

Systematic Review in Community Health

Sleep duration, sleep quality, excessive daytime sleepiness, and chronotype in university students in India: A systematic review

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Abstract

Introduction: Optimal sleep is an important aspect of academic performance and mental health. However, poor sleep health is often present among university students due to their lifestyle and academic requirements. University students in India have been shown to have poor sleep health. Though self-reported sleep issues have been evaluated among university students in India, these results have not been synthesized to date. We aimed to identify factors that may be associated with poor sleep health among university students in India from January 2010 to April 2021, inclusive. As a secondary aim, we sought to evaluate factors associated with sleep among university students in India during the COVID-19 pandemic.

Methods: A systematic review was conducted using PubMed, CINAHL, and Google Scholar to identify studies conducted in India related to sleep among university students. The studies were synthesized by aspects of sleep (sleep quality, sleep duration, excessive daytime sleepiness (EDS)) and chronotype, types of university students in India (non-medical and medical) and if they examined sleep in university students during the COVID-19 pandemic.

Results: 12 articles were identified that evaluated sleep duration, sleep quality, and excessive daytime sleepiness and included university students in India. Findings suggested that between 25-72% of Indian university students reported poor sleep quality, and 17-44% experienced EDS. Similar associations were noted in both non-medical and medical undergraduate students. Students with evening chronotype vs. intermediate chronotype and morning chronotype were more likely to

experience poor sleep quality. Studies conducted during the COVID-19 pandemic reported differing results of poor sleep quality and increased sleep duration.

Discussion: Demographic, psychological, and socio-behavioral factors are statistically significantly related to poor sleep quality, EDS, and short sleep duration among university students in India.

Take-home message: Poor sleep quality is prevalent among university students in India. To improve sleep issues among university students in India, researchers should design tailored sleep interventions that account for demographic, psychological, and socio-behavioral factors that may place students at risk for poor sleep quality, excessive daytime sleepiness, and short sleep duration.

Key words: India; sleep; sleep duration; sleep quality; university.

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INTRODUCTION

For optimal health, sleep is vital [1]. Several factors including adequate sleep duration, good quality sleep, proper sleep timing and regularity, and the absence of sleep disorders all play a role in obtaining healthy sleep and promoting optimal health [1]. Inadequate sleep duration and poor sleep quality have been associated with several adverse cardiometabolic health outcomes including hypertension [2], obesity [3], type two diabetes mellitus [3,4], and cardiovascular disease [5]. It is recommended adults aged 18 to 60 obtain at least seven hours of sleep per night to promote optimal health, although some young adults may need more than nine hours of sleep per night [1].

Life pressures and academic stress serve as potential barriers to university students experiencing the proper amount and quality of sleep; poor sleep quality has been associated with psychological factors and behavioral and lifestyle factors [6]. Several factors have been related to excessive sleepiness and sleep quality among college students in India including spending a significant amount of time on the internet and social media, risk-taking behaviors, irregular sleep times, and working too close to bedtimes [7]. Previous research has found an association between poor sleep quality and poor general health among university students in India [8]. As a result of rapid lifestyle changes among youth, the sleep patterns and general health of university students in India have been changing [8]. Additionally, the COVID-19 pandemic has impacted the sleep of college students in India; one study found that 68% of university students reported longer sleep durations during the pandemic [9].

Given the lack of research on sleep in college students in India [10], we conducted a comprehensive systematic review on the current state of sleep and chronotype among university students in India. We examined the prevalence of sleep issues (i.e., poor sleep quality and excessive daytime sleepiness), the impact of COVID-19 on sleep issues, and the identification of psychological, demographic, and socio-behavioral determinants of sleep quality, sleep duration, and excessive daytime sleepiness among university students in India. This review will also explore if there are any demographic differences, specifically in the students' age, year in university, and gender in sleep among university students in India. For the purpose of this review, the terms "undergraduate", "college", and "university" students can be considered interchangeable.

METHODS

Research question

The PEOD strategy (population, exposure, outcome, study design) was used to develop a research question that guided the direction of this systematic review.

Population: University students in India

Exposures: Demographic, psychological, and socio-behavioral factors

Outcomes: Sleep duration, sleep quality, excessive daytime sleepiness, and chronotype

Design: Systematic Review

Search strategy

To identify potential studies to be included in the systematic review, a literature search was conducted in PubMed, Cumulative Index to Nursing and Allied Health Literature (CINAHL), and Google Scholar between February 10, 2021, and April 30, 2021. The search terms utilized were “sleep” and “university students” and “India”. An abstract review was conducted to determine whether individual studies met inclusion criteria as follows: studies were included if they were published in the English language, included students attending university in India, and were published from January 1, 2010 – April 30, 2021. Studies were excluded if they did not include university students, did not have the full text in English available, did not evaluate sleep or chronotype, or did not take place in India. The PRISMA 2020 guidelines were followed for the preparation and reporting of the systematic review [11]; however, the review was not registered in PROSPERO.

Selection criteria

CD and OG reviewed titles and abstracts of the articles returned in the searches to determine potential eligibility for inclusion. Full-text articles that met inclusion were then reviewed by CD and OG and included based on the criteria identified above. Agreement between both reviewers was reached prior to inclusion in the systematic review.

Data extraction

After articles were selected for inclusion, the following data were extracted: study type, sample size, sleep measures, location, mean age, and percentages of each gender. In addition, prevalence rates of poor sleep quality and excessive daytime sleepiness, as well as of sleep duration, were extracted when applicable.

Methodological quality

In 2013, the National Heart, Lung, and Blood Institute (NHLBI) at the National Institute of Health (NIH) developed a set of quality assessment tools to evaluate various study designs [12]. To assess the methodological quality of the included studies, the “NIH Quality Assessment Tool for Observational Cohort and Cross-sectional Studies” was used for 11 of the included studies and the “NIH Quality Assessment Tool Before-After (Pre-Post) Studies with No Control Group” was used for the one longitudinal study [12]. All of the included studies rated at least fair with a score of six or above out of a total of 12 for the quality assessment tool examining before-after (pre-post) studies with no control group or 14 for observational cohort and cross-sectional studies. CD and OG conducted the quality evaluation independently using the tailored quality assessment tools [12] and confirmed scoring.

Data synthesis

The included studies were organized into three categories based on population and time frame: (1) studies that evaluated sleep among undergraduate students in general, (2) studies of sleep in

medical university students from undergraduate through internships in medical school, and (3) studies that addressed sleep in university students during the COVID-19 pandemic (see Figure 1).

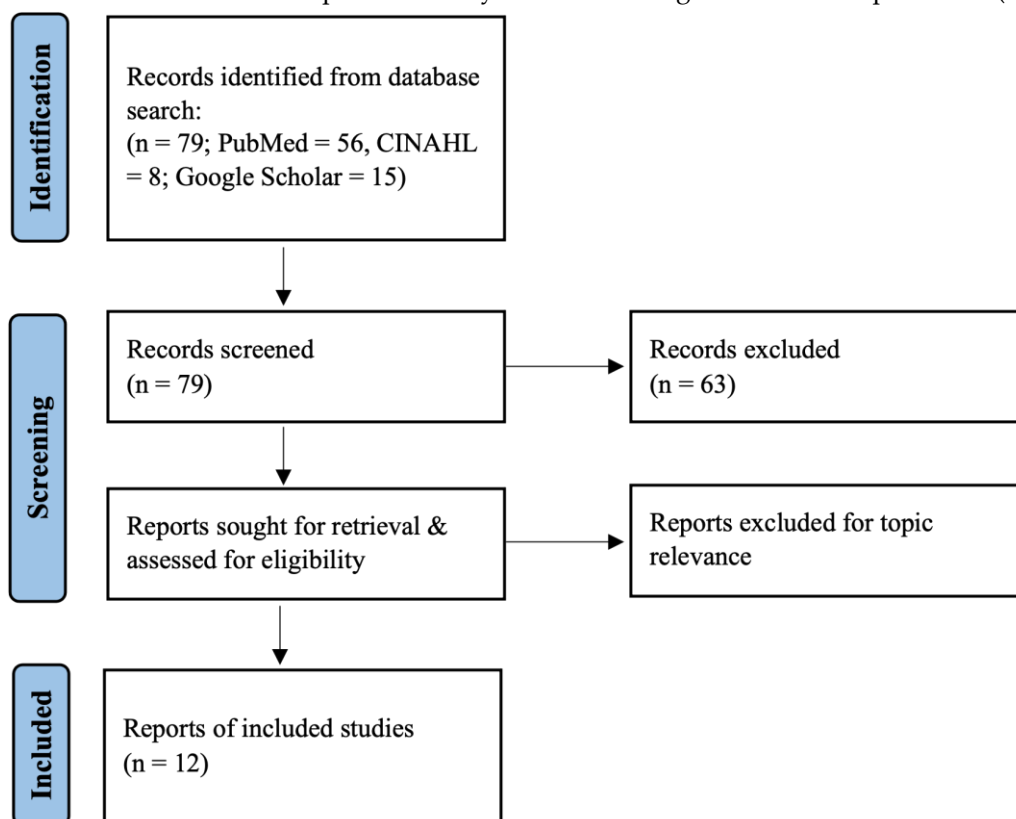


Figure 1. Initial search and inclusion of articles for the systematic review.

RESULTS

Through searches of PubMed, Google Scholar, and CINAHL, a total of 79 articles were identified. The PubMed search resulted in 56 total articles. However, after review, only 11 studies were found to be applicable based on the inclusion and exclusion criteria. The Google Scholar search resulted in 15 articles, but only one was applicable. The CINAHL search resulted in eight articles; however, none were applicable to the review. Thus, 12 total studies were included in the present systematic review.

Research design and instruments

Of the studies included in the systematic review, two different study designs were utilized. All studies but one were cross-sectional and sampled a group of students at one time point with no follow-up measures in place [13–23]. Only one study was conducted with a longitudinal design, specifically, a follow-up six months after the baseline survey to measure changes during the COVID-19 pandemic [24] (see Table 1).

Table 1. Summary of studies included in systematic review of literature on sleep duration, sleep quality, excessive sleepiness, and chronotype in university students in India ($n = 12$).

Citation	Study type	Sample size	Sleep measure(s)	Location	% of poor sleep quality (*daytime sleepiness)	Key outcomes
University Students						
Ghrouz et al, 2019 [14]	Cross-Sectional Questionnaire	617	Pittsburgh Sleep Quality Index	New Delhi, India	51%	Symptoms of anxiety or depression were statistically significantly related to poor sleep quality.
Kaur & Singh, 2017 [18]	Cross-Sectional Questionnaire	1,215	Epworth Sleepiness Scale	Chandigarh, India	*44% (Daytime sleepiness)	Not consuming coffee or tea, abstaining from alcohol, not smoking, and participating in weekly physical activity were all statistically significantly related to less daytime sleepiness.
Kumari et al, 2020 [20]	Cross-Sectional Questionnaire	335	Pittsburgh Sleep Quality Index	Uttarakhand, India	66%	Not practicing yoga, moderate to severe stress, and mobile phone use were statistically significant predictors of poor sleep quality.
Manzar et al, 2014 [22]	Cross-Sectional Questionnaire	418	Pittsburgh Sleep Quality Index	New Delhi, India	43%	Bedtime and total sleep time statistically significantly differed between 1 st and 2 nd year students. Additionally, female students reported earlier bedtimes.
Medical University Students						
Gangwar et al, 2018 [13]	Cross-Sectional Questionnaire	203	Pittsburgh Sleep Quality Index,	Lucknow, India	40.39%	Participants with an evening chronotype experienced greater

			Epworth Sleepiness Scale, & Morningness-Eveningness Questionnaire		(≤ 20 years old), 32.51% (> 20 years old)	poor sleep quality. Age and gender were statistically significantly associated with poor sleep quality.
Giri et al, 2013 [15]	Cross-Sectional Questionnaire	150	Pittsburgh Sleep Quality Index	Maharashtra, India	*17.3% (Daytime sleepiness)	Gender, anxiety, alcohol use, age, smoking, caffeine intake, BMI, and mobile phone and laptop use were statistically significant and positively correlated with the global Pittsburgh Sleep Quality Index scores.
R. Gupta et al, 2020 [16]	Cross-Sectional Questionnaire	222	Pittsburgh Sleep Quality Index	North Delhi, India	59.9%	Internet addiction and poor sleep quality were statistically significant and positively correlated.
S. Gupta et al, 2020 [17]	Cross-Sectional Questionnaire	400	Pittsburgh Sleep Quality Index	Haryana, India	25%	Worse sleep quality was reported among first-year medical undergraduate students.
Shad et al, 2015 [23]	Cross-Sectional Questionnaire	214	Pittsburgh Sleep Quality Index & Oldenberg Burnout Inventory	India	62.6% (medical students-72.9%; non-medical students-51.9%)	More daytime dysfunction and fewer sleep disturbances were reported among women compared to men. 72.9% of medical students reported poor sleep compared to 51.9% of non-medical students.

COVID-19 Studies

Kochuvilayil et al, 2021 [19]	Cross-Sectional Questionnaire	212 (113 from India only)	State-Trait Anxiety Inventory & Investigator Developed Questions	Kerala, India, and Australia	NR	4.4% of nursing students in India reported difficulty sleeping during the pandemic.
Majumdar et al, 2020 [21]	Cross-Sectional Questionnaire	325	Munich Chrono-Type Questionnaire & Epworth Sleepiness Scale	India	NR	During the COVID-19 lockdown period, sleep duration statistically significantly increased and a majority of the participants reported good sleep quality. University students reported later wake and bedtimes during lockdown compared to the pre-lockdown period. Poor sleep quality was statistically significantly associated with depression, stress, and anxiety; and remained statistically significant during the follow-up period.
Saraswathi et al, 2020 [24]	Prospective Longitudinal Study	217	Pittsburgh Sleep Quality Index	Chennai, India	34.5%	Poor sleep quality was statistically significantly associated with depression, stress, and anxiety; and remained statistically significant during the follow-up period.

Note: *Indicates percentage of daytime sleepiness as sleep quality was not reported. NR = Not reported

To measure sleep among university students, the studies included employed self-reported sleep measures, namely, the Pittsburgh Sleep Quality Index [25], the Epworth Sleepiness Scale [26], the Munich Chronotype Questionnaire [27], and the Morningness-Eveningness Questionnaire [28]. The most used measure was the Pittsburgh Sleep Quality Index, which measured sleep quality in nine studies [13–17,20,22–24]. The Epworth Sleepiness Scale was used to evaluate daytime sleepiness in one study [18] and used in combination with the Munich Chronotype Questionnaire, which measures chronotype, in another [21]. Another study derived sleep difficulty from the six-item State-Trait Anxiety Inventory [29] in addition to the investigator-developed questions on anxiety in an online survey [19]. The Oldenberg Burnout Inventory [30] was used in one study to evaluate exhaustion alongside the Pittsburgh Sleep Quality Index to measure sleep quality [23]. Gangwar et al [13] used three measures in their study: the Pittsburgh Sleep Quality Index to measure sleep quality, the

Epworth Sleepiness Scale to measure daytime sleepiness, and the Morningness-Eveningness Questionnaire to measure chronotype (see Table 1).

Sleep in non-medical university students

The first cross-sectional study was conducted among 418 undergraduate college students at a university in New Delhi, India [22]. About 43% of the respondents reported poor sleep quality, as assessed by the Pittsburgh Sleep Quality score. Almost half of the sample reported less than six hours of sleep regularly [22]. Most results were reported based on years spent in the university, one, two, or three and/or more years [22]. Bedtime was found to be statistically significantly different among the groups, with first-year students going to sleep earlier than others ($p < 0.0001$) [22]. Total sleep time differed statistically significantly among first- and second-year students ($p < 0.05$) [22]. In examining differences in sleep by gender, females had a slightly higher prevalence of sleep problems compared to males (51.7% vs 48.3%); however, there was no statistically significant difference between males and females for the seven components of the Pittsburgh Sleep Quality Index ($p > 0.05$) [22].

A cross-sectional study of university students in a city in India used the Epworth Sleepiness Scale to identify differences in sleepiness among the student population [18]. Of the 1,215 students who responded about lifestyle variables that may affect sleep [18], 44% of them reported excessive daytime sleepiness [18]. The following variables were statistically significantly related to less daytime sleepiness including not consuming coffee or tea ($p = 0.026$), abstaining from alcohol ($p = 0.008$), not smoking ($p = 0.027$), and participating in weekly physical activity ($p = 0.036$) [18].

Another cross-sectional study of college students used a questionnaire based on the Pittsburgh Sleep Quality Index to evaluate the associations between mental health and sleep quality [14]. Of the 617 undergraduate student respondents, 51% experienced poor sleep quality, and individuals with poor sleep quality were statistically significantly more likely to have both anxiety and depression symptoms ($p = 0.001$) [14].

Kumari and colleagues [20] evaluated poor sleep quality among college students at one university utilizing the Pittsburgh Sleep Quality Index [20]. A total of 335 students were included, and 66% experienced poor sleep quality [20]. Statistically significant predictors of poor sleep quality were not practicing yoga ($p = 0.012$), moderate to severe stress ($p = 0.002$), and mobile phone use ($p = 0.044$) [20].

Sleep in medical university students

Giri et al [15] examined sleep habits and problems among 150 medical undergraduate, interns, and postgraduate university students in India. The authors used a self-administered questionnaire incorporating the Pittsburgh Sleep Quality Index and Epworth Daytime Sleepiness Scale to assess daytime sleepiness and sleep quality among medical students [15]. Of the 150 medical students, 17.3% experienced high levels of daytime sleepiness, while 13.3% experienced borderline levels of daytime sleepiness based on the Epworth Sleepiness Scale [15]. Female students experienced better sleep quality compared to male students [15]. Gender ($r = 0.23$, $p < 0.001$), anxiety ($r = 0.29$, $p < 0.001$), alcohol use ($r = 0.37$, $p < 0.001$), age ($r = 0.38$, $p < 0.001$), smoking ($r = 0.29$, $p < 0.001$), caffeine intake ($r = 0.25$, $p < 0.001$), body mass index ($r = 0.17$, $p = 0.035$), and the use of mobile phones and laptops ($r = 0.17$, $p < 0.001$) were statistically significantly and positively correlated with the global Pittsburgh Sleep Quality Index scores [15]. On the other hand, sleep duration was statistically significantly and negatively correlated ($r = -0.34$, $p < 0.001$) with the global Pittsburgh Sleep Quality Index scores [15]. Mean global Pittsburgh Sleep Quality Index scores were 5.28 for undergraduate students, 4.76 for

interns, and 7.88 for postgraduate students [15]. A global Pittsburgh Sleep Quality Index score >5 yields a sensitivity of 89.6% and specificity of 86.5%, distinguishing good sleepers and poor sleepers [25]. Therefore, based on the global Pittsburgh Sleep Quality Index diagnostic via Buysse et al [25], medical undergraduate students and postgraduate students in this study would be classified as poor sleepers [15].

In a similar study, R. Gupta and colleagues [16] examined the prevalence of sleep quality, internet addiction, and depressive symptoms among medical undergraduate students and interns using self-assessment questionnaires including the Pittsburgh Sleep Quality Index, Young's Internet Addiction Test, and the Patient Health Questionnaire-9. This cross-sectional study found that 59.9% of the students experienced poor sleep quality, and 16.1% of participants with internet addiction reported sleep difficulties [16]. Although the authors were able to determine that internet addiction was more prevalent among male students [16], they did not state if there was any association between gender and sleep quality in their study. However, overall, the authors were able to conclude that internet addiction (Young Internet Addiction Test scores >50) was statistically significant and positively correlated with poor sleep quality (Pittsburgh Sleep Quality Index global scores >5) ($r = 0.18, p < 0.001$) among undergraduate medical students and interns [16].

S. Gupta and colleagues [17] also examined sleep quality among undergraduate medical students in India by examining sleep quality among students at different phases of the medical curriculum. Using the Pittsburgh Sleep Quality Index, sleep quality was assessed among 400 medical undergraduate students in four different class years [17]. Poor sleep quality was high for all students regardless of their class year, with 25% of the medical students reporting having fairly bad or very bad quality sleep. The authors concluded that first-year medical undergraduate students reported worse sleep quality scores compared to all other class years [17]. An assessment of sleep latency and sleep duration via the Pittsburgh Sleep Quality Index revealed that 31.1% of the students self-reported taking more than 30 minutes to fall asleep and that their average hours of sleep per night ranged from 5.89 hours to 8.31 hours (7.1 ± 1.21 hours) [17]. Using the Pittsburgh Sleep Quality Index, the authors were able to conclude that 72.2% of the students reported poor sleep, and 40% reported having difficulty staying awake during the day at least once a week, with 17.9% of the student participants reporting daytime dysfunction [17].

A cross-sectional study of sleep among undergraduate medical university students by Gangwar and colleagues [13] used the Pittsburgh Sleep Quality Index to assess sleep quality, the Epworth Sleepiness Scale to assess daytime sleepiness, and the Morningness-Eveningness Questionnaire Self-assessment version to determine chronotype. The authors categorized the participants into three groups [definite evening chronotype (group one), intermediate chronotype (group two), and definite morning chronotype (group three)] and concluded that undergraduate medical students with an evening chronotype experienced more poor sleep quality compared to other chronotypes [13]. Evening chronotypes were also associated with smoking, alcohol use, gender, type of diet (vegetarian or non-vegetarian), and unhealthy eating patterns (having late night dinners) [13]. A combined assessment of all three groups showed that age ($p < 0.05$) and gender ($p < 0.05$) were statistically significantly associated with poor sleep quality [13]. The researchers found that evening-type individuals reported worse sleep quality compared to morning-type and intermediate-type individuals [13]. Additionally, there was a statistically significant positive correlation between poor sleep quality and age in groups two ($r = 0.45, p < 0.05$) and three ($r = 0.74, p < 0.05$); diet in groups one

($r = 0.54, p < 0.05$) and two ($r = 0.37, p < 0.05$); alcohol consumption in groups one ($r = 0.43, p < 0.05$) and two ($r = 0.45, p < 0.05$); gender in group one ($r = 0.89, p < 0.05$), group two ($r = 0.79, p < 0.05$), and group three ($r = 0.51, p < 0.05$); smoking in group one ($r = 0.51, p < 0.05$), group two ($r = 0.45, p < 0.05$), and group three ($r = 0.51, p < 0.05$); timing of dinner in group one ($r = 0.26, p < 0.05$); Epworth Sleepiness Scale scores in group two ($r = 0.26, p < 0.05$); and electronic media use duration in group two ($r = 0.38, p < 0.05$) [13]. On the other hand, there was a statistically significant negative correlation between poor sleep quality and age ($r = -0.33, p < 0.05$) and electronic media use duration ($r = -0.36, p < 0.05$) in group one [13]. Overall, the authors concluded that there was a high prevalence of poor sleep quality (40.39% for participants ≤ 20 years, 32.51% for participants > 20 years) and excessive diurnal sleepiness among undergraduate medical students in India [13].

In a cross-sectional study comparing non-medical undergraduate university students to medical undergraduate university students in India, Shad and colleagues [23] used the Pittsburgh Sleep Quality Index and the Oldenburg Burnout Inventory to assess sleep quality and burnout. Medical students were compared to non-medical students based on the premise that medical students have less free time, longer courses, and longer work hours compared to non-medical students [23]. Of the 214 students surveyed (112 medical and 102 non-medical), 62.6% of the students were poor sleepers, and 20% of the students reported less than five hours of sleep per day [23]. Shad and colleagues [23] reported no significant differences in Pittsburgh Sleep Quality Index scores between males and females, although 65.8% of women were found to be poor sleepers compared to 62.1% of men [23]. However, Shad and colleagues [23] concluded that women reported more daytime dysfunction and fewer sleep disturbances when compared to men. Overall, a higher percentage of medical students reported poor sleep (72.9%) compared to non-medical students (51.9%) [23].

Sleep during COVID-19

Several researchers have evaluated how the recent COVID-19 pandemic impacted sleep among college students. One study compared the effects on students in Australia and India by evaluating anxiety among nursing students [19]. Australian students reported statistically significantly higher anxiety rates overall compared to students in India ($p = 0.000$) [19]. Only 4.4% of students in India reported difficulty sleeping during the pandemic, while 46.4% of Australian students had trouble sleeping ($p < 0.00001$) [19]. The study authors hypothesized that the impact of the COVID-19 pandemic was not as disruptive to nursing students in India due to their previous (pre-COVID-19) lifestyles and social norms [19].

Another study evaluated sleep and electronic usage among office workers and college students [21]. The study compared self-reported pre- and post-lockdown conditions to evaluate how undergraduate and postgraduate university students, in addition to corporate sector professionals, perceived changes in their lifestyles throughout the COVID-19 lockdown in India [21]. The study found that undergraduate and postgraduate university students in India significantly improved their sleep duration throughout the lockdown period compared to the pre-lockdown period [21]. Although sleep duration statistically significantly increased ($p < 0.001$) and a majority of the participants reported good sleep quality, both wake and bedtimes among university students were generally later during lockdown than during the pre-lockdown period according to the midsleep time on the Munich Chrono-Type Questionnaire [21]. Overall, many participants in this study subjectively reported that anxiety, mental stress, and screen time before bed likely affected their sleep [21].

One prospective longitudinal study was conducted among college students during the COVID-19 pandemic to evaluate sleep and mental health among college and medical students [24]. The baseline was assessed in December 2019 before the pandemic in India, and a follow-up survey was then conducted in June 2020 during COVID-19 [24]. Although baseline sleep quality was not reported in the study, 34.5% of respondents reported poor sleep quality at the follow-up period during COVID-19 [24]. At baseline, poor sleep quality was statistically significantly related to depression, stress, and anxiety ($p < 0.001$) among participants [24]. These associations remained statistically significant during the follow-up period ($p < 0.001$) [24].

DISCUSSION

Several themes emerged from the results of the 12 studies included in this systematic review as the research highlighted demographic, psychological, and socio-behavioral risk factors related to sleep quality, sleep duration, and excessive daytime sleepiness among university students in India (see Table 2). The mean age of students ranged from 18.47-24.1 in the 12 included studies [13–24]. Generally, age and/or year in school were statistically significantly related to differences in shorter sleep duration and poor sleep quality [13,15,17,22,23]. First-year undergraduate students had statistically significantly more and earlier sleep than second-year students [22], which was similarly observed in first-year undergraduate medical students who had earlier and longer sleep time than students further along in the medical program [17]. These differences in sleep quality may suggest that increased academic requirements through later years of coursework may negatively impact sleep. Gender (male/female as examined in studies) was another demographic variable that was related to statistically significant differences in poor sleep quality in several studies [13,15,22]. In two studies it was noted that females had significantly better sleep times and quality than males [15,22]. These findings are in contrast to a study by Kaur [10] which found that sleep quality was worse among female undergraduate non-medical students compared to male students. Gangwar et al [13] found a statistically significant relationship between poor sleep quality and gender, which is the opposite of the findings of Shad et al [23] that sleep quality did not significantly differ by gender. More research is necessary to understand the specific nuances between sleep quality and gender, given the mixed findings.

Table 2. Risk factors associated with poor sleep quality, sleep duration, and excessive sleepiness based on the 12 included studies.

Category	Risk Factors
Demographic	<ul style="list-style-type: none"> • Age • Year in university • Gender (female/male as defined in articles)
Psychosocial	<ul style="list-style-type: none"> • Self-reported anxiety • Self-reported depression • Moderate to severe stress
Socio-Behavioral	<ul style="list-style-type: none"> • Smoking • Alcohol use

- Caffeine intake
- Attending university
- Poor diet
- Body mass index
- Lack of physical activity
- Not practicing yoga
- Excessive internet use
- Mobile phone and laptop use

Note: Data from the 12 studies included in the systematic review [13–24].

Poor mental health was also related to poor sleep quality in several of the studies included in this systematic review [14–16,19,24]. The results of two studies showed that anxiety was statistically significantly related to poor sleep quality and difficulty sleeping [15,19]. Depression and anxiety symptoms were also related to poor sleep quality among undergraduates before and during the COVID-19 pandemic [14,24]. Furthermore, depressive symptoms may be related to both internet usage and poor sleep quality [16].

The studies identified socio-behavioral factors that were also statistically significantly related to sleep quality. The results from three studies identified smoking status [13,15,18], alcohol use [13,15,18], and caffeine intake [15,18] as statistically significant positive correlations of poor sleep quality [13,15] and statistically significantly associated with excessive daytime sleepiness [18]. Unhealthy eating [13], body mass index [15], and no yoga practice [20] were also predictors of poor sleep quality. Lack of weekly physical activity was related to excessive daytime sleepiness [18]. Excessive internet use [16] and mobile phone and laptop use [13,15,20] were also statistically significantly associated with poor sleep quality. Promoting healthy behaviors related to diet, exercise, substance use, internet use, and mobile phone and laptop use among college and medical students may thus help improve overall sleep quality.

There are several limitations to the studies included in the present systematic review examining sleep quality, duration, chronotype, and excessive daytime sleepiness in undergraduate students in India. All but one of the included studies were cross-sectional, precluding longitudinal assessment of sleep quality, sleep duration, and excessive sleepiness. All studies included solely self-reported measures of sleep which may lead to response bias [18,19,24]. Respondents may have provided responses that they felt would be more desirable to the researchers conducting the study, especially among three of the studies where researchers administered the questionnaires face-to-face rather than online [15,19,21]; this could have led to selection bias. Participants also might have had trouble remembering past events, which may have introduced recall bias; this was also acknowledged as a potential limitation in several articles [13,16,18]. Majumdar et al [21] inquired about pre-lockdown habits during COVID-19 in the middle of a pandemic, which may have led to recall bias. These biases may have impacted the results of the studies included in the systematic review. The study design in Kochuvilayil et al [19] may have limited recall bias since the study evaluated the effects of COVID-19 by utilizing a questionnaire during the pandemic.

An area not addressed by the 12 studies is the socioeconomic status differences that may have impacted study results. A previous study among adolescents in India showed that the highest

socioeconomic status was associated with shorter sleep duration compared to those in the lowest socioeconomic status ($p = 0.001$) [31], yet none of the studies evaluated this factor. Kumari et al [20] was the only study, of the 12 included studies, to evaluate whether participants lived at home or in a hostel as well as whether families at home were nuclear or extended [20]. Though the findings were not significant in relation to hostel or home life and type of family at home [20], living situation and family dynamics should be considered in future studies involving sleep among university students in India to evaluate if living situation and family dynamics are related to sleep.

The results of this systematic review may help provide insights into avenues for future research regarding risk factors for poor sleep quality among university students in India. Only one of the 12 studies included in the systematic review used a longitudinal design, and this study examined sleep during COVID-19 [24]. Thus, a longitudinal study design might be needed to evaluate temporal relationships associated with sleep quality under non-pandemic conditions. Future studies should seek to understand gender differences that may affect students' sleep quality as current research has provided conflicting results since two studies showed females had better sleep than males [15, 22], one study not included in our systematic review showed males had better sleep quality than females [10], one study found a significant difference in sleep by gender [13], and another study identified no significant difference in sleep quality by gender [23]. Furthermore, socioeconomic and familial differences that may exist among various student populations which could be associated with sleep quality should be considered in future studies. Additionally, the promotion of healthy sleep behaviors among student groups at the highest risk for poor sleep quality [13,14,16,17,20,22,23] and more daytime sleepiness [15,18] may help prevent poor sleep and improve mental health outcomes, even if the COVID-19 pandemic continues [19,21,24]. Possible interventions could be focused on groups at most risk such as students using caffeine, smoking, and drinking alcohol throughout their time at a university which can negatively impact sleep [18], and older students with more academic demands [15].

Significance of results

The synthesis of studies on sleep and chronotype among university students in India suggests that medical undergraduate and graduate students, as well as non-medical undergraduate university students in India, suffer from poor sleep quality, in addition to inadequate sleep duration, prolonged sleep latency, and excessive daytime sleepiness while in non-pandemic conditions. Additionally, demographic (i.e., gender and age) [13,15], psychological (i.e., symptoms of anxiety or depression and moderate to severe stress) [2,14,15,20], and socio-behavioral (i.e., not practicing yoga, alcohol consumption, smoking, excessive caffeine intake, internet addiction, body mass index, and mobile phone and laptop use) [13,15,16,20] factors were associated with poor sleep quality among university students in India. Studies conducted during the COVID-19 pandemic found mixed results, signifying the need for more research on sleep among university students in India during the pandemic if the COVID-19 pandemic continues.

Implications for policy and practice

Interventions and prevention programs such as educational campaigns and sleep courses are examples of strategies that can be used to improve the sleep quality of university students in India. In the Sleep Treatment and Education Program for Students (STEPS) developed by Brown and colleagues [32] for university students in the United States, the authors found that students in the treatment group who received a 30-minute oral presentation on sleep difficulties, stimulus control,

sleep hygiene, and information on caffeinated substances took less medication with caffeine, took fewer naps, and went to bed hungry less often [32]. A similar program can perhaps be adapted for use among medical and non-medical university students in India by creating a culturally tailored presentation on the importance of sleep to improve sleep quality among university students in India. Another example of a sleep education intervention is a sleep media campaign developed by Orzech and colleagues [33] for university students in the United States. A similar campaign can potentially be adapted for implementation in India.

The sleep education programs developed by Brown and colleagues [32] and Orzech and colleagues [33] can be tailored to fit the sleep health and sleep quality concerns of university students in India, in addition to bringing awareness to risk factors identified to be associated with poor sleep quality among Indian university students. However, it is important to note that culture is a crucial factor to consider when designing sleep educational and intervention programs [34]. The percentage of poor sleep quality is higher among Indian undergraduate students (62.6%) [23] compared to documented percentages of students in other countries such as Ethiopia (55.8%) [35], Chile (51.8%) [36], and Taiwan (54.7%) [37]. Therefore, in designing a tailored sleep education program for university students in India, it is important to keep in mind the evolving sleep patterns and general health of college students in India [8]; in order to help address the high prevalence of poor sleep quality among university students in India. To improve sleep health among university students, researchers and public health professionals must address important psychological and socio-behavioral factors such as anxiety, stress, excessive internet use, nutrition, and exercise that may impact the sleep quality of college students in India. Additionally, university administrators play a role in creating a supportive university environment that prioritizes their students' sleep health and overall general health.

CONCLUSION

University students in India are considered to be one of the most vulnerable population groups in India that experiences sleep problems [18]. Our review found that poor sleep quality is prevalent among medical and non-medical Indian university students and highlights the importance of further research on sleep among university students in India. Meanwhile, current research can be used to develop interventions that promote healthy sleep among a young adult student population. Effective interventions can also hopefully help address the potential consequences of poor sleep quality, short sleep duration, and excessive daytime sleepiness, namely socio-behavioral risk factors, in addition to demographic, mental health [38], and academic performance [39] decrements.

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