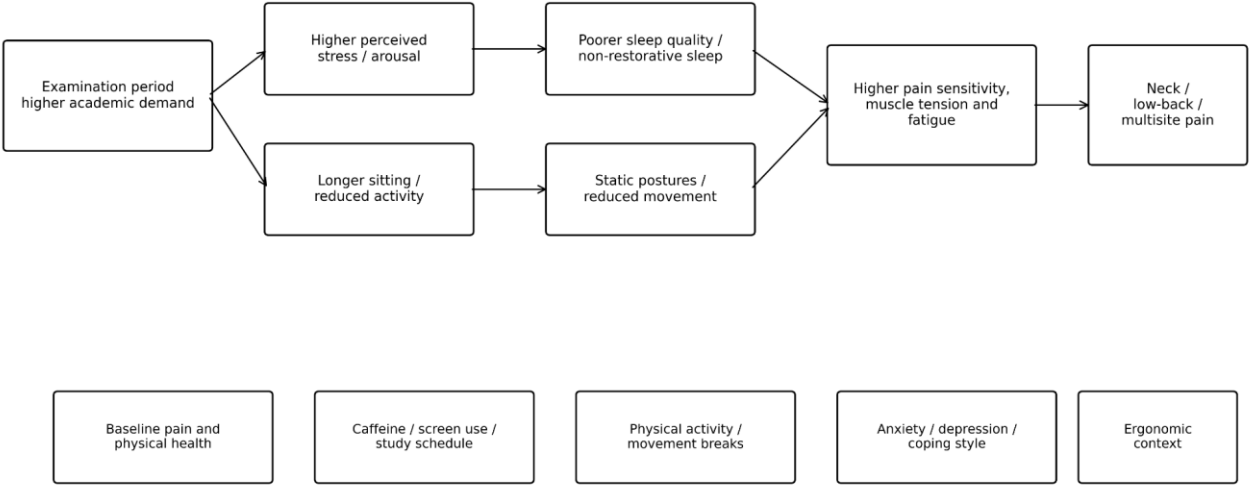
Table 4. Components of the proposed examination-period model

Component	Likely effect	Evidence interpretation
Increased academic demand	Greater perceived stress	Direct exam-period evidence
Stress	Poorer sleep quality and daytime dysfunction	Strong student evidence and meta-analysis
Extended studying	Longer sedentary/static exposure	Highly plausible behavioral co-exposure
Reduced physical activity	Reduced movement variability and recovery	Longitudinal pain evidence
Poor sleep	Greater vulnerability to musculoskeletal pain	Student cross-sectional and broader longitudinal evidence
Stress	Greater subsequent chronic-pain risk	Young-adult longitudinal evidence
Existing pain	Further sleep disturbance	Likely bidirectional mechanism
Post-exam recovery	Reduction in stress and improvement in sleep	Direct longitudinal exam-period evidence

Table 5. Evidence-informed framework for future university interventions

Target	Intervention concept	Primary intended mechanism
Examination stress	Time-management and coping interventions	Reduce cognitive and physiological arousal
Sleep timing	Protect consistent sleep opportunity during examinations	Reduce sleep disruption
Long study sessions	Scheduled movement interruptions	Reduce static musculoskeletal loading
Physical inactivity	Maintain moderate activity through examination periods	Improve recovery and pain resilience
Night-time study behavior	Reduce unnecessary late-night studying and stimulating screen exposure	Improve sleep initiation and restoration
Existing neck/back pain	Early symptom management without catastrophizing	Prevent persistence and functional limitation
High-risk students	Combined stress, sleep, and pain screening	Identify interacting exposures
University research	Repeated pre-exam/exam/post-exam measurement	Establish within-person temporal relationships

Figure 1. Proposed biopsychosocial pathway linking examination stress with sleep disruption and musculoskeletal pain



The evidence supports an interacting stress-sleep-behavior pathway rather than a single mechanical cause of examination-period pain.

Figure 1. Proposed biopsychosocial pathway linking examination stress with sleep disruption and musculoskeletal pain.

Academic demand may increase perceived stress and arousal while simultaneously extending sedentary study time and reducing physical activity. Poorer or non-restorative sleep, static postures and reduced movement can converge on greater fatigue, muscle tension and pain sensitivity, while baseline pain, caffeine or screen use, activity patterns, psychological state and ergonomic context may modify the pathway.

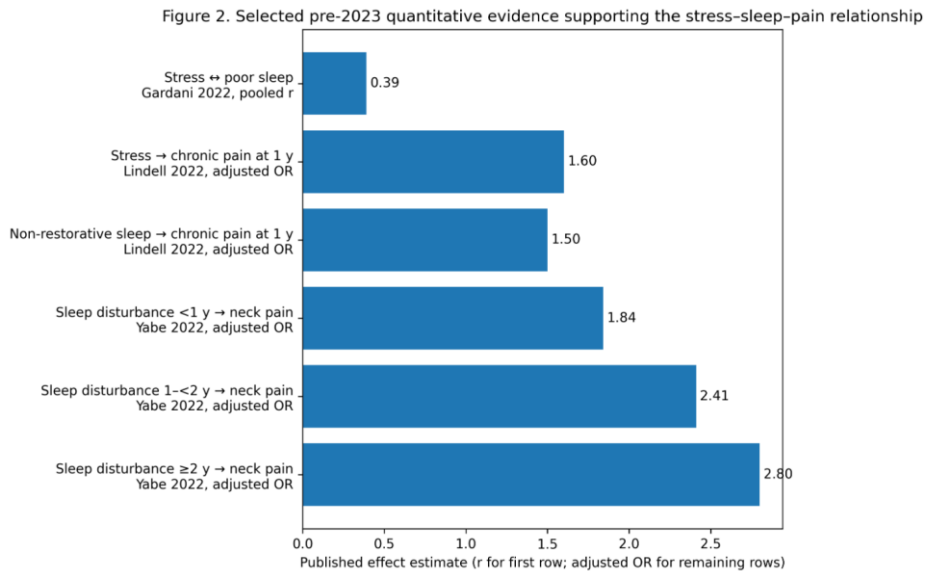


Figure 2. Selected pre-2023 quantitative evidence supporting the stress-sleep-pain relationship.

Published quantitative estimates are shown as contextual benchmarks only. The first estimate is a pooled correlation between stress and poor sleep, whereas the remaining estimates are adjusted odds ratios for subsequent chronic or neck pain. Because these are different effect measures, they should not be pooled or interpreted as equivalent scales.

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