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Original Article

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Sleep disparities in the first month of college: implications for academic achievement

Vanessa N. Bermudez[1,2], Danielle Fearon-Drake[3], Meaghann Wheelis[3], Michelle Cohenour[4], Zainab Suntai[5] and Michael K. Scullin[1,*]

[1] Department of Psychology and Neuroscience, Baylor University, USA,
[2] School of Education, University of California, Irvine, USA,
[3] Office of Institutional Research, Baylor University, USA,
[4] Paul L. Foster Success Center, Baylor University, USA and
[5] Diana R. Garland School of Social Work, Baylor University, USA

*Corresponding author. Michael K. Scullin, Department of Psychology and Neuroscience, Baylor University, One Bear Place 97334, Waco, TX 76798, USA. Email: Michael_Scullin@Baylor.edu

Abstract

Study Objective: We investigated sleep disparities and academic achievement in college.

Methods: Participants were 6,002 first-year college students attending a midsize private university in the southern United States [62.0% female, 18.8% first-generation, 37.4% Black, Indigenous, or People of Color (BIPOC) students]. During the first 3–5 weeks of college, students reported their typical weekday sleep duration, which we classified as short sleep (<7 hours), normal sleep (7–9 hours), or long sleep (>9 hours).

Results: The odds for short sleep were significantly greater in BIPOC students (95% CI: 1.34–1.66) and female students (95% CI: 1.09–1.35), and the odds for long sleep were greater in BIPOC students (95% CI: 1.38–3.08) and first-generation students (95% CI: 1.04–2.53). In adjusted models, financial burden, employment, stress, STEM academic major, student athlete status, and younger age explained unique variance in sleep duration, fully mediating disparities for females and first-generation students (but only partially mediating disparities for BIPOC students). Short and long sleep predicted worse GPA across students' first year in college, even after controlling for high school academic index, demographics, and psychosocial variables.

Conclusions: Higher education should address sleep health early in college to help remove barriers to success and reduce disparities.

Key words: achievement gap; emerging adulthood; health disparities; socioeconomic status

Statement of Significance

Persons from disadvantaged and underrepresented backgrounds often show poorer sleep health (sleep disparities) and lower academic performance (academic achievement gap). The current work identified that sleep disparities were present for females, racial/ethnic minority students, and first-generation students in the first month of college. Thus, sleep disparities persist at this important life transition stage, even within a university context that has implemented housing, food, orientation, and healthcare programs to minimize disadvantages. Short sleep predicted grade point averages in the first and second semesters of college, even when controlling for high school achievement, socioeconomic factors, and psychosocial factors. Sleep interventions with four-year follow-ups are needed to establish whether correcting for sleep disparities at matriculation will bridge academic achievement gaps.

Introduction

Just as we must drink water and consume food to survive, sleep is a fundamental drive for all human beings. The majority of adults require 7–9 hours of sleep [1, 2], and sleeping less or more than this amount is associated with increased risk for cardiovascular diseases [3, 4], depression [5], anxiety [6], and learning difficulties [7], among many other health and wellbeing outcomes [8]. Unfortunately, not everyone sleeps well, and sleep difficulties are particularly prominent in late adolescence and emerging adulthood due to bioregulatory and psychosocial pressures [9, 10]. In the current work, we investigated whether social, economic, and environmental factors increase the risk of short or long sleep patterns in disadvantaged groups of college students [11]. We also investigated whether sleep duration

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predicted students' academic achievement in their first year of college.

Sleep Disparities

The present work defines *sleep disparities* as increased rates of short sleep (<7 hours) or long sleep (>9 hours) in female students relative to male students; Black, Indigenous, or People of Color (BIPOC) students relative to non-Hispanic White students; and first-generation students relative to students whose parents attended college. Sleep disparities have long been recognized for females. One meta-analysis found that females were at a 40% greater risk for insomnia than males [12], even after controlling for gender differences in anxiety and depression [13].

Sleep disparities are also well-documented in BIPOC individuals [14–16]. African American adults show shorter, more variable, and poorer-quality sleep than other groups [17, 18]. Hispanic or Latinx adults generally report better sleep quality than African American adults, but they tend to show shorter and poorer sleep quality than White adults [14, 15, 19]. Asian adolescents and adults have shown group-level success in academic achievement in science, technology, engineering, and mathematics (STEM) fields [20–22]; however, this group still is at increased risk for short or poor quality sleep [23–26]. Students who identify as Native American, Alaskan Native, or American Indian—the least studied underrepresented groups—also seem to show shorter sleep durations than White adults [27, 28], particularly if such students do not have feelings of belonging within their university culture [29].

Much less is known about sleep health in first-generation college students [30]. However, one might expect increased risk for poor sleep in first-generation college students because they are more likely to be BIPOC students [31]. In addition, first generation college students have elevated rates of financial burden and employment requirements, less available support from family and friends, and they report greater rates of feeling academically unprepared for college [32–34]. Each of these factors could increase risk for sleep problems during college.

Academic Achievement

Educators should consider sleep disparities in college settings in light of the known group differences in academic success ("achievement gap") [35]. BIPOC students and first-generation college students show lower attendance, higher attrition, and lower academic performance compared to White students [36–46]. There are mechanistic reasons to expect that sleep loss should contribute to academic achievement in students from all backgrounds. First, sleep after learning is beneficial to stabilizing declarative memories; when sleep is short, fragmented, or absent, memories will be less accessible the next day and beyond [47–49]. Second, poor sleep disrupts the balance between the frontoparietal attentional network and the default-mode "mind wandering" network [50]; if one is sleep-deprived, then one will have greater difficulty sustaining attention while studying and will be more likely to mind wander during class [51]. Third, sleep loss disrupts prefrontal—limbic system connectivity causing impaired socio-emotional processing [52]. Most often, such prefrontal—limbic impairments manifest as increased stress reactivity, rumination, worry, and poor coping skills [53–56]. As Figure 1 depicts, sleep is likely bidirectionally and cyclically linked to each of these neurocognitive mechanisms, leading to associations between short/poor-quality sleep and low GPA [57, 58].

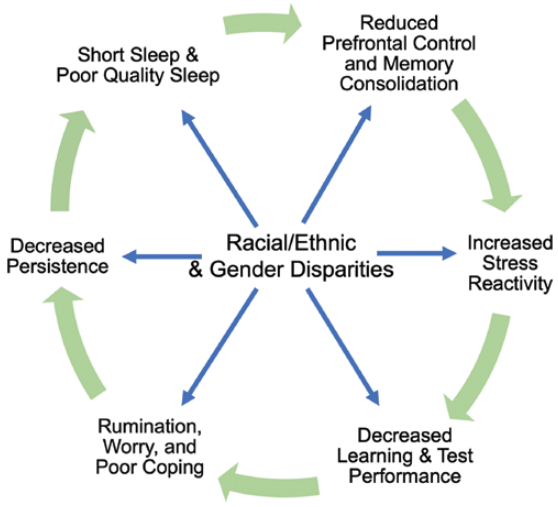

Figure 1. Theoretical model by which sleep loss and sleep disparities cyclically relate to poor academic achievement.

Current Study

The primary goal of the study was to investigate demographic-based differences in short sleep (<7 hours) and long sleep (>9 hours) [1, 2] during the first month of college. There are at least three reasons why the first month of college is an important period for examining sleep disparities. First, there is a tremendous amount of new learning required during this time period, including meeting all new people, learning the campus' spatial layout, and attending challenging classes. Therefore, sleep is needed, perhaps even more than usual during this time [59]. Second, the first month of college represents a life transition point when students break from their family environment structure and begin to develop independence and new lifestyle habits that can persist beyond college [60]. Third, at some universities (including this study's institution), there is a system-wide effort to minimize or eliminate disadvantages for incoming students by requiring attendance of pre-semester orientation events, providing all-access meal plans, providing access to free or reduced-cost health clinics, providing free counseling services, and encouraging freshmen to live on campus (similar housing and neighborhoods).

A second goal of the study was to test whether sleep disparities were explained by financial burden [61], feelings of belonging [29], stress [62], student athlete status [63], age [64], off-campus living [65], or major (STEM discipline) [66–68]. The third goal of the study was to investigate whether sleep patterns reflected students' past performance/ability (high school academic index) versus predicted future academic performance (GPA during the first two semesters of college).

Method

Participants

Participants were 6002 first-semester undergraduate students at a midsize private university in the southern United States. Age ranged from 16 to 21 years (M = 18.57, SD = 0.39) and the sample included 62.0% female students, 18.8% first-generation college students, and 37.4% non-White students. These proportions approximate the total undergraduate student population at the institution, which at the time of study was composed of 60% female students, 18% first-generation college students, and 35% non-White students.

We defined first-generation college students as those whose parents did not have a four-year college degree. We analyzed race/ethnicity by comparing non-Hispanic White students (62.6%) to BIPOC students (5.3% Black or African American; 0.4% American Indian or Alaskan Native; 8.1% Asian or Pacific Islander; 16.2% Hispanic or Latinx; 4.8% Multiracial; 2.6% non-Resident International). Approximately half of students (49.3%) were majoring in a STEM field, which was operationally defined as anthropology, applied mathematics, astrophysics, aviation sciences, biochemistry, bioinformatics, biology, chemistry, clinical laboratory science, communication sciences and disorders, computer science, engineering, environmental studies, exercise physiology, geology, health science studies, kinesiology, medical humanities, mathematics, neuroscience, nursing, nutrition sciences, public health, physics, science research fellows, and statistics.

We excluded individuals from analyses if they provided no response to the race/ethnicity question (or responded with "not specified") because insufficient information was available for grouping into categories. Participants who provided impossible values on the sleep question (≥24 hours) were removed. We also excluded individuals if they were listed as transfer students to ensure that analyses focused on first-month college students who take part in orientation and advising activities and have the same all-access campus meal plan.

Procedure

Participants received an email link to the voluntary online survey three weeks after the start of the fall semester and had two weeks to respond. Approximately 94% of first-year students completed the survey in 2017 (n = 2849) and 2018 (n = 3153). The survey is conducted annually by the university's student success initiative for the purposes of learning about the students' journey, understanding students' early college experiences, and assisting students who may be at risk for withdrawal or health issues. De-identified data were made available to the research team for the purpose of addressing the research question of sleep disparities, factors influencing sleep disparities, and potential relationships to academic achievement. The study was approved as exempt by the university's Institutional Review Board.

Online Survey

The survey consisted of 50 questions in 2017 and 33 questions in 2018. In each survey, students reported their total sleep time. Specifically, the 2017 survey asked, "How many hours of sleep do you get most weekday nights?" and the 2018 survey asked, "On most nights during the week, I get ___ hours of sleep" (participants were instructed to enter a number between 0 and 20). The distribution of responses was similar across the two surveys (see Figure S1). In addition to sleep duration, we reviewed each survey's items to identify those that might be important to understanding sleep disparities. For each survey we extracted data on financial burden, employment, stress, and feelings of belonging (see Table S1 for the wording of items). Data on chronological age, student athlete status (n = 196), off-campus living (n = 226), major (STEM or non-STEM), and academic achievement were not in the surveys, but made available by the institutional research department. Note that we initially analyzed outcomes for 2017 and 2018 separately, but upon identifying that the two surveys produced the same results, we combined them for a streamlined presentation (see Tables S2-S4 for analyses separated by survey year).

Academic Performance

Past academic performance was estimated by the Academic Index, a metric that is used by many admissions committees, but with exact formulas differing across institutions [69]. At this study's institution, Academic Index takes into account class rank, high school GPA, high school rigor, and ACT/SAT test scores, though the weighting on these variables is proprietary. To supplement Academic Index analyses, we examined highest standardized test scores. Scores were converted to a standard metric by converting all SAT scores to ACT-equivalent values using the Princeton Review conversion tool (https://www.princetonreview.com/college-advice/act-to-sat-conversion).

Future academic performance was estimated by semester GPA data, which were based on university records and available for the university's student success initiative. Only de-identified data were shared with the research team for the purpose of comparing sleep duration to academic achievement. De-identified GPA data were available for all participants in the first semester and for 96% of the participants (n = 5766) in the second semester of their first year.

Statistical Analysis

Based on the field's total sleep time consensus papers [1, 2], we classified participants' self-reported total sleep time into short sleep (<7 hours), normal sleep (7–9 hours), or long sleep (>9 hours). Participants could indicate fragment values (e.g. 6.5, 9.25), though they generally responded with whole numbers; therefore, most of the short sleep group was composed of persons reporting 6 or fewer hours, and most of the long sleep group was composed of persons reporting 10 or greater hours. We conducted a multinomial logistic regression to investigate whether female, first-generation, and BIPOC students had higher odds of short and long sleep. The reference group was students who reported 7–9 hours of sleep (normal sleep) [1, 2]. Accordingly, each predictor (gender, first-generation, and race/ethnicity) had two odds ratios, one for predicting short sleep (<7 hours) and another for predicting long sleep (>9 hours), compared to the normal sleep group.

We conducted both unadjusted and adjusted analyses, with the latter including measures of survey year, financial burden, employment, stress, belonging, student athlete status, age, off-campus living, and major (STEM or non-STEM). Within each survey year, we transformed responses to each item into z scores (except for employment, which was binary), ensuring that items worded in the opposite direction were reverse-scored. We then averaged individual z scores into domain composite scores such that higher numbers represented greater financial burden, greater stress, and greater feelings of belonging.

To investigate academic achievement gaps, we conducted independent samples t-tests to compare the groups based on gender, first-generation, and race/ethnicity on high school academic index, ACT equivalent scores, and college GPA. To investigate whether past academic achievement predicted short or long sleep in college, we conducted a hierarchical multiple regression analysis on high school academic index, controlling for demographic groups, survey year, financial burden, employment, stress, belonging, student athlete status, age, off-campus living, and academic major in Step 1; we then evaluated the unique contribution of short and long sleep durations in Step 2. To investigate whether sleep duration predicted future GPA in college, we conducted similar hierarchical multiple regression analyses on first and second semester college GPA, separately, controlling for high school academic index and all covariate variables in Step 1, and then

testing the unique contributions of short and long sleep in Step 2. In the hierarchical regressions, we additionally explored intersectionality [70, 71], which refers to how social identities exist at intersections (e.g. female and BIPOC) and within social structure hierarchies (e.g. degree of financial burden). Specifically, in Step 3 of the regression analyses, we tested for interactions between each of the demographic groups (race/ethnicity × first-generation status, race/ethnicity × gender, and gender × first-generation status) and interactions between each demographic group and financial burden.

Results

Sleep Duration

Table 1 shows descriptive statistics for sleep and academic achievement variables. Participants reported an average of 6.64 hours of sleep (*SD* = 1.61, Median = 7.0). The distribution of sleep duration responses is illustrated in Figure S1, with skewness of 3.12. Some students (1.2%) reported unlikely sleep durations (≤2 hours, ≥13 hours), and removing these students eliminated skewness (0.018; *M* = 6.55, *SD* = 1.16, Median = 7.0). Distribution skewness was also eliminated (0.21) when grouping participants into a priori categories of short sleep (48.2%), long sleep (1.7%), and normal sleep (50.1%).

The primary goal of this research was to test for sleep disparities in the first month of college. We conducted a multinomial logistic regression on short and long sleep duration (normal sleep as reference group) with gender, race/ethnicity, and first-generation status as predictors. The model was a significant improvement in fit over the null model, $\chi^2(6) = 83.15$, $p < .001$, and the Deviance and Pearson chi square tests also indicated good fit (indicated by nonsignificant values), $\chi^2(8) = 9.26$, $p = .32$ and $\chi^2(8) = 9.35$, $p = .31$, respectively. The analysis showed evidence for sleep disparities: as illustrated in Figure 2a, the odds for short sleep were significantly increased in female students ($p < .001$; OR = 1.22, 95% CI: 1.09–1.35) and BIPOC students ($p < .001$; OR = 1.49, 95% CI: 1.34–1.66), but not in first-generation students ($p = .55$; OR = 1.04, 95% CI: 0.91–1.19). Meanwhile, Figure 2b shows that the odds for long sleep were increased in first-generation students ($p = .034$; OR = 1.62, 95% CI: 1.04–2.53) and BIPOC students ($p < .001$; OR = 2.06, 95% CI: 1.38–3.08), but not in female students ($p = .51$; OR = 0.88, 95% CI: 0.59–1.30). When we examined intersectionality effects in the multinomial logistic regression model, the two-way interactions were all nonsignificant ($p > .05$).

We next repeated the above multinomial logistic regressions after adjusting for survey year, financial burden, employment, stress, belonging, student athlete status, age, off-campus living, and academic major. As shown in Figure 2c, the odds for short sleep were elevated in students with greater financial burden ($p < .001$), greater stress ($p < .001$), younger students ($p = .002$), and students who were STEM majors ($p = .029$); conversely, the odds for short sleep were decreased in student athletes ($p < .001$). As shown in Figure 2d, the odds for long sleep were greater in students with greater financial burden ($p < .001$), greater stress ($p = .04$), part-time employment ($p < .001$), and in the 2018 survey year ($p = .003$). These covariates fully explained the associations of sleep duration with gender ($\chi^2(2) = 0.89$, $p = .64$) and first-generation status ($\chi^2(2) = 4.31$, $p = .12$). In contrast, significant sleep disparities remained in BIPOC students ($\chi^2(2) = 26.32$, $p < .001$), as evidenced by their continued increased odds for short sleep ($p < .001$; OR = 1.31, 95% CI: 1.17–1.47) and long sleep ($p = .003$; OR = 1.87, 95% CI: 1.23–2.82). When repeating the above regression after excluding participants who reported sleeping ≤2 hours or ≥13 hours, there was still significantly increased odds for short sleep in BIPOC students ($p < .001$), younger students ($p = .002$), STEM majors ($p = .030$), non-athletes ($p < .001$), individuals with greater financial burden ($p < .001$), and individuals with greater stress ($p < .001$). Risk for long sleep was only significantly associated with greater financial burden ($p = .001$; BIPOC effect: $p = .155$; OR = 1.56, 95% CI: 0.85–2.87). Figure 3 displays the rates of short and long sleep across individual racial/ethnic subgroups; sleep disparities were evident in Black or African American students, Hispanic or Latinx students, Asian or Pacific Islander students, and Multiracial students.

Academic Achievement Gap

We observed academic achievement gaps for first-generation and BIPOC students, both before college and during college (Figure S2). High school academic index and standardized test scores were significantly lower in first-generation students [High School Index: $t(5997) = 11.97$, $p < .001$, $d = .38$; ACT Scores: $t(5997) = 15.29$, $p < .001$, $d = .47$] and BIPOC students [High School Index: $t(5997) = 11.52$, $p < .001$, $d = .31$; ACT Scores: $t(5997) = 11.82$, $p < .001$, $d = .32$] compared to their counterparts (corrected for unequal variances). During college, first-generation and BIPOC students showed GPAs that were 0.25–0.28 points lower than their counterparts during the first college semester [first-generation: $t(6000) = 11.10$, $p < .001$, $d = .40$; BIPOC: $t(6000) = 13.00$, $p < .001$, $d = .36$] and 0.22–0.27 points lower than their counterparts during the second

Table 1. Descriptive statistics for sleep and academic achievement.

					95% Confidence Interval	
Variable	**Mean**	**SD**	**Median**	**Skewness**	**Lower**	**Upper**
Total Sleep Time (continuous)	6.64	1.61	7.00	3.12[a]	6.60	6.68
High School Academic Index[b]	161.66	16.34	161.00	–0.62	161.24	162.07
Standardized Test (ACT equivalent)	27.62	3.40	27.00	0.06	27.53	27.71
GPA 1st Semester	3.33	0.66	3.50	–1.62	3.32	3.35
GPA 2nd Semester	3.29	0.63	3.42	–1.44	3.28	3.31

[a]Categorizing into short/normal/long sleepers changes skewness to 0.21 (primary analyses) and removing responses of ≤2 or ≥13 changes continuous data skewness to 0.018 (sensitivity analyses).
[b]The Academic Index was based on students' high school rank, high school GPA, high school rigor, and college entrance tests (SAT or ACT).

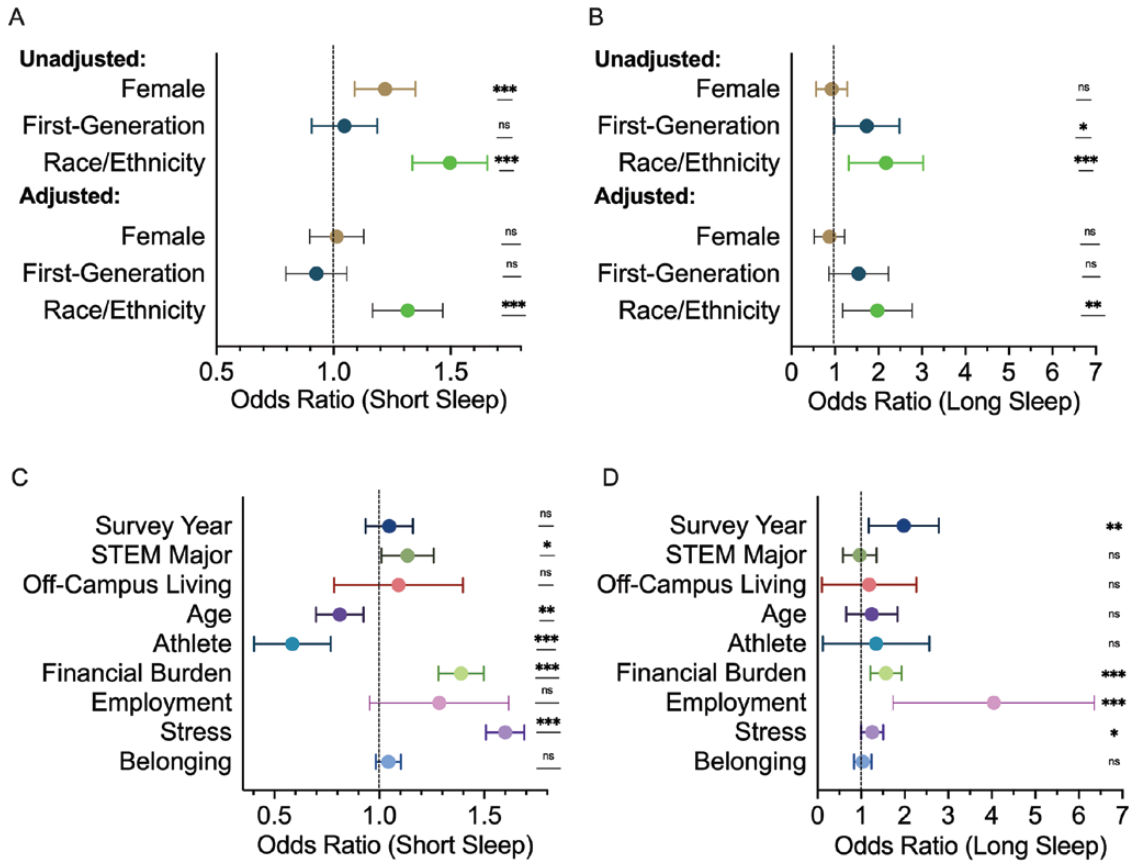

Figure 2. Odds ratios with 95% confidence intervals for being a short sleeper (**A**) and a long sleeper (**B**), relative to a normal sleeper (7–9 hours) across gender (female), first-generation, and race/ethnicity (BIPOC) groups. Data are provided before and after adjusting for control variables. The independent impact of control variables is shown for short sleep **(C)** and long sleep (**D**). ns indicates p > .05, * $p < .05$, ** $p < .01$, *** $p < .001$.

college semester [first-generation: $t(5764) = 11.81$, $p < .001$, $d = 43$; BIPOC: $t(5764) = 12.66$, $p < .001$, $d = .36$; corrected for unequal variances].

An interesting pattern emerged for gender differences in academic achievement. Relative to males, females showed similar high school academic indices [$t(5997) = 0.63$, $p = .26$, $d = .017$] albeit lower standardized test scores [$t(5997) = 7.26$, $p < .001$, $d = .19$]. During the first and second semesters of college, females outperformed males by 0.18 and 0.17 GPA points, respectively [first semester: $t(6000) = 9.46$, $p < .001$, $d = .26$; second semester: $t(5764) = 9.80$, $p < .001$, $d = .28$; corrected for unequal variances]. Even when accounting for high school academic index, survey year, financial burden, employment, stress, belonging, student athlete status, age, off-campus living, and academic major, there were significant differences in college GPA in relation to gender (1st semester: $M_{Difference} = .23$, $p < .001$; 2nd semester: $M_{Difference} = .21$, $p < .001$), race/ethnicity (1st semester: $M_{Difference} = .10$, $p < .001$; 2nd semester: $M_{Difference} = .07$, $p < .001$), and first-generation status (1st semester: $M_{Difference} = .13$, $p < .001$; 2nd semester: $M_{Difference} = .12$, $p < .001$). The interaction tests for intersectionality were nonsignificant for first and second semester GPA scores (all $p > .05$). See Figure 3c and 3d for academic outcomes separated by racial/ethnic subgroups.

Associations Between Sleep and Academic Achievement

One of the field's unanswered questions is whether past academic performance predicts future sleep patterns, or vice versa. The data are shown in Figure 4. We first conducted a hierarchical linear regression on past high school academic index that controlled for demographic variables, survey year, financial burden, employment, stress, feelings of belonging, student athlete status, age, off-campus living, and academic major (Step 1). High school academic index was related to each of these demographic and psychosocial variables, except for gender, belonging, financial burden, and off-campus living (Table 2), $F(12, 5970) = 57.56$, $p < .001$. In Step 2, sleep duration was weakly associated with high school academic index, $F(2, 5968) = 4.13$, $p = .02$, with the correlation driven by the long sleepers (156.58 ± 15.05). High school academic index did not distinguish those who would be short sleepers (161.47 ± 15.83) versus normal sleepers (162.06 ± 16.84, $p = .16$) in the first month of college (Figure 4a). Similarly, Figure 4b shows that standardized test scores (ACT equivalent) were similar between normal sleepers (27.68 ± 3.49) and short sleepers (27.60 ± 3.29; $p = .40$), but significantly lower in long sleepers (26.52 ± 3.39, $p < .001$).

We next examined the reverse direction, that is, whether sleep duration predicted future academic performance. We conducted hierarchical linear regressions for first and second semester GPA, controlling for the same covariate variables as above, as well as high school academic index (Step 1). Table 2 displays that each of these Step 1 variables explained significant variance in students' first semester GPA, $F(13, 5969) = 149.96$, $p < .001$, or second semester GPA, $F(13, 5736) = 170.41$, $p < .001$. Importantly, in Step 2, sleep duration predicted additional variance in first semester GPA (Figure 4b), $F(2, 5967) = 27.257$, $p < .001$, and second semester GPA (Figure 4c), $F(2, 5734) = 30.61$, $p < .001$. In both semesters, short sleepers (first semester: 3.21 ± 0.75;

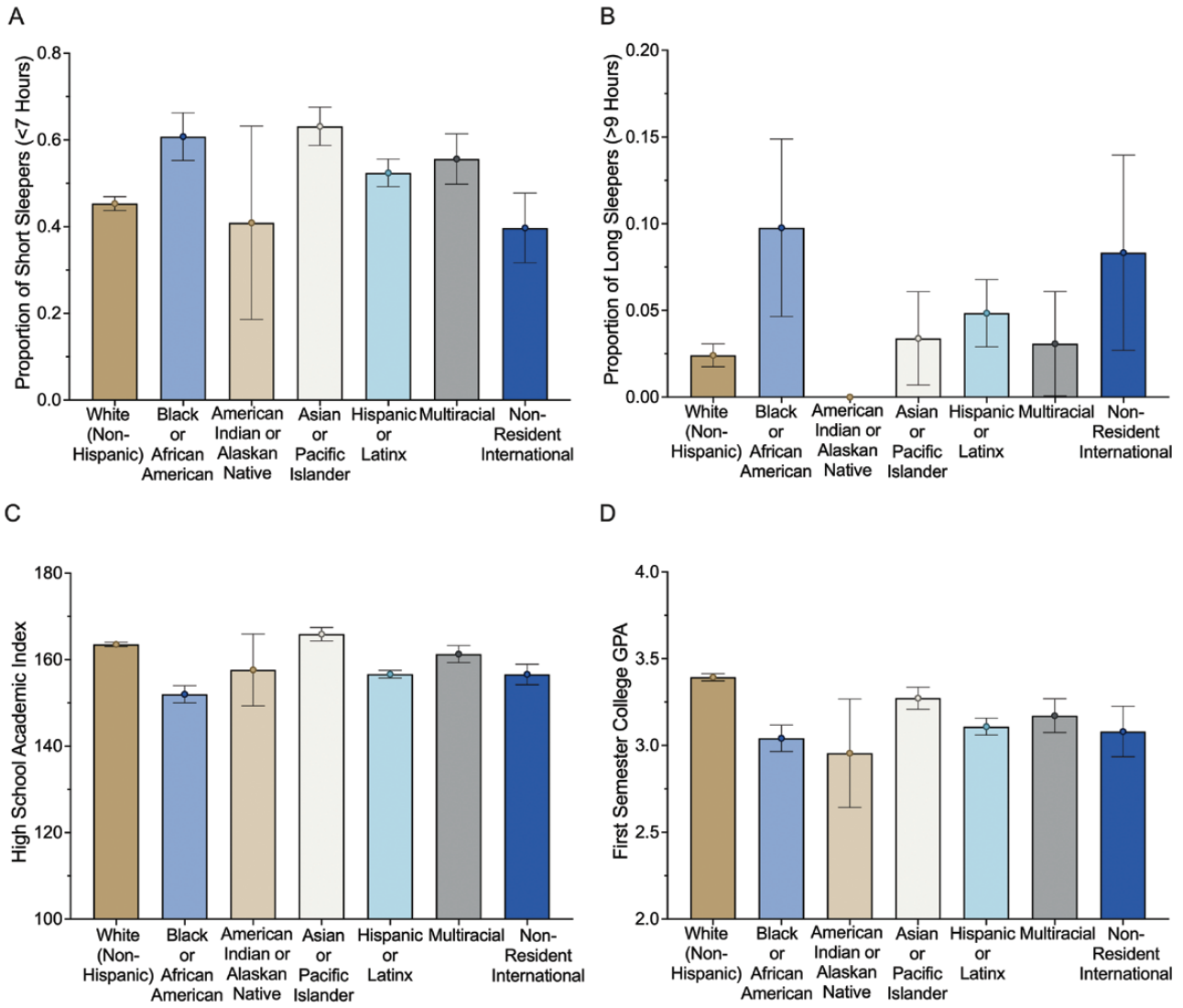

Figure 3. Prevalence of short sleep (A) and long sleep (B) for each racial/ethnic subgroup are displayed alongside high school academic index (C) and first semester GPA (D). Error bars represent 95% confidence intervals.

second semester: 3.22 ± 0.65) and long sleepers (first semester: 2.96 ± 0.91; second semester: 2.95 ± 0.85) showed significantly worse GPAs than normal sleepers (first semester: 3.39 ± 0.65; second semester: 3.38 ± 0.57; $p < .001$). Interaction tests for intersectionality in Step 3 were nonsignificant for first and second semester GPA (all $p > .05$).

To determine the robustness of effects, we repeated the above hierarchical regression after excluding participants who reported sleeping ≤2 hours or ≥13 hours. With these outliers excluded, short sleep and long sleep continued to be significant predictors of first and second semester GPA ($p < .001$). We further repeated the analysis after exchanging the short/long sleep categorization with sleep duration as a continuous variable. After adjusting for covariates in Step 1, continuously-measured sleep duration explained significant additional variance in Step 2, $F(1, 5890) = 54.43$, $\Delta R2 = .01$, $p < .001$. Adding the quadratic function of sleep duration to Step 3 resulted in significant additional variance being explained $F(1, 5889) = 68.31$, $\Delta R2 = .01$, $p < .001$, reflecting that both short and long sleep patterns in the first month of college are important predictors of academic achievement.

General Discussion

We observed first-generation, gender, and race/ethnic-based sleep disparities. Particularly noteworthy was that these sleep disparities were captured during the first month of college, a life transition point during which students are establishing new habits. During this period, sleep habits appeared to be consequential: both short and long sleep predicted academic performance during the first year of college, even after controlling for past academic performance, socioeconomic factors, and psychosocial factors. In this section, we will discuss how the current findings contribute to the literature on sleep disparities and achievement gaps before offering recommendations for administrators, teachers, and students on addressing poor sleep.

Patterns of Short Sleep

Short sleep is common in college students, in part due to academic responsibilities [10, 72, 73]. For example, in the current study, students who were enrolled in STEM majors reported significantly shorter sleep durations, despite entering college with higher academic indices. This finding converges with reports of

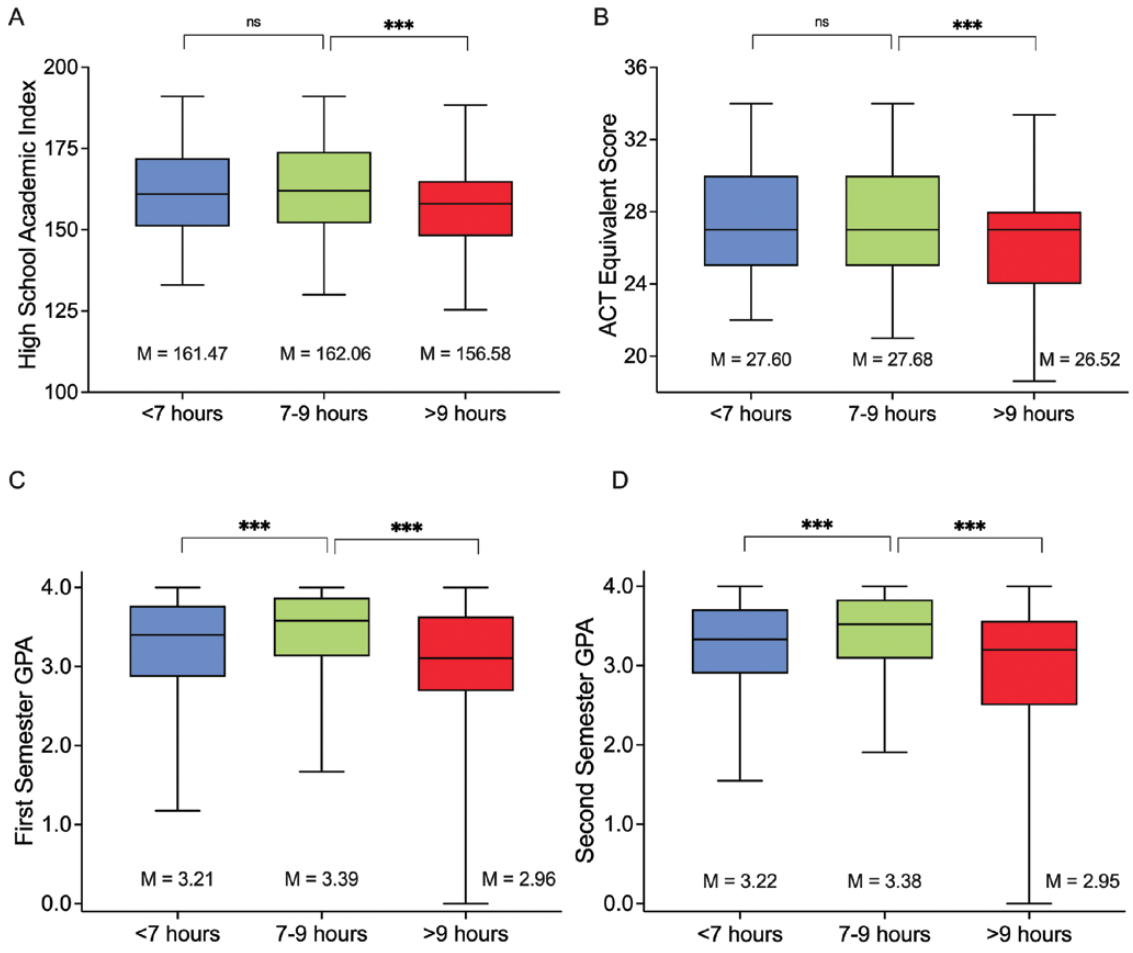

Figure 4. Sleep duration in the first month of college in relation to past high school academic index (A) and past standardized test scores (B). Sleep duration is further illustrated as a predictor for future GPA, in the first semester (C) and second semester (D) of college. Error bars represent 95% confidence intervals. *** $p < .001$, ns $p > .05$.

late bedtimes and short sleep patterns in students enrolled in physics [66], biology [67], and chemistry [68] collegiate courses. Additional work is needed to understand if these associations reflect the demands and difficulty of STEM coursework, the psychosocial characteristics of STEM majors, or both. We also expected that the demands of being a student-athlete would be associated with short sleep patterns [63], but the reverse was observed. Better sleep in student-athletes in the current sample may reflect the resources and structure available to such students at this study's institution (e.g. private exercise facilities, dining center with nutritionists, set practice and study times) and/or it may reflect that many athletes arrive to campus the summer before the semester to engage in team activities (thereby affording social networking and familiarity with campus). Future work is needed to determine whether student-athletes' sleep gradually declines across the semesters from the cumulative burden of balancing academic and athletic responsibilities, or as sports-related injuries such as concussions accrue [74].

Notably, we also observed that demographic measures predicted sleep duration in college students. The odds of short sleep increased by 22% in female students and 49% in BIPOC students (nonsignificant 4% increased odds in first-generation college students). Sleep disparities have typically been studied in middle-aged and older adults, perhaps decades after sleep habits have been established [19, 75], or in children whose bedtime routine is influenced or dictated by their parents [17, 76]. Observing similar outcomes during the first month of independence is important because this is a time period in which new lifestyle habits are formed and can persist [60], the demands on learning/cognition are heightened, and universities often have system-wide programming efforts to minimize disadvantages for students (meal plans, health care resources, etc.). Nevertheless, sleep disparities persisted in this context, indicating that there remain differential experiences for disadvantaged students in occupational/work stressors and other factors [77]. Our results showed that financial burden, employment, and stress contributed to sleep disparities, though these factors did not account for all of the variance in sleep disparities for BIPOC students.

There is increasing recognition that both anticipated and experienced discrimination negatively affect sleep [78], and this may be a particularly relevant consideration for BIPOC students at predominantly White institutions. In the adult population, discrimination and other experiences of unfair treatment have been linked to short or poor quality sleep in survey, actigraphy, and polysomnography studies [79–81]. Furthermore, poorer sleep coincides with discriminatory experiences in students of all ages, from elementary school through college [82–84]. In student groups, discrimination heightens loneliness and chronic stress [85], including the chronic stressor of racism-related vigilance [86, 87], which leads to academic disengagement [88]. Therefore,

Table 2. Hierarchical regression analyses of predictors of past and future academic achievement.

	High School Academic Index		1st Semester College GPA		2nd Semester College GPA	
Predictor	**β**	**ΔR2**	**β**	**ΔR2**	**β**	**ΔR2**
Step 1: Control Variables		.10***		.25***		.28***
First-Generation	−.13***		−.07***		−.07***	
Gender (Female)	.002		.16***		.16***	
Race/Ethnicity (BIPOC)	−.14***		−.05***		−.04**	
Survey Year	.14***		−.07***		−.10***	
Stress	−.05***		−.08***		−.05***	
Belonging	.02		.04**		.01	
Financial Burden	.009		−.04**		−.05***	
Employment	−.04**		−.001		−.02	
Student Athlete	−.17***		.04***		.05***	
STEM Major	.11***		−.16***		−.17***	
Age	−.04**		.02		.03*	
Off-Campus Living	−.02		−.07***		−.03**	
Academic Index	-----		.40***		.45***	
Step 2: Sleep Duration		.001*		.01***		.01***
Short Sleep (<7 hours)	−.01		−.08***		−.08***	
Long Sleep (>9 hours)	−.03**		−.05***		−.05***	
Step 3: Intersectionality		.002*		.001		<.001
Race/Ethnicity × Gender	−.04		−.02		−.01	
Race/Ethnicity × First-Gen	.006		.02		.02	
Gender × First-Gen	−.01		−.03		−.003	
Financial Burden × Gender	−.01		.003		.01	
Financial Burden × First-Gen	.04**		−.02		−.006	
Financial Burden × Race	−.02		−.01		−.008	

* $p < .05$, ** $p < .01$, *** $p < .001$.

addressing sleep disparities in college settings is likely to require institutional commitments to changing implicit, explicit, and systemic discrimination. This may include a greater effort to hire more BIPOC faculty, so that all students feel that they are represented within an institution.

Patterns of Long Sleep

It was notable that the odds of long sleep also increased—doubled, in fact—in BIPOC students and first-generation students. In older adults, the causes of long sleep are varied [89]. The same can be said for young adults. For example, long sleep may be a manifestation of fragmented sleep or clinical sleep disorders such as sleep apnea, idiopathic hypersomnia, or narcolepsy [89–91]. Reports of long sleep may also reflect clinical depression [92]: some studies indicate that nearly 40% of young adults with depression show long sleep patterns [93, 94]. Alternatively, those who responded with long sleep values (e.g. 10 hours) may have been considering days with additional daytime naps [95, 96] or extended sleep patterns on weekend nights (a marker of social jetlag [97]). Therefore, it is probably not the case that sleep per se is harming these individuals' academic performance, but they may have an underlying condition that is harmful. Administrators/staff should direct such students to a healthcare provider for further screening.

Sleep and Academic Achievement

An important question for educators is whether poor academic performance causes poor sleep health or if poor sleep health causes worsened academic performance. Our theoretical model posited a bi-directional, and cyclical, association (Figure 1), which was supported by the overall regression analyses. However, a closer inspection indicated that short sleep was predominantly associated with future college performance rather than with past high school academic index (or standardized test scores). Therefore, at this transition point from high school to college, pre-existing abilities appear to matter less than the new habits being formed for sleep (as well as the new habits formed for studying, time management, exercise, nutrition, etc.). Approximately half of these first-year students showed below-minimum recommendations for sleep duration immediately upon matriculation and sleep debt may be cumulative across the semester [98], as sleep loss cannot be fully "re-paid" during weekend sleep recovery efforts [99]. Sleep loss likely contributes to college GPA via reductions in memory consolidation, decreased attention, worsened stress control, or some combination of these processes (Figure 1). Future research should address whether correcting for sleep problems early in college reduces academic achievement gaps [35].

Solutions to Poor Sleep in College Students

Pre-matriculation online sleep education has been shown to discourage all-nighters, evening consumption of caffeine, and drowsy driving [100]. Furthermore, sleep interventions in college students that are based on behavioral change theory [101, 102], that include incentives or motivators for change [103–105], and that build upon cognitive-behavioral therapy principles for insomnia (CBT-I) [106], can have a positive impact on sleep duration. CBT-I education typically involves education on *sleep hygiene* (e.g. avoiding energy drinks and other sources of caffeine after 5pm), *stimulus control* (e.g. using the bed only for sleep rather than studying or entertainment), *cognitive factors* (e.g. avoiding clock checking, writing down one's worries), and *targeted sleep restriction* (e.g. getting out of bed if unable to fall asleep in 20 minutes). It is largely unknown whether such programs help eliminate sleep disparities, but Tavernier and Adam's [107] study provides a cautionary lesson. They found that a sleep education + text-message bedtime reminder intervention led to a large improvement in sleep in non-Hispanic White high school students, but not in BIPOC students.

Sleep education could be part of the standard, freshman-year health education at colleges. Such education might benefit from being culturally tailored [77, 108] as well as responsive to environmental and socioeconomic disadvantages including living in a neighborhood with greater noise or safety concerns, sharing sleeping environments with roommates, working part-time or shift work jobs, lacking access to high nutrition food, or experiencing other financial stressors [30, 109]. Coupling sleep education with environmental investments (blackout curtains, white noise machines, and daytime campus jobs with stronger wages), diversity and anti-bias training [110–112], and other institutional changes for opposing racism, is needed in academic settings.

Limitations and Conclusions

The current findings should be contextualized as arising from a midsized institution in the southern United States. Inferences regarding sleep were based on a single-item retrospective assessment that changed in wording across the 2017 and 2018 survey years. Additional work is needed to understand whether sleep duration responses are reflective of how students slept during high school or predictive of how they slept across their entire first year. Other study limitations were that gender response options only included male/female/no-response, academic outcome data may have been influenced by racial/ethnic biases in standardized testing or variability in prior education quality (e.g. due to underfunding [113]), and there may have been more effective survey measures of stress, financial burden, and belonging [29]. Additional work on sleep and academic achievement is also needed to understand the contributions of chronotype [114], learning or physical disabilities [58], depression or other mental health disorders [115], substance abuse [116], living arrangements [117, 118], and commuting hours [119].

The above notwithstanding, the study had several strengths, including a large sample size, a 94% survey response rate, integration of key covariates, replication of findings across two surveys, and examination of past and future academic achievement. When added to the context of the broader literature, it seems clear that BIPOC, first-generation, and female students are at elevated odds for short or long sleep patterns, and that sleep duration predicts future academic outcomes even when past academic achievements are controlled.

Given the collective findings in the sleep and higher education literature, we see merit in Quan, Ziporyn, and Czeisler's [120] conclusion that "it is time for college administrators to embrace mandatory sleep health education for all students." We offer one amendment, though: sleep health education should be culturally tailored (e.g. using diverse and inclusive cases when providing examples) with an individualized component, and universities need to address the implicit, explicit, and systemic expressions of discrimination that are chronic stressors to sleep in students from disadvantaged backgrounds. Promoting equity in sleep is an achievable goal that will help universities in their broader efforts to promote equity in health and academics.

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