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Publication Date

2022-06-28

DOI

10.1080/08964289.2022.2085651
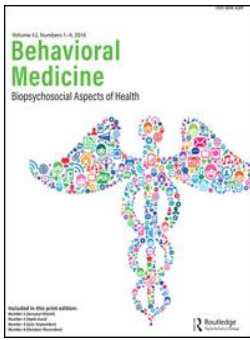
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Published online: 28 Jun 2022.

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Undergraduate Student Stress, Sleep, and Health Before and during the COVID-19 Pandemic

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ABSTRACT

Before the COVID-19 pandemic, undergraduate students experienced sleep problems and mental health issues that were negatively associated with academic achievement. Studies comparing undergraduate sleep and health pre- to mid-pandemic have yielded mixed results, necessitating additional research on other cohorts and examination of potential moderators. The present study was conducted to examine whether American undergraduate students tested mid-pandemic experienced poorer sleep, health, and academic achievement relative to students tested pre-pandemic, as well as to examine whether poor sleep during the pandemic was preferentially associated with poorer health in women. The current cross-sectional study included 217 participants tested pre-pandemic (February-December 2019) and a separate sample of 313 participants tested mid-pandemic (November-December 2020). Participants in both samples provided demographic information and completed questionnaires inquiring about participant sleep quality, insomnia, and cumulative grade point average (GPA); participants in the mid-pandemic sample also reported on measures of general, physical, and mental health. Participants tested mid-pandemic reported poorer global sleep quality, greater insomnia severity, greater stress, and higher cumulative GPAs relative to participants tested pre-pandemic. For the mid-pandemic sample only, poorer sleep quality was associated with reduced physical health; interactions indicated that women with poor sleep quality reported poorer mental health relative to both women with good sleep quality and men with poor quality sleep. Perceived stress mediated the association between sleep problems and GPA. These findings indicate that the pandemic negatively impacted the functioning of undergraduate students and highlights the need for future studies examining additional moderators of the reported effects.

Introduction

Even before the onset of the COVID-19 pandemic, undergraduate students experienced sleep problems (e.g., poor quality sleep, insomnia, insufficient sleep)[1,2] and mental health issues (e.g., anxiety, depression, stress)[3–5] that were negatively associated with academic achievement.[5,6] During the pandemic, students experienced additional stressors including the transition to online learning, potential loss of employment, and the threat of illness and death resulting from the COVID virus, among others.[7,8] Importantly, these stressors more negatively impacted the sleep and mental health of undergraduate women relative to men.[9–11] The present study was conducted to (1) examine undergraduate students' self-reported sleep, stress, and academic achievement before and during the

COVID-19 pandemic as well as (2) to determine whether poor quality sleep during the pandemic was preferentially associated with reduced health for female undergraduates relative to males. This research is important as other cross-sectional studies have revealed somewhat divergent findings when considering the impact of the pandemic on undergraduate student sleep and well-being (e.g., see references[12–15]) This work is also needed to elucidate whether female undergraduates are more negatively impacted by poor quality sleep during the pandemic relative to males, a question that has not been addressed to our knowledge in the cross-sectional work conducted to date.

Data collected during the pandemic (without a pre-pandemic comparison sample) have revealed that undergraduates have experienced significant stress, anxiety, and depression during the pandemic, with

women and other minority groups most significantly affected.[9–11] Research has also suggested that adults have modified their sleep phases during the pandemic in relation to changing responsibilities: perhaps due to reduced or altered work and school commitments, bedtime and wake times were later mid- relative to pre-pandemic, although participants reported poorer quality sleep overall.[11,16,17] During a period of quarantine in Jordan, approximately 75% of university students met the criteria for categorically poor quality sleep, with the majority of students indicating that the quarantine negatively impacted their nighttime sleep duration (95%) and sleep habits (74%). The quarantine was also associated with poorer mental health for over half of the tested students (64%).[11] Indeed, independent reports of increased stress, mental health issues, and sleep problems during the pandemic are individually concerning. The interactions between these conditions, however, are potentially even more problematic, as sleep problems may be both a cause and consequence of mental health issues.[18–20]

Stress, mental health issues, and sleep problems are also troubling given associations between these conditions and academic achievement. Research conducted before the onset of the COVID-19 pandemic revealed that these various factors were associated with reduced grade point averages (GPAs) in undergraduate students.[21–23] The additional challenges associated with transitioning to online learning environments during the pandemic[24] may amplify negative relations among academic achievement and stress, mental health issues, and sleep problems. On the other hand, the transition to online education was broadly accompanied by instructional changes consistent with compassionate education,[25] such as the implementation of flexible deadlines, elimination of late submission penalties, and enhanced communication, among others.[26] As such, it is possible that significant associations between stress, mental health, and sleep problems will be maintained during the pandemic but will co-occur with higher GPAs reported mid-pandemic relative to pre-pandemic.

Although a number of studies has examined the impact of the COVID-19 pandemic on stress, mental health issues, and sleep problems in undergraduate students around the world, the majority of these studies included one-time assessments of students tested during the pandemic;[7,11] only a small subset has investigated these measures cross-sectionally in separate groups of undergraduates tested before and after the onset of the pandemic.[12–15] When considering mental health, undergraduate students in Brazil reported

heightened anxiety and depression during the pandemic relative to students tested before its onset.[13] Changes in participant sleep habits were also evident in American university students, such that participants tested after local COVID cases were identified reported later bedtimes, wake times, and spent more time in bed relative to participants tested before local cases were identified.[15] These sleep-related findings have also been reported in community samples: perhaps due to reduced or altered work and school commitments, later bedtimes and wake times were reported mid-pandemic relative to pre-pandemic, although participants tested mid-pandemic had poorer sleep quality overall relative to those tested pre-pandemic.[16,27]

As indicated previously, mental health issues and sleep problems do not occur in isolation: in a community sample of Italian participants, increased stress, anxiety, and depression were related to greater sleep problems;[16] in a community sample of Indian participants, increased depression co-occurred with shorter sleep duration.[27] Importantly, pandemic-related sleep problems and mental health issues differ by gender, with females reporting both poorer sleep quality[11] and greater anxiety, depression, and stress[9–11] relative to males (although see reference[13] for non-significant gender differences on these constructs). As such, research is needed to better understand how males and females may differentially respond to the challenges associated with pandemic life. A specific empirical focus on university students is also warranted: although there has been consistency in findings from university student to community samples, differences have emerged as well. Cross-sectional research conducted with different undergraduate samples pre- and mid-pandemic at a Texas university confirmed previous findings indicating that participants tested mid-pandemic went to bed later, woke up later, and obtained more sleep during the pandemic relative to pre-pandemic. Contrary to previous reports, however, participant sleep quality and insomnia severity did not differ by group, and participants tested mid-pandemic did not report greater stress than students tested pre-pandemic; in fact, one of the mid-pandemic samples reported in reference[12] actually reported experiencing less stress relative to students tested pre-pandemic. The author of this work suggested that this lack of significant group differences may be methodological: for example, the PSQI global score may have been too broad of a measure to reveal significant group differences (the individual subscores were more informative in revealing groups differences in particular aspects of sleep quality). However, more recent research conducted with the same measures

has revealed significant differences in global sleep quality and stress in separate groups of participants tested pre- and mid-pandemic,[14] indicating that the utility of the PSQI global score should be reevaluated and other potential explanations for the lack of group differences should be explored.

To this end, the present study is a cross-sectional investigation with separate samples of undergraduate participants tested before and during the COVID-19 pandemic. Analyses were conducted to determine whether participants tested mid-pandemic reported poorer functioning relative to students tested pre-pandemic when considering measures of global sleep quality, insomnia, stress, and cumulative GPA. We predicted that (1) participants tested mid-pandemic would report poorer global sleep quality relative to participants tested pre-pandemic, and that group differences would be evident on continuous measures and the included subscales; (2) we anticipated that participants tested mid-pandemic would report greater symptoms of insomnia and stress than participants tested pre-pandemic; and (3) we expected that students tested mid-pandemic would report poorer cumulative GPAs relative to students tested pre-pandemic. Additional analyses were conducted to determine whether poor quality sleep and female gender were preferentially associated with poorer mental and physical health for students tested mid-pandemic. (4) We predicted that poor quality sleep would be associated with poorer health, with particularly prominent negative effects apparent for women with poor quality sleep. (5) Finally, we also anticipated that perceived stress would mediate the association between sleep problems (greater insomnia severity and poorer global sleep quality) and cumulative GPA.

Methods

Participants

Pre-pandemic sample
Two hundred seven undergraduate students (127 females) were recruited from a large public university in the southwestern United States to participate in a dissertation study examining sleep and well-being in college club athletes and non-athletes;[28] data concerning associations between sleep and temperament in this sample have been published previously.[29] Participants were tested in-person in university testing space from February-December 2019. Additional details about the recruitment procedures, testing timelines, and participation incentives for the athlete and non-athlete groups are provided in reference.[28]

Mid-pandemic sample
Three hundred thirteen undergraduate students (267 females) were recruited from the Human Subjects Lab Pool (HSLP) at the same university from which the pre-pandemic sample was recruited. Participants were tested from November-December 2020; Figure 1 documents the state of the pandemic during this time. These students completed an online questionnaire and were provided with one point of extra credit to be allocated to an eligible psychology class in appreciation for their participation. Because the mid-pandemic data were collected online, the questionnaire included three "attention check" questions (e.g., "please select 'sometimes;'" "please select 'definitely false'") embedded into banks of Likert-style questions to ensure that participants were reading and accurately responding to the presented items. The final dataset only includes the data from male or female undergraduates who correctly completed the attention check questions.

Measures

Participants in both samples completed the following questionnaires along with others that are not the focus of this report. This research was approved by the UC Irvine Institutional Review Board (HS #2018-4872: Sleep and Well-Being).

Demographic information
Participants tested in the pre-pandemic sample reported on their gender, age,[1] academic standing, race and ethnicity, whether they were being treated for any sleep problems, and whether they were taking any medications that might impact their sleep. They also indicated whether they were college club athletes or not at the time of the study.

The same demographic questions were asked of participants in the mid-pandemic sample, with the exception that participants reported whether they were ever involved in college club or NCAA athletics, as sporting practices and events were disrupted during the pandemic. Additional questions inquired as to whether participants were in therapy (i.e., "Are you currently receiving therapy for a psychiatric or psychological condition or disorder [e.g., depression or generalized anxiety disorder]?") and whether they were taking any psychoactive medications at the time of the study; participants were also asked to report on their living and sleeping arrangements (e.g., "Which of the following options best describes your current living situation?").
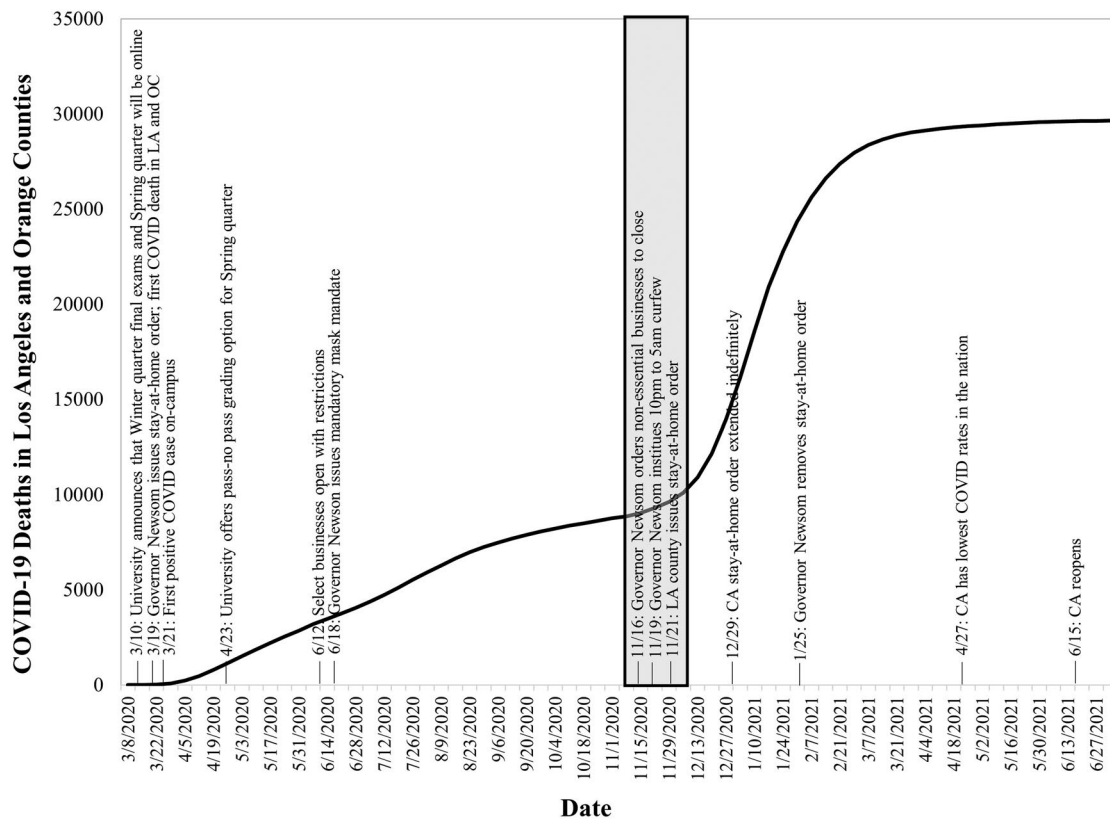
Figure 1. The social-ecological context in Los Angeles and orange counties during mid-pandemic data collection.

GPA

Participants in the pre-pandemic sample were asked to access their unofficial university transcript online after completing the questionnaires associated with this research; the cumulative GPA shown on the screen was recorded by a research assistant. Participants in the mid-pandemic sample agreed to the release of GPA data by the university registrar through a Family Educational Rights and Privacy Act (FERPA) consent statement; these data were obtained after participant testing was complete. Given the procedural differences in which GPA data were obtained, the cumulative GPA data for participants tested pre-pandemic did not include grades from the quarter in which testing occurred, whereas grades from the quarter testing occurred were included in the cumulative GPA data obtained for participants tested mid-pandemic.

Global sleep quality

The Pittsburgh Sleep Quality Index (PSQI[30]) was used to assess self-reported sleep quality. This 19-item measure asks respondents to report on various aspects of their sleep over the previous 30 days (e.g., bedtime, wake time, subjective sleep quality). Responses to the individual items (e.g., "During the past month, what time have you usually gotten up in the morning?" and

"During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?") were reduced and combined to yield seven subscales (daytime dysfunction, sleep disturbances, sleep duration, sleep efficiency, sleep latency, sleep quality, use of sleep medication) that were scored from 0 to 3. These scores were then summed to yield one measure of global sleep quality. Scores range from 0 to 21, with higher scores indicating poorer global sleep quality; scores exceeding 5 indicate categorically poor quality sleep. This measure is commonly regarded as the gold standard for assessing self-reported sleep quality as it has adequate test-retest stability and has successfully differentiated the sleep profiles of patient samples (i.e., individuals with depression and diagnosed sleep problems) and healthy controls. Acceptable measures of internal consistency have been demonstrated in community samples, with slightly lower values obtained with university students (in the present study, α = .64; see references[31,32] for similar values).

Insomnia severity

The 7-item Insomnia Severity Index (ISI[33]) was used to assess self-reported symptoms of insomnia and the extent to which they impacted daily life. Individual items (e.g., "How satisfied/dissatisfied are you with your

current sleep pattern?" and "How noticeable to others do you think your sleep problem is in terms of impairing the quality of your life?") were rated on a scale from 0 to 4 and were summed to yield one composite measure. Scores range from 0 to 28, with higher scores indicating greater sleep problems. This measure has demonstrated consistency with established indicators of insomnia in clinical populations and has adequate internal consistency (in the present study, α = .84).

Stress

The 10-item Perceived Stress Scale (PSS[34]) was used to assess the frequency with which participants experienced various indicators of stress. Individual items (e.g., "In the last month, how often have you felt confident about your ability to handle your personal problems?" and "In the last month, how often have you found that you could not cope with all the things you had to do?") were rated on a scale from 0 to 4 and were summed to yield one composite measure. Scores range from 0 to 40, with higher scores indicating greater stress. This measure has demonstrated acceptable levels of convergent validity and adequate internal consistency in university student samples[35] (in the present study, α = .88).

Health

The RAND-36[36] was used to assess general, physical, and mental health (this questionnaire can be accessed here). Participants responded to 36 items that were rescored and averaged as described here to yield four summary scores assessing physical health (i.e., energy and fatigue, pain, physical functioning, and role limitations due to physical health), three summary scores assessing mental health (i.e., emotional well-being, role limitations due to emotional health, and social functioning), and one item assessing general health. Scores range from 0-100; higher summary scores indicate better functioning. In previous research, scales assessing physical health adequately discriminated between participants with minor versus more severe physical health issues, and scales assessing mental health discriminated among individuals with and without psychiatric issues.[37] In previous research,[38] measures of internal consistency for the various scales ranged from .65 to .94 (in the present study, αs for the individual scales ranged from .73-.89).

Procedure

Participants in the pre-pandemic sample signed written informed consent statements prior to completing the study, whereas participants in the mid-pandemic sample read an online study information sheet (a waiver of written informed consent).

Pre-pandemic sample

Participants completed the questionnaire battery online in university testing space along with other tasks not featured in this report (see reference[28] for more information).

Mid-pandemic sample

Participants read the study advertisement posted on the HSLP website and clicked forward to complete the online questionnaire battery.

Results

Statistical analysis

The outcome measures were examined to identify any outliers, defined as values that were 2.5 standard deviations above or below the mean. Outlying values were truncated to the highest or lowest acceptable values in the dataset, respectively. Review of the raw data also revealed that a subset of the continuous sleep efficiency values exceeded 100% (approximately 7%); these values were truncated to 100% before evaluating the data for outliers.

Cross-sectional comparisons by group and gender

Preliminary between-subjects analyses of variance (ANOVAs) and chi square analyses were conducted to examine whether group (pre-pandemic or mid-pandemic) and gender (male or female) were associated with demographic characteristics. When significant differences were found, separate one-way ANOVAs were conducted to determine whether the demographic data were associated with the primary measures of interest. Demographic variables were included as covariates in the primary analyses of interest when (a) significant differences were found by group or gender and (b) the demographic characteristic was significantly associated with at least one of the primary outcome measures.

After identifying relevant covariates, partial correlations were conducted between the study measures across participants tested pre- and mid-pandemic. In addition, between-subjects analyses of covariance (ANCOVAs) were conducted by group and gender on PSQI scores, the ISI composite, the PSS composite, and cumulative GPA.

Sleep and well-being mid-pandemic

Preliminary between-subjects ANOVAs and chi square analyses were conducted to examine whether categorical sleep quality (good or poor) and gender (male or female) were associated with demographic characteristics for the mid-pandemic sample only. The same process described previously was used to determine when demographic characteristics were included as covariates. Based on previous research revealing poorer mental and physical health for women relative to men during the pandemic,[9–11] between-subjects analyses were conducted to determine whether gender moderated the effect of sleep quality (good or poor) on the eight measures obtained from the RAND-36.

For participants tested in the mid-pandemic sample, we also evaluated competing mediation models to identify pathways among sleep patterns, perceived stress, and cumulative GPA. One set of models included sleep problems (insomnia severity or global sleep quality) as the predictors (x), perceived stress as the mediator (m), and cumulative GPA as the outcome (y). In the other set of models, perceived stress was the predictor (x), sleep problems (insomnia severity or global sleep quality) were the mediators (m), and cumulative GPA was the outcome (y). Mediation was assessed using PROCESS Model 4 as outlined in reference.[39] Mediation was supported when k = 10,000 bias-corrected bootstrap confidence intervals did not include zero.

In the following sections, statistically significant results are reported when $p < .05$; conceptual interpretations are only provided for the highest-order main effect or interaction that achieved statistical significance.

Preliminary analyses conducted by group and gender

As shown in Table 1, significant differences were not found when considering participant age in years. Chi square analyses revealed differences by group on participant gender, however: $\chi^2(1, N = 515) = 38.92$, $p < .001$, $r = .27$, such that a greater percentage of females (85%) were tested mid-pandemic relative to pre-pandemic (61%). Differences were not found by group or gender when considering the distribution of participants by race, academic standing, or use of medications that might impact sleep.

Somewhat unexpectedly, chi square analyses revealed differences by group when considering the percentage of students who were being treated for sleep problems: $\chi^2(1, N = 513) = 14.40$, $p < .001$, $r = .17$, such that a greater percentage of participants tested pre-pandemic reported sleep problems (11%) relative to students tested mid-pandemic (3%). Differences by gender were also observed on this variable: $\chi^2(1, N = 513) = 4.23$, $p = .040$, $r = .09$, as a greater percentage of males were being treated for sleep problems (10%) relative to females (5%). Because self-reported treatment for sleep problems differed by group, we conducted separate one-way ANOVAs to determine whether scores on this variable were associated with the primary measures of interest in this study (i.e., summary scores from the PSQI, ISI, PSS, and GPA). Only one of the conducted analyses achieved statistical significance, such that participants who reported sleep problems had poorer global sleep quality scores on the PSQI (10.09 ± .89) relative to those who did not report sleep problems (6.25 ± .14): $F(1, 458) = 18.30$, $p < .001$, $r = .20$.

Table 1. Demographic information by gender for participants tested pre- and mid-pandemic.

	Pre-pandemic		Mid-pandemic	
	Males	Females	Males	Females
Age (years)	20.54 ± .32	20.32 ± .25	20.93 ± .43	21.05 ± .18
* Gender	39%	61%	15%	85%
* Athletic participation (% yes)	36%	30%	16%	11%
Academic standing				
Freshman	10%	11%	4%	7%
Sophomore	21%	20%	20%	20%
Junior	29%	32%	29%	37%
Senior	40%	37%	47%	36%
Race				
Asian	36%	47%	37%	39%
Hispanic	21%	30%	32%	31%
White	34%	16%	20%	19%
Other	9%	7%	12%	12%
Sleep medication (% yes)	13%	9%	2%	6%
* Sleep problems (% yes)	13%	9%	4%	2%

Note: Means and standard errors are presented for participant age. Significant differences are marked with an asterisk ($p < .05$); information about whether differences were found by group, gender, or both is whether marked variables differ by group, gender, or both is reported in the text.

Group: $\chi^2(1, N = 515) = 31.82$, $p < .001$, $r = .25$, and gender differences: $\chi^2(1, N = 515) = 7.59$, $p = .006$, $r = .12$, were also found when considering whether participants were involved in college sports, such that a greater percentage of males (29%) and participants tested pre-pandemic (32%) participated in sports relative to females (17%) and participants tested mid-pandemic (12%). Because of these differences, we conducted separate one-way ANOVAs to determine whether participation in college sports was associated with the primary measures of interest referenced earlier. The analyses concerning perceived stress: $F(1, 512) = 12.85$, $p < .001$, $r = .16$, and cumulative GPA were statistically significant: $F(1, 482) = 17.80$, $p < .001$, $r = .19$, such that participants who were never involved in college sports reported greater stress (20.32 ± .35) and higher GPAs (3.45 ± .02) than participants

who were involved in college sports (perceived stress: 17.52 ± .70; cumulative GPA: 3.23 ± .05).

Because of (1) the a priori group differences in self-reported treatment for sleep problems and participation in college sports and (2) the associations between these demographic characteristics and at least one of the primary measures included in report, self-reported treatment for sleep problems (0 = no, 1 = yes) and participation in college sports (0 = no, 1 = yes) were included as categorical covariates in the following analyses.

Cross-sectional comparisons by group and gender

Partial correlations between the study measures are shown in Table 2; between-subjects ANCOVAs are presented in Table 3.

Table 2. Partial correlations among study measures for participants tested pre- and mid-pandemic.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.
1. PSQI composite	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
2. Dysfunction	.53*	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
3. Disturbance	.54*	.18*	---	---	---	---	---	---	---	---	---	---	---	---	---	---
4. Duration	.51*	.18*	.19*	---	---	---	---	---	---	---	---	---	---	---	---	---
5. Efficiency	.50*	.02	.19*	.19*	---	---	---	---	---	---	---	---	---	---	---	---
6. Latency	.70*	.24*	.33*	.12*	.24*	---	---	---	---	---	---	---	---	---	---	---
7. Medication	.42*	.13*	.15*	.00	.11*	.22*	---	---	---	---	---	---	---	---	---	---
8. Quality	.67*	.33*	.30*	.31*	.22*	.38*	.23*	---	---	---	---	---	---	---	---	---
9. Bedtime	.20*	.17*	-.03	.23*	-.05	.16*	.05	.26*	---	---	---	---	---	---	---	---
10. Wake time	.17*	.08	.02	-.27*	.30*	.19*	.15*	.16*	.63*	---	---	---	---	---	---	---
11. Sleep latency	.58*	.22*	.21*	.10*	.21*	.76*	.27*	.33*	.23*	.23*	---	---	---	---	---	---
12. Sleep efficiency	-.54*	-.10*	-.23*	-.22*	-.89*	-.28*	-.13*	-.25*	.08	-.31*	-.21*	---	---	---	---	---
13. Time in bed	-.04	-.11*	.03	-.62*	.42*	.06	.13*	-.11*	-.25*	.58*	.05	-.45*	---	---	---	---
14. Time spent asleep	-.48*	-.20*	-.15*	-.85*	-.26*	-.12*	.03	-.33*	-.17*	.35*	-.07	.32*	.66*	---	---	---
15. ISI composite	.73*	.50*	.43*	.32*	.20*	.51*	.28*	.65*	.28*	.20*	.49*	-.25*	-.09	-.30*	---	---
16. PSS composite	.36*	.34*	.23*	.12*	.08	.17*	.18*	.29*	.24*	.20*	.14*	-.12*	-.02	-.11*	.45*	---
17. Cumulative GPA	.10*	-.04	-.12*	-.16*	-.01	.02	-.03	-.11*	.05	.13*	.02	.01	.13*	.15*	-.13*	-.16*

Note: Correlations were conducted controlling for gender (0 = male, 1 = female), athletic participation (0 = no, 1 = yes), and self-reported sleep problems (0 = no, 1 = yes). Variables 2-8 are PSQI subscores; variables 9-14 are continuous measures obtained from the PSQI. Significant associations are marked with an asterisk ($p < .05$).

Table 3. Study measures by gender for participants tested pre- and mid-pandemic.

		Pre-pandemic		Mid-pandemic	
	Overall	Males	Females	Males	Females
1. PSQI composite	6.05 ± .16	5.87 ± .36	5.58 ± .28	6.00 ± .43	6.74 ± .18
2. Daytime dysfunction	1.33 ± .04	1.42 ± .10	1.36 ± .07	1.16 ± .12	1.39 ± .05
3. Sleep disturbance	1.13 ± .03	1.03 ± .06	1.12 ± .05	1.21 ± .07	1.18 ± .03
4. Sleep duration	.58 ± .05	.70 ± .10	.60 ± .08	.49 ± .13	.52 ± .05
5. Sleep efficiency	0.39 ± .04	0.34 ± .09	0.28 ± .07	0.49 ± .11	0.45 ± .04
6. Sleep latency	1.26 ± .06	1.15 ± .13	1.10 ± .10	1.27 ± .16	1.53 ± .06
7. Sleep medication	0.11 ± .02	0.06 ± .04	0.08 ± .03	0.12 ± .05	0.18 ± .02
8. Sleep quality	1.15 ± .03	1.15 ± .07	1.04 ± .06	1.16 ± .09	1.24 ± .04
9. Bedtime	0.76 ± .10	0.31 ± .23	0.18 ± .18	1.33 ± .28	1.22 ± .12
10. Wake time	8.58 ± .12	7.71 ± .25	7.71 ± .20	9.50 ± .31	9.39 ± .13
11. Sleep latency	25.15 ± 1.43	20.94 ± 3.15	19.72 ± 2.45	26.83 ± 3.81	33.11 ± 1.58
12. Sleep efficiency	88.97 ± .63	89.81 ± 1.38	90.73 ± 1.07	87.78 ± 1.67	87.56 ± .69
13. Time in bed	7.81 ± .09	7.40 ± .21	7.53 ± .16	8.18 ± .25	8.14 ± .10
14. Time spent asleep	6.93 ± .07	6.61 ± .16	6.84 ± .13	7.17 ± .20	7.08 ± .08
15. ISI composite	7.89 ± .27	7.12 ± .57	7.51 ± .45	7.56 ± .74	9.39 ± .32
16. PSS composite	18.88 ± .38	17.11 ± .80	18.92 ± .63	18.29 ± 1.05	21.21 ± .44
17. Cumulative GPA	3.36 ± .03	3.23 ± .06	3.26 ± .04	3.48 ± .07	3.49 ± .03

Note: Means and standard errors are presented. Analyses were conducted controlling for athletic participation (0 = no, 1 = yes) and self-reported sleep problems (0 = no, 1 = yes). Variables 2-8 are PSQI subscores; variables 9-14 are continuous measures obtained from the PSQI. Significant interactions between group and gender were not found on any of the listed variables; significant main effects are reported in the text.

PSQI

Categorical differences in participant sleep quality were not found on chi square analyses conducted separately by group and gender, nor was there a significant difference on PSQI global scores by group, gender, or their interaction. Significant group differences were found, however, on three of the seven PSQI subscales. That is, relative to students tested mid-pandemic, those tested pre-pandemic reported better functioning on the disturbance subscale (pre-pandemic: 1.07 ± .04; mid-pandemic: 1.19 ± .04): $F(1, 454) = 4.76$, $p = .030$, $r = .10$; efficiency subscale (pre-pandemic: .31 ± .06; mid-pandemic: .47 ± .06): $F(1, 454) = 3.97$, $p = .047$, $r = .09$; and latency subscale (pre-pandemic: 1.12 ± .08; mid-pandemic: 1.40 ± .08): $F(1, 454) = 5.52$, $p = .019$, $r = .11$. Group differences were not found on the subscales pertaining to daytime dysfunction, sleep duration, sleep quality, and use of sleep medication.

Following previous research,[12,16] additional analyses were conducted on the continuous data obtained from the PSQI. Main effects of group were found on each analyzed variable. Specifically, participants tested pre-pandemic reported earlier bedtimes (.24 ± .15) than participants tested mid-pandemic (1.28 ± .15): $F(1, 454) = 23.72$, $p < .001$, $r = .22$. Participants tested pre-pandemic (7.71 ± .16) also reported earlier morning wake times relative to those tested mid-pandemic (9.44 ± .17): $F(1, 454) = 54.50$, $p < .001$, $r = .33$. Participants reported shorter latency to sleep onset pre-pandemic (20.33 ± 2.01) relative to mid-pandemic (29.97 ± 2.07): $F(1, 454) = 10.94$, $p = .001$, $r = .15$, and participants tested pre-pandemic (90.27 ± .88) reported better sleep efficiency relative to those tested mid-pandemic (87.67 ± .91): $F(1, 454) = 4.15$, $p = .042$, $r = .10$. Finally, participants tested pre-pandemic reported spending less time in bed (7.47 ± .13) than participants tested mid-pandemic (8.16 ± .14): $F(1, 454) = 13.09$, $p < .001$, $r = .17$; similarly, participants tested pre-pandemic reported spending less time asleep (6.73 ± .10) relative to participants tested mid-pandemic (7.12 ± .11): $F(1, 454) = 6.99$, $p = .008$, $r = .12$. Significant effects of gender were not found on any measures obtained from the PSQI; similarly, interactions between group and gender were not apparent.

ISI

A main effect of group was found on the ISI composite: $F(1, 504) = 4.43$, $p = .036$, $r = .09$, as students tested pre-pandemic (7.31 ± .37) reported fewer symptoms of insomnia relative to students tested mid-pandemic (8.48 ± .41). A significant main effect of gender was also apparent: $F(1, 504) = 4.24$, $p = .040$, $r = .09$, such that males reported less severe insomnia (7.34 ± .47) relative to females (8.45 ± .27). A significant interaction between group and gender was not found.

PSS

Main effects of group: $F(1, 506) = 4.97$, $p = .026$, $r = .10$, and gender: $F(1, 506) = 9.74$, $p = .002$, $r = .14$, were found on the PSS composite, such that participants tested pre-pandemic (18.01 ± .51) and males (17.70 ± .66) reported less stress than participants tested mid-pandemic (19.75 ± .57) and females (20.06 ± .38). An interaction between group and gender was not apparent.

Academic achievement

A main effect of group was found on cumulative GPA: $F(1, 476) = 20.96$, $p < .001$, $r = .21$, such that participants tested pre-pandemic (3.24 ± .04) had lower GPAs than participants tested mid-pandemic (3.48 ± .04). A main effect of gender was not found, and a group by gender interaction was not apparent.

Preliminary analyses conducted by categorical sleep quality and gender

As shown in Table 4, a between-subjects ANOVA revealed no differences in participant age by sleep quality, gender, or their interaction; similarly, chi square analyses conducted separately by sleep quality and gender did not identify significant differences on academic standing, the use of medications that may impact sleep, the use of psychoactive medications, or participant sleep arrangements.

Significant differences by sleep quality were found, however, when considering participant race: $\chi^2(3, N = 280) = 12.16$, $p = .007$, $r = .21$, participation in therapy: $\chi^2(1, N = 294) = 4.17$, $p = .041$, $r = .12$, living arrangements: $\chi^2(1, N = 294) = 4.42$, $p = .036$, $r = .12$, and self-reported sleep problems: FET = .010. Visual examination of the data pertaining to sleep problems revealed that none of the participants with good quality sleep reported sleep problems; a subsequent chi square analysis indicated that there were no differences by gender in the incidence of sleep problems among participants with poor quality sleep. For these reasons, sleep problems were not given further consideration as a potential categorical covariate. We did, however, examine whether participant race, participation in therapy, and living arrangements were associated with measures of well-being obtained from the RAND-36.

Between-subjects ANOVAs conducted by race and participant living arrangements did not reveal any

Table 4. Demographic information by sleep quality and gender for participants tested mid-pandemic.

	Good Sleep Quality		Poor Sleep Quality	
	Males	Females	Males	Females
Age (years)	20.27 ± .73	20.65 ± .33	21.50 ± .77	21.44 ± .29
Gender	17%	83%	12%	88%
Athletic participation (% yes)	14%	11%	20%	12%
Academic standing				
Freshman	9%	8%	0%	7%
Sophomore	23%	19%	15%	18%
Junior	36%	41%	20%	35%
Senior	32%	32%	65%	40%
Race				
Asian	41%	44%	20%	30%
Hispanic	27%	19%	35%	37%
White	14%	21%	25%	17%
Other	9%	9%	15%	13%
Sleep medication (% yes)	0%	7%	5%	6%
Sleep problems (% yes)	0%	0%	10%	4%
Psychoactive medication (% yes)	0%	7%	5%	6%
Therapy (% yes)	5%	6%	15%	13%
Living arrangements (% alone)	9%	2%	15%	8%
Sleeping arrangements (% alone in own room)	91%	74%	65%	73%

Note: Means and standard errors are presented for participant age.

significant associations with health. Group differences were found by participation in therapy when considering measures of emotional well-being: $F(1, 292) = 4.37$, $p = .038$, $r = .12$, and pain: $F(1, 292) = 7.35$, $p = .007$, $r = .16$, such that participants who were not in therapy reported better functioning (emotional well-being: 57.35 ± 1.21; pain: 83.19 ± .95) relative to those who were in therapy (emotional well-being: 49.47 ± 3.58; pain: 75.17 ± 2.80).

Because participation in therapy (0 = no, 1 = yes) differed by group and was associated with measures of health from the RAND-36, this variable was included as a categorical covariate in the following analyses.

Sleep and well-being mid-pandemic

Between-subjects ANCOVAs on the eight measures obtained from the RAND-36 are presented in Table 5.

General health

A main effect of sleep quality was found on the one question assessing general health: $F(1, 289) = 6.69$, $p = .010$, $r = .15$, such that participants with good quality sleep reported better general health at the time of the study (67.94 ± 2.47) relative to participants with poor quality sleep (58.80 ± 2.52).

Physical health

Main effects of sleep quality were found on physical functioning: $F(1, 289) = 4.91$, $p = .027$, $r = .13$, and role limitations due to physical health: $F(1, 289) =$

5.76, $p = .017$, $r = .14$, such that students with good quality sleep reported better physical functioning (94.09 ± 1.46) and fewer role limitations due to physical health (76.51 ± 4.27) relative to those with poor quality sleep (physical functioning: 89.47 ± 1.48; role limitations due to physical health: 61.86 ± 4.35). When considering energy and fatigue, significant main effects of sleep quality: $F(1, 289) = 16.83$, $p < .001$, $r = .23$, and gender: $F(1, 289) = 10.59$, $p = .001$, $r = .19$, were apparent, such that students with good quality sleep reported having more energy (49.62 ± 1.97) relative to students with poor quality sleep (38.06 ± 2.01) and males (48.40 ± 2.59) reported having more energy relative to females (39.27 ± 1.07). Significant effects were not found for pain.

Mental health

When considering emotional well-being, main effects of sleep quality: $F(1, 289) = 14.15$, $p < .001$, $r = .22$, and gender: $F(1, 289) = 5.24$, $p = .023$, $r = .13$, were qualified by an interaction with one another: $F(1, 289) = 10.51$, $p = .001$, $r = .19$. Similarly, when considering role limitations due to emotional problems, a main effect of gender: $F(1, 289) = 10.56$, $p = .001$, $r = .19$, was qualified by an interaction with sleep quality: $F(1, 289) = 15.04$, $p < .001$, $r = .22$. Finally, when considering social functioning, a main effect of sleep quality: $F(1, 289) = 4.93$, $p = .027$, $r = .13$, was qualified by an interaction with gender: $F(1, 289) = 5.44$, $p = .020$, $r = .14$. Follow-up pairwise comparisons conducted for these interactions revealed the same pattern of statistical significance. That is, among participants with poor quality sleep, males reported

Table 5. Study measures by sleep quality and gender for participants tested mid-pandemic.

	Overall	Good quality sleep		Poor quality sleep	
		Males	Females	Males	Females
Cross-study measures					
* ISI composite	8.16 ± .35	5.30 ± .89	5.21 ± .40	9.59 ± .93	12.53 ± .35
* PSS composite	19.62 ± .52	17.45 ± 1.33	17.78 ± .60	19.37 ± 1.40	23.87 ± .52
* Cumulative GPA	3.52 ± .04	3.42 ± .09	3.59 ± .04	3.63 ± .10	3.44 ± .04
RAND-36					
General health	63.37 ± 1.76	64.69 ± 4.49	71.20 ± 2.03	60.43 ± 4.71	57.18 ± 1.76
Physical health					
Energy or fatigue	43.84 ± 1.40	52.08 ± 3.58	47.15 ± 1.62	44.72 ± 3.76	31.39 ± 1.40
Pain	83.29 ± 1.25	84.05 ± 3.19	86.83 ± 1.44	83.70 ± 3.35	78.59 ± 1.25
Physical functioning	91.78 ± 1.04	92.44 ± 2.65	95.74 ± 1.20	90.30 ± 2.78	88.65 ± 1.04
Role limitations due to physical health	69.19 ± 3.04	73.71 ± 7.76	79.32 ± 3.51	64.81 ± 8.14	58.91 ± 3.04
Mental health					
* Emotional well-being	60.11 ± 1.43	64.16 ± 3.66	66.89 ± 1.65	62.62 ± 3.84	46.78 ± 1.43
* Role limitations due to emotional health	47.11 ± 3.20	49.95 ± 8.17	53.98 ± 3.69	65.05 ± 8.56	19.47 ± 3.20
* Social functioning	71.82 ± 2.02	74.79 ± 5.17	77.88 ± 2.34	75.20 ± 5.42	59.41 ± 2.02

Note: Means and standard errors are presented. Analyses were conducted controlling for self-reported participation in therapy (0 = no, 1 = yes). Significant interactions between sleep quality group and gender are marked with an asterisk (*p* < .05); significant main effects are reported in the text.

better emotional well-being (*p* < .001), social functioning (*p* = .007), and fewer role limitations due to emotional problems (*p* < .001) relative to females; differences were not found by gender for participants with good quality sleep. Pairwise comparisons conducted by gender indicated that females with good quality sleep reported better emotional well-being (*p* < .001), social functioning (*p* < .001), and fewer role limitations due to emotional problems (*p* < .001) relative to females with poor quality sleep; differences were not found by sleep quality for males.

Mediation models for the mid-pandemic sample

The results of the conducted mediation models are shown in Figure 2. As presented in Panel A, sleep problems (i.e., greater insomnia severity and poorer global sleep quality) were associated with greater perceived stress, and greater perceived stress was negatively related to cumulative GPA. The direct effects of sleep problems on cumulative GPA were not statistically significant, but there was evidence of mediation, such that both greater insomnia severity and poorer global sleep quality negatively impacted cumulative GPA through perceived stress.

Competing mediation models were also tested and are presented in Figure 2, Panel B. As shown, perceived stress was associated with both greater insomnia severity and poorer global sleep quality. Variability in participant sleep problems, however, was unassociated with cumulative GPA. There was a significant direct effect of perceived stress on cumulative GPA, such that greater perceived stress was associated with poorer cumulative GPA. The indirect effects of perceived stress on cumulative GPA through insomnia

severity or global sleep quality were not statistically significant.

Discussion

The COVID-19 pandemic has been associated with poorer sleep and mental health in community samples[17] and in undergraduate students.[13–15] The present cross-sectional study was conducted to (1) determine whether undergraduate students tested before the COVID-19 pandemic reported poorer sleep, greater stress, and poorer academic achievement relative to students tested during the pandemic, (2) identify whether the impact of poor sleep quality on health was moderated by gender for students tested mid-pandemic, and (3) examine whether associations between sleep problems and GPA were mediated by perceived stress. As discussed below, our findings confirmed our hypotheses that students tested mid-pandemic would report poorer sleep and greater stress relative to students tested pre-pandemic and also revealed the anticipated gender disparity in mental health that co-occurred with poor quality sleep.

As predicted based on some previous research,[14,15] students tested mid-pandemic reported poorer sleep, including greater symptoms of insomnia, and increased stress relative to students tested pre-pandemic. Although group differences were not found on either the categorical or continuous measures of global sleep quality obtained from the PSQI, group differences were found on a number of the PSQI subscales. Analyses of the continuous data in particular confirmed previous findings by indicating that participants tested mid-pandemic went to bed later at night, woke up later in the morning, took longer to fall
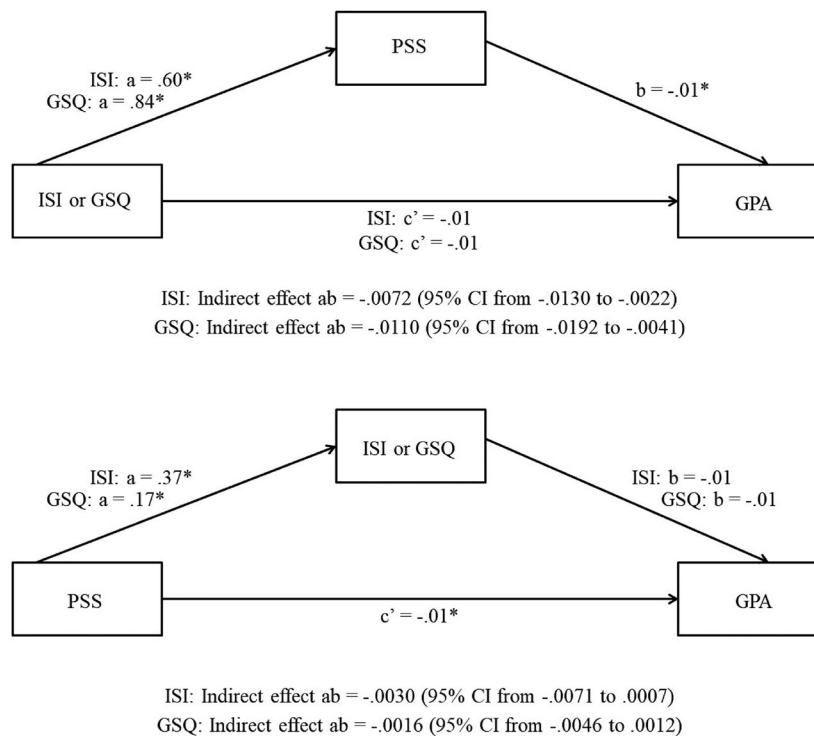
Figure 2. Competing mediation models testing associations among sleep problems, perceived stress, and cumulative GPA for participants tested mid-pandemic. **Note:** Mediation models were conducted controlling for self-reported participation in therapy (0 = no, 1 = yes). Abbreviations are as follows: insomnia severity index (ISI), global sleep quality (GSQ), perceived stress (PSS), and cumulative GPA (GPA). Significant effects are marked with an asterisk ($p < .05$).

asleep, had poorer sleep efficiency, and spent more time in bed and more time asleep at night relative to participants tested pre-pandemic. As described in reference,[16] these findings may be at least partially explained by social changes resulting from the pandemic, such that the transition to working and attending school online may have allowed participants greater ability to set and maintain their preferred sleep-wake schedule than may have been possible pre-COVID. Despite this increased flexibility, however, participants in this and in previous research reported poorer sleep quality on select PSQI subscales mid-relative to pre-pandemic, with greater sleep problems evident for those with poorer mental health.[16,40] Our findings and those reported in reference[12] confirm these associations, as greater stress was associated with poorer sleep on most measures (see Table 2 of this report). Taken together, these results indicate that the challenges associated with the COVID-19 pandemic may have been more harmful than the potential benefits afforded by a more flexible sleep-wake schedule.

Although our findings demonstrate that participants tested mid-pandemic fared more poorly on almost every measured construct relative to those tested pre-pandemic, previous research conducted with undergraduate students has not always revealed similar associations. For example, one other study revealed that participants did not report greater stress during the pandemic relative to before its occurrence; on the contrary, one of the mid-pandemic samples in this research actually reported experiencing less stress relative to students tested pre-pandemic.[12] Although some of our findings were consistent with theirs (e.g., analyses of the continuous data obtained from the PSQI as well as group differences on select PSQI subscales), the summary scores from the ISI and PSS were seemingly more sensitive to group differences in this research relative to that study (our findings from the PSQI global scores were consistent with those reported in reference[12]) The author of that work suggested that the relative lack of significant group differences on these scales may have resulted from the potential insensitivity of these broad measures, highlighting the significant effects obtained on individual items from the PSQI or the PSQI subscales. Our results partially support this assertion, but also suggest the need for another explanation of the divergence in findings across studies. Both studies included large samples of undergraduate students, and both samples were predominantly female. Whereas a greater proportion of Hispanic participants were tested in reference[12] than in this research, both samples were

racially and ethnically diverse. Given these methodological similarities, we evaluated whether study-related differences in the timing of participant testing might be influential, particularly when considering the COVID-related social-ecological context.

Figure 1 of this research and Figure 1 from reference[12] document the timing of participant testing in relation to the broader social-ecological context. As shown in reference,[12] participants in the Spring 2020 mid-pandemic sample were tested at a time when COVID-related deaths were low and a stay-at-home order had been imposed by Texas Governor Abbott. Their Summer 2020 mid-pandemic data collection started shortly after businesses re-opened and the death toll rose from approximately 47 to 1200. The participants in the current study, however, were tested over a short 36-day interval in Fall 2020 amidst a rising death count and serious COVID-related social restrictions (e.g., non-essential businesses were closed, a mandatory nightly curfew was imposed by California Governor Newsom, and a stay-at-home order was in place for Los Angeles County residents). We suspect that the somewhat divergent pattern of findings across this and previous research – despite the use of identical measures and similarities in the undergraduate student samples – result from the unique social-ecological contexts in which participants were tested. These differences highlight the potential utility of (1) examining microgenetic changes in sleep and well-being within the same participants as the social-ecological context (e.g., transmission rates, death counts, hospital capacities, mask wearing practices, guidelines provided by local officials) fluctuates as well as (2) evaluating group differences in participants tested in various parts of the country and the world at the same point in time. Significant group differences should emerge in both instances and should be examined in relation to potentially important social-ecological moderators.

Academic achievement should also be evaluated in relation to these potential moderators. Our findings revealed that the challenges students experienced with sleep and stress were not widely associated with academic achievement and that students tested mid-pandemic had higher cumulative GPAs relative to those tested pre-pandemic (a similar small mid-pandemic increase was reported in reference[41]) The slight apparent boost in students' grades during the pandemic may have resulted in part from mid-pandemic instructional changes consistent with compassionate education,[25] such as the implementation of flexible deadlines, elimination of late submission penalties, and enhanced communication, among others.[26] Although gender differences were not found when considering academic achievement in this research, future studies should be conducted to examine whether women experience greater academic and psychological benefits when compassionate educational practices are used as has been recently documented in a small qualitative research study.[42]

Finally, additional analyses were conducted to identify whether gender moderated associations between sleep and health for participants tested mid-pandemic. The conducted analyses revealed main effects of sleep quality when considering general and physical health, such that students who had poor quality sleep also had poorer general health, poorer physical functioning, greater role limitations due to their physical health, and greater energy and fatigue. As expected, however, associations between sleep quality and mental health were qualified by interactions with gender when considering emotional well-being, role limitations due to emotional problems, and social functioning. The same pattern of significant effects was evident for each outcome, such that women with poor quality sleep reported poorer mental health relative to both men with poor quality sleep and women with good quality sleep; none of the other follow-up pairwise comparisons were statistically significant. Taken together, these findings indicate that poor quality sleep is associated with reduced general and physical health across genders, whereas poor quality sleep is preferentially associated with poorer mental health in female undergraduates.

The finding that female undergraduates experience poor sleep,[43] mental health challenges,[43,44] and the combination of poor sleep quality and mental health[45] has been confirmed in other research conducted during the COVID-19 pandemic. However, the mechanism underlying these significant group differences is not well understood. Previous research has indicated that poor sleep may be both a cause and consequence of mental health issues[18–20] and, as such, longitudinal and experimental work is needed to better understand whether sleep problems precede mental health issues in undergraduates tested during the COVID pandemic, or vice versa.

Additional research should also be conducted to address some of the limitations of the present study. One of the primary shortcomings of this research is that the entire dataset was self-report and questionnaire-based. These measures were used because they could be easily implemented online, which was necessary during the pandemic due to university restrictions on in-person testing. Because we recruited a convenience sample of undergraduate students for the mid-pandemic sample, this group

included a greater proportion of female relative to male participants, and relative to the proportion of females included in the pre-pandemic sample. Future researchers should attempt to recruit a more balanced sample of participants, as issues with statistical power and Type I errors may result when sample sizes are unbalanced.[46] Additional studies should also examine other moderators of sleep and health associations in pre- and mid-pandemic samples (e.g., participant race or ethnicity) to better characterize the impact of the pandemic on potentially unique subsets of the undergraduate population. Future researchers should also conduct longitudinal studies to evaluate causal relations among changing pandemic-related environmental circumstances, sleep patterns, and health with the goal of developing a conceptual model that is amenable to statistical analysis. Testing a comprehensive model of this nature was unfortunately beyond the scope of the current study as the cross-sectional nature of the design precluded our ability to account for the dynamic nature of the pandemic in our analyses.

Despite the need for future research, the present study has significant clinical implications. This work indicates that the stressors associated with the pandemic have been non-trivial for university students, resulting in poorer sleep quality, greater insomnia severity, and poorer health relative to a pre-pandemic sample. Importantly, female undergraduates experienced poorer functioning during the pandemic relative to males, suggesting that intervention efforts should focus on these individuals in particular. Although undergraduate student GPA was higher during the pandemic relative to pre-pandemic times, perceived stress was directly associated with poorer undergraduate student achievement during the pandemic; in addition, poorer global sleep quality and greater insomnia severity indirectly impaired cumulative GPA through perceived stress. For this reason, interventions designed to improve undergraduate student academic achievement may be best focused on helping students reduce or better manage the stressors in their lives.

Conclusions

Although additional work remains to be done, the present study contributes significantly to the existing literature by indicating that (1) undergraduate students tested mid-pandemic report poorer sleep quality, greater symptoms of insomnia, greater stress, and higher cumulative GPAs relative to students tested pre-pandemic, (2) categorically poor sleep quality co-occurred with poorer physical health in students tested mid-pandemic, (3) females with poor quality sleep reported poorer mental health functioning during the pandemic relative to both men with poor quality sleep and women with good quality sleep, and (4) perceived stress mediated the association between sleep problems and cumulative GPA. Identifying potential mechanisms responsible for the observed pattern of effects should be of high priority in future research, with the ultimate goal of developing interventions to be tested and evaluated in experimental settings.

Note

1. The procedure for collecting age information for the club athletes and non-club athletes differed in the pre-pandemic sample: whereas club athletes entered their ages into text boxes, non-club athletes responded to a multiple choice question with responses ranging from 18 years old to over 25 years old. We computed a continuous age variable for the four athletes were who over 25 years old and replaced the missing data for the three non-athletes who were over 25 years old with this value (i.e., 26 years old).

Data availability statement

De-identified data from the mid-pandemic sample are available from the first author upon request; de-identified data from the pre-pandemic sample cannot be released due to restrictions placed on these data by our Institutional Review Board (IRB).

Disclosure statement

No potential conflict of interest was reported by the author(s).

Institutional information

Each of the authors was affiliated with the Department of Psychological Science, UC Irvine, when this work was conducted.

Funding

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References

[1] Oswalt SB, Wyatt TJ. Who needs more sleep? Comparing undergraduate and graduate students' sleep habits in a national U.S. sample. *Int J High Educ.* 2015;4(1):77–85.

[2] Yang C-M, Wu C-H, Hsieh M-H, Liu M-H, Lu F-H. Coping with sleep disturbances among young adults: a survey of first-year college students in Taiwan. *Behav Med*. 2003;29(3):133–138. doi:10.1080/089642803 09596066.

[3] Bayram N, Bilgel N. The prevalence and socio-demographic correlates of depression, anxiety and stress among a group of university students. *Soc Psychiatry Psychiatr Epidemiol*. 2008;43(8):667–672. doi:10.1007/s00127-008-0345-x.

[4] Eisenberg D, Gollust SE, Golberstein E, Hefner JL. Prevalence and correlates of depression, anxiety, and suicidality among university students. *Am J Orthopsychiatry*. 2007;77(4):534–542. doi:10.1037/0002-9432.77.4.534.

[5] Zivin K, Eisenberg D, Gollust SE, Golberstein E. Persistence of mental health problems and needs in a college student population. *J Affect Disord*. 2009;117(3):180–185. doi:10.1016/j.jad.2009.01.001.

[6] Kelly WE, Kelly KE, Clanton RC. The relationship between sleep and grade-point average among college students. *Coll Stud J*. 2001;35(1):84–86.

[7] Cohen AK, Hoyt LT, Dull B. A descriptive study of COVID-19-related experiences and perspectives of a national sample of college students in Spring 2020. *J Adolesc Health*. 2020;67(3):369–375. 10.1016/j.jadohealth.2020.06.009

[8] Son C, Hegde S, Smith A, Wang X, Sasangohar F. Effects of COVID-19 on college students' mental health in the United States: interview survey study. *J Med Internet Res*. 2020;22(9):e21279–14. doi:10.2196/21279.

[9] Clabaugh A, Duque JF, Fields LJ. Academic stress and emotional well-being in United States college students following onset of the COVID-19 pandemic. *Front Psychol*. 2021;12:628787.

[10] Lee J, Jeong HJ, Kim S. Stress, anxiety, and depression among undergraduate students during the COVID-19 pandemic and their use of mental health services. *Innov High Educ*. 2021;46(5):519–538. doi:10.1007/s10755-021-09552-y.

[11] Saadeh H, Saadeh M, Almobaideen W, et al. Effect of COVID-19 quarantine on the sleep quality and the depressive symptom levels of university students in Jordan during the Spring of 2020. *Front Psychiatry*. 2021;12(February):605676–605613. 10.3389/fpsyt.2021.605676

[12] Benham G. Stress and sleep in college students prior to and during the COVID-19 pandemic. *Stress Health*. 2021;37(3):504–515. 10.1002/smi.3016

[13] Maia BR, Dias PC. Anxiety, depression and stress in university students: the impact of COVID-19. *Estud Psicol*. 2020;37:1–8. doi:10.1590/1982-0275202037 e200067.

[14] Marelli S, Castelnuovo A, Somma A, et al. Impact of COVID-19 lockdown on sleep quality in university students and administration staff. *J Neurol*. 2021;268(1):8–15. 10.1007/s00415-020-10056-6

[15] Wright KP, Linton SK, Withrow D, et al. Sleep in university students prior to and during COVID-19 stay-at-home orders. *Curr Biol*. 2020;30(14):R797–R798. http://dx.doi.org/10.1016/j.cub.2020.06.022

[16] Cellini N, Canale N, Mioni G, Costa S. Changes in sleep pattern, sense of time and digital media use during COVID-19 lockdown in Italy. *J Sleep Res*. 2020;29(4):1–5. doi:10.1111/jsr.13074.

[17] Casagrande M, Favieri F, Tambelli R, Forte G. The enemy who sealed the world: effects quarantine due to the COVID-19 on sleep quality, anxiety, and psychological distress in the Italian population. *Sleep Med*. 2020;75:12–20. 10.1016/j.sleep.2020.05.011

[18] Jansson-Fröjmark M, Lindblom K. A bidirectional relationship between anxiety and depression, and insomnia? A prospective study in the general population. *J Psychosom Res*. 2008;64(4):443–449. 10.1016/j.jpsychores.2007.10.016

[19] Sivertsen B, Salo P, Mykletun A, et al. The bidirectional association between depression and insomnia: the HUNT study. *Psychosom Med*. 2012;74(7):758–765. doi:10.1097/PSY.0b013e3182648619.

[20] Lustberg L, Reynolds CF. Depression and insomnia: questions of cause and effect. *Sleep Med Rev*. 2000;4(3):253–262. 10.1053/smrv.1999.0075

[21] Eisenberg D, Golberstein E, Hunt JB. Mental health and academic success in college. *BE J Econ Anal Policy*. 2009;9(1):1–40. doi:10.2202/1935-1682.2191.

[22] Frazier P, Gabriel A, Merians A, Lust K. Understanding stress as an impediment to academic performance. *J Am Coll Health*. 2019;67(6):562–570. doi:10.1080/074 48481.2018.1499649

[23] Hartmann ME, Prichard JR . Calculating the contribution of sleep problems to undergraduates' academic success. *Sleep Health*. 2018;4(5):463–471. doi:10.1016/j.sleh.2018.07.002

[24] Besser A, Flett GL, Zeigler-Hill V. Adaptability to a sudden transition to online learning during the COVID-19 pandemic: understanding the challenges for students. *Scholarship Teach Learn Psychol*. 2020;8(2):85–105. doi:10.1037/stl0000198.

[25] Jazaieri H. Compassionate education from preschool to graduate school. *J Res Innovative Teach Learn*. 2018;11(1):22–66. doi:10.1108/JRIT-08-2017-0017.

[26] Zinger J. *Compassionate Flexibility: Rethinking Course Policies and Deadlines in the Time of COVID-19*. American Psychological Association. Published 2020. https://www.apa.org/ed/precollege/psychology-teacher-network/introductory-psychology/compassionate-flexibility.

[27] Gupta R, Grover S, Basu A, et al. Changes in sleep pattern and sleep quality during COVID-19 lockdown. *Indian J Psychiatry*. 2020;62(4):370–378. doi:10.4103/psychiatry.IndianJPsychiatry_523_20.

[28] Tsukerman D. *Sleep in College Club Athletes: Patterns, Correlates, and Comparisons with College Non-Athletes*. Irvine: University of California, Irvine. Published online 2020;

[29] Lukowski AF, Tsukerman D. Temperament, sleep quality, and insomnia severity in university students: examining the mediating and moderating role of sleep hygiene. *PLoS One*. 2021;16(7):e0251557. doi:10.1371/journal.pone.0251557

[30] Buysse DJ, Reynolds CF, Monk TF, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiatry Res*. 1989;28(2):193–213. doi:10.1016/0165-1781(89)90047-4.

[31] Lukowski AF, Eales L, Tsukerman D. Sleep hygiene mediates, but does not moderate, associations between

temperament and sleep quality in university students. *Behav Med*. 2019;45(4):282–293. doi:10.1080/0896428 9.2018.1509052

[32] Lukowski AF, Milojevich HM. Sleep quality and temperament among university students: differential associations with nighttime sleep duration and sleep disruptions. *Behav Sleep Med*. 2015;13(3):217–230. doi:1 0.1080/15402002.2013.855214

[33] Bastien CH, Vallières A, Morin CM. Validation of the insomnia severity index as an outcome measure for insomnia research. *Sleep Med*. 2001;2(4):297–307. doi:10.1016/S1389-9457(00)00065-4.

[34] Cohen S, Kamarck T, Mermelstein R. A global measure of perceived stress. *J Health Soc Behav*. 1983;24(4):385–396. 10.2307/2136404

[35] Roberti JW, Harrington LN, Storch EA. Further psychometric support for the 10-Item version of the Perceived Stress Scale. *J Coll Couns*. 2006;9(2):135–147. doi:10.1002/j.2161-1882.2006.tb00100.x.

[36] Ware JE, Sherbourne CD. The MOS 36-Item Short-Form Health Survey (SF-36): I. Conceptual framework and item selection. *Med Care*. 1992;30(6):473–483. https://www.jstor.org/stable/3765916.

[37] McHorney CA, Ware JE, Raczek AE. The MOS 36-Item Short-Form Health Survey (SF-36): II. Psychometric and clinical tests of validity in measuring physical and mental health constructs. *Med Care*. 1993;31(3):247–263. https://www.jstor.org/stable/3765819

[38] McHorney CA, Ware JE, Lu JFR, Sherbourne CD. The MOS 36-Item Short-Form Health Survey (SF-36): III. Tests of data quality, scaling assumptions, and reliability across diverse patient groups. *Med Care*. 1994;32(1):40–66. https://www.jstor.org/stable/3766189

[39] Hayes AF. *Introduction to Mediation, Moderation, and Conditional Process Analysis: A Regression-Based Approach*. 2nd ed. New York, NY: Guilford Press; 2018.

[40] Evans S, Alkan E, Bhangoo JK, Tenenbaum H, Ng-Knight T . Effects of the COVID-19 lockdown on mental health, wellbeing, sleep, and alcohol use in a UK student sample. *Psychiatry Res*. 2021;298 (January):113819. doi:10.1016/j.psychres.2021.113819.

[41] Supriya K, Mead C, Anbar AD, et al. Undergraduate biology students received higher grades during COVID-19 but perceived negative effects on learning. *Front Educ*. 2021;6. doi:10.3389/feduc.2021.759624.

[42] Gelles LA, Lord SM, Hoople GD, Chen DA, Mejia JA. Compassionate flexibility and self-discipline: student adaptation to emergency remote teaching in an integrated engineering energy course during COVID-19. *Educ Sci*. 2020;10(11):304–323. doi:10.3390/educs-ci10110304.

[43] Ahammed B, Jahan N, Seddeque A, et al. Exploring the association between mental health and subjective sleep quality during the COVID-19 pandemic among Bangladeshi university students. *Heliyon*. 2021;7(5):e07082. doi:10.1016/j.heliyon.2021.e0 7082.

[44] Prowse R, Sherratt F, Abizaid A, et al. Coping with the COVID-19 pandemic: examining gender differences in stress and mental health among university students. *Front Psychiatry*. 2021;12:650759–650711. doi:10.3389/fpsyt.2021.650759.

[45] Ruscio J, Roche B. Variance heterogeneity in published psychological research: a review and a new index. *Methodology*. 2012;8(1):1–11. doi:10.1027/1614-2241/a000034.

[46] Wong ML, Lau EYY, Wan JHY, Cheung SF, Hui CH, Mok DSY. The interplay between sleep and mood in predicting academic functioning, physical health and psychological health: a longitudinal study. *J Psychosom Res*. 2013;74(4):271–277. doi:10.1016/j.jpsychores.2012.08.014