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The impact of sleep, mental health, and gender on academic performance in Canadian university students

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Purpose: To understand the independent and combined effects of sleep and mental health on academic performance, while also exploring gender differences.

Methods: A cross-sectional survey was distributed to undergraduate students at two Canadian universities in March 2022. Sleep quality and quantity was assessed using the Pittsburgh Sleep Quality Index. Mental health variables included stress, depression, and anxiety. Academic performance was self-reported as students' cumulative percent average. Multiple linear regressions were used to investigate how (1) sleep, (2) mental health, (3) sleep and mental health together related to academic performance. These analyses were then repeated, stratified by gender.

Results: A total of 1,258 undergraduate students participated. While mental health and sleep duration predicted academic performance among the whole sample, there were important gender differences. In gender-stratified data, sleep quality and quantity predicted academic performance in men but not mental health in the combined model. For women, stress, depression, and anxiety predicted academic performance but not sleep quality. Sleep duration squared, but not sleep duration simply, was associated with academic performance in women.

Conclusion: Sleep and mental health are essential for academic performance in undergraduate students. Further, gender may play a critical role. Universities should consider gender-specific supports to improve the wellbeing of their students.

KEYWORDS

sleep, gender, mental health, depression, anxiety, stress, academic performance

Introduction

Academic performance is a significant source of stress for many university students (Hurst et al., 2012; Logan and Burns, 2021). The pressure to excel can stem from internal factors, such as the desire for academic success, self-comparison, perfectionism, or external factors like expectations from family and friends (Hurst et al., 2012; Logan and Burns, 2021). For some students, high grades are essential for entry into graduate programs,

while for others, academic performance is closely tied to their self-worth (Crockner, 2002). Notably, higher stress levels are associated with poorer academic outcomes (Frazier et al., 2019; Richardson et al., 2012). Understanding the intricate relationship between stress and academic performance is crucial given its critical importance to students.

The World Health Organization defines mental health as “a state of mental wellbeing that enables people to cope with the stresses of life, realize their abilities, learn well and work well, and contribute to their community” (World Mental Health Report, 2022). Mental health, particularly anxiety, plays a pivotal role in academic performance. While stress is often a reaction to external pressures (such as taking a test), anxiety is an internal response that can persist even without immediate threats (National Institute of Mental Health, 2020). High anxiety correlates with lower academic performance (Jamil et al., 2022), though moderate anxiety levels may be optimal (Waqas et al., 2015). This aligns with the Yerkes–Dodson Law, which posits that moderate arousal can enhance performance, while too little or too much can be detrimental (Teigen, 1994). Depression is another common mental health condition associated with worse academic performance and characterized by persistent feelings of sadness and loss of interest (Hysenbegasi et al., 2005).

Sleep also significantly impacts academic performance. Students who experience poor, insufficient, or inconsistent sleep often perform worse academically (Baert et al., 2015; Gomes et al., 2011; Maheshwari and Shaikat, 2019; Okano et al., 2019; Phillips et al., 2017; Raley et al., 2016; Turner et al., 2021). Additionally, those with sleep disorders, such as insomnia or sleep apnea, show similar trends (Gaultney, 2010, 2016; Turner et al., 2021). Despite recommendations for seven to nine hours of sleep (Hirshkowitz et al., 2015), nearly one-third of students do not meet this guideline (Humphries et al., 2021; Norbury and Evans, 2019). Sacrificing sleep for extra study time may impair cognitive functions and memory consolidation (Alhola and Polo-Kantola, 2007; Rasch and Born, 2013), leading to poorer academic results (Raley et al., 2016; Zeek et al., 2015).

While the individual effects of sleep and mental health on academic performance are well-documented, their combined impact is less well understood. One study found that poor sleep quality negatively affected academic performance, while mental distress had a positive association when considered independently (El Hangouche et al., 2018). However, only sleep remained a significant factor when controlling for other variables (El Hangouche et al., 2018). Gender differences also exist in sleep and mental health, with men typically getting less sleep and women experiencing difficulties falling asleep (Chaput et al., 2017) and higher rates of depression and anxiety (McLean et al., 2011; Salk et al., 2017). Interestingly, women with higher test anxiety may perform better academically (Colbert-Getz et al., 2013).

Therefore, this study aims to examine the independent and combined effects of sleep and mental health on academic performance among university undergraduate students. Additionally, it explores the gender difference in these relationships to provide a comprehensive understanding of these factors. We hypothesized that better sleep would be associated with better academic performance, and that worse mental health would negatively impact academic performance.

Materials and methods

Study design

This secondary analysis uses data from a cross-sectional study which investigated variations in sleep attitudes across university disciplines (Kuhn et al., 2024). The survey was conducted in March 2022 among students at the University of Waterloo and McMaster University in Ontario, Canada. The study received approval from the ethics committees from both institutions (University of Waterloo ORE #43903, McMaster University MREB #5834). All participants provided electronic informed consent.

Participants

Participants were recruited through a combination of social media, posters, email advertisements, and use of the McMaster Sona System, a platform commonly used for recruiting participants in psychological research. To ensure representation from the broader student population, emails were sent to representatives from all departments or faculties requesting they forward the study information to their student mailing lists. To be eligible, participants had to be currently enrolled as a student at the University of Waterloo or McMaster University. While the survey was open to graduate and undergraduate students, only undergraduate students were included in the present analyses, as the factors affecting academic performance likely differ between these groups.

Measures

Sleep quality and quantity

Sleep quality and quantity were assessed using the Pittsburgh Sleep Quality Index (PSQI; Buysse et al., 1989). The PSQI evaluates sleep over the past month across seven components, with participants reporting the frequency of sleep disturbances from 0 (least frequent) to 3 (most frequent). The maximum score is 21, with higher scores indicating greater sleep disturbance and poorer sleep quality. A global score greater than five signifies significant sleep disturbance. One question asks participants to report the number of hours of sleep they get each night, which was used to determine sleep duration.

Participants were also asked “Have you ever pulled an ‘all-nighter’ (voluntarily skipping sleep and staying up for nearly 24 h or greater) during your academic career?” The response options were “yes”, “no”, or “prefer not to say.” If participants responded “yes,” they were prompted with open text boxes to indicate how many all-nighters they had completed and the timing of their most recent all-nighter.

Mental health

Stress was assessed using the Perceived Stress Scale (PSS; Cohen et al., 1983), a 10-item questionnaire that asked participants to indicate how often they experienced specific feelings or thoughts during the last month. Responses are rated on a scale from 0 (never) to 4 (very often). The total score ranges from 0 to 40, with

higher scores indicating greater perceived stress. The scores can be categorized into low, moderate, or high perceived stress.

Anxiety was assessed using the General Anxiety Disorder scale (GAD-7; Spitzer et al., 2006). This seven-item questionnaire asks participants how often they had been bothered by various problems over the past two weeks, with response ranging from 0 (not at all) to 3 (nearly every day). The total score ranges from 0 to 21. A higher score indicates greater anxiety level, and scores can be categorized into minimal, mild, moderate, and severe anxiety.

Depression was assessed using the Patient Health Questionnaire (PHQ-9; Kroenke et al., 2001). This nine-item questionnaire asks participants to select the statement that best describes how they have been feeling over the past two weeks, with responses ranging in intensity from 0 to 3. The total score ranges from 0 to 27, with higher scores indicating greater levels of depression. These scores can be categorized into none-minimal, mild, moderate, moderately severe, or severe levels of depression.

Academic performance

All students, regardless of their university, were shown a grading chart based on the University of Waterloo's grading scheme. The University of Waterloo uses a 10-point grading system, where the highest grade is A+ or 90–100%, and the lowest grade is a F or 0–59%. Using this chart, students were asked to report their average as both a percentage and a letter grade. If a participant only provided a letter grade, a numeric grade was estimated using the median value for that letter grade. For example, an “A+” was considered 95%, an “A” was considered 87%. The academic performance in percentage was treated as a continuous variable and was the primary outcome of the analyses.

Demographic characteristics

Participants provided demographic information, including age (in years), sex at birth (male, female, prefer not to say), household income (< \$20,000; \$20,000–\$49,999; \$50,000–\$99,999; > \$100,000), and study discipline (Health, Arts [Social Sciences, Fine Arts, Humanities], Science & Math, and Engineering & Computer Science). Regarding gender, participants were asked “how do you describe yourself,” selecting from the following gender categories: man, woman, non-binary, two-spirit, other, or prefer not to say.

Statistical analyses

Statistical analyses were completed using R computing software (R Core Team, 2023). Data were screened for missing and extreme values. For participants with two or fewer missing values in the mental health measures ($n = 4$), mean imputation was used to resolve missing data (Kroenke et al., 2010). All incomplete PSQI sleep durations ($n = 2$) and global scores ($n = 19$) were removed, as these scores could not be estimated or imputed. Additionally, data were screened for extreme values, and participants suspected of providing random responses (e.g., a value outside of the accepted scores for multiple measures) were removed ($n = 2$).

Participant characteristics were described using mean (standard deviation) for continuous variables and n (percentage) for categorical variables. Differences in participant characteristics

by gender (men, women) were analyzed using t -tests for continuous variables and chi-squared tests for categorical variables.

To investigate the relationship between sleep and academic performance, stepwise multiple linear regressions were conducted, with self-reported grade point average (percentage) as the outcome measure. Given that sleep duration, stress, and anxiety are thought to have non-linear relationships with cognition or academic performance (Teigen, 1994; Wild et al., 2018), non-linear terms (squared variables) were added for these measures.

The unadjusted sleep model included the sleep duration, sleep duration squared, and the PSQI global score, all as continuous variables, with no additional covariates. The adjusted sleep model included these sleep variables along with demographic covariates (age, sex, income, university location, study discipline).

A similar approach was used to examine the relationship between mental health and academic performance. The unadjusted mental health models included perceived stress, perceived stress squared, depression, anxiety, and anxiety squared. The adjusted models included these mental health variables along with demographic covariables.

When analyzing the combined effects of sleep and mental health on academic performance, the unadjusted models included all sleep and mental health measures (including squared terms). The fully adjusted models added demographic characteristics to these variables.

The analyses described above were also stratified by gender, comparing participants who identified as “men” or “women.” These models were theoretically driven, based on prior evidence that men and women have differing relationships with sleep and mental health on academic performance. Participants who did not indicate their gender or had a gender identity outside of the “man/woman” binary were excluded from the analysis due to small sample size ($n = 41$).

Results

Participant characteristics

A total of 1,258 undergraduate students participated in this study. 881 (70.0%) of the total sample identified as women and 336 (26.7%) identified as men. The majority of the sample was under 25 years of age, in their first or second year of study, and with a high average household income. Most students were poor sleepers and had completed at least one all-nighter, although the majority of students were getting the recommended seven to nine hours of sleep. On average, students were going to bed at 12:32 AM (± 102 min) and getting out of bed at 8:34 AM (± 110 min). About half the students had minimal to mild depression and anxiety, while most reported moderate to high levels of stress. Detailed demographic characteristics of the total sample and stratified by gender are provided in Table 1.

There were few demographic differences by gender. However, the distribution of students by gender varied across faculties, and there was a greater representation of women among first and second-year students. While no significant gender differences were observed in sleep quality and quantity, men were more likely to have completed an all-nighter. Additionally, women were more

TABLE 1 Participant characteristics ($n = 1,258$).

Characteristics	Mean (SD) or N (%)			<i>p</i> -for difference by gender
	Total	Men	Women	
Number of participants	1,258 (100)	336 (27.6)	881 (70.0)	
Age, years	20.96 (3.1)	20.66 (4.1)	20.14 (2.7)	0.03
Grade point average, %	82.3 (7.0)	82.4 (7.6)	82.4 (6.6)	0.99
University, % McMaster	749 (59.5)	190 (56.5)	535 (60.7)	0.21
Race/ethnicity, % white/Caucasian	494 (39.3)	115 (34.2)	356 (40.4)	0.06
Student year, % first or second year	661 (52.5)	153 (45.7)	487 (55.4)	0.03
Household income, % < \$50,000	389 (30.9)	108 (33.1)	262 (30.8)	0.40
Academic discipline, %				< 0.001
Health	229 (18.2)	29 (8.6)	196 (22.2)	
Engineering	409 (32.5)	194 (57.7)	203 (23)	
Science and math	310 (24.6)	67 (19.9)	233 (26.4)	
Arts	310 (24.6)	46 (13.7)	249 (28.3)	

likely to report more severe mental health symptoms. Finally, men had later in-bed ($t = -2.99$, $p \leq 0.001$) and wake-times ($t = -1.87$, $p = 0.04$) than women, where men on average reported going to bed around 12:46 AM (± 97 min) and getting up at 8:44 AM (± 109 min), whereas women reported going to bed at 12:26 AM (± 112 min) and waking up at 8:29 AM (± 109 min) (not shown in table). Detailed sleep and mental health characteristics for the overall sample and by gender are provided in Table 2.

Sleep on academic performance

Measures of sleep quantity and quality were associated with academic performance in both unadjusted and adjusted models (Table 3, Section A). Better sleep quality, as indicated by a lower PSQI score, was associated with better academic performance. There were significant linear and non-linear relationships for sleep duration, in that those who were on the extreme ends of short or long sleep durations had worse academic performance.

Mental health on academic performance

All mental health measures were associated with academic performance in both unadjusted and adjusted models (Table 3, Section B). Perceived stress exhibited significant linear and non-linear effect, with higher stress levels associated with worse academic performance. However, this effect plateaued at moderate to very high levels of stress, where GPA remains similar despite increasing stress. More depressive symptoms were associated with worse academic performance. Additionally, anxiety showed significant linear effect and non-linear effects; increasing anxiety levels were associated with better academic performance up to a point, after which extremely high anxiety levels led to a decline in academic performance.

Sleep and mental health on academic performance

In the combined models of sleep and mental health, all measures of sleep quality, sleep quantity, and mental health were associated with academic performance in the unadjusted models. However, in the adjusted models, sleep quality was no longer associated with academic performance (Figure 1A). In contrast, sleep duration, depressive symptoms, stress levels, and anxiety remained significant predictors of academic performance (Figures 1B–E).

There were significant linear and non-linear effects for sleep duration, indicating that both insufficient and excessive sleep were associated with poorer academic performance (Figure 1B). High levels of stress (Figure 1C) and depression (Figure 1D) were negatively associated with academic performance, whereas higher anxiety levels were positively associated with academic performance (Figure 1E). Notably, there were significant non-linear effects for perceived stress and anxiety: increasing stress levels were associated with worse academic performance until a plateau was reached at moderate to severe stress levels. Similarly, anxiety was positively associated with academic performance up to a point, after which severe anxiety levels was detrimental. See Table 3, Section C for summary of the results.

Sleep and academic performance by gender

Gender-stratified data are presented in Table 4. In both men and women, poor sleep quality was negatively associated with academic performance. Among men, there was significant linear and non-linear relationships between sleep duration in academic performance in the adjusted and unadjusted models, indicating that both insufficient sleep and excessive sleep were associated with worse academic performance than moderate levels of sleep. For women, while the linear term did not reach significance

TABLE 2 Sleep and mental health characteristics.

Characteristics	N (%)			<i>p</i> -for difference by gender*
	Total	Men	Women	
Completed an all-nighter	733 (58.3)	206 (61.3)	500 (56.8)	0.03
Sleep duration				0.11
< 7 h	491 (39.0)	117 (34.8)	356 (40.6)	
7–9 h	742 (59.2)	215 (64.0)	505 (57.6)	
> 9 h	20 (1.6)	4 (1.2)	16 (1.8)	
PSQI “good” sleeper (global score ≤ 5)	377 (30.4)	108 (32.4)	265 (30.6)	0.59
PHQ				< 0.001
Minimal to mild	686 (54.5)	214 (63.7)	461 (52.3)	
Moderate	263 (20.9)	55 (16.4)	199 (22.6)	
Moderately severe to severe	309 (24.6)	67 (19.9)	221 (25.1)	
PSS				< 0.001
Low	161 (12.8)	69 (20.5)	89 (10.1)	
Moderate	864 (68.7)	231 (68.8)	608 (69.0)	
High	233 (18.5)	36 (10.7)	184 (20.9)	
GAD-7				< 0.001
Minimal	283 (22.5)	112 (33.3)	166 (18.8)	
Mild	374 (29.7)	106 (31.5)	257 (29.2)	
Moderate	342 (27.2)	70 (20.8)	259 (29.4)	
Severe	259 (20.6)	48 (14.3)	199 (22.6)	

PSQI, Pittsburgh Sleep Quality Index; PHQ, Patient Health Questionnaire; PSS, Perceived Stress Scale; GAD-7, General Anxiety Disorder-7. *Reflect *p*-values for chi-squared test.

(*p* = 0.07), the non-linear term was significant, suggesting a similar pattern where extreme sleep durations were associated with worse academic performance. See Table 4, Section A for the gender-stratified data for sleep and academic performance.

Mental health and academic performance by gender

In both men and women (Table 4, Section B), higher depressive scores were associated with worse academic performance in both the unadjusted and adjusted models. Additionally, anxiety showed a positive linear association with academic performance in both genders in both models.

For women only, stress exhibited significant linear and non-linear relationship with academic performance in the unadjusted and adjusted model, indicating their stress levels influence their academic outcomes in a complex manner. In contrast, stress did not significantly predict academic performance in men.

Sleep, mental health, and academic performance by gender

While examining the combined effects of sleep and mental health, several gender differences emerged (Table 4, Section C). In men, sleep quality significantly predicted academic performance,

whereas this relationship was not significant in women. In the adjusted models, men exhibited significant linear and non-linear effects for sleep duration, demonstrating an inverted U-shaped relationship where both insufficient and excessive sleep were associated with worse academic performance compared to moderate sleep levels. Women showed a similar inverted U-shaped relationship; however, the linear term did not reach significance (*p* = 0.09), while the non-linear term was significant.

Regarding women’s mental health, stress showed a significant linear and non-linear relationship with academic performance in both adjusted and unadjusted models. Higher stress levels were associated with worse academic performance, although this relationship plateaued at moderate-high levels of stress. Men exhibited a similar trend, but stress was not a significant predictor of academic performance in either model.

Depression severity negatively impacted academic performance in women but not in men. Anxiety had a positive linear association with academic performance in women in both models. Men displayed a similar positive linear relationship between anxiety and academic performance, though this effect approached but did not reach significance in the adjusted model (*p* = 0.051).

Discussion

This study aimed to understand the relationship between sleep, mental health and academic performance in university undergraduate students, while also exploring gender differences.

TABLE 3 Regression coefficients for the association between sleep, mental health, and their combined effect on academic performance.

	Unadjusted model		Full model*	
	<i>b</i> (95% CI)	<i>P</i>	<i>b</i> (95% CI)	<i>p</i>
Section A—Sleep and academic performance				
PSQI global	−0.36, (−0.51, −0.21)	< 0.001	−0.33, (−0.48, −0.18)	< 0.001
Sleep duration	3.36, (0.94, 5.77)	0.006	3.33, (0.91, 5.74)	0.007
Sleep duration ²	−0.27, (−0.43, −0.10)	0.002	−0.27, (−0.43, −0.10)	0.002
Section B—Mental health and academic performance				
PSS	−0.61, (−0.95, −0.29)	< 0.001	−0.62, (−0.95, −0.29)	< 0.001
PSS ²	0.01 (0.005, 0.02)	0.001	0.01 (0.01, 0.02)	< 0.001
PHQ	−0.24, (−0.34, −0.15)	< 0.001	−0.23, (−0.32, −0.13)	< 0.001
GAD	0.52, (0.22, 0.83)	< 0.001	0.51, (0.21, 0.81)	< 0.001
GAD ²	−0.02 (−0.03, −0.005)	0.007	−0.02 (−0.03, −0.004)	0.007
Section C—Sleep, mental health, and academic performance				
PSQI global	−0.18, (−0.34, −0.004)	0.04	−0.15, (−0.33, 0.02)	0.09
Sleep duration	3.18, (0.78, 5.59)	0.01	3.14, (0.73, 5.55)	0.01
Sleep duration ²	−0.25, (−0.42, −0.08)	0.003	−0.25, (−0.42, −0.08)	0.003
PSS	−0.62, (−0.96, −0.29)	< 0.001	−0.63, (−0.96, −0.30)	< 0.001
PSS ²	0.01 (0.005, 0.02)	0.001	0.01 (0.005, 0.02)	0.001
PHQ	−0.18, (−0.29, −0.08)	< 0.001	−0.18, (−0.28, −0.07)	< 0.001
GAD	0.51, (0.20, 0.82)	0.001	0.49, (0.19, 0.80)	0.002
GAD ²	−0.02 (−0.03, −0.004)	0.01	−0.02 (−0.03, −0.004)	0.01

*Adjusted for age, sex, income, university, study discipline. PSQI, Pittsburgh Sleep Quality Index; PSS, Perceived Stress Scale; PHQ, Patient Health Questionnaire; GAD-7, General Anxiety Disorder-7. This superscript “2” refers to that variables being a squared term, as it is a non-linear term.

Although most sleep and mental health measures were associated with academic performance in the overall sample, important gender differences emerged. For men, academic performance was associated with sleep quality and quantity, but not mental health. In contrast, for women, academic performance was associated with mental health but not sleep quality or quantity. Interestingly, stress and anxiety influenced academic performance in opposite ways for the entire group and specifically among women. Stress was associated with worse academic performance, whereas anxiety was associated with better academic performance.

This study found several gender differences in the relationship between sleep and mental health and their impact on academic performance. For women, all mental health measures influenced academic performance, while for men these measures did not. There has been little research into how gender impacts sleep, mental health and academic performance. Of the limited literature, some studies suggest that test-anxiety may benefit academic performance for women but not men (Chapell et al., 2005; Colbert-Getz et al., 2013). In contrast, others studies indicate that depression has a stronger impact on women and general anxiety has a stronger impact on men regarding academic performance (Eisenberg et al., 2009). Conflicting results have also been observed regarding mental health and education attainment in teenagers (Burger and Strassmann Rocha, 2023; Cornaglia et al., 2015; Hjorth et al., 2016; Needham, 2009). These discrepancies may be related to gender differences in mental health reporting. Men tend to report lower mental distress (McLean et al., 2011; Salk et al., 2017), but may underreport it due to social desirability or express it in ways not captured by questionnaires (Whitley, 2021,

Chapter 5). Social desirability may further contribute in part to why sleep, but not mental health, had a stronger association with academic performance. Having poor sleep might be more socially acceptable, and for some, even be intertwined with their sense of masculinity (Warren and Campbell, 2021). Thus, men might be more willing to disclose when they are experiencing poor sleep but not poor mental health. Alternatively, the smaller number of men in this study may have led to insufficient power to detect the effect of mental health. For example, anxiety was associated with academic performance among men in the unadjusted models but did not reach significance in the fully adjusted models ($p = 0.051$; see Table 4, Section C).

In women, stress had a significant non-linear relationship with academic performance, where academic performance decreased as stress increased until it plateaued. This suggests a saturation point where greater stress has similar impact on academic performance. Anxiety had a positive effect on academic performance, consistent with prior studies (Chapell et al., 2005; Colbert-Getz et al., 2013). Since anxiety is an internalized reaction to stress (National Institute of Mental Health, 2020), there may be an optimal level of anxiety that motivates students to perform well without overwhelming them, aligning with the Yerkes–Dodson Law model (Teigen, 1994). Anxiety may motivate women to work harder, enhancing performance (Stricker et al., 1993). However, in the present study the same was not true for men.

Regarding academic performance, sleep appeared to be more essential for men than women. Previous research found that the relationship between sleep duration and academic performance was stronger in men than in women (Okano et al., 2019). Sleep quality

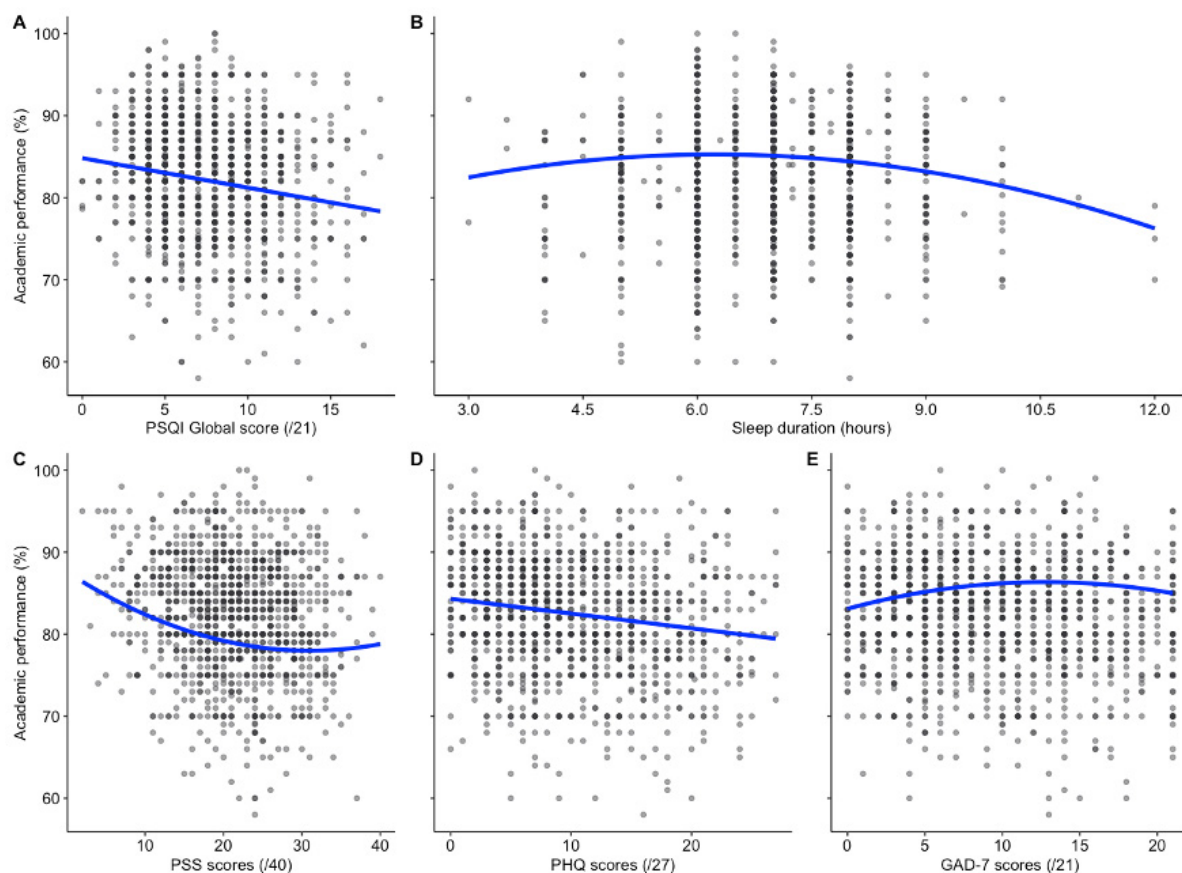


FIGURE 1

Scatterplots of the unadjusted relationship between sleep, mental health and academic performance. Sleep quality was associated with worse academic performance (A), while sleep duration showed a non-linear relationship with academic performance (B). Higher levels of stress (C) and depression (D) were associated with worse academic performance. Anxiety (E) had a positive, non-linear association with academic performance.

was significantly associated with academic performance only in men (Okano et al., 2019), aligning with our results. However, this finding is not consistent across all studies as one study found the opposite (Marta et al., 2020). Timing of sleep and circadian alignment may be one factor contributing to these differences. Although the Okano et al. (2019) study did not report gender differences in bedtimes, they found those who went to bed earlier had better academic performance. As found in the present study, young men tend to go to bed later than women (Becker et al., 2018; Kabrita and Hajjar-Muça, 2016; Tsai and Li, 2004) and are more likely to be evening chronotypes (Fischer et al., 2017; Randler and Engelke, 2019). Thus, their personal and circadian schedules may not be aligned with their academic schedules. Critically, circadian misalignment (Montaruli et al., 2019; Phillips et al., 2017) and later bedtimes (Eliasson et al., 2010) are associated with worse academic performance.

Given the gender differences in the relationships between sleep, mental health and academic performance, universities may need to implement gender-specific interventions. For men, interventions should focus on promoting sleep awareness, while for women, mental health awareness should be prioritized. Universities can offer programming or workshops on sleep hygiene, cognitive behavioral therapy, and relaxation/mindfulness, which have been shown to improve

sleep and mental health in university students (Friedrich and Schlarb, 2018). Additionally, resources for scheduling, time-management, and organization may help students better adapt to the university environment, allowing them to allocate time for sleep and other wellness activities to promote mental wellbeing.

There are several limitations to this study. First, it is cross-sectional, so causality cannot be inferred between sleep, mental health, and academic performance. Second, the measures were self-reported, introducing potential error and bias. Students may have inflated their grades, as the global average of this sample was 82% (A–). Third, there is likely self-selection bias, where certain types of students (e.g., high achieving students or those concerned about their sleep) may have been more likely to participate. Fourth, these results may not apply to graduate students who may experience different stressors and challenges related to sleep and mental health than undergraduate students (Pfeiffer, 2001; Tan et al., 2023; Wyatt and Oswalt, 2013). Finally, there may be differences by other demographic characteristics not examined here, such as ethno-racial groups (Karsan et al., 2024).

TABLE 4 Regression coefficients for the association between sleep, mental health, and their combined effect on academic performance in undergraduate men (*n* = 336) and women (*n* = 881).

	Men				Women			
	Unadjusted model		Full model*		Unadjusted model		Full model*	
	<i>b</i> (95% CI)	<i>p</i>	<i>b</i> (95% CI)	<i>p</i>	<i>b</i> (95% CI)	<i>p</i>	<i>b</i> (95% CI)	<i>p</i>
Section A–Sleep and academic performance								
PSQI global	−0.54, (−0.85, −0.22)	< 0.001	−0.53, (−0.85, −0.2)	0.001	−0.32, (−0.49, −0.15)	< 0.001	−0.28, (−0.45, −0.11)	0.001
Sleep duration	5.39, (0.48, 10.31)	0.03	5.7, (0.81, 10.6)	0.02	2.51, (−0.32, 5.35)	0.08	2.59, (−0.26, 5.44)	0.07
Sleep duration ²	−0.41, (−0.75, −0.07)	0.02	−0.43, (−0.77, −0.09)	0.01	−0.21, (−0.4, −0.01)	0.04	−0.22, (−0.41, −0.02)	0.03
Section B–Mental health and academic performance								
PSS	−0.53, (−1.16, 0.09)	0.09	−0.60, (−1.22, 0.02)	0.06	−0.52, (−0.92, −0.11)	0.01	−0.49, (−0.89, −0.08)	0.02
PSS ²	0.01, (−0.005, 0.03)	0.18	0.01, (−0.004, 0.03)	0.14	0.01, (0.001, 0.02)	0.03	0.01, (0.001, 0.02)	0.03
PHQ	−0.31, (−0.53, −0.08)	0.01	−0.29, (−0.51, −0.06)	0.01	−0.22, (−0.33, −0.11)	< 0.001	−0.21, (−0.31, −0.1)	< 0.001
GAD	0.65, (0.04, 1.26)	0.04	0.62, (0.01, 1.24)	0.04	0.41, (0.05, 0.78)	0.02	0.41, (−0.06, 0.76)	0.02
GAD ²	−0.02 (−0.05, 0.01)	0.11	−0.02 (−0.05, 0.01)	0.16	−0.01 (−0.03, 0.003)	0.1	−0.01 (−0.03, 0.001)	0.07
Section C–Sleep, mental health, and academic performance								
PSQI global	−0.47, (−0.86, −0.08)	0.02	−0.44, (−0.84, −0.04)	0.03	−0.13, (−0.32, 0.07)	0.22	−0.10, (−0.30, 0.10)	0.31
Sleep duration	4.79, (−0.17, 9.74)	0.06	5.29, (0.37, 10.21)	0.04	2.50, (−0.32, 5.32)	0.08	2.43, (−0.40, 5.26)	0.09
Sleep duration ²	−0.37, (−0.71, −0.03)	0.04	−0.4, (−0.74, −0.06)	0.02	−0.2, (−0.40, −0.01)	0.04	−0.20, (−0.40, −0.01)	0.04
PSS	−0.52, (−1.14, 0.09)	0.09	−0.56, (−1.18, 0.05)	0.07	−0.52, (−0.93, −0.11)	0.01	−0.49, (−0.89, −0.09)	0.02
PSS ²	0.01, (−0.01, 0.02)	0.23	0.01, (−0.01, 0.02)	0.21	0.01, (0, 0.02)	0.04	0.01, (0, 0.02)	0.04
PHQ	−0.11, (−0.36, 0.13)	0.35	−0.1, (−0.35, 0.15)	0.42	−0.19, (−0.30, −0.07)	0.002	−0.18, (−0.30, −0.07)	0.002
GAD	0.66, (0.05, 1.27)	0.03	0.61, (−0.002, 1.22)	0.05	0.38, (0.02, 0.75)	0.04	0.39, (0.03, 0.75)	0.03
GAD ²	−0.02 (−0.05, 0.01)	0.12	−0.02 (−0.05, 0.01)	0.19	−0.01 (−0.03, 0.005)	0.16	−0.01 (−0.03, 0.003)	0.11

*Adjusted for age, sex, income, university, study discipline. Sleep quality was measured with the Pittsburgh Sleep Quality Index (PSQI), stress was measured with the Perceived Stress Scale (PSS), depressive symptoms were measured with the Patient Health Questionnaire (PHQ), anxiety was measured with the General Anxiety Disorder-7 (GAD-7). This superscript “2” refers to that variables being a squared term, as it is a non-linear term.

Conclusion

The present study sought to understand how sleep and mental health impacts academic performance and the influence of gender on this relationship. Gender-stratified analyses revealed that sleep may be a more critical factor for academic performance in men, whereas mental health may impact women's academic performance more. These findings suggest that the benefits of mental health and sleep interventions may vary by gender, highlighting the need for gender-specific support strategies in university.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the University of Waterloo Office of Research Ethics. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

TK: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Writing – original draft. JH: Conceptualization, Resources, Supervision, Writing – review and editing. LM: Conceptualization, Resources, Supervision, Writing – review and editing.

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