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Original Article

Exploring Sleep Patterns in 3,475 College Students: A Comparative Study of Geographical Location, Gender, and Age

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Sleep Sci

Abstract

Objective Sleep is a fundamental physiological process essential for maintaining overall health and optimal functioning across various cognitive, emotional, and physical domains. To cross-sectionally investigate the sleep pattern among college students according to geographical location, gender, and age.

Materials and Methods A total of 3,475 valid responses, 3,366 from 4 continents (Africa – $n = 1,095$; America – $n = 182$; Asia – $n = 1,562$; Europe – $n = 527$); 2,075 from female students and 1,369 from male students ($n = 3,444$), were analyzed. Sleep quality, insomnia, and daytime sleepiness were assessed using validated questionnaires (Pittsburgh Sleep Quality Index [PSQI], Insomnia Severity Index [ISI], and Epworth Sleepiness Scale [ESS], respectively).

Results Students from all continents had poor sleep quality, and there were inter-countries differences in sleep quality. The frequency of poor sleep quality and subclinical-to-clinical insomnia were higher among Asian (AsiS) and African students (AfS) compared with American (AmS) and European students (EuS) ($p < 0.05$). Asian students had a greater frequency of excessive daytime sleepiness (EDS) compared with those from other continents ($p < 0.05$). Females showed higher mean ISI scores ($p < 0.001$) as well as a greater frequency of poor sleep quality ($p < 0.05$),

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- community survey
- continental population group
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subclinical-to-clinical insomnia ($p < 0.05$), and EDS ($p < 0.05$) compared with males. Insufficient sleep duration was more frequent in older-aged groups (i.e., 26–30, 31–35, and > 36 years) compared with the ≤ 20 years age group ($p < 0.05$). Excessive daytime sleepiness was more frequent in younger age groups (i.e., ≤ 20 and 21–25 years) versus the > 36 years ($p < 0.05$) group. There were no significant differences in the frequency of various degrees of insomnia across age groups.

Conclusion Our results suggest the need for tailored interventions for addressing sleep disturbances among college students of all age groups, with a specific focus on AsiS and AfS, as well as female students.

Introduction

Sleep is a fundamental physiological process essential for maintaining overall health and optimal functioning across various cognitive, emotional, and physical domains.[1] Adequate and restorative sleep plays a crucial role in memory consolidation, learning, mood regulation, immune function, and cardiovascular health, amongst others.[2–5] However, a growing body of evidence suggests that sleep disturbances have become increasingly prevalent, affecting individuals of all age groups and populations worldwide.[6,7]

Among the populations vulnerable to sleep disturbances, college and university students emerge as a distinctive group facing unique challenges.[8–10] Indeed, the transition to higher education brings about a myriad of academic, social, and environmental changes that can disrupt students' sleep patterns.[11] For instance, a cohort study at a southeast state university in the United States of America reported that 27% of students were at risk for at least 1 sleep disorder, while 16% of them at risk for narcolepsy. The prevalence of these disturbances is substantially high and concerning, as this study showed that those students at risk for them may also be at risk for academic failure.[12] Galvin et al.[13] also noted that 32.4% of students reported requiring 30 minutes or more to initiate sleep, a duration suggestive of a sleep issue. Factors such as increased academic workload, irregular schedules, social pressures, living away from home and/or part-time jobs have all been reported as contributing factors to the high frequency of sleep disturbances in college students.[9]

Sleep disturbances among college students, such as poor sleep quality, chronic insomnia, and excessive daytime sleepiness (EDS), have been linked to a range of negative consequences.[14] These include impaired academic performance, increased risk of mental health disorders, compromised immune function, and/or decreased quality of life.[15–17] Moreover, Wang et al.[18] showed that cognitive deficits are more common in people with obstructive sleep apnea, a condition for which there is an effective first-line treatment once it has been diagnosed, as well as recent tools supported by artificial intelligence.[19,20] Consequently, understanding the factors influencing sleep patterns in this population is of paramount importance for the development of prevention programs. In this regard, targeted prevention and treatment interventions would hopefully mitigate/reduce the adverse effects of sleep disturbances and promote better mental and physical health and academic outcomes in students.

While the impact of sleep disturbances on college students has received considerable attention, there remains a need to explore the variations in sleep patterns according to global geographical location, gender, and age within this population. Indeed, geographical factors, cultural norms, and social environments can influence sleep practices and behaviors, potentially leading to diverse sleep patterns among college students across the globe.[14,15,19] Additionally, gender differences in sleep architecture, sleep disorders, and sleep-related behaviors differ by populations.[8] Thus, it is of paramount importance to investigate gender-specific sleep patterns in students of both genders from different global regions. Furthermore, the transition from adolescence to young adulthood encompasses significant changes in sleep needs, preferences, and schedules, warranting an examination of how age impacts sleep patterns within college students.[14]

Therefore, the primary objective of this cross-sectional, web-based, global survey, was to investigate the sleep pattern among college students according to geographical location, gender, and age. This would contribute to identifying at-risk groups that require targeted interventions.

Materials and Methods

The participants' information is detailed in the results section (see ►**Table 1**).

Sleep-related Terminology

The definitions of sleep-related terms are listed below ►**Table 2**.

Data Collection

This global survey has been promoted via social-media platforms (such as Instagram, Facebook, and X), instant-messaging services (such as WhatsApp, Viber), and official universities channels (such as the University of Witwatersrand, South Africa, and the University of Indianapolis, United States) from October 1st, 2021, to March 31st, 2022. The survey has been closed on that specific date (corresponding to the eve of Ramadan month for Muslims worldwide) to prevent potential influences from Ramadan observance on the study outcomes.[21]

Table 1 Characteristics of the participants.

	Count	Valid percentage
Age group (years)		
≤ 20	1,497	43.1
21–25	1,393	40.1
26–30	288	8.3
31–35	140	4.0
36+	157	4.5
Total	3,475	100.0
Missing	4	
Gender		
Female	2,075	60.2
Male	1,369	39.8
Missing: Prefer not to say	35	
Continent		
Africa	1,095	32.5
America	182	5.4
Asia	1,562	46.4
Europe	527	15.7
Missing		
Not mentioned	91	
Australia	22	

The participants accessed the online survey hosted on Google Forms in three languages: Arabic, English, and French.

Inclusion criteria: University/College students, aged 18 years or more at the time of completing the survey, who declared they were not taking medication for chronic illness conditions.

Exclusion criteria: Individuals who self-reported having been diagnosed with chronic sleep disorders were excluded from the study. To enable binary gender analysis, we excluded the participants who did not declare their gender from the inter-gender comparisons but not from continent and age comparisons.

For the survey, participants were required to answer basic demographic questions (that is, on age, gender, and country of residence) and to fill out three sleep-related questionnaires: the Pittsburgh Sleep Quality Index (PSQI),[22] the Epworth Sleepiness Scale (ESS),[23] and the Insomnia Severity Index (ISI).[24]

Instruments

The PSQI Questionnaire

This is a comprehensive tool used to distinguish between individuals who experience poor or good-quality sleep. It assesses seven key areas related to sleep patterns: self-reported bedtimes and wake-up times, total sleep duration, time in bed, sleep efficiency, and sleep-onset latency and daytime dysfunction over the month preceding the assessment. The global PSQI score ranges from 0 to 21, with lower scores indicating better sleep quality: a score ≥ 5 indicates poor sleep quality, while ≥ 8 indicates very poor sleep quality.[22] We used the original English version[22] as well as the validated Arabic[25] and French[26] versions.

The ESS Questionnaire

This questionnaire assesses excessive sleepiness associated with accumulated sleep debt or clinical sleep disorders. This 8-item scale assesses how sleepy one has felt in the 6 months prior to answering the questionnaire; participants indicate the likelihood that they would fall asleep while doing everyday activities (such as watching TV, sitting and talking to someone, or stopping at a traffic light), with responses ranging from 0, would never doze, to 3, high chance of dozing. The ESS scores were interpreted as follows: Scores (i) 0 to 5 indicate lower normal daytime sleepiness; (ii) 6 to 10 indicate higher normal daytime sleepiness; (iii) 11 to 12 indicate mild excessive daytime sleepiness; (iv) 13 to 15 indicate moderate excessive daytime sleepiness, and (v) 16 to 24 indicate severe excessive daytime sleepiness. We used the original English version,[23] as well as the validated Arabic[27] and French[28] versions.

The ISI Questionnaire

This questionnaire evaluates insomnia in adults during the month preceding the assessment. Each item (e.g., falling asleep, staying asleep, and early awakening) in the test is measured using a 5-point Likert scale. Scores (i) ranging from 0 to 7 indicate the absence of clinically significant insomnia; (ii) 8 to 14 indicate subthreshold insomnia; (iii) 15 to 21 indicate moderately serious clinical insomnia, and (iv) 22 to 28 indicate severe clinical insomnia.[29] We utilized the original English version[24] and the validated Arabic[24] and French[30] versions.

Sample Size Calculation

The sample size was a priori calculated using the G*Power software (University of Düsseldorf, Düsseldorf, Germany). The study compares the sleep quality of students from four different continents. Therefore, the F family test was chosen, with one-way analysis of variance (ANOVA) as the statistical test. A small effect size (0.01) was selected because of the subjective nature of the study. Alpha was set at $p = 0.05$ as the default value, and β was set at 0.01 to achieve a higher level of confidence. The G*Power software indicated a minimum of 2,682 participants. According to Romdhani et al.,[31] the assumption of 15% for duplicate answers, entry errors, and ineligibility of inclusion criteria gave a revised sample of at least 3,084 participants. With the considerations, the achieved power of the study was 0.99.

Statistical Analysis

We performed the statistical analysis using the IBM SPSS Statistics for Windows, version 26.0 (IBM Corp., Armonk, NY, United States) software. Summary statistics mean ± standard

Table 2 Comparison of sleep variables across different continents ($n = 3,366$).

Variables	Africa ($n = 1,095$)	America ($n = 182$)	Asia ($n = 1,562$)	Europe ($n = 527$)
Age (years)*	$22.4 \pm 5.2^{b,c,d}$	$25.4 \pm 6.3^{c,d}$	23.0 ± 5.5^{d}	21.3 ± 4.9
PSQI global score (A.U.)*	6.7 ± 2.8^{d}	6.3 ± 2.8^{c}	6.9 ± 2.9^{d}	5.8 ± 2.6
Frequency of poor sleep quality (PSQI $\geq$ 5) (%)†	60.8%[d]	57.7%	65.9% [a,b,c]	47.6%
Hours spent in bed (h)*	7.9 ± 1.6^{c}	7.0 ± 1.2	7.6 ± 1.9	8.0 ± 1.3^{c}
Sleep latency (min)* Median (IQR)*	27.6 ± 30.2 20 [10–30]	28.5 ± 31.9 20 [15–30]	28.6 ± 34.1 20 [10–30]	24.4 ± 28.0 [a,b,c] 15 [10–30]
Sleep efficiency (%)* Median (IQR)	93.8 ± 6.9 95.7 [92.3–97.7]	93.8 ± 6.2 95.7 [93.3–96.8]	93.2 ± 8.2 95.5 [92.3–97.6]	94.8 ± 5.5 [a,b,c] 96.5 [93.7–97.9]
Frequency of poor sleep efficiency ($\leq$ 85%) (%)†	6.7%	4.9%	8.6%[d]	4.7%
Sleep duration (h)*	7.1 ± 1.6^{c}	7.0 ± 1.1	6.8 ± 1.8	7.2 ± 1.1^{c}
Frequency of insufficient sleep duration ($\leq$ 7 hours) (%)†	59.3%[d]	58.2%	63.8%[d]	49.7%
ESS score (A.U.)*	$9.4 \pm 4.6^{b,c,d}$	7.5 ± 3.9^{c}	10.0 ± 4.7^{d}	8.0 ± 4.1
Frequency of moderate EDS (ESS: 13–15) (%)†	15.7%[b,d]	5.5%	16.8%[b,d]	8.9%
Frequency of severe EDS (ESS: 16–24) (%)†	9.4%[d]	4.4%	12.2% [a,b,d]	4.7%
ISI score (A.U.)*	$9.6 \pm 6.0^{b,d}$	7.5 ± 5.3^{c}	10.0 ± 5.8^{d}	8.3 ± 5.4
Frequency of clinical insomnia of moderate severity (ISI 15–21) (%)†	18.2%	12.1%	17.7%	13.1%
Frequency of severe clinical insomnia (ISI $\geq$ 22) (%)†	3.8%	1.1%	3.6%	1.9%

Abbreviations: A.U., arbitrary units; ESS, Epworth Sleepiness Scale; EDS, excessive daytime sleepiness; IQR, interquartile range; ISI, Insomnia Severity Index; PSQI, Pittsburgh Sleep Quality Index.
Notes: [a]Significantly different from Africa at $p < 0.05$.
[b]Significantly different from America at $p < 0.05$.
[c]Significantly different from Asia at $p < 0.05$.
[d]Significantly different from Europe at $p < 0.05$.
*One-way analysis of variance.
†Chi-squared test.

deviation ($M \pm SD$) was used to describe continuous variables, and frequencies and percentages were used to describe categorical variables. The Shapiro–Wilk test of normality revealed that the data were normally distributed, which enabled the use of parametric tests. We compared parameters of sleep health between male and female students using the independent sample *t*-test. For comparing sleep health parameters between 4 continents, 12 countries (see below), and different age groups, we used a one-way ANOVA followed by Bonferroni adjusted post-hoc pairwise comparisons whenever the ANOVA was significant. The findings were presented as mean difference (MD), 95% confidence interval (95% CI) and Cohen (d)[32] effect size (qualitatively interpreted as small [$d < 0.5$], moderate [$0.5 \leq d < 0.8$], and large [$d \geq 0.8$] effects). In addition, we also compared the frequency of sleep disturbances by age, gender, and continents using the Chi-squared (χ^2) test. Following this, post-hoc comparisons of columns proportions were performed after adjusting for multiple comparisons using the Bonferroni method. The level of statistical significance was set at $p < 0.05$ (two-tailed).

Results

In total, we received 3,509 survey responses. After data cleaning based on inclusion and exclusion criteria (see ►**Fig. 1**), we used 3,475 valid responses for analysis (mean age: 25.06 ± 8.9; range 18–61 years). For the geographical analysis of the data, responses from 49 countries ($n = 3,366$) were categorized into (i) 4 continents: Asia ($n = 1,562$); America ($n = 182$); Europe ($n = 527$); and Africa ($n = 1,095$) and (ii) 12 countries (►**Supplementary Table S1** [online only]). The sample consisted of 1,369 males and 2,075 females, with the 1% [$n = 35$ who preferred not to declare their gender being excluded from the inter-gender comparisons, $n = 3,444$).

Geographical Analysis

Sleep Duration and Quality

The PSQI global score of European students (EuS) was significantly lower than that of African students (AfS)

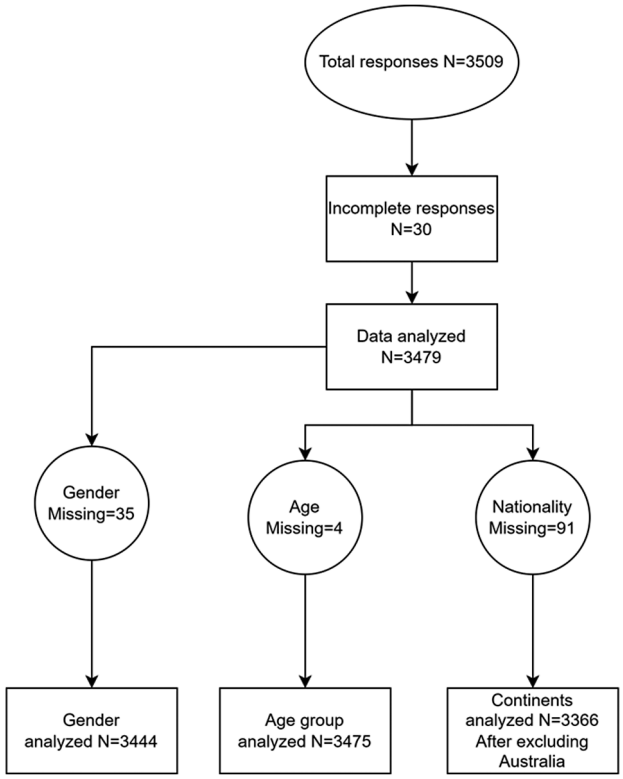

Fig. 1 Organizational chart of data filtering.

(d = 0.4; MD = -0.9; 95% CI = -1.3 to -0.5, $p < 0.001$) and Asian students (AsiS) (d = 0.5; MD = -1.13; 95% CI = 1.5–0.8; $p < 0.001$). Additionally, the PSQI global score of AsiS was higher than that of AmS (d = 0.2; MD = 0.7; 95% CI = 0.1–1.2, $p < 0.05$ - ►**Table 2**). An analysis by country was performed on the 12 selected countries that had an adequate sample as the other countries had less than 50 participants (see ►**Supplementary Table S1** [online only]). The sub-analysis by country showed the sleep patterns also varied between countries within each continent. The sleep quality (PSQI) of students from France was significantly better than those of students from Jordan ($p < 0.05$), Tunisia ($p < 0.01$), Egypt, Iran, Malaysia, Qatar, and South Africa ($p < 0.001$). In addition, students from Qatar had lower sleep quality that those from Jordan ($p < 0.001$) and Oman ($p < 0.05$).

There was a significant difference in the frequency of poor sleep quality between continents ($p < 0.001$, $\chi^2 = 56.3$). The frequency of poor sleep quality was significantly higher in (i) AsiS compared with AfS and EuS, and (ii) AfS compared with their EuS counterparts (all $p < 0.05$).

The frequency of insufficient sleep duration was significantly higher among AsiS and AfS compared with EuS ($p < 0.05$).

The sleep efficiency of EuS was significantly higher than that of AsiS. The frequency of poor sleep efficiency showed a significant difference among continents ($p = 0.009$, $\chi^2 = 11.5$), with a higher frequency observed among AsiS compared with EuS ($p < 0.05$).

Daytime Sleepiness

The sleepiness score of AfS was significantly higher than that of AmS (d = 0.4; MD = 1.8; 95% CI = 0.9–2.8; $p < 0.001$) and EuS (d = 0.3; MD = 1.3; 95% CI = 0.8–2.0; $p < 0.001$). Additionally, AsiS had significantly higher ESS score than AmS (d = 0.6; MD = 2.4; 95% CI = 1.5–3.4; $p < 0.001$), EuS (d = 0.4; MD = 2.0; 95% CI = 1.4–2.6; $p < 0.001$), and AfS (d = 0.1; MD = 0.6; 95% CI = 0.1–1.1; $p < 0.01$).

The frequency of severe EDS showed a significant difference among continents ($p < 0.001$, $\chi^2 = 120.4$), with AsiS demonstrating a higher frequency compared with AfS, AmS, and EuS ($p < 0.05$).

Insomnia

The mean ISI score of AfS was significantly higher compared with AmS ($p < 0.001$; d = 0.4; MD = 2.1; 95% CI = 0.9–3.3) and EuS (d = 0.2; MD = 1.3; 95% CI = 0.4–2.1; $p < 0.001$). Asian students had significantly higher ISI score compared with AmS (d = 0.4; MD = 2.5; 95% CI = 1.3–3.7; $p < 0.001$) and EuS (d = 0.3; MD = 1.6; 95% CI = 0.9–2.4; $p < 0.001$).

The frequency of subthreshold insomnia was significantly higher in AsiS compared with AfS, AmS, and EuS ($p < 0.001$, $\chi^2 = 61.1$).

Difference between Genders

Sleep Duration and Quality

Overall, PSQI score significantly differed between genders, with better sleep quality in males versus females (t = 4.6; d = 0.2; MD = 0.4; 95% CI = 0.3–0.6; $p < 0.001$). The frequency of poor sleep quality was significantly higher in females versus males, with females reporting a significantly longer duration of sleep than males. Furthermore, the frequency of insufficient sleep duration was significantly higher in males compared with females ($p < 0.05$). Sleep latency and hours spent in bed were significantly greater in females compared with males (►**Table 3**). By investigating the same differences within each country, instead of continent, French male students reported significantly better sleep quality than French females (►**Supplementary Figure S1** [online only]).

Daytime Sleepiness

The ESS and EDS scores were significantly higher among females compared with males.

Insomnia

Moderate and severe clinical insomnia were significantly higher among females.

Difference between Ages

Sleep Duration and Quality

The global PSQI score of the 21-to-25 years age group was significantly higher compared with that of those ≤ 20 years ($p < 0.05$), as seen in ►**Table 4**. Students aged ≤ 20 years reported longer sleep duration than those aged 26 to 30 years ($p < 0.001$; d = 0.3; MD = 0.4; 95% CI = 0.2–0.7), 31 to 35 years

Table 3 Comparison of sleep-related variables between sexes.

Variables	Female ($n = 2075$)	Male ($n = 1369$)	t	*p*-value	d	MD	95% CI
Age (years)*	22.5 ± 5.4	23.1 ± 5.6	-2.8	0.005	0.097	-0.53	-0.91 to -0.16
PSQI global score (A.U.)*	6.8 ± 2.9	6.3 ± 2.7	4.6	< 0.001	0.159	0.45	0.26–0.65
Frequency of poor sleep quality (PSQI ≥ 5) (%)†	63.5%	56.9%		< 0.001			
Hours spent in bed (h)*	7.9 ± 1.7	7.7 ± 1.6	2.4	0.016	0.084	0.14	0.03–0.26
Sleep latency (min)* Median (IQR)	28.5 ± 31.6 20 [10–30]	26.2 ± 31.9 15 [10–30]	2.1	0.037 [0.002]	0.073	2.31	0.14–4.49
Sleep efficiency (%)* Median (IQR)	93.6 ± 7.1 95.5 [92.3–97.7]	94.0 ± 7.5 96 [93.3–97.7]	-1.6	0.118 [0.015]	0.054	-0.40	-0.89–0.10
Frequency of poor sleep efficiency (≤ 85%) (%)†	7.6%	6.6%	–	0.269	–	–	
Sleep duration (h)*	7.0 ± 1.6	6.9 ± 1.5	2.4	0.015	0.085	0.14	0.03–0.25
Frequency of insufficient sleep duration (≤ 7 hours) (%)†	57.8%	62.5%	–	0.007	–		
ESS score (A.U.)	9.7 ± 4.6	8.7 ± 4.6	5.7	<0.001	0.200	0.92	0.61–1.24
Frequency of moderate EDS (ESS: 13–15) (%)†	15.7%	12.9%		<0.001			
Frequency of severe EDS (ESS: 16–24) (%)†	11.0%	78.8%		<0.001			
ISI score (A.U)*	9.8 ± 5.9	8.9 ± 5.5	4.8	< 0.001	0.167	0.96	0.57–1.36
Frequency of clinical insomnia of moderate severity (ISI 15–21) (%)†	19%	13.7%		< 0.001			
Frequency of severe clinical insomnia (ISI ≥ 22 (%)†	3.9%	2.1%		< 0.001			

Abbreviations: A.U., arbitrary units; CI, confidence interval; d, Cohen effect size; EDS, excessive daytime sleepiness; ESS, Epworth Sleepiness Scale; IQR, interquartile range; ISI, Insomnia Severity Index; MD, mean difference; PSQI, Pittsburgh Sleep Quality Index.
Notes: *Independent samples *t*-test.
†Chi-squared test.

($p < 0.001$; d = 0.4; MD = 0.6; 95% CI = 0.2–1.0), and > 36 years ($p < 0.01$; d = 0.3; MD = 0.4; 95% CI = 0.1–0.8). Insufficient sleep duration frequency significantly differed between age groups ($p < 0.001$, $\chi^2 = 33.2$), with higher frequency in the 26-to-30 years, 31-to-35 years, and > 36 years age groups compared with those ≤ 20 years ($p < 0.05$).

Daytime Sleepiness

Students aged 21 to 25 years had higher sleepiness compared with those aged 26 to 30 years ($p < 0.01$; d = 0.2; MD = 1.0; 95% CI = 0.2–1.9), 31 to 35 years ($p < 0.05$; d = 0.2; MD = 1.2; 95% CI = 0.1–2.4) and > 36 years ($p < 0.01$; d = 0.3; MD =1.4; 95% CI = 0.4–2.5). Excessive daytime sleepiness frequency statistically differed between age groups ($p < 0.001$, $\chi^2 = 24.2$), with higher frequency observed in the ≤ 20 years and 21-to-25 years age groups compared with those > 36 years.

Insomnia

Students aged > 36 years had significantly lower insomnia than those aged ≤ 20 years ($p < 0.05$; d = -0.3; MD = -1.6; 95% CI = -3.0 to -0.2) and 21 to 25 years ($p < 0.01$; d = - 0.3; MD = -1.8; 95% CI = -3.2 to -0.4).

Discussion

We showed that in our large sample of college students: (i) our participants had poor sleep quality; (ii) AfS and AsiS were more prone to sleep disruptions than EuS and AmS, and students from France had significantly better sleep quality compared with those of several other countries in the countries' sub-analysis; (iii) females experienced more sleep disruptions than males; and (iv) students of all age groups were likely to experience sleep disruptions.

Sleep Variables and Geographical Location

Sleep disturbances are common among students.[17,33] The global PSQI score of the students from the four continents was higher than five, indicating poor sleep quality.[22] This could be attributed to suboptimal sleep hygiene practices driven by factors such as irregular sleep schedules, late-night use of electronic devices, prevalent use of sleep-disrupting substances (such as caffeine and alcohol,[34] unhealthy diets, lack of physical activity, and/or high stress levels[35]). Additionally, we showed higher frequency of poor sleep quality among (i) AsiS compared with AfS, and (ii) AsiS and AfS compared with EuS. Several factors may explain our findings. Indeed, AsiS and AfS often face

Table 4 Comparison of sleep-related variables between different age groups.

Variables	≤ 20 years (*N* = 1,495)	21–25 years (*N* = 1,392)	26–30 years (*N* = 288)	31–35 years (*N* = 91)	> 36 years (*N* = 157)
PSQI global score (A.U.)*	6.5 ± 2.8	6.8 ± 2.9[a]	6.9 ± 2.8	6.7 ± 2.9	6.5 ± 2.8
Frequency of poor sleep quality (PSQI ≥ 5) (%)†	59.2	62.3	64.9	61.4	58.6
Hours spent in bed (h)*	7.9 ± 1.7[e]	7.9 ± 1.7[e]	7.6 ± 1.6	7.7 ± 1.6	7.3 ± 1.5
Sleep efficiency (%)* Median [IQR]	93.9 ± 7.7 96.0 [93.1–97.8]	93.8 ± 6.5 95.7 [92.3–97.6]	92.8 ± 8.9 95.5 [92.3–97.3]	93.2 ± 7.9 95.5 [91.8–97.8]	93.9 ± 6.5 95.5 [92.9–97.7]
Frequency of poor sleep efficiency (≤ 85%) (%)†	6.7%	7.2%	9.4%	9.3%	7.0%
Sleep latency (min)* Median [IQR]	27.3 ± 32.6 19.5 [10–30]	27.4 ± 305 20 [10–30]	29.9 ± 33.7 20 [10–30]	28.6 ± 32.7 20 [10–30]	27.2 ± 33.3 20 [10–30]
Sleep duration (h)*	7.1 ± 1.6[c,d,e]	7.0 ± 1.6[c,d]	6.6 ± 1.5	6.5 ± 1.6	6.6 ± 1.3
Frequency of insufficient sleep duration (≤ 7 hours) (%)†	56.6%	58.5%	69.4%[ab]	72.1%[ab]	69.4%[a]
ESS score (A.U.)*	9.3 ± 4.5[e]	9.6 ± 4.7[c,d,e]	8.6 ± 4.6	8.4 ± 5.1	8.2 ± 4.8
Frequency of moderate EDS (ESS: 13–15) (%)†	14.2%	16.3%	11.8%	11.4%	10.2%
Frequency of severe EDS (ESS: 16–24) (%)†	9.3%	10.8%	7.3%	10.0%	8.3%
ISI score (A.U.)*	9.5 ± 5.8[e]	9.6 ± 5.8[e]	9.4 ± 5.8	9.2 ± 6.0	7.9 ± 5.1
Frequency of clinical insomnia of moderate severity (ISI 15–21) (%)†	17.2%	17.6%	16%	17.1%	17.6%
Frequency severe clinical insomnia (ISI ≥ 22 (%)†	3.5%	3.2%	3.1%	3.6%	1.3%

Abbreviations: A.U, arbitrary units; EDS, excessive daytime sleepiness; ESS, Epworth Sleepiness Scale; IQR, interquartile range; ISI, Insomnia Severity Index; PSQI, Pittsburgh Sleep Quality Index.
Notes: [a]Significantly higher than ≤ 20 years at $p < 0.05$.
[b]Significantly higher than 21–25 years at $p < 0.05$.
[c]Significantly higher than 26–30 years at $p < 0.05$.
[d]Significantly higher than 31 to 35 years at $p < 0.05$.
[e]Significantly higher than +36 years at $p < 0.05$.
*One-way analysis of variance.
†Chi-squared test.

socioeconomic challenges (such as limited access to resources and support), which can lead to increased stress and uncertainty.[14] The latter may have contributed to impaired sleep quality and higher levels of insomnia among these students compared with their AmS and EuS counterparts. Africa and Asia generally have lower gross domestic product per capita (gross domestic product, GDP) than Europe and America.[36] This suggests that students in countries with higher GDP per capita are potentially less likely to experience sleep disturbances and insomnia symptoms compared with those in countries with lower GDP per capita. This finding aligns with a similar observation regarding insomnia among students.[37] Food security is another influential factor in sleep quality and overall well-being. For instance, Rizk et al.[38] found that a high prevalence of food insecurity in Lebanon had negative effects on sleep and wellbeing among Lebanese students compared with German. This could partially explain our findings, as global data on hunger and malnutrition show that sub-Saharan Africa and South Asia have higher rates of malnourishment compared with North America and Europe (https://ourworldindata.org/hunger-and-undernourishment). These factors may also account for the differences in sleep latency and sleep efficiency observed among EuS compared with those from other continents. The countries sub-analysis showed that even though the above results are confirmed, with students from European and American countries having better sleep quality than students from Africa and Asia, there were inter-countries differences that deserve to be pointed out. For instance, if students from France and the USA had the best sleep quality, there were intra-continent differences with sleep quality of the students from Qatar being lower than those from Jordan and Oman. This shows that the conclusions on the intercontinental differences should be interpreted with caution. Indeed, within the same continent, people can live in locations with different latitudes, hence, being exposed to different photoperiods. Cultural diversity might also result in different effects on sleep habits (such as the habit of regularly taking naps or not). For instance, France and Turkey, from the same continent (even though the latter is

predominantly located in Asia), deserve more attention as both countries have quite different cultural and socioeconomical situations, resulting in different sleep quality profiles (►**Supplementary Figure S1** [online only]). Additional impacting factors could be linked to the surrounding environment of the students, such as the size of the cities they live in, transportation mode, and/or the noisy/hot environment they are exposed to, among other factors.

The sleep duration of the AsiS was shorter than the recommended 7 to 9 hours for young adults and 7 to 8 hours for older adults.[39] This may adversely affect mental health, physical performance, and academic achievement.[40] Moreover, the frequency of insufficient sleep duration was higher among students from Asia and Africa compared with students from Europe, consequently resulting in higher frequency of EDS in AfS and AsiS. This aligns with Jiang et al.,[7] who reported higher levels of sleepiness and insomnia among AsiS compared with both AmS and EuS. The ESS scores of students from the four continents indicate a higher-than-normal daytime sleepiness.[23] Students experiencing EDS are more likely to struggle with concentration, memory, and/or cognitive function, which can potentially negatively affect their learning and educational outcomes.[37] Additionally, EDS can lead to mood disturbances, including increased irritability and symptoms of depression,[41] further affecting students' mental health. Furthermore, sleep deficit in students has been associated with lack of concentration and attention during classes.[9] Given the importance of adequate sleep on students' quality of life,[37] wellbeing, and academic outcomes, specific attention should be paid to the implications of sleep-related issues of students, especially in those from Africa and Asia.

Sleep Variables between Males and Females

The frequency of poor sleep quality was higher among females compared with males, with French male students having significantly better sleep quality compared with French females. Tsai and Li[8] showed that male students tend to have later bedtimes than females, who often report more frequent awakenings per night, potentially contributing to the poorer overall sleep quality. Females reported longer sleep durations and higher levels of insomnia and daytime sleepiness compared with males. Additionally, the frequency of sleep difficulties (that is, subclinical-to-clinical insomnia, EDS) was higher among females compared with males. This aligns with previous studies in Peru,[42] Pakistan,[43] Iran,[44] and the Kingdom of Saudi Arabia.[45] The findings from a meta-analysis indicated a predisposition to insomnia among females compared with males. The authors also noted that the factors contributing to the gender difference in insomnia require further elucidation.[46] Nevertheless, we can hypothesize that a combination of biological (such as hormonal fluctuations throughout the menstrual cycle, differences in brain structure and function)[47] and psychological (such as stress, anxiety, mood disorders)[13] factors could collectively explain gender differences in terms of sleep disruptions. Future studies should investigate the underlying factors contributing to these gender differences.

Sleep Variables Across Different Age Groups

The sleep quality of our sample of students was poor across age groups. Students aged 21 to 25 reported higher insomnia levels compared with those over 36 years. The mean ESS score of students aged 21 to 25 years was higher than both 26-to-30 and 36+ years groups. This aligns with previous research on sleep patterns across age.[14] Maslowsky and Ozer,[48] studying the sleep pattern of a USA sample of adolescents and young adults, showed age-related trends in sleep duration; this variable decreased through adolescence, with 13 years old youth sleeping 8.5 hours per night, with a substantial lower duration of 7.3 hours at age 18. Thereafter, sleeping duration re-increases in emerging adulthood to 8.5 hours at age 22, and a gradual second decline across early adulthood (7.7 hours at 32).[48] Our students aged >26 years averaged a sleep duration inferior to the recommended 7 hours, while for the other age groups, the averaged sleep duration was ~ 7 hours per night. The sleep durations of our study samples are lower than those reported in the general population,[48] and might be explained by students' academic commitments, which often involve late-night studying and/or waking up early for classes.[49]

Our study shows the need to improve awareness about sleep hygiene in students, with special attention to (i) females, (ii) those in the 21-to-25 years age group, and (iii) students from AfS and AsiS. In that regard, Levenson et al.[50] showed the importance of sleep health promotion program to improve the sleep duration of college students, while Orzech et al.[51] demonstrated how a health education media campaign efficiently affected students' sleep patterns

Strengths and Limitations

An international research team with diverse backgrounds, including sleep specialists, conducted the current study. We acknowledge that the subjective nature of the questionnaires used, and cross-sectional design study could potentially introduce bias. However, given the size and diversity of our cohort, we believe that any resultant bias is likely negligible. Moreover, with the use of an online survey with randomized sampling, our control of the sampling has been obviously limited resulting in a non-perfect representation of continents and gender ratio. Students with sleep disturbances might also be more interested in participating, while non-students might falsely claim student status for instance. Furthermore, students of older age groups (that is, >26 years) were less represented compared with younger ones (<25 years), limiting the assumptions about the age-based comparisons. However, we believe that the current age groups distribution does reflect the actual age distribution among college students. The American sample was underrepresented compared with samples from other continents, which may limit the ability to draw definitive conclusions about AmS sleep patterns. Our study included students from various continents, including those studying in countries/continents different from their native ones. Whether this fact may affect our assumptions is not within the scope of this

study. In our frequency comparisons, we only considered the potential clinical ranges for the ESS and ISI questionnaires. For the ESS, we used a cutoff score of 10 to identify daytime sleepiness at a potential clinical level.[52] Regarding the ISI, our analysis included only the ranges indicative of clinical insomnia: 15 to 21 (moderate severity) and 22 to 28 (severe),[24] with the exclusion of the subthreshold-insomnia range. Indeed, subthreshold insomnia includes individuals experiencing sleep-related disturbances that do not meet the criteria for a clinical diagnosis of insomnia. Future studies should address these limitations by employing objective measures of sleep, despite the inherent challenges associated with conducting such assessments on large and diverse samples of students, as was the case in our study. Lastly, our study data has been collected from October 2021 to March 2022, and we do not know if the post-COVID-19 pandemic period had any effect on our results.

Conclusion

We showed geographical differences in sleep patterns in college students, with AsiS and AfS self-reporting poorer sleep health (lower sleep quality, higher insomnia and sleepiness) compared with AmS and EuS. Moreover, there were also intra-continental differences between countries regarding sleep quality. Gender and age comparisons showed that female and older students had poorer sleep health compared with male and younger students, respectively. Future research should consider using objective sleep assessment tools and focus on identifying the underlying factors contributing to the observed differences. We also call onto studies evaluating the effectiveness of interventions aimed at mitigating sleep-related issues with region' tailored interventions among students. In that regard, interventions aiming to raise the awareness of appropriate sleep hygiene in students are promising. They will potentially result in higher academic performance and wellbeing while preserving the students' physical and mental health.

Ethics Approval and Informed Consent

The study's protocol (web-based, cross-sectional survey administered in three languages: Arabic, English, and French) (i) received approval from the Ethics Committee of Qatar University (QU-IRB 1510-EA/21), (ii) adheres to the ethical standards of the Declaration of Helsinki (2013 and its subsequent amendments), and (iii) ensures anonymity according to the guidelines of the General Data Protection Regulation (gdpr-info.eu). Participation in the study was voluntary, and participants had the right to withdraw from the study at any time without facing any penalties or consequences. Before commencing the survey, participants provided online informed consent for their involvement.

Conflict of Interests

The authors have no conflict of interests to report.

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