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Sleep in a Large, Multi-University Sample of College Students: Sleep Problem Prevalence, Sex Differences, and Mental Health Correlates

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Abstract

Objectives—To (1) describe sleep problems in a large, multi-university sample of college students, (2) evaluate sex differences, and (3) examine the unique associations of mental health symptoms (i.e., anxiety, depression, attention-deficit/hyperactivity disorder inattention [ADHD-IN], ADHD hyperactivity-impulsivity [ADHD-HI]) in relation to sleep problems.

Methods—7,626 students (70% female; 81% White) ages 18–29 years (M=19.14, SD=1.42) from six universities completed measures assessing mental health symptoms and the Pittsburgh Sleep Quality Index (PSQI).

Results—A substantial minority of students endorsed sleep problems across specific sleep components. Specifically, 27% described their sleep quality as poor, 36% reported obtaining less than 7 hours of sleep per night, and 43% reported that it takes >30 minutes to fall asleep at least once per week. 62% of participants met cutoff criteria for poor sleep, though rates differed between females (64%) and males (57%). In structural regression models, both anxiety and depression symptoms were uniquely associated with disruptions in most PSQI sleep component

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domains. However, anxiety (but not depression) symptoms were uniquely associated with more sleep disturbances and sleep medication use, whereas depression (but not anxiety) symptoms were uniquely associated with increased daytime dysfunction. ADHD-IN symptoms were uniquely associated with poorer sleep quality and increased daytime dysfunction, whereas ADHD-HI symptoms were uniquely associated with more sleep disturbances and *less* daytime dysfunction. Lastly, ADHD-IN, anxiety, and depression symptoms were each independently associated with poor sleep status.

Conclusions—This study documents a high prevalence of poor sleep among college students, some sex differences, and distinct patterns of mental health symptoms in relation to sleep problems.

Keywords

ADHD; anxiety; depression; daytime sleepiness; PSQI; sex differences; university students

Introduction

College students frequently have poor sleep (1–3). Using the *Pittsburgh Sleep Quality Index* (PSQI) (4), a commonly used measure of sleep in adults, between 40 and 65% of college students in the United States meet cutoff criteria for poor sleep (2, 5–7). Fewer studies have examined rates of specific sleep components, though it appears clear that many (if not most) college students obtain insufficient sleep, have an extended sleep onset latency, and experience generally poor sleep quality (2, 3, 5). Additional studies are needed to describe rates of sleep problems in college students, particularly as a number of studies have only examined total sleep and not specific sleep components (3, 8–12). Further, most studies that have examined sleep in college students included participants from a single university and often had modest sample sizes (2, 3, 5–9, 11, 13). In the present study, we describe sleep in a sample of 7,626 college students recruited from six universities, making it one of the largest studies to date to describe the sleep patterns and problems in college students in the United States.

Studies using the PSQI report mixed findings regarding possible sex differences in sleep problems among college students. Some studies found no differences in sleep problems between male and female college students (9, 11, 14, 15), whereas other studies found female college students to have more sleep problems than male college students (3, 7, 10, 12). The conflicting findings may be due to some studies examining only total sleep (3, 9–12), even though males and females may differ on some domains of sleep but not others. Some studies indicate that females may have poorer sleep than males in the specific domains of sleep quality, sleep duration, sleep disturbances, and daytime dysfunction, though conflicting findings have been reported both across and within extant studies depending on the sleep variables examined (7, 14–16).

It is clear that mental health symptoms are related to poor sleep. What is less clear, however, is whether certain mental health symptoms are more clearly associated with college students' total sleep and/or specific sleep components. In the present study, we focus on anxiety, depression, and attention-deficit/hyperactivity disorder (ADHD) symptoms, as these

are three of the most prevalent mental health problems among college students (17, 18). Given the high co-occurrence between anxiety and depression (19), as well as the high co-occurrence of these internalizing symptoms (anxiety/depression) with ADHD (20), it is important to examine these mental health domains simultaneously. However, studies examining mental health symptoms in relation to college students' sleep have examined internalizing symptoms (anxiety, depression) (3, 10, 11, 21) *or* ADHD symptom dimensions (i.e., inattention [IN], hyperactivity-impulsivity [HI]) (5, 22). Still other studies have only examined anxiety symptoms (15) or depressive (14, 23) symptoms. We are unaware of any study that has simultaneously examined the unique associations of anxiety, depression, and ADHD symptoms in college students.

Depressive symptoms have been examined most frequently in relation to college student sleep, with studies showing depression to be associated with most aspects of sleep. For example, one study found that students with depressive symptoms reported poorer sleep quality, longer sleep onset latency, more night wakings, and greater daytime sleepiness than students without depressive symptoms (23), and depressive symptoms are also related to college students' insomnia specifically (14). Studies of university students that considered both anxiety and depressive symptoms have generally found both of these internalizing mental health domains to be associated with poorer sleep quality (2, 10). For instance, in a sample of over 85,000 United States college students, those with co-occurring anxiety and depression (either diagnosed or symptomatic) had the highest occurrence of self-reported sleep problems, and depression/anxiety status was also associated with students more frequently reporting that sleep problems had a negative impact on their academic performance (24). Conversely, in a recent study of college students that examined both anxiety and depressive symptoms, anxiety symptoms were more clearly associated than depressive symptoms with poorer overall sleep quality, though this study did not examine separate components of sleep (25). Thus, although there are some mixed findings in the extant literature, the findings are generally such that both anxiety and depressive symptoms are independently associated with poorer sleep in college students.

Fewer studies have examined ADHD symptoms in relation to college students' sleep. One study of college students diagnosed with ADHD did not find ADHD symptom severity to be prospectively correlated with either daytime sleepiness or sleep duration, though separate ADHD symptom dimensions were not examined (26). Two other studies found ADHD-IN and ADHD-HI symptoms to have differential associations with sleep components. In a sample of 288 college students, Becker et al. (5) found ADHD-IN symptoms to be uniquely related with increased daytime sleepiness, whereas hyperactivity was uniquely associated with poorer sleep quality, longer sleep onset latency, shorter sleep duration, and greater use of sleep medication. Similarly, Gau et al. (22) found ADHD-IN symptoms to relate to increased daytime sleepiness whereas ADHD-HI symptoms were related to shorter sleep duration in a large sample of college students in Taiwan. It thus appears that ADHD-IN symptoms may be more clearly associated with daytime dysfunction/sleepiness whereas ADHD-HI symptoms may be more clearly associated with nighttime sleep problems. However, neither of these ADHD studies included measures of anxiety or depression in their analyses. Thus, additional studies are needed to examine separate ADHD symptom

dimensions in relation to college students' sleep, as well as to simultaneously consider internalizing symptoms.

The present study had three objectives. First, we described rates of PSQI total sleep problems and component sleep problems in a large, multi-university sample of college students, including rates of college students meeting established cutoff criteria for "poor sleep." We expected approximately half of the sample would be classified with poor sleep on the PSQI (2, 5–7). Second, we examined sex differences in sleep, and we hypothesized that females would generally demonstrate poorer sleep than males, particularly in the PSQI domains of sleep quality, sleep duration, sleep disturbances, and daytime dysfunction (3, 7, 10, 12). Third, we examined the unique associations of anxiety, depression, ADHD-IN, and ADHD-HI symptoms in relation to the PSQI total sleep score and specific PSQI sleep components. We hypothesized that both depression and anxiety symptoms would be uniquely associated with poorer sleep, though we did not make predictions regarding specific sleep components given the absence of literature to guide more specific hypotheses (2, 10, 14, 23). We also hypothesized that ADHD-IN symptoms would be uniquely associated with increased daytime dysfunction, whereas ADHD-HI symptoms would be uniquely associated with longer sleep onset, more sleep disturbances, and shorter sleep duration (5, 22).

Methods

Participants

Participants were 7,626 college students enrolled in six universities in the United States (between 961 and 1,704 students participated at each university). Five of the six universities are public universities, and the universities are located in the Midwest, South, and West regions of the United States. Participants ranged in age from 18 to 29 years (M=19.14, SD=1.42). As summarized in Table 1, the majority of participants self-identified as female (70%), White (81%), and non-Hispanic (91%). Most participants (59%) were in their first year of college.

Procedures

This study was approved by the local Institutional Review Board at each university, with the individual study protocols specifying that data would be merged across sites for analysis and dissemination. Students were informed about the study and could choose to participate if they were ≥18 years old. The survey was offered during both the fall and spring semesters of the 2015–2016 and 2016–2017 academic years, and the survey was open to participants throughout the semester but not during finals week. Participants at each institution completed the survey in Qualtrics and received course credit for participation.

Measures

Sleep—The *Pittsburgh Sleep Quality Index* (PSQI) (4) has 9 items (including one multi-part item with 10 subitems) that assess seven well-validated components of sleep: subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbance (e.g., bad dreams, pain, feeling too hot/too cold), use of sleep medication, and daytime dysfunction.

The daytime dysfunction component is significantly associated with measures of daytime sleepiness (27). Scoring for all components is based on a four-point scale with higher scores reflecting poorer sleep over the past month. Four items (e.g., assessing sleep duration; sleep latency) are open-ended responses that, based on participants' answers, are converted to the four-point scale. A total PSQI score is also calculated, with scores >5 used to classify participants as "poor sleepers" (i.e., clinically significant sleep problems) and scores ≤5 used to classify participants as "good sleepers" (4). The PSQI is internally consistent (4, 27), is reliable across four weeks (2), correlates with other measures of sleep disturbance and daily diaries of sleep activity (27), and has been frequently used with college students (2, 3, 5–16). In addition, the PSQI total score is strongly correlated with scores on the *Insomnia Severity Index* (ISI) in college students ($r = 0.63$) (28). In the present study, $\alpha=0.69$.

ADHD symptoms—The *Barkley Adult ADHD Rating Scale-IV* (BAARS-IV) (29) was used to assess current ADHD symptoms. The BAARS-IV includes 18 items that are consistent with the *Diagnostic and Statistical Manual of Mental Disorders* (4^{th} ed.; *DSM-IV*) symptoms of ADHD that have been updated in their wording to reflect modifications made in *DSM-5*. Using a four-point scale (1=*not at all*, 4=*very often*), participants respond to each item with reference to how often each statement best describes their behavior over the past six months. The ADHD-IN (e.g., "difficulty sustaining my attention in tasks or fun activities") and ADHD-HI (e.g., "fidget with hands and feet or squirm in seat") subscales of the BAARS-IV have demonstrated satisfactory internal consistency and test-retest reliability over a 2- to 3-week time period (29). In the present study, Cronbach's αs were .89 and .83 for the ADHD-IN and ADHD-HI symptom dimensions, respectively.

Internalizing symptoms—The depression and anxiety subscales of the *Depression Anxiety Stress Scales-21* (DASS-21) (30, 31) were used to assess internalizing symptoms. Both the anxiety subscale (e.g., "I was worried about situations in which I might panic and make a fool of myself") and depression subscale (e.g., "I felt down-hearted and blue") consist of seven items, none of which focus on sleep specifically. Participants respond to each item in reference to the past week using a four-point scale (0 = *did not apply to me at all*, 3 = *applied to me very much or most of the time*). The DASS-21 demonstrates high reliability and is widely accepted as being valid for use with college-aged participants (30, 32). In the present study, Cronbach's αs were .81 and .90 for anxiety and depression, respectively.

Analytic Approach

Survey validity checks—Prior to running primary analyses, data were screened for invalid responses. In order to improve the quality of participant responses, we utilized an instructional manipulation check (IMC) (33). The IMC consists of a set of instructions and a question similar to other survey questions in length and response format. In contrast to other questions, though, the instructions indicate that the respondent should ignore the question and click on a specific answer. The use of such questions has been shown to improve subsequent responses, since respondents are primed to focus on the importance of reading the instructions, see Oppenheimer et al. (33). The IMC has been shown to be effective even when participants respond incorrectly to the initial IMC (i.e., they did not read the

instructions carefully). We modeled our question after the example used in Oppenheimer et al. (33); please see Figure 1 in that paper for details.

In addition to the IMC, we also utilized "trap" questions that were designed to detect individuals who were quickly responding to survey questions without sufficient attention to item content. Within each measure of our battery, we included a question that stated something like "If you are paying attention, please click on the response 'sometimes'." In addition to these questions, we had one question at the end of the full survey that asked participants the following: "How much effort did you put into this study from 0 to 10 (0=*not much effort at all*, 5=*moderate effort*, 10=*my best effort*)?" To ensure the validity of responding, we set a threshold of 50% accuracy or higher for the "trap questions" and a self-reported effort rating of 5 or higher. We chose this threshold because we wanted to ensure that participants were putting forth sufficient effort while also not excluding participants who might have responded inaccurately due to attention lapses or impulsive responding (e.g., those with elevated ADHD). This threshold was met by 7,851 of the 8,262 participants (95%) who completed the survey, and 7,626 of these 7,851 participants (97%) completed the items necessary for scoring the PSQI; these 7,626 participants were used in analyses.

Statistical analyses—First, descriptive statistics for the PSQI variables (component scores and poor/good sleep status) were calculated. Independent samples *t*-tests were also used to compare participants classified as poor vs. good sleepers in their bedtime, wake time, sleep onset latency, and sleep duration. Cohen's *d* was computed as a measure of effect size, with 0.2 considered a small effect, 0.5 a medium effect, and 0.8 a large effect (34). Second, independent *t*-tests were conducted to examine whether males and females differed in their mean scores in sleep, and Cohen's *d* was again computed as a measure of effect size. We also calculated the percentage of males and females meeting the cutoff for poor sleep and conducted a chi-square test to examine whether females and males differed in their likelihood of being classified with sleep problems. Third, zero-order correlation analyses were conducted to examine the correlations among the study variables. A correlation of .10 is considered a small effect, .30 is considered a medium effect, and .50 is considered a large effect (34). Fourth, structural regression analyses were conducted in Mplus Version 7.3 (35) to examine the independent associations of ADHD-IN, ADHD-HI, anxiety, and depressive symptoms in relation to sleep. The mental health symptoms were latent constructs comprised of their respective items which were treated as ordered-categories. Analyses used the robust weighted least squares (WLSMV) estimator. There was little missing information (covariance coverage was approximately 99%; the WLSMV uses a pairwise approach to missing information). Separate models were conducted for continuous sleep and dichotomous "poor/good sleep" classification dependent variables. Participant demographics (i.e., age, sex, race [dummy-coded]) and site were included as covariates in the structural regression analyses. The collinearity diagnostics were within acceptable limits for the regression analyses (tolerance = 0.32 to 0.48; variance inflation factor [VIF] = 2.07 to 3.16). The Mplus model constraint procedure was used to test factor correlations and the partial standardized regression coefficients for significant differences among the mental health symptom dimensions in relation to sleep.

Results

Rates of Sleep Problems in College Students on the PSQI

As summarized in Table 2, approximately 27% of participants described their sleep quality as either “fairly bad” or “very bad.” Approximately 43% indicated that they cannot fall asleep within 30 minutes at least once per week (with 21% indicating that it takes over 30 minutes to fall asleep three or more times per week). As shown in Table 3, participants reported an average bedtime of 12:17am, an average wake time of 8:27am, and an average sleep onset latency of 30.59 minutes. Most participants reported good sleep efficiency (60% with scores ≥85%), no use of sleep medications in the past month (76%), low levels of sleep disturbance (71% with component scores of 0 or 1), and low levels of daytime dysfunction (75% with component scores of 0 or 1) (see Table 2).

Only a third of participants (36.7%) reported obtaining 7 or more hours of sleep per night (see Table 2). Since 7–9 hours is the current recommendation for sleep duration among young adults (36), we also examined the percentage of students who reported obtaining <7 hours and >9 hours of sleep each night. Slightly over one-third of participants (35.7%, n = 2,719) reported obtaining <7 hours of sleep each night, almost two-thirds (62.0%, n=4,730) reported obtaining the recommended 7–9 hours of sleep each night, and a small percentage (2.3%, n=177) reported obtaining >9 hours of sleep each night.

As shown in Table 2, 62% of participants were classified as poor sleepers (i.e., PSQI total score >5). Since the poor sleep classification is based on the PSQI component scores, it is unsurprising that students classified as poor sleepers had significantly poorer sleep than students classified as good sleepers across all seven PSQI component scores (ts=34.67 to 63.61, all ps<.001). Poor sleepers also reported going to bed an average of half an hour later than good sleepers (12:29am ± 79 min. and 11:58pm ± 68 min., respectively; t=17.82, p<.001, d=.42) and waking approximately eight minutes later than good sleepers (8:30am ± 83 min. and 8:22am ± 74 min., respectively; t=4.76, p<.001, d=.11). Poor sleepers also reported taking approximately 21 minutes longer to fall asleep than good sleepers (38.78 ± 31.00 min. and 17.33 ± 12.71 min., respectively; t=42.01, p<.001, d=.91). Finally, poor sleepers reported getting over an hour less sleep duration each night than good sleepers (6.54 ± 1.18 hr. and 7.73 ± 0.95 hr., respectively; t=48.19, p<.001, d=1.11).

Sex Differences in Sleep

Sex differences in bedtime, wake time, sleep onset latency, and PSQI component scores are summarized in Table 3, including effect sizes of sex differences. Males reported going to bed an average of 20 minutes later than females. Males also reported waking six minutes later than females. Females reported taking longer to fall asleep than males, using sleep medication more frequently, having more daytime dysfunction, having lower sleep efficiency, and having more sleep disturbances. Males and females did not differ in sleep duration or sleep quality. However, females had higher total PSQI scores than males. Likewise, consistent with these analyses, using continuous measures of sleep, 64% of females (n=3,421) met the established cutoff for poor sleep, compared to 57% of males (n=1,289), χ^2=35.90, p<.001.

Correlation Analyses

Table 4 provides the intercorrelations and descriptive statistics of the study variables[1]. There were instances when non-White race was associated with poorer sleep (with the exception of White race being associated with increased sleep medication use), though effect sizes were consistently negligible or small. Age was generally unassociated with sleep and the few significant correlations were negligible in size. In addition to female sex being significantly associated with poorer sleep across all sleep domains except sleep duration and sleep quality (see above and Table 3), female sex was also significantly correlated with higher anxiety (small effect size); sex was unassociated with depression or ADHD symptoms.

All four mental health symptom dimensions (i.e., ADHD-IN, ADHD-HI, anxiety, depression) were significantly correlated with each of the sleep variables (all *p*s<.05; see Table 4). Most effect sizes were in the small to moderate range, with the exception of both ADHD-IN and depression symptoms being strongly associated with daytime dysfunction (large effect sizes). Of note, the intercorrelations among the sleep components were generally only small to medium in size (*r*s=0.04 to 0.44; see Table 4).

Mental Health Symptom Dimensions Uniquely Associated with Sleep Problems

Table 5 shows the unique associations (standardized partial regression coefficients) of ADHD-IN, ADHD-HI, anxiety and depression symptoms in relation to continuous sleep variables. Although ADHD-HI symptoms were significantly associated with all sleep components at the bivariate level, in the regression analysis, ADHD-HI symptoms were only significantly associated with increased sleep disturbances and *less* daytime dysfunction. ADHD-IN symptoms remained significantly associated with only two specific sleep components: poorer sleep quality and increased daytime dysfunction. Anxiety and depressive symptoms both remained uniquely associated with most sleep components, with a few exceptions: anxiety (but not depression) symptoms were uniquely associated with increased sleep disturbances and sleep medication use whereas depressive (but not anxiety) symptoms was uniquely associated with increased daytime dysfunction. ADHD-IN, anxiety, and depression symptoms were each uniquely associated with significantly higher PSQI total score (see Table 5)[2].

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[1]Site was generally unassociated with sleep and all significant correlations were small in magnitude (all *r*s<|.07|). Further, an analysis of variance (ANOVA) was applied to the PSQI component scores to determine the magnitude of site effects. The η^2 values ranged from .001 (Component 3: sleep duration) to .008 (Component 2: sleep latency) with the average effect size for the 7 sleep components being .0057 (*SD* = .002). Although the effect size for site was small, to be conservative site was nevertheless included as a covariate in the structural regression analyses.

[2]The PSQI Daytime Dysfunction component is based on two items: one item assesses daytime sleepiness (i.e., "During the past month, how often have had had trouble staying awake while driving, eating meals, or engaging in social activity?") whereas another item assesses energy/enthusiasm for completing things (i.e., "During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?"). As participants may respond to this latter item in reference to poor sleep or a number of other factors (e.g., motivation, academic engagement, physical health), we conducted exploratory analyses examining these items separately. A paired samples *t*-test found that participants had higher mean scores on the "enthusiasm to get things done" item (*M* = 1.07, *SD* = 0.87) compared to the "trouble staying awake" item, (*M* = 0.58, *SD* = 0.79), *t* = 47.98, *p* < .001). A structural regression model including these separate items as dependent variables was conducted, with age, race, sex, ADHD-IN, ADHD-HI, anxiety, and depression included together as independent variables. Only depressive symptoms were significantly associated with higher scores on the "enthusiasm to get things done" item (β = 0.55, *SE* = 0.02, *p* < .001). In contrast, female sex (β = 0.05, *SE* = 0.01, *p* = .001), ADHD-IN symptoms (β = 0.19, *SE* = 0.02, *p* < .001), anxiety symptoms (β = 0.15, *SE* = 0.03, *p* < .001), and depressive symptoms (β = 0.13, *SE* = 0.03, *p* < .001) were each uniquely associated with higher scores on the "trouble staying awake" item.

As summarized in Table 5, the Mplus model constraint procedure indicated that there were some differences in the magnitude of the significant associations between mental health symptoms and sleep. Depressive symptoms were more strongly associated than ADHD-IN symptoms with poorer sleep quality (p=.007). Anxiety symptoms were more strongly associated than ADHD-HI symptoms with sleep medication use (p<.001). Depression and ADHD-IN symptoms did not differ in their magnitude of their associations with daytime dysfunction (p>.05). Anxiety and depression symptoms did not differ in the magnitude of their associations with sleep quality, sleep latency, sleep duration, or sleep efficiency (all ps>.05). Anxiety and depression symptoms also did not differ in the magnitude of their associations with the PSQI total score (p>.05), though both anxiety and depression were more strongly associated than ADHD-IN symptoms with the PSQI total score (both ps=.04).

Table 6 shows the unique associations of mental health symptoms in predicting dichotomous poor sleep status. Above and beyond race and age, female sex remained significantly associated with being classified with poor sleep. In addition, ADHD-IN, anxiety, and depression symptoms were each uniquely associated with being classified as a poor sleeper, and the Mplus model constraint procedure indicated that these mental health symptoms did not differ in the magnitude of their associations with poor sleep status.

Discussion

This study is important in adding to the growing literature examining sleep in college students. In particular, our study included over 7,600 college students from six universities, which increases the generalizability of our findings and is one of the largest study to date describing the sleep of college students in the United States. In addition, we included both total sleep and specific sleep components to [1] describe sleep patterns and problems in college students, [2] evaluate sex differences in sleep, and [3] examine the unique associations of several mental health symptom dimensions in relation to college students' sleep.

Findings indicate that a sizeable minority (25–33%) of college students experience poor sleep across the PSQI components. For example, over one-quarter of participants described their sleep quality as poor, one-third of participants reported obtaining less than seven hours of sleep per night, and almost half of participants reported that it takes more than 30 minutes to fall asleep at least once per week. These prevalence rates are important since poor sleep quality, shortened sleep duration, and delayed sleep onset latency can have a significant impact on college students' daytime functioning. For example, these sleep difficulties portend poorer academic functioning, emotion dysregulation, and increased daytime sleepiness which is itself associated with adverse outcomes such as motor vehicle accidents (9, 37–40). Furthermore, over 60% of college students across six universities met cutoff criteria for poor sleep, a rate that is troublesome but is remarkably similar to previous studies with smaller sample sizes examining rates of PSQI-defined sleep problems in college students (2, 5).

Also consistent with several previous studies with college students (3, 7, 10, 12, 41), we found that females generally reported more sleep problems than males, though it should be

noted that in several instances the group differences were small in magnitude, and we found no evidence for sex differences in sleep duration or sleep quality specifically. The largest effects for sex differences were in the domains of sleep efficiency and sleep disturbances, as well as total sleep. These differences are in line with several smaller-scale studies examining sex differences in college students. Similarly, females were significantly more likely than males to meet cutoff criteria for poor sleep. Considered together, female college students report more sleep problems than males, though research is needed to evaluate whether these differences are clinically meaningful.

Finally, we found that mental health symptoms, when examined simultaneously, had different patterns of associations with sleep. Anxiety and depressive symptoms were most consistently associated with poorer sleep, with similar associations with sleep quality, sleep latency, sleep duration, and sleep efficiency. However, anxiety and depressive symptoms also parted ways in several instances: anxiety symptoms (but not depressive symptoms) were uniquely associated with more sleep disturbances and sleep medication use, whereas depressive symptoms (but not anxiety symptoms) were uniquely associated with increased daytime dysfunction. However, when the PSQI daytime dysfunction items were examined separately in supplemental analyses, anxiety, depression, and ADHD-IN symptoms were each significantly associated with more “trouble staying awake” during daytime activities (i.e., daytime sleepiness), whereas depressive symptoms alone were associated with more problems keeping up “enough enthusiasm to get things done” (see Footnote 2). We are not aware of previous studies that have examined these specific unique associations, and these findings underscore the importance of specificity when examining internalizing mental health symptoms and sleep. To that end, ADHD symptom dimensions were uniquely associated with fewer sleep domains in the current study than in previous studies (5, 22), likely due to our simultaneous inclusion of internalizing symptoms. Nevertheless, ADHD-IN symptoms were uniquely associated with poorer sleep quality and increased daytime dysfunction, whereas ADHD-HI symptoms were uniquely associated with more sleep disturbances but *less* daytime dysfunction. Lastly, ADHD-IN, anxiety, and depressive symptoms were each uniquely associated with poorer overall sleep – defined continuously or categorically. Our findings point to the importance of evaluating multiple mental health symptoms together, particularly since mental health symptom dimensions are themselves strongly associated among each other (19, 20).

Our findings indicate that it is important to assess for *both* mental health and sleep problems in college students. In fact, recent intervention research suggests that improving college students’ sleep may also improve mood (42, 43), though there is clearly a need for more studies that examine the impact of current interventions for both sleep and mental health and whether interventions need to be tailored or modified based on the specific sleep and/or mental health problems present. In any event, existing research suggests that the largest effects for sleep interventions in college students are cognitive-behavioral therapy (CBT) based interventions (as opposed to sleep hygiene interventions) (44), and CBT-based interventions may also be particularly useful in targeting associated mental health problems (45, 46). However, it is important to note that directionality and causality cannot be determined in the present study, and bidirectional relations are certainly possible. Although we were interested in how different mental health symptom dimensions were associated with

sleep, it is likewise possible that mental health symptoms could be consequences of (or exacerbated by) inadequate or poor sleep. Longitudinal studies will be needed to determine directionality and potential cascading effects, while also pointing to potential intervention targets.

Several limitations are important to note and should inform future research. Although our sample size was large and drawn from multiple universities in an effort to increase representativeness and generalizability, our study did not use a nationally representative design. Only a handful of universities were included and the majority of participants were female and non-Hispanic White. Our sample might thus have been overly likely to report sleep problems, though our sample was demographically similar to other large studies examining sleep in college students (2, 24). It would also have been helpful to have other information about the study participants, such as academic major, alcohol/tobacco use, health-related factors/medical conditions, and electronic media use. Interestingly, though more research is needed, there is evidence suggesting that college students may use alcohol and media to cope with sleep problems rather than alcohol/media use contributing to sleep problems (39, 47). Future studies should include mental health symptoms when examining these associations. For example, it is possible that mental health symptoms contribute to sleep problems, which in turn contribute to increased alcohol/substance and media use, which in turn worsens both mental health and sleep in a reciprocal, cascading negative cycle. In addition, in this study we focused on depression, anxiety, and ADHD symptoms as these are three of the most common mental health problems among college students (17, 18), though we were unable to examine other mental health domains (e.g., bipolar disorder) or specific facets of anxiety and depression (e.g., anhedonia). In addition, in order to execute the study with the number of participants included, we relied solely on self-report measures and were unable to include other measures of either mental health (e.g., diagnostic interviewing) or sleep (e.g., actigraphy, polysomnography). In particular, the PSQI is insufficient by itself for diagnosing insomnia, which occurs in approximately 8% of college students (48). In addition, the PSQI does not differentiate between weekday and weekend sleep, so we were unable to evaluate constructs related to this distinction such as weekend oversleep or social jet lag; we also did not assess chronotype/circadian preference, sleep variability, or obstructive sleep apnea syndrome. Our study also used a cross-sectional design for which claims of directionality and causality cannot be made. Future studies would benefit from even greater representativeness as well as a multi-method, longitudinal design (e.g., daily sleep diaries, actigraphy). Longitudinal research will also be crucial for testing pathways among the variables examined in this study, and it would be particularly informative to have studies that span the transition to college in order to document how sleep changes as college commences.

Despite these limitations, several strengths are also important to note. This is one of the largest studies to date describing sleep patterns and problems in college students. This is particularly important since data were merged from six different universities. In addition, ours is the first study to simultaneously examine anxiety, depression, and ADHD symptom dimensions in an effort to more thoroughly evaluate the unique associations of specific mental health symptoms in relation to sleep. In sum, our study documents the high prevalence of sleep problems among college students, points to possible sex differences in

sleep, and demonstrates distinct patterns when examining mental health symptoms in relation to sleep.

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Table 1

Demographic Characteristics of Study Participants (N = 7,626)

Variable	% (*N*)
Sex[a]	
Male	29.8% (2,272)
Female	70.2% (5,343)
Other	0.1% (9)
Year of Study	
Freshman	58.8% (4,483)
Sophomore	21.3% (1,623)
Junior	12.3% (940)
Senior	7.3% (557)
Other	0.3% (23)
Race[a]	
White	81.3% (6,175)
Black	6.5% (497)
Asian	6.1% (460)
Native American	0.5% (40)
Native Hawaiian/Pacific Islander	0.4% (29)
Biracial/Multiracial	5.1% (390)
Ethnicity[a]	
Non-Hispanic	91.2% (6,947)
Hispanic	8.8% (668)

Note.

[a]Two participants did not complete the sex question, 35 did not complete the race question, and 11 did not complete the ethnicity question.

Table 2

Sleep Quality and Its Component Scores on the Pittsburgh Sleep Quality Index (PSQI) in College Students

Variable	% (*N*)
Total sleep quality	
Good sleep	38.1% (2,906)
Poor sleep	61.9% (4,720)
Subjective sleep quality	
Very good	12.1% (926)
Fairly good	60.7% (4,628)
Fairly bad	24.4% (1,859)
Very bad	2.8% (213)
Cannot sleep within 30 minutes	
Not during the past month	27.5% (2,094)
Less than once a week	29.1% (2,218)
Once or twice a week	22.5% (1,715)
Three or more times a week	20.9% (1,595)
Sleep duration	
>7 hours	36.7% (2,797)
6–7 hours	32.6% (2,485)
5–6 hours	27.8% (2,118)
< 5 hours	3.0% (226)
Sleep efficiency	
≥ 85%	60.3% (4,597)
75–84%	25.1% (1,916)
65–74%	9.6% (735)
< 65%	5.0% (378)
Sleep latency component[a]	
≤15 minutes	20.2% (1,537)
16–30 minutes	36.6% (2,791)
31–60 minutes	27.0% (2,059)
>60 minutes	16.2% (1,239)
Use of sleep medications	
Not during the past month	75.6% (5,762)
Less than once a week	13.1% (1,001)
Once or twice a week	6.3% (479)
Three or more times a week	5.0% (384)
Sleep disturbances[a]	
0	3.7% (279)
1	66.8% (5,097)
2	28.0% (2,137)
3	1.5% (113)
Daytime dysfunction[a]	

Variable	% (*N*)
0	23.1% (1,759)
1	51.6% (3,937)
2	21.6% (1,650)
3	3.7% (280)

Note. $N = 7{,}626$.

[a]Minimum score = 0 (better), maximum score = 3 (worse). For additional details on the scoring of the PSQI components, see Buysse et al. (4).

Table 3

Pittsburgh Sleep Quality Index (PSQI) Descriptive Statistics and Sex Differences

		Sex Differences			
	Full Sample (*N* = 7,626)	**Females (*N* = 5,343)**	**Males (*N* = 2,272)**		
Variable	***M* ± *SD***	***M* ± *SD***	***M* ± *SD***	***t***	***d***
Bedtime	12:17am ± 76 min.	12:11am ± 75 min.	12:31am ± 76 min.	−10.64***	0.27
Wake time	8:27am ± 80 min.	8:25am ± 79 min.	8:31am ± 82 min.	4.82***	0.08
Sleep onset latency (min)	30.59 ± 27.65	31.53 ± 28.35	28.31 ± 25.77	3.12**	0.12
Total sleep time (h)	6.99 ± 1.24	7.00 ± 1.27	6.99 ± 1.17	0.35	0.01
PSQI total score	6.87 ± 3.29	7.05 ± 3.35	6.44 ± 3.10	7.72***	0.19
PSQI component scores					
Sleep quality	1.18 ± 0.67	1.19 ± 0.67	1.16 ± 0.66	1.71	0.05
Sleep latency	1.39 ± 0.98	1.42 ± 0.99	1.34 ± 0.98	2.99**	0.08
Sleep duration	0.97 ± 0.87	0.98 ± 0.88	0.95 ± 0.86	1.04	0.03
Sleep efficiency	0.59 ± 0.86	0.65 ± 0.89	0.47 ± 0.77	8.79***	0.22
Sleep disturbances	1.27 ± 0.55	1.31 ± 0.55	1.19 ± 0.53	8.72***	0.22
Sleep medication	0.41 ± 0.82	0.44 ± 0.85	0.34 ± 0.74	5.17***	0.13
Daytime dysfunction	1.06 ± 0.77	1.09 ± 0.77	0.99 ± 0.76	4.93***	0.13

Note. The range for PSQI total score is 0 to 20 for females and 0 to 19 for males; the range for the PSQI component score variables is 0 to 3 for both females and males. For all PSQI variables, higher scores indicate worse sleep. PSQI = Pittsburgh Sleep Quality Index.

*** $p < .001$.

** $p < .01$.

* $p < .05$.

Table 4

Intercorrelations and Descriptive Statistics of Study Variables

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Sex	--															
2. Race	.02	--														
3. Age	**−.09***	**−.09***	--													
4. ADHD-IN	−.01	−.02	.03*	--												
5. ADHD-HI	.01	**.04***	−.01	**.57***	--											
6. Anxiety	**.07***	−.03*	.01	**.52***	**.46***	--										
7. Depression	.01	−**.04***	.03*	**.53***	**.32***	**.64***	--									
8. Sleep quality	.02	−.03*	.02	**.27***	**.19***	**.28***	**.31***	--								
9. Sleep latency	**.03***	−.001	.03*	**.19***	**.15***	**.22***	**.22***	**.44***	--							
10. Sleep duration	.01	**−.11***	**.04***	**.17***	**.13***	**.19***	**.21***	**.44***	**.22***	--						
11. Sleep efficiency	**.10***	−.02*	.02	**.12***	**.08***	**.14***	**.14***	**.26***	**.24***	**.42***	--					
12. Sleep disturbances	**.06***	.003	.02	**.28***	**.26***	**.38***	**.31***	**.34***	**.34***	**.15***	**.18***	--				
13. Sleep medication	**.06***	**.08***	.01	**.14***	**.13***	**.18***	**.15***	**.19***	**.23***	**.04***	**.12***	**.23***	--			
14. Daytime dysfunction	**.09***	.01	.02	**.46***	**.27***	**.39***	**.49***	**.36***	**.21***	**.25***	**.12***	**.30***	**.16***	--		
15. Total sleep	**.09***	minus;.02	**.04***	**.37***	**.28***	**.41***	**.42***	**.71***	**.67***	**.62***	**.58***	**.55***	**.47***	**.56***	--	
16. Sleep status	**.07***	minus;.02*	.01	**.28***	**.21***	**.29***	**.30***	**.53***	**.56***	**.50***	**.40***	**.41***	**.31***	**.43***	**.76***	--
Mean	--	--	19.14	0.66	0.63	0.49	0.54	1.18	1.39	0.97	0.59	1.27	0.41	1.06	6.87	--
SD	--	--	1.42	0.55	0.50	0.52	0.62	0.67	0.98	0.87	0.86	0.55	0.82	0.77	3.29	--

Note. N = 7,626. For sex, 0 = male, 1 = female. For race, 0 = non-White, 1 = White. For sleep status, 0 = good sleep, 1 = poor sleep. For all sleep variables, higher scores indicate worse sleep. ADHD-HI = attention-deficit/hyperactivity disorder hyperactivity-impulsivity symptoms. ADHD-IN = attention-deficit/hyperactivity disorder inattention symptoms.

* $p < .05$.

* ***p* < .01 (bold)**.

* ***p*< .001 (bold and underline)**.

Table 5

Standardized Unique Associations (Standard Errors) of ADHD and Internalizing Symptom Dimensions on College Students' Sleep

	Sleep Quality	**Sleep Latency**	**Sleep Duration**	**Sleep Efficiency**
Sex	.01 (.01)	.02 (.01)	.01 (.01)	.08 (.01) ***
Race	−.01 (.01)	.01 (.01)	−.10 (.01) ***	−.02 (.01)
Age	−.01 (.01)	.01 (.01)	.04 (.01) **	.02 (.01)
ADHD-IN	.09 (.02) ***a	.04 (.02)a	.03 (.02)a	.04 (.02)a,b
ADHD-HI	.01 (.02)b	.03 (.02)a	.02 (.02)a	−.02 (.02)a
ANX	.11 (.03) ***a,c	.12 (.03) ***b	.08 (.03) **a,b	.08 (.03) **b
DEP	.19 (.02) ***c	.12 (.03) ***b	.14 (.03) ***b	.07 (.03) **b
	Sleep Disturbances	Sleep Medication	Daytime Dysfunction	PSQI Total
Sex	.06 (.01) ***	.04 (.01) **	.06 (.01) ***	.07 (.01) ***
Race	.02 (.01)	.09 (.01) ***	.03 (.01) ***	.001 (.01)
Age	.01 (.01)	.01 (.02)	.003 (.01)	.02 (.01)
ADHD-IN	.04 (.02)a	.03 (.02)a	.29 (.02) ***a	.13 (.02) ***a
ADHD-HI	.05 (.02) *a	.02 (.02)a	−.05 (.02) **b	.01 (.02)b
ANX	.35 (.03) ***b	.17 (.03) ***b	.02 (.02)b	.20 (.03) ***c
DEP	.02 (.02)a	.001 (.03)a	.35 (.02) ***a	.21 (.02) ***c

Note. N = 7,626. For sex, 0 = male, 1 = female. For race, 0 = non-White, 1 = White. For all PSQI variables, higher scores indicate worse sleep (the first seven outcome variables in the table are the seven PSQI component scores, whereas the eighth outcome variable is the PSQI total score). Within each sleep variable, regression coefficients with different superscripts among the mental health symptom dimensions differ significantly in relation to the outcome variable at $p < .05$. All analyses controlled for site. ADHD-HI = attention-deficit/hyperactivity disorder hyperactivity-impulsivity symptoms. ADHD-IN = attention-deficit/hyperactivity disorder inattention symptoms. ANX = anxiety symptoms. DEP = depressive symptoms. PSQI = Pittsburgh Sleep Quality Index.

* $p < .05$.

** $p < .01$.

*** $p < .001$

Table 6

Standardized Unique Associations (Standard Errors) of ADHD and Internalizing Symptom Dimensions on Being Classified with Poor Sleep

	Poor Sleep Status
Sex	.07 (.02)***
Race	−.01 (.01)
Age	−.01 (.02)
ADHD-IN	.13 (.03)***[a]
ADHD-HI	.02 (.03)[b]
ANX	.19 (.04)***[a]
DEP	.22 (.03)***[a]

Note. N = 7,626. For sex, 0 = male, 1 = female. For race, 0 = non-White, 1 = White. For poor sleep status, 0 = good sleep, 1 = poor sleep. ADHD-HI = attention-deficit/hyperactivity disorder hyperactivity-impulsivity symptoms. ADHD-IN = attention-deficit/hyperactivity disorder inattention symptoms. ANX = anxiety symptoms. DEP = depressive symptoms.

* $p < .05$.

** $p < .01$.

*** $p < .001$.