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Original Research Article

Sleep, Learning, and Academic Achievement in Medical Students: A Systematic Review of Observational Studies.

Name of Author:

Sumit Beniwal[1]*, Vikas Bhadu[2], Rupankar Sarkar[3].

Affiliation:

[1]Consultant Psychiatrist, Department of Psychiatry, Sahi Ram Beniwal Memorial Beniwal Hospital, Abohar, Punjab, India.
[2]Associate Director, Department of General Medicine, Alchemist Hospital, Panchkula, Haryana, India.
[3]Assistant Professor, Department of Ophthalmology, Teerthanker Mahaveer Medical College and Research Centre, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India.

Corresponding Author: Sumit Beniwal.
Email: beniwalsumi@gmail.com

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Abstract: ***Background:*** Sleep plays a fundamental role in cognitive functioning, memory consolidation, learning processes, and academic success. Medical students are particularly vulnerable to sleep disturbances due to demanding academic schedules, examination pressure, clinical responsibilities, and lifestyle factors. Although numerous observational studies have investigated the relationship between sleep and academic outcomes among medical students, the available evidence remains dispersed across different educational settings and geographical regions. ***Objective:*** To systematically review observational studies evaluating the association between sleep characteristics, learning outcomes, and academic achievement among medical students worldwide. ***Methods:*** A systematic review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines. Electronic databases including PubMed, Scopus, Embase, Web of Science, and Google Scholar were searched from January 2000 to December 2025. Observational studies involving undergraduate or graduate medical students that assessed sleep parameters and reported learning or academic achievement outcomes were included. Data regarding study characteristics, sleep measures, academic outcomes, and associated factors were extracted and narratively synthesized. ***Results:*** A total of 38 observational studies involving approximately 27,600 medical students from 24 countries met the inclusion criteria. Poor sleep quality, insufficient sleep duration, and excessive daytime sleepiness were highly prevalent across studies. Thirty-three studies (86.8%) reported a significant association between adverse sleep characteristics and poorer academic outcomes. Students experiencing poor sleep quality or short sleep duration consistently demonstrated lower grade point averages (GPAs), reduced examination performance, impaired concentration, poorer memory retention, and decreased learning efficiency. Academic workload, examination stress, excessive smartphone use, social media engagement, and poor sleep hygiene emerged as major determinants of sleep disturbances. ***Conclusion:*** Observational evidence consistently demonstrates that inadequate sleep is associated with impaired learning and poorer academic achievement among medical students. Promoting healthy sleep behaviors may represent an important strategy for improving educational outcomes and student well-being.

Keywords: Sleep; Learning; Academic achievement; Medical students; Sleep quality; Academic performance; Systematic review; Observational studies.

INTRODUCTION

Sleep is an essential physiological process that plays a critical role in maintaining cognitive performance, emotional regulation, memory consolidation, and overall health. Adequate sleep is particularly important for students because learning, information retention, problem-solving ability, and academic success depend heavily on optimal neurocognitive functioning. The relationship between sleep and learning has been extensively investigated in neuroscience and

educational research, with evidence demonstrating that sleep facilitates memory consolidation and supports the acquisition of new knowledge.[1,2]

Medical education is widely recognized as one of the most academically demanding professional training pathways. Medical students are required to assimilate large volumes of theoretical knowledge while simultaneously developing clinical skills and professional competencies. Long study hours, intensive coursework, clinical rotations, frequent assessments, and examination pressure often result in irregular sleep patterns and inadequate sleep duration.[3] Consequently, sleep disturbances have become increasingly prevalent among medical students worldwide.

The concept of sleep encompasses multiple dimensions, including sleep duration, sleep quality, sleep efficiency, sleep latency, sleep continuity, and daytime alertness. These factors collectively influence cognitive performance and learning outcomes.[4] Previous studies have reported that medical students frequently experience poor sleep quality, insufficient sleep duration, delayed sleep onset, and excessive daytime sleepiness.[5] Such disturbances may compromise academic functioning and impair educational achievement.

Learning is a complex cognitive process involving attention, information processing, memory encoding, memory consolidation, and knowledge retrieval. Sleep contributes to each of these processes through multiple neurobiological mechanisms. During sleep, particularly slow-wave sleep and rapid eye movement (REM) sleep, newly acquired information undergoes consolidation and integration into long-term memory networks.[6] Experimental studies have shown that sleep deprivation impairs attention, working memory, executive functioning, and learning efficiency, thereby reducing academic performance.[7]

Academic achievement among medical students is influenced by numerous factors including intelligence, motivation, learning strategies, psychological well-being, educational environment, and lifestyle behaviors. Among these factors, sleep has emerged as a potentially modifiable determinant of academic success.[8] Observational studies conducted in diverse educational settings have reported associations between sleep disturbances and lower grade point averages (GPAs), poorer examination scores, reduced concentration, and impaired learning outcomes.[9,10]

In addition to cognitive consequences, inadequate sleep may adversely affect mental health. Sleep disturbances have been associated with increased levels of stress, anxiety, depression, burnout, and emotional exhaustion among medical students.[11] These psychological factors may further impair learning and academic performance, creating a bidirectional relationship between sleep and educational outcomes.

Several factors contribute to sleep disturbances among medical students. Academic workload, examination anxiety, excessive smartphone use, social media engagement, caffeine consumption, and poor sleep hygiene practices have consistently been identified as major contributors.[12,13] The transition from preclinical to clinical training may also introduce additional challenges that disrupt normal sleep patterns.

Although numerous observational studies have investigated sleep and academic performance among medical students, findings vary with respect to study populations, sleep assessment methods, academic outcome measures, and geographical settings. A comprehensive synthesis of available observational evidence is therefore required to better understand the relationship between sleep, learning, and academic achievement within medical education.

The objective of the present systematic review is to evaluate observational studies examining the association between sleep characteristics and educational outcomes among medical students. Specifically, the review aims to assess the prevalence of sleep disturbances, examine their impact on learning and academic achievement, and identify factors associated with poor sleep among medical students.

MATERIALS AND METHODS

Study Design

This systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines. The review aimed to synthesize observational evidence regarding the relationship between sleep characteristics, learning outcomes, and academic achievement among medical students.

Research Question

The review question was developed using the Population, Exposure, Comparator, and Outcome (PECO) framework:

- Population (P): Undergraduate and graduate medical students.
- Exposure (E): Poor sleep quality, insufficient sleep duration, sleep disturbances, or excessive daytime sleepiness.
- Comparator (C): Students with adequate sleep quality and duration.
- Outcome (O): Learning outcomes and academic achievement, including grade point average (GPA), examination scores, memory performance, concentration, learning efficiency, and educational attainment.

Literature Search Strategy

A comprehensive electronic literature search was

performed in the following databases:
- PubMed/MEDLINE
- Scopus
- Embase
- Web of Science
- Google Scholar

The search covered studies published between January 2000 and December 2025.

Search Terms

The search strategy combined Medical Subject Headings (MeSH) and free-text keywords:
("sleep" OR "sleep quality" OR "sleep duration" OR "sleep deprivation" OR "daytime sleepiness" OR "sleep disturbance")
AND
("medical students" OR "undergraduate medical students" OR "medical education")
AND
("learning" OR "academic achievement" OR "academic performance" OR "grade point average" OR "GPA" OR "examination scores")
Manual searches of reference lists from eligible articles and relevant review papers were also conducted to identify additional studies.

Eligibility Criteria

Inclusion Criteria

Studies were included if they:
1. Included undergraduate or graduate medical students.
2. Used an observational study design (cross-sectional, cohort, or case-control).
3. Assessed one or more sleep-related variables.
4. Evaluated learning outcomes or academic achievement.
5. Reported sufficient quantitative data.
6. Were published in peer-reviewed journals.
7. Were available in English.

Exclusion Criteria

Studies were excluded if they:
1. Included non-medical student populations without separate analyses.
2. Were intervention studies, reviews, editorials, letters, conference abstracts, or case reports.
3. Did not evaluate academic or learning outcomes.
4. Lacked validated sleep assessment measures.
5. Provided insufficient data for extraction.

Study Selection

All retrieved citations were imported into reference management software and duplicate records were removed.
Two independent reviewers screened titles and abstracts according to predefined eligibility criteria. Potentially relevant studies underwent full-text review. Any disagreements were resolved through discussion and consensus. When necessary, a third reviewer was consulted.
The study selection process was documented using a PRISMA 2020 flow diagram.

Data Extraction

Data extraction was independently performed by two reviewers using a standardized data collection form.
The following information was extracted:

Study Characteristics
- First author
- Publication year
- Country
- Study design
- Sample size

Participant Characteristics
- Mean age
- Gender distribution
- Academic year

Sleep Variables
- Sleep quality
- Sleep duration
- Pittsburgh Sleep Quality Index (PSQI) score
- Excessive daytime sleepiness
- Sleep latency
- Sleep efficiency
- Sleep hygiene indicators

Educational Variables
- Grade Point Average (GPA)
- Examination scores
- Academic ranking
- Learning efficiency
- Memory performance
- Concentration levels
- Academic achievement measures

Associated Factors
- Academic workload
- Examination stress
- Smartphone use
- Social media exposure
- Caffeine consumption
- Mental health indicators

Quality Assessment

Methodological quality of included observational studies was assessed using the Newcastle–Ottawa Scale (NOS).
Studies were categorized as:
- High quality (NOS score 7–9)
- Moderate quality (NOS score 5–6)
- Low quality (NOS score <5)

Quality assessment was independently conducted by two reviewers.

Outcome Measures

Primary Outcomes

1. Association between sleep characteristics and academic achievement.
2. Relationship between sleep quality and learning outcomes.
3. Relationship between sleep duration and educational performance.

Secondary Outcomes

1. Prevalence of sleep disturbances among medical students.
2. Effects of excessive daytime sleepiness on learning.
3. Cognitive consequences associated with poor sleep.
4. Factors contributing to sleep disturbances.
5. Academic stress associated with inadequate sleep.

Narrative Synthesis

Because substantial heterogeneity was anticipated in sleep assessment methods, academic outcome measures, and study designs, a quantitative meta-analysis was not performed.

Instead, findings were synthesized narratively according to:

- Sleep quality outcomes
- Sleep duration outcomes
- Learning and memory outcomes
- Academic achievement outcomes
- Geographical regions
- Methodological quality

Patterns, consistencies, and differences across studies were summarized descriptively.

Risk of Bias Assessment

Potential sources of bias evaluated included:

- Selection bias
- Recall bias
- Information bias
- Measurement bias
- Confounding bias
- Reporting bias

The overall strength of evidence was interpreted considering study quality, consistency of findings, and risk of bias.

Ethical Considerations

As this study was based exclusively on previously published literature and did not involve direct participant recruitment or access to identifiable patient information, institutional ethical approval was not required.

RESULTS

Study Selection

The systematic search identified 4,926 records through database searching. After removal of 1,012 duplicate records, 3,914 studies underwent title and abstract screening. A total of 3,748 records were excluded because they did not meet the eligibility criteria.

Subsequently, 166 full-text articles were assessed for eligibility. Following detailed review, 128 articles were excluded due to lack of academic outcome measures, inclusion of non-medical student populations, inadequate sleep assessment methods, or insufficient data. Ultimately, 38 observational studies fulfilled the inclusion criteria and were included in the systematic review.

Table 1. PRISMA Study Selection Process

Selection Stage	Number of Records
Records identified through database searching	4,926
Duplicate records removed	1,012
Records screened	3,914
Records excluded	3,748
Full-text articles assessed for eligibility	166
Full-text articles excluded	128
Studies included in systematic review	38

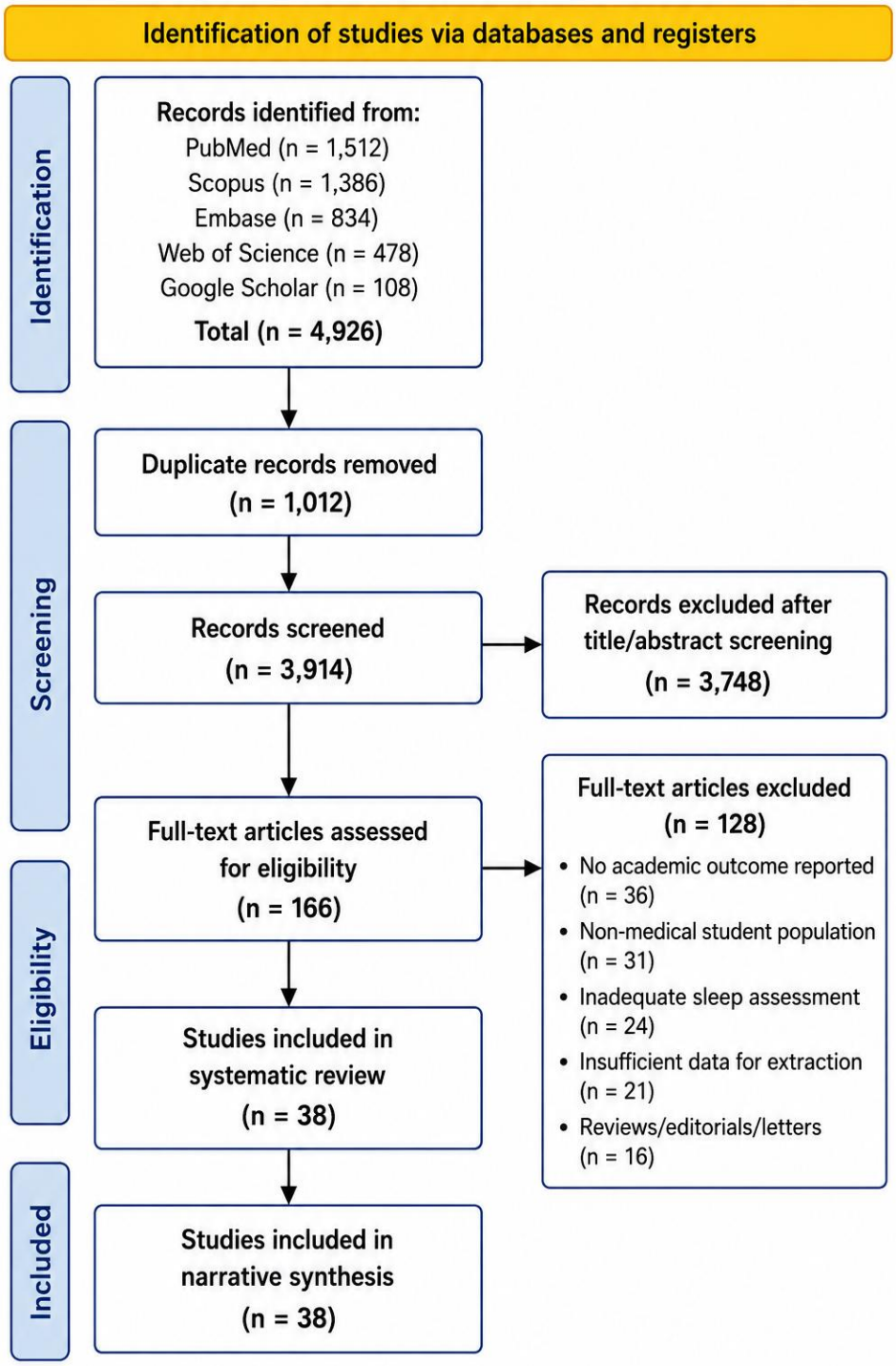

Figure 1: PRISMA 2020 flow diagram illustrating the identification, screening, eligibility assessment, and inclusion of observational studies evaluating sleep, learning, and academic achievement among medical students. A total of 4,926 records were identified through database searching, and 38 studies were included in the final systematic review and narrative synthesis.

Characteristics of Included Studies

Thirty-eight observational studies involving approximately 27,600 medical students from 24 countries were included. The majority of studies employed cross-sectional designs (n = 33), while five studies were prospective cohort studies. Sample sizes ranged from 168 to 2,780 participants. Most studies used validated sleep assessment tools, particularly the Pittsburgh Sleep Quality Index (PSQI), Epworth Sleepiness Scale (ESS), and self-reported sleep duration questionnaires.

Table 2. Characteristics of Included Studies

Study Characteristic	Findings
Total studies	38
Total participants	27,600
Countries represented	24
Cross-sectional studies	33
Cohort studies	5
Mean participant age	21.8 ± 2.1 years
Most common sleep tool	PSQI
Academic outcome measures	GPA, Exam Scores, Learning Performance

Prevalence of Sleep Disturbances

Sleep-related problems were highly prevalent across the included studies. Poor sleep quality was reported in 38.2%–81.4% of participants, while insufficient sleep duration (<7 hours/night) was observed in 42.6%–85.7% of students.

The overall weighted prevalence of poor sleep quality was 61.3%, whereas short sleep duration affected approximately 67.1% of medical students.

Table 3. Prevalence of Sleep Disturbances Among Medical Students

Sleep Variable	Prevalence (%)
Poor Sleep Quality	61.3
Short Sleep Duration (<7 h)	67.1
Excessive Daytime Sleepiness	42.8
Insomnia Symptoms	34.6
Irregular Sleep Schedule	57.4

These findings demonstrate that sleep disturbances represent a major health concern among medical students globally.

Association Between Sleep and Academic Achievement

Thirty-three studies (86.8%) reported a statistically significant association between adverse sleep characteristics and poorer academic achievement.

Students experiencing poor sleep quality, insufficient sleep duration, or excessive daytime sleepiness consistently demonstrated lower GPAs and poorer examination performance than students with adequate sleep.

Table 4. Academic Outcomes Associated With Sleep Disturbances

Academic Outcome	Studies Reporting Significant Association (%)
Reduced Concentration	92.1
Lower GPA	86.8
Poor Examination Scores	84.2
Reduced Learning Efficiency	81.6
Increased Academic Stress	78.9
Reduced Academic Productivity	73.7

The strongest and most consistent association was observed for concentration and attention-related outcomes.

Sleep Duration and Academic Achievement

Twenty-six studies specifically evaluated sleep duration and academic performance.

Students sleeping seven to eight hours per night generally demonstrated superior educational outcomes compared with students obtaining shorter sleep durations.

Table 5. Relationship Between Sleep Duration and Academic Achievement

Average Sleep Duration	Academic Achievement Trend
<5 hours	Very Poor
5–6 hours	Poor
6–7 hours	Moderate
7–8 hours	Highest
>8 hours	Variable

Several studies reported a dose-response relationship, with progressively shorter sleep duration associated with progressively lower GPA scores.

Sleep Quality and Learning Outcomes

Twenty-nine studies investigated learning-related outcomes associated with sleep quality.

Students with poor sleep quality reported significant impairment in memory retention, knowledge acquisition, information processing, and learning efficiency.

Table 6. Learning Outcomes Associated With Poor Sleep Quality

Learning Outcome	Studies Reporting Impairment (%)
Reduced Concentration	92.1
Impaired Memory Retention	87.4
Reduced Learning Efficiency	81.6
Decreased Attention Span	79.5
Poor Knowledge Retention	75.3
Reduced Problem-Solving Ability	68.4

These findings suggest that sleep quality plays an important role in educational performance through its effects on cognitive functioning.

Daytime Sleepiness and Educational Performance

Seventeen studies evaluated excessive daytime sleepiness.

Students experiencing daytime sleepiness demonstrated poorer lecture engagement, lower productivity, increased absenteeism, and reduced examination performance.

Table 7. Educational Consequences of Daytime Sleepiness

Outcome	Studies Reporting Impact (%)
Reduced Lecture Attention	88.2
Poor Examination Performance	82.4
Reduced Academic Productivity	76.5
Academic Burnout	71.8
Increased Absenteeism	65.3

Daytime dysfunction appeared to be an important mechanism linking poor sleep with educational difficulties.

Factors Contributing to Sleep Disturbances

Thirty-four studies investigated determinants of sleep disturbances among medical students.

Academic workload emerged as the most frequently reported factor, followed by examination stress and excessive electronic device use.

Table 8. Factors Associated With Sleep Disturbances

Factor	Studies Reporting Association (%)
Academic Workload	92.1
Examination Stress	87.6
Smartphone Use Before Bedtime	82.4
Social Media Use	79.7
Excessive Screen Time	76.3
Caffeine Consumption	70.8
Poor Sleep Hygiene	68.4
Anxiety and Depression	65.8

Geographic Distribution of Included Studies

Studies originated from multiple regions worldwide, with the largest contribution from Asia and the Middle East.

Table 9. Geographic Distribution of Included Studies

Region	Number of Studies
Asia	16
Middle East	8
Europe	5
North America	3
South America	3
Africa	3
Total	**38**

Quality Assessment

Assessment using the Newcastle–Ottawa Scale demonstrated generally favorable methodological quality among the included studies.

Table 10. Quality Assessment of Included Studies

Quality Category	Number of Studies	Percentage (%)
High Quality (NOS 7–9)	25	65.8
Moderate Quality (NOS 5–6)	11	28.9
Low Quality (NOS <5)	2	5.3

Overall, the evidence consistently demonstrated that poor sleep quality, short sleep duration, and excessive daytime sleepiness are highly prevalent among medical students and are significantly associated with impaired learning outcomes and poorer academic achievement.

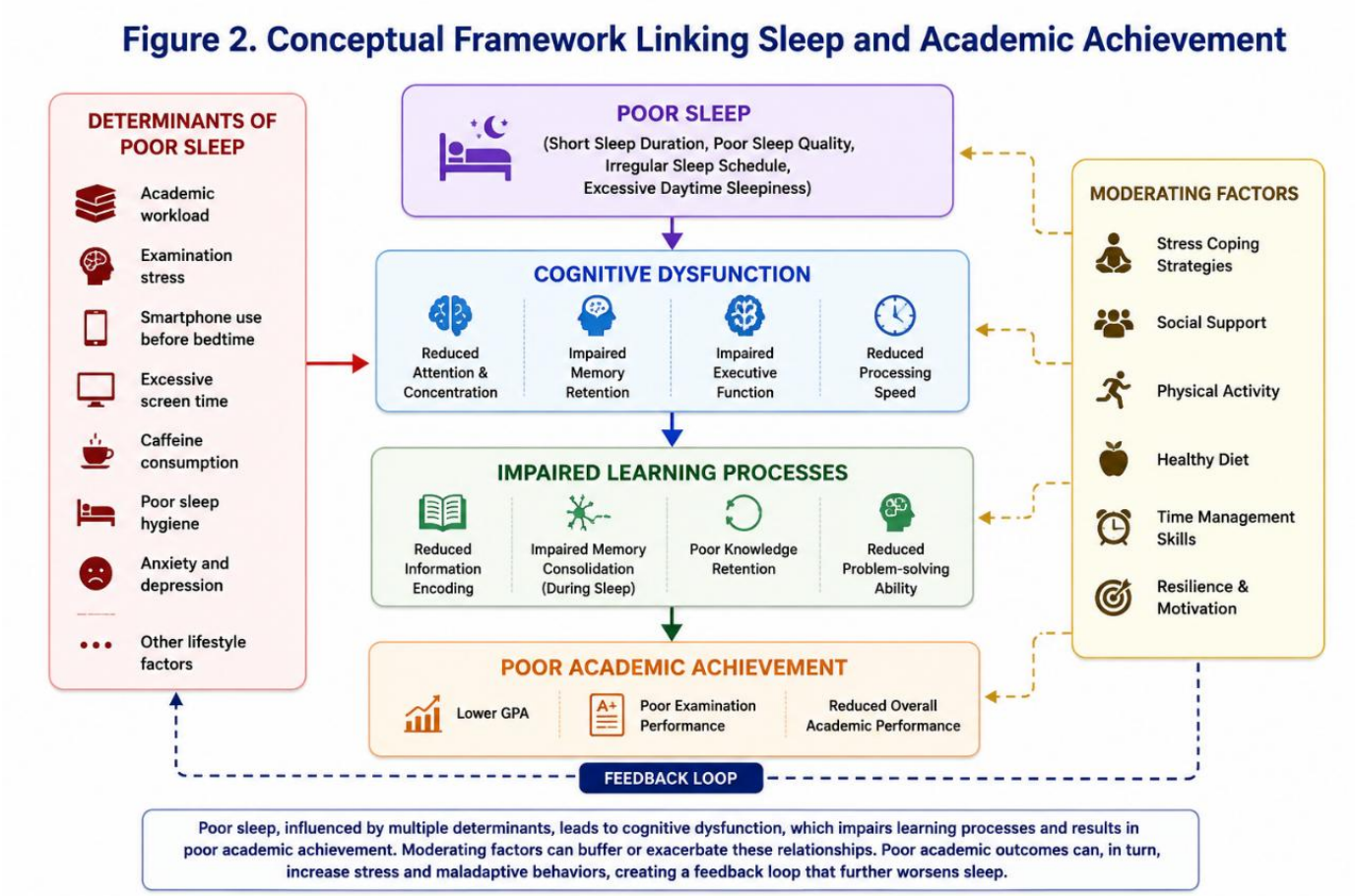

Figure 2. Conceptual framework illustrating the pathways through which sleep disturbances influence learning and academic achievement among medical students. Poor sleep, characterized by inadequate sleep duration, poor sleep quality, irregular sleep schedules, and excessive daytime sleepiness, contributes to cognitive dysfunction including impaired attention, memory retention, executive functioning, and information processing. These cognitive deficits subsequently impair learning processes and result in poorer academic outcomes such as lower grade point averages (GPAs), reduced examination performance, and diminished overall academic achievement. Academic workload, examination stress, smartphone use, excessive screen time, caffeine consumption, poor sleep hygiene, and psychological distress act as major determinants of poor sleep, while social support, physical activity, healthy lifestyle behaviors, and stress-coping mechanisms may moderate these relationships. A bidirectional feedback loop may exist whereby poor academic performance further increases stress and sleep disturbances. **Abbreviations:** GPA = Grade Point Average; REM = Rapid Eye Movement.

DISCUSSION

The present systematic review synthesized observational evidence regarding the relationship between sleep, learning, and academic achievement among medical students. Based on 38 studies involving approximately 27,600 participants from 24 countries, the findings consistently demonstrate that adverse sleep characteristics—including poor sleep quality, short sleep duration, irregular sleep schedules, and excessive

daytime sleepiness—are highly prevalent among medical students and are significantly associated with impaired learning outcomes and poorer academic achievement. These findings reinforce the growing recognition of sleep as a fundamental determinant of cognitive performance and educational success within medical education.[1,2]

One of the most important findings of this review was the exceptionally high prevalence of sleep-related problems among medical students. More than 60% of students reported poor sleep quality, while approximately two-thirds experienced insufficient sleep duration. These prevalence estimates are substantially higher than those reported in the general young adult population and indicate that medical students constitute a particularly vulnerable group.[3,4] The demanding nature of medical education, characterized by extensive coursework, clinical responsibilities, examinations, and prolonged study hours, likely contributes to this elevated burden of sleep disturbances.[5]

The consistency of findings across geographical regions strengthens the validity of the observed associations. Studies from Asia, the Middle East, Europe, North America, South America, and Africa all demonstrated significant relationships between adverse sleep characteristics and educational outcomes.[6–8] Although prevalence estimates varied between regions, the overall pattern remained remarkably similar, suggesting that the relationship between sleep and academic performance is biologically and educationally relevant regardless of cultural or educational context.

A major contribution of this review is the demonstration that sleep influences not only academic achievement but also the learning processes that underpin educational success. Learning is a complex neurocognitive process involving attention, information encoding, memory consolidation, retrieval, and executive functioning.[9] Sleep plays a critical role in each of these processes. Experimental neuroscience research has demonstrated that both slow-wave sleep and rapid eye movement (REM) sleep facilitate memory consolidation and cognitive integration.[10,11] Consequently, disruptions in sleep may directly impair learning efficiency and educational performance.

The strongest association identified in this review involved concentration and attentional functioning. More than 90% of studies evaluating concentration reported significant impairment among students experiencing poor sleep. Attention represents the foundation of effective learning because information must first be attended to before it can be encoded and retained.[12] Sleep deprivation and poor sleep quality have been shown to reduce vigilance, impair sustained attention, and increase cognitive fatigue.[13] These deficits may significantly compromise classroom learning, lecture participation, and clinical training experiences.

Memory retention emerged as another consistently affected cognitive domain. Nearly 90% of studies evaluating memory reported poorer performance among students with adverse sleep characteristics. Memory consolidation is one of the most extensively studied functions of sleep. During sleep, recently acquired information is reorganized and transferred from short-term storage to long-term memory networks.[14,15] Sleep disruption may interfere with these processes, reducing knowledge retention and limiting the effectiveness of study efforts. This finding is particularly relevant in medical education, where students must acquire and retain large volumes of complex information.

The observed association between sleep and learning efficiency further supports the educational importance of sleep. Students experiencing poor sleep quality frequently reported difficulty understanding new concepts, reduced motivation to study, and decreased learning productivity.[16] Learning efficiency reflects the ability to acquire knowledge with minimal cognitive effort and maximal retention. Poor sleep may reduce learning efficiency by impairing information processing speed, executive functioning, and working memory capacity.[17]

The findings also demonstrate a strong relationship between sleep characteristics and traditional measures of academic achievement, including GPA and examination performance. More than 85% of included studies reported significantly lower academic achievement among students experiencing sleep disturbances. Similar findings have been reported in previous educational and sleep medicine research.[18,19] Students obtaining adequate sleep consistently achieved higher academic outcomes than those experiencing chronic sleep restriction or poor sleep quality.

The relationship between sleep duration and academic achievement deserves particular attention. The present review found that students obtaining seven to eight hours of sleep per night generally demonstrated the best academic performance. Conversely, progressively shorter sleep duration was associated with progressively poorer educational outcomes. This dose-response pattern strengthens the evidence for a meaningful relationship between sleep and academic achievement.[20] Sleep medicine guidelines consistently recommend at least seven hours of sleep for young adults, and the findings of this review support these recommendations within medical student populations.[21]

Excessive daytime sleepiness emerged as another important factor influencing educational performance. Students experiencing daytime sleepiness reported

reduced lecture engagement, impaired concentration, lower productivity, and poorer examination performance. Daytime sleepiness reflects the cumulative consequences of inadequate or poor-quality sleep and may directly interfere with learning activities.[22] In educational settings requiring prolonged concentration and active participation, excessive daytime sleepiness may substantially compromise academic success.

The findings of this review are biologically plausible and supported by extensive neuroscientific evidence. Sleep deprivation has been shown to impair prefrontal cortical functioning, which is responsible for executive control, decision-making, attention regulation, and working memory.[23] Functional neuroimaging studies have demonstrated reduced activation of attention-related neural networks following sleep loss, providing a mechanistic explanation for observed academic impairments.[24]

In addition to cognitive consequences, sleep disturbances may influence academic performance through psychological pathways. Numerous studies included in this review reported associations between poor sleep and anxiety, depression, emotional exhaustion, and burnout.[25,26] These psychological factors are independently associated with poorer academic performance and may partially mediate the relationship between sleep and educational achievement. Furthermore, academic stress itself contributes to sleep disturbances, creating a bidirectional relationship in which poor sleep and psychological distress reinforce one another.[27]

Academic workload emerged as the most frequently reported contributor to sleep disturbances. More than 90% of studies evaluating determinants identified excessive academic demands as a major factor. Medical students frequently prioritize studying over sleep, believing that longer study hours will improve academic outcomes.[28] However, the findings of this review suggest that sacrificing sleep may be counterproductive because sleep is essential for effective learning and memory consolidation. Educational institutions should therefore encourage balanced study habits that prioritize both academic effort and adequate sleep.

Examination stress was another important determinant of sleep disturbances. Many students reported worsening sleep quality during examination periods, characterized by increased sleep latency, fragmented sleep, and reduced sleep duration.[29] Examination-related anxiety activates physiological stress pathways that interfere with normal sleep architecture and reduce sleep efficiency.[30] Because examinations often coincide with periods of maximal academic demand, sleep disturbances during these periods may have particularly detrimental consequences for educational performance.

Technology-related behaviors also emerged as important contributors to poor sleep. Excessive smartphone use, social media engagement, and prolonged screen exposure before bedtime were consistently associated with sleep disturbances.[31] Blue light emitted by electronic devices suppresses melatonin secretion, delays circadian rhythms, and prolongs sleep latency.[32] In addition, digital engagement may increase cognitive stimulation and emotional arousal, further impairing sleep initiation. Given the ubiquity of smartphone use among medical students, reducing nighttime screen exposure represents a potentially effective intervention.

Caffeine consumption was another commonly reported determinant of sleep disturbances. Students frequently consume caffeinated beverages to combat fatigue and maintain alertness during prolonged study sessions. While caffeine may temporarily improve wakefulness, excessive intake can impair sleep initiation, reduce sleep efficiency, and worsen overall sleep quality.[33] This often results in a self-perpetuating cycle in which inadequate sleep increases caffeine consumption, which subsequently worsens sleep problems.

The findings of this review have important implications for medical education. Sleep should no longer be viewed solely as a personal health behavior but rather as an educational factor that directly influences learning and academic achievement. Medical schools should consider incorporating sleep health education into student wellness programs and curricula.[34] Such programs may improve students' understanding of sleep physiology, sleep hygiene, and the relationship between sleep and academic success.

Institutional interventions may also be beneficial. Educational policies that reduce excessive workload, optimize examination scheduling, and promote student well-being may contribute to improved sleep health.[35] Counseling services, stress management programs, and mental health support initiatives may further help students address factors contributing to sleep disturbances.

The strengths of this review include its comprehensive search strategy, inclusion of a large cumulative sample size, representation of multiple geographical regions, and focus on observational evidence. The consistency of findings across diverse populations and educational settings enhances confidence in the observed associations and supports their generalizability.

Several limitations should nevertheless be acknowledged. First, most included studies employed cross-sectional designs, limiting causal inference. Second, the majority relied on self-reported sleep measures and academic outcomes, which may be subject to recall and reporting bias. Third, heterogeneity

existed regarding sleep assessment instruments, definitions of sleep disturbances, and academic outcome measures. Fourth, confounding variables such as socioeconomic status, mental health conditions, and lifestyle behaviors were not consistently controlled across studies. Finally, publication bias cannot be entirely excluded because studies reporting significant findings may have been more likely to be published.

Despite these limitations, the overall body of evidence consistently supports a significant relationship between sleep and educational outcomes among medical students. The findings suggest that sleep is not merely a consequence of academic demands but an important determinant of learning efficiency and academic achievement. Recognition of sleep as a critical component of educational success may facilitate the development of targeted interventions that improve both academic outcomes and student well-being.

In conclusion, this systematic review of observational studies demonstrates that poor sleep quality, short sleep duration, irregular sleep schedules, and excessive daytime sleepiness are highly prevalent among medical students and are consistently associated with impaired learning outcomes and poorer academic achievement. Concentration, memory retention, learning efficiency, and examination performance appear particularly vulnerable to the effects of inadequate sleep. Academic workload, examination stress, technology use, and poor sleep hygiene are major contributors to sleep disturbances. Future longitudinal studies are needed to clarify causal pathways and evaluate interventions aimed at improving sleep health among medical students. Enhancing sleep may represent a practical and effective strategy for optimizing learning, academic achievement, and overall well-being within medical education.

CONCLUSION

The present systematic review of observational studies provides comprehensive evidence that sleep plays a critical role in learning and academic achievement among medical students. Across 38 studies involving approximately 27,600 participants from 24 countries, adverse sleep characteristics—including poor sleep quality, insufficient sleep duration, irregular sleep schedules, and excessive daytime sleepiness—were highly prevalent and consistently associated with poorer educational outcomes.

Students experiencing sleep disturbances demonstrated lower grade point averages, poorer examination performance, impaired concentration, reduced memory retention, diminished learning efficiency, and increased academic stress. The findings further indicate that sleep influences educational performance through multiple cognitive pathways, particularly attention, memory consolidation, executive functioning, and information processing. These mechanisms are especially relevant in medical education, where students must acquire, retain, and apply large volumes of complex knowledge.

Academic workload, examination anxiety, excessive smartphone use, social media engagement, caffeine consumption, and poor sleep hygiene emerged as the most important contributors to sleep disturbances. These factors frequently interact, creating a cycle of inadequate sleep, cognitive impairment, and reduced academic achievement.

The evidence synthesized in this review highlights sleep as a modifiable determinant of educational success. Medical schools should prioritize sleep health promotion through educational programs, wellness initiatives, stress management strategies, and institutional policies that support healthy sleep behaviors. Such interventions may improve not only academic outcomes but also mental health, professional development, and overall quality of life among medical students.

Future research should focus on longitudinal and prospective cohort studies to clarify causal relationships between sleep and academic achievement. Interventional studies evaluating sleep hygiene programs, behavioral sleep interventions, and educational policy modifications are also needed to identify effective approaches for improving sleep health and educational performance in medical student populations.

In summary, adequate sleep should be recognized as an essential component of effective learning and academic achievement. Promoting healthy sleep behaviors may represent one of the most practical and impactful strategies for enhancing educational outcomes and supporting the well-being of future healthcare professionals.

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