Alcohol Consumption, Sleep, and Academic Performance Among College Students

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ABSTRACT. Objective: Three independent lines of inquiry have found associations between alcohol use and academic performance, sleep and academic performance, and alcohol use and sleep. The present study bridges this research by examining the links among alcohol use, sleep, and academic performance in college students. **Method:** Personal interview surveys were conducted with a random sample of 236 students (124 women) at a liberal arts college. The interviews measured alcohol consumption, gender, academic class, weekday and weekend bedtimes and rise times, and daytime sleepiness; 95% of the sample granted permission to obtain grade-point average (GPA) and Scholastic Aptitude Test (SAT) scores from official college records. **Results:** Ordinary least squares regressions showed that alcohol consumption was a significant predictor of four sleep patterns: the duration of sleep, the timing of sleep, the difference between weekday and weekend nighttime sleep hours (oversleep), and the difference between weekday and weekend bedtimes (bedtime delay). Women and students with late sleep schedules were more apt to report daytime sleepiness. SAT score was the strongest predictor of GPA. However, gender, alcohol consumption, sleep duration, and daytime sleepiness also were significant predictors when other variables were controlled. In addition to alcohol's direct relationship with GPA, mediational analysis indicated that alcohol had indirect effects on sleepiness and GPA, primarily through its effect on sleep schedule. **Conclusions:** The findings show how alcohol use among college students is related to sleep–wake patterns and further support the connection between alcohol use and grades. (*J. Stud. Alcohol Drugs* **70:** 355-363, 2009)

TWO FORMS OF UNHEALTHFUL BEHAVIOR that are well documented among college students are heavy alcohol use (Wechsler and Wuethrich, 2002) and insufficient and irregular sleep (Buboltz et al., 2006). Both heavy alcohol consumption and unhealthy sleep habits are associated with various behavioral problems, including poor academic performance (Buboltz et al., 2006; Perkins, 2002). Yet alcohol and sleep researchers who have examined these harmful effects have done so in relative isolation, as neither line of inquiry is informed by the other. This is surprising, especially with respect to academic performance, given the known effects of alcohol on sleep (Roehrs and Roth, 2001). For it is possible that alcohol influences both sleep patterns and academic performance and that sleep mediates the effects of alcohol use on performance. The present study examines these possibilities, bringing together three independent lines of research involving alcohol, sleep, and academic performance.

Alcohol use and academic performance

Because it is unethical and illegal to provide alcohol to minors, controlled studies of the effects of alcohol use on academic performance are nonexistent. Research with adults has shown that alcohol use disrupts learning and memory (Ziegler et al., 2005). However, such effects may be only temporary, and their severity and duration may depend on the frequency and quantity of alcohol consumed. Furthermore, the relatively few correlational studies that have examined the relationship between alcohol use and academic performance among college students have produced inconsistent results.

On the one hand, national surveys have shown that heavy episodic drinkers are far more likely than nonheavy drinkers to report that drinking caused them to miss class, fall behind in their schoolwork, and perform poorly on a test or other project (Presley and Pimentel, 2006; Wechsler et al., 2000). Large-scale surveys also have found an inverse association between alcohol consumption and self-reported grade-point average (GPA; Core Institute, 2006). In one study, based on a multivariate analysis of the 1993 College Alcohol Study, heavy alcohol use was found to be associated with a lower GPA both directly and indirectly through its association with fewer study hours (Wolaver, 2002).

On the other hand, studies of this relationship at three different institutions produced varying results. Two studies attributed the association between alcohol misuse and academic problems to student differences at matriculation. Wood et al. (1997) found a bivariate correlation of .32 between alcohol "involvement" in the first year and subsequent academic problems among 444 students at a large midwestern

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university. However, this association was nonsignificant when controlling for academic aptitude, high school rank, and other baseline variables. Similarly, in a study of 465 first-year students at the University of California, Berkeley, Paschall and Freisthler (2003) found that high school GPA predicted both heavy drinking and self-reported college GPA and that drinking was unrelated to college GPA.

In contrast, a third study of 754 students at a northeastern liberal arts college found a negative association between alcohol consumption and GPA after controlling for precollege factors such as academic aptitude, high school class rank, and parents' education (Singleton, 2007).

Sleep and academic performance

A burgeoning literature also exists on the relationship between sleep difficulties and academic performance, although much of the research has focused on precollege populations. Only 3 of 14 studies cited in Wolfson and Carskadon's (2003) review on sleep and academic performance involved college students. A more recent review (Curcio et al., 2006) identified only two additional studies. In all, five questionnaire studies have examined sleep patterns and course grades or GPA among college students. Carried out at one Australian, one Canadian, and three U.S. universities, these studies used an assortment of sleep measures, all based on self-reported sleep habits, which produced mixed findings. Lower grades were associated with delayed sleep phase syndrome (Lack, 1986), shorter sleep duration (Kelly et al., 2001), later bedtimes, and later rise times (Gray and Watson, 2002; Trockel et al., 2000). Grades were not related to scores on the Epworth Sleepiness Scale (Howell et al., 2004), although the same study showed that poor sleep quality was associated with lower grades among students carrying a full academic load.

Two other studies examined the association between sleep problems and cognitive functioning in college students. Pilcher and Walters (1997) measured critical thinking after manipulating sleep deprivation among 65 volunteers. Students who were deprived of sleep for 24 hours scored significantly lower than students who slept under normal sleeping conditions for approximately 8 hours. Similarly, Campos-Morales and colleagues (2005) found that Mexican undergraduates classified as "sleepy" according to the Epworth Sleepiness Scale were less able to solve mathematical problems than nonsleepy students.

Altogether these studies suggest that poor sleep quality and deprivation impair learning and academic performance. The Pilcher and Walters (1997) experiment implies that sleep is the *cause* in the relationship. Also, those studies in which the measurement of sleep preceded the measurement of performance establish temporal order. Still, all but one study consisted of volunteer participants, often first-year students enrolled in introductory psychology courses. The only exception was a random sample of first-year students living on campus (Trockel et al., 2000).

In addition, the findings yielded few consistent patterns, and analytical deficiencies obfuscate the meaning of some results. For example, nearly all of the studies failed to measure and control other factors that could explain or moderate the relationship. The relationship could be moderated by academic class, the effects of which would have been suppressed in studies with predominantly first-year students. There is evidence suggesting that sleep patterns might change over the emerging adulthood and college years, becoming more consistent and less delayed (Roenneberg et al., 2004). It also is possible that the relationship is spurious—that academic aptitude or alcohol consumption accounts for both sleep habits/problems and academic performance.

Sleep habits and daytime alertness

One way that sleep habits may influence academic performance is through their effect on daytime alertness or sleepiness. Determinants of sleepiness include the quantity and quality of sleep and the misalignment of circadian rhythms (Roehrs et al., 2005). The sleep–wake cycle is a circadian rhythm that functions in accord with other circadian rhythms such as core body temperature (Carskadon and Dement, 2005). Abrupt changes in the sleep–wake schedule, such as occurs in shift work and jet lag, lead to misaligned circadian rhythms (Roehrs et al., 2005).

Some studies also suggest that irregular day-to-day sleep–wake habits can produce similar effects. For example, in an intervention study of undergraduates, Manber and associates (1996) found that regularization of sleep–wake schedules was associated with less daytime sleepiness when nocturnal sleep was not deprived. Similarly, Wolfson and Carskadon (1998) found that high school students who experienced delays of more than 2 hours (vs less than 1 hour) between weekday and weekend bedtimes reported significantly more daytime sleepiness.

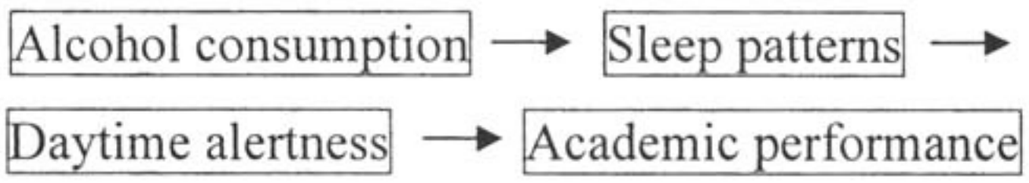
Alcohol use and sleep

Most investigations of alcohol use and sleep have taken place in the laboratory and have focused on physical indicators of sleep states. In their overview of this literature, Roehrs and Roth (2001) reported that alcohol has direct and indirect effects on daytime alertness among healthy nonalcoholic subjects. Alcohol consumption tends to disrupt sleep, particularly during the second half of a night of sleep, and these disruptive effects increase daytime sleepiness and decrease alertness. Other evidence also indicates that alcohol use is associated with sleep–wake habits in everyday life. Roehrs and Roth cited a British survey in which heavier drinking was associated with shorter periods of sleep in men. Analyzing data from the 2004-2006 National Health Interview Survey, Schoenborn and Adams (2008) found that men

and young adults (ages 18-44 years) who had five or more drinks in 1 day in the past year got less sleep than others.

Current study

Taken together, these findings suggest the following model:



We hypothesize that alcohol use leads to problematic sleep–wake schedules. Specifically, college students who tend to drink heavily will go to bed later and get less sleep. And given greater alcohol consumption on the weekend, they will sleep longer on weekend nights and experience a greater delay between weekday and weekend bedtimes. These erratic and inadequate sleep patterns lead to daytime sleepiness and reduce the alertness necessary for focusing on course work and paying attention in class, thereby undermining academic performance.

The present study investigates these linkages by analyzing survey data from a liberal arts college, drawing on a subset of a larger data set previously reported in Singleton (2007). Whereas the larger data set combined data from four campus surveys, this study analyzes data from a single semester in which the survey topic was health behaviors. The present study includes the two background factors—Scholastic Aptitude Test (SAT) total score and gender—that were significantly related to academic performance in the larger study. It also controls for academic class year, because the college years appear to be a crucial transitional period in the timing of sleep (Roenneberg et al., 2004).

Besides including these controls, this study improves on earlier investigations of academic performance conducted by alcohol and sleep researchers by using grade data from official records, a random sample of the student body, and multiple measures of alcohol use and sleep. Much of the research on college drinking dichotomizes students into two categories according to a threshold of consumption, typically five or more drinks on a single occasion for men and four or more drinks for women. Studies show, however, that a large percentage of students drink at levels well beyond this threshold (White et al., 2006) and that this threshold may not adequately capture problematic alcohol use (Read et al., 2008). By contrast, we use measures of how frequently and, most important, how heavily students drink.

Method

Participants

Participants were undergraduates at a northeastern U.S. liberal arts college who were randomly selected from a list of currently enrolled students provided by the registrar in the fall of 2003. From an initial sample of 260, 236 students chose to participate, yielding a response rate of 91%.

Procedures

To carry out the survey, students enrolled in a research methods course conducted structured, face-to-face interviews with fellow students. The study was approved by the college's institutional review board, as participants were informed that their responses were confidential and their participation voluntary. Interviewers received thorough training and were carefully supervised. Interviews were carried out between October 21 and November 23, 2003. At the conclusion of each interview, respondents were asked for written consent to retrieve information on grades and SAT scores from official college records; 225 respondents (95% of the sample) granted permission. Of these, 218 had reported SAT scores.

Measures

Academic performance. Two measures of academic performance, obtained from the registrar, were added to the data file at the end of the semester during which the survey was conducted: a student's GPA during the semester of the survey and his or her cumulative GPA at that point.

Alcohol consumption. Students were asked three main questions about alcohol consumption. First they were asked to describe themselves as drinkers: "Do you abstain from drinking or would you describe yourself as a light, moderate, or heavy drinker?" Nonabstainers were then asked how often they drink alcoholic beverages, with seven possible responses ranging from "about once a year" to "almost every day." Finally, they were asked, "On a typical weekend night when you choose to drink, about how many drinks do you consume?" In operationalizing *frequency of use* and *amount consumed,* respectively, abstainers were assigned a code of 0 for the second and third questions. For purposes of comparison, students also were asked the College Alcohol Study standard measure of heavy alcohol use: "During the past two weeks, how many times have you had five or more drinks in a row [4 or more for women], that is, within a couple hours?" (Wechsler and Nelson, 2001). *Frequency of heavy alcohol use* showed a moderate to high correlation with both frequency of use ($r = .59$) and amount consumed ($r = .70$).

Sleep patterns. The interview schedule contained several measures of sleep habits and related constructs adapted from Wolfson and Carskdon's (1998) sleep habits survey, which focused on students' behavior in the previous 2 weeks. Because college students often keep irregular sleep schedules, respondents were asked first to indicate whether they usually went to bed at the same time or at different times on weekday nights. If the times differed, they were then asked

to report the latest time and the earliest time they had gone to bed. Similarly, if their rise times differed over the past 2 weeks, respondents were asked to indicate the earliest and latest times they had gotten up. Based on this information, *weekday bedtime* was operationally defined as either a student's regular bedtime (reported by 73% of the sample) or the average of earliest and latest bedtimes. *Weekday rise time* was defined as either a student's regular rise time (reported by 52%) or the average of earliest and latest rise times. Students also reported their usual *weekend bedtime* and usual *weekend rise time.*

Based on these four measures of sleep schedules, we created four distinct variables indicative of different sleep patterns. For the first two measures, weekday and weekend times were given weights of 5 and 2, respectively, according to the number of days of the week that each represents. *Sleep duration,* or average hours of daily sleep, was calculated as the weighted average of the difference between weekday bedtime and rise time plus the difference between weekend bedtime and rise time. *Sleep schedule*—that is, the timing of a student's nighttime sleep—was defined as the weighted average of the four sleep schedule times (weekday and weekend bedtimes and rise times) divided by 2. This provided a schedule or time reference that was the midpoint time of nighttime sleep (see Roenneberg et al., 2004). Finally, two other sleep constructs were derived to measure sleep irregularity: *Bedtime delay* is the absolute difference between weekday and weekend bedtimes; *oversleep* is the absolute difference between weekday and weekend total sleep times (Wolfson and Carskadon, 1998).

Daytime alertness. To assess sleepiness, we adapted a measure originally designed for high school students (Carskadon et al., 1991; Wolfson and Carskadon, 1998). The *sleepiness index* consisted of the sum of responses to items asking whether the respondent had struggled to stay awake (fought sleep) in 14 different situations in the last 2 weeks, such as in conversation, while studying, and in class. Respondents rated each item on a 3-point scale, with 1 = no problems, 2 = struggled to stay awake, and 3 = fell asleep. Scores on this index ranged from 14 to 30.

Exogenous variables. These consisted of gender, academic aptitude, and class year. *Academic aptitude* was represented by a student's combined verbal and math scores on the SAT, obtained from student records. *Class year* was highly correlated with age at this college (r = .89) and, therefore, essentially serves as a proxy for age. Because of the small number of nonwhite respondents (26; including 7 blacks, 8 Asian Americans, and 9 Hispanic Americans), we did not include race or ethnicity.

Results

Sample characteristics

Closely representative of the student body, 52% of the sample was female, 89% was white, and 98% ranged in age from 18 to 22 years old. Eighty-two percent of the respondents lived on campus. By academic class, 27% were first-year, 25% were second-year, 21% were third-year, and 27% were fourth-year students.

Fifteen percent of the respondents reported that they abstained from drinking, and two thirds reported that they drank at least one to two times a week. The average (SD) number of drinks consumed on a typical weekend night was 5.57 (3.96). Men and women did not differ significantly in how often they drank ($p > .05$), but men consumed significantly more drinks than women (mean = 7.11 [4.51] vs 4.19 [2.74], respectively; t = 5.94 [equality of variances not assumed], 179 df, $p < .001$).

Sleep variables showed evidence of both insufficient and ill-timed sleep. On weekday nights, only 24% of the sample reported getting the recommended 8.4 hours of sleep for this age group (Wehr, 1991). The vast majority (79%) reported average weekday bedtimes after midnight (mean = 1:06 AM), and 90% went to bed after 1:00 AM on the weekends (mean = 2:45 AM). Consequently, students' weekday versus weekend schedules were greatly delayed: 53% reported a 2- to 4-hour delay in their weekend bedtime in comparison with weeknights (mean = 1 hour, 46 minutes). Women and men differed on two sleep variables: sleep schedule (women's average sleep midpoint was 18 minutes earlier than men's: $\text{mean}_{\text{women}}$ = 5.28 or 5:17 AM [0.73]; mean_{men} = 5.58 or 5:35 AM [0.94]; t = 2.72, 234 df, $p < .01$) and sleepiness (women reported higher levels of daytime sleepiness than men: $\text{mean}_{\text{women}}$ = 20.17 [3.12]; mean_{men} = 19.26 [3.19]; t = 2.22, 234 df, $p < .05$).

Class year was associated with both alcohol measures (frequency of alcohol use: F = 5.63, 3/232 df, $p < .001$; amount consumed: F = 5.82, 3/232 df, $p < .001$), sleep schedule (F = 4.01, 3/232 df, $p < .01$), and bedtime delay (F = 3.36, 3/232 df, $p < .05$). Post hoc tests, however, yielded inconsistent patterns with no clear linear trends. Therefore, in subsequent analyses, class was represented by three dummy variables for the first-, second-, and third-year classes. Thus, the reference group for the regression coefficients is fourth-year students.

Zero-order correlations

Table 1 reports variable means, SDs, and intercorrelations. The correlation between semester and cumulative GPA was high (r = .87), and correlations between each measure of GPA and other variables were highly similar. Therefore, multivariate analyses focused on the more stable estimate of grade average, cumulative GPA. Both measures of alcohol consumption (i.e., number of drinks consumed and frequency of alcohol use) were significantly correlated with GPA; however, the strongest association was with number of drinks consumed, r = -.28 (vs r = -.21 for frequency of use). Both alcohol measures were also more strongly correlated

TABLE 1. Means, standard deviations, and intercorrelations among study variables (n = 236)

	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Cumulative GPA	3.18	.438													
2. Semester GPA	3.22	.479	.87†												
3. SAT total score	1,264	119	.48†	.40†											
4. Gender (male = 1)	.475	.500	-.17*	-.20†	.07										
5. First year	.271	.446	.08	.02	.01	-.06									
6. Second year	.250	.434	.01	-.00	.07	.08	-.35†								
7. Third year	.208	.406	-.11	-.16*	-.20†	.06	-.30†	-.30†							
8. Freq. of alcohol use	4.28	1.96	-.21†	-.21†	-.01	.03	-.23†	.02	.12						
9. Amount consumed	5.57	3.96	-.28†	-.29†	-.02	.36†	-.21†	.07	.21†	.70†					
10. Daytime sleepiness	19.7	3.18	-.20†	-.18†	-.02	-.17*	-.01	-.02	-.01	.20†	.08				
11. Sleep duration	7.71	1.03	-.15*	-.06	-.07	.06	-.06	-.12	.08	-.16*	-.10	-.11			
12. Sleep schedule	5.42	.848	-.25†	-.24†	-.02	.20†	-.05	-.20†	.21†	.37†	.40†	.21†	.13		
13. Oversleep	1.29	1.09	-.02	-.01	-.08	.08	.00	.07	.09	-.05	.17*	.09	-.16*	.03	
14. Bedtime delay	1.76	.912	-.10	-.09	-.00	-.03	.11	-.01	.11	.19†	.29†	-.08	.03	.01	-.15*

Notes: Listwise deletion of cases used to compute correlation coefficients; n = 225 for grade-point average (GPA); n = 218 for Scholastic Aptitude Test (SAT). Freq. = frequency.
*$p < .05$; †$p < .01$.

with cumulative GPA than was the standard College Alcohol Study measure frequency of heavy alcohol use (r = -.18). Given these patterns as well as considerable evidence that the maximum amount of alcohol consumed is a crucial indicator of problem drinking (Greenfield et al., 2006), we focused on the amount of alcohol consumed in the multivariate analyses.

Two sleep constructs were significantly correlated with cumulative GPA: daytime sleepiness and sleep schedule. Sleepier students and those with later sleep schedules had lower GPAs. Each alcohol measure showed a somewhat different pattern of correlations with the various sleep constructs. How often students drank was significantly correlated with sleepiness, but how much they consumed was not. Both alcohol measures were most strongly related to sleep schedule and bedtime delay: Students who drank more frequently and consumed more alcohol had later sleep schedules and greater delays between weekday and weekend bedtimes.

With respect to the exogenous variables, SAT total score, as expected, was positively associated with GPA (r = .48, p < .001) but was unrelated to any of the measures of alcohol consumption or sleep. Each class year was associated with at least one alcohol or sleep variable, suggesting the importance of controlling for different class years. Finally, in addition to the gender differences reported above, men got lower grades than women.

TABLE 2. Ordinary least squares standardized regression coefficients for sleep variables with amount of alcohol consumed and exogenous variables as predictors (n = 218)

Variable	Sleep duration	Sleep schedule	Oversleep	Sleep delay
SAT total	-.065	.006	-.065	.005
Gender (male = 1)	.133	.075	.020	-.163*
First year	-.140	-.025	.125	.281†
Second year	.167*	-.220†	.143	.133
Third year	-.003	.051	.126	.181*
Amount consumed	-.168*	.368†	.155*	.358†
R^2	.057	.215	.055	.158
Adjusted R^2	.030	.193	.028	.135

Note: SAT = Scholastic Aptitude Test.
*$p < .05$; †$p < .01$

Alcohol use and sleep patterns

Table 2 presents the ordinary least squares regressions when each of the four sleep constructs is regressed on the exogenous variables plus number of drinks consumed. Amount consumed was a significant predictor of each sleep pattern: Students who drank more had less nighttime sleep, had later sleep schedules, got more sleep on weekends compared with weekdays, and had greater delays between weekday and weekend bedtimes. With one exception, the results were similar when the same regressions were performed with frequency of alcohol use as the predictor instead of amount consumed. Whereas amount consumed was a significant predictor of oversleep, frequency of alcohol use was not.

Class year also was associated with sleep patterns. First- and second-year students tended to get less sleep than fourth-year students, which is probably because, at this college in fall 2003, 75% of the students enrolled in 8:00 AM classes were first- or second-year students, whereas only 9% were in their fourth year. In addition, second-year students kept a later sleep schedule, and fourth-year students tended to experience less bedtime delay than each of the other classes. Finally, men experienced more bedtime delay than women.

Alcohol use, sleepiness, and academic performance

Table 3 presents the regression results for sleepiness and cumulative GPA. With alcohol consumption in the equation, two variables were significant predictors of sleepiness: being male and the lateness of one's sleep schedule. Our general

TABLE 3. Ordinary least squares standardized regression coefficients for daytime sleepiness and cumulative grade-point average (GPA) (n = 218)

		Cumulative GPA	
Variable	Sleepiness	Model 1	Model 2
SAT total	-.014	.497†	.492†
Gender (male = 1)	-.240†	-.119	-.152*
First year	-.006	.057	.048
Second year	.006	.047	.000
Third year	-.053	.078	.080
Amount consumed	.076	-.241†	-.174*
Sleep duration	-.104		-.129*
Sleep schedule	.253†		-.099
Oversleep	.061		.043
Bedtime delay	-.093		-.070
Daytime sleepiness			-.207†
R^2	.125	.325	.400
Adjusted R^2	.083	.306	.368

Note: SAT = Scholastic Aptitude Test.
*$p < .05$; †$p < .01$.

model assumes that sleep patterns mediate the relationship between alcohol use and daytime sleepiness. The results indicate that this occurs for sleep schedule but not for the other sleep variables. According to Mackinnon et al. (2007), the most widely used method to assess mediation is the approach outlined by Baron and Kenny (1986). Their method requires four steps to establish mediation: (1) amount consumed must be correlated with sleepiness (β = .16 when controlling for exogenous variables), (2) amount consumed must be associated with sleep schedule (β = .37 in Table 2), (3) sleep schedule must be related to sleepiness (β = .25 in Table 3), and (4) the association between amount consumed and sleepiness should be reduced when sleep schedule is controlled (β = .08, NS, in Table 3). In addition, the Sobel test confirmed that this reduction was statistically significant (Z = 2.84, p = .004) (Sobel, 1982).

Also as predicted, daytime sleepiness mediates the effect of sleep schedule on cumulative GPA. Meeting the Baron and Kenny (1986) requirements, sleep schedule was associated with GPA and daytime sleepiness; daytime sleepiness was a significant predictor of GPA in Model 2; and the association between sleep schedule and GPA was reduced to nonsignificance when sleepiness was controlled. Finally, according to the Sobel test, the reduction attributable to daytime sleepiness was statistically significant (Z = 2.39, p = .017).

The strongest predictor of cumulative GPA is SAT total score. When cumulative GPA is regressed on the exogenous variables plus alcohol consumption (Model 1), amount consumed is a significant predictor. However, when the sleep variables are added to the equation (Model 2), the regression coefficient, although still significant, is reduced, indicating that alcohol is associated with GPA both directly and indirectly. Indirectly, alcohol is associated with GPA via this pathway: Students who drank more had later sleep schedules; later sleep schedules correlated with reports of greater daytime sleepiness; and greater daytime sleepiness was related to lower grades. Based on the joint significance test (Taylor et al., 2008), this three-path mediation of alcohol and GPA is significant because each of the three paths (i.e., regression coefficients) is significant.

To examine the relative strength of various alcohol predictors, we substituted three other variables for amount consumed in Model 2: frequency of alcohol use and two composite measures, one based on an additive and the other on a multiplicative function of frequency of use and amount consumed. Finally, we included both frequency of use and amount consumed in the same equation. In every case, the R^2 value with amount consumed was as high as or higher than the R^2 value with the alternative measures. Furthermore, when both alcohol measures were included in the regression model, amount consumed was a significant predictor but frequency of use was not.

To illustrate the relationships in Tables 2 and 3, we constructed the path diagram in Figure 1. The model was specified based on the above regression outcomes plus the regression of amount consumed on the exogenous variables. Path coefficients were estimated after eliminating variables with nonsignificant regression coefficients, and the model was analyzed using the model-fitting program AMOS, Version 16 (SPSS Inc., Chicago, IL). According to several indexes, the model provides an acceptable fit. The χ^2/df ratio was 1.664, which is below the recommended cutoff point of < 3; the Bentler Comparative Fit Index was .941 and the Jöreskog-Sörbom Adjusted Goodness-of-fit Index was .926, each greater than the recommended value of at least .90 (see Kline, 1998).

One other sleep variable, sleep duration, was negatively associated with cumulative GPA: Students who reported getting more sleep had lower GPAs. Although counterintuitive, this seems to replicate the finding of a nonsignificant negative association between sleep duration and grades reported in two earlier studies (Gray and Watson, 2002; Trockel et al., 2000).

Discussion

To our knowledge, this is the first study to investigate the link between alcohol use and nighttime sleep patterns in the everyday lives of college students. Bridging research by sleep and alcohol researchers, the present study sheds light on how alcohol use is related to sleep habits and how these habits and resulting daytime sleepiness mediate alcohol's possible influence on academic performance. College students tend to keep late sleep schedules, get fewer than the recommended hours of sleep for their age, and have irregular sleep patterns (going to bed later and sleeping longer on the weekends than during the week). The results of the present research show that all of these tendencies are related to al-

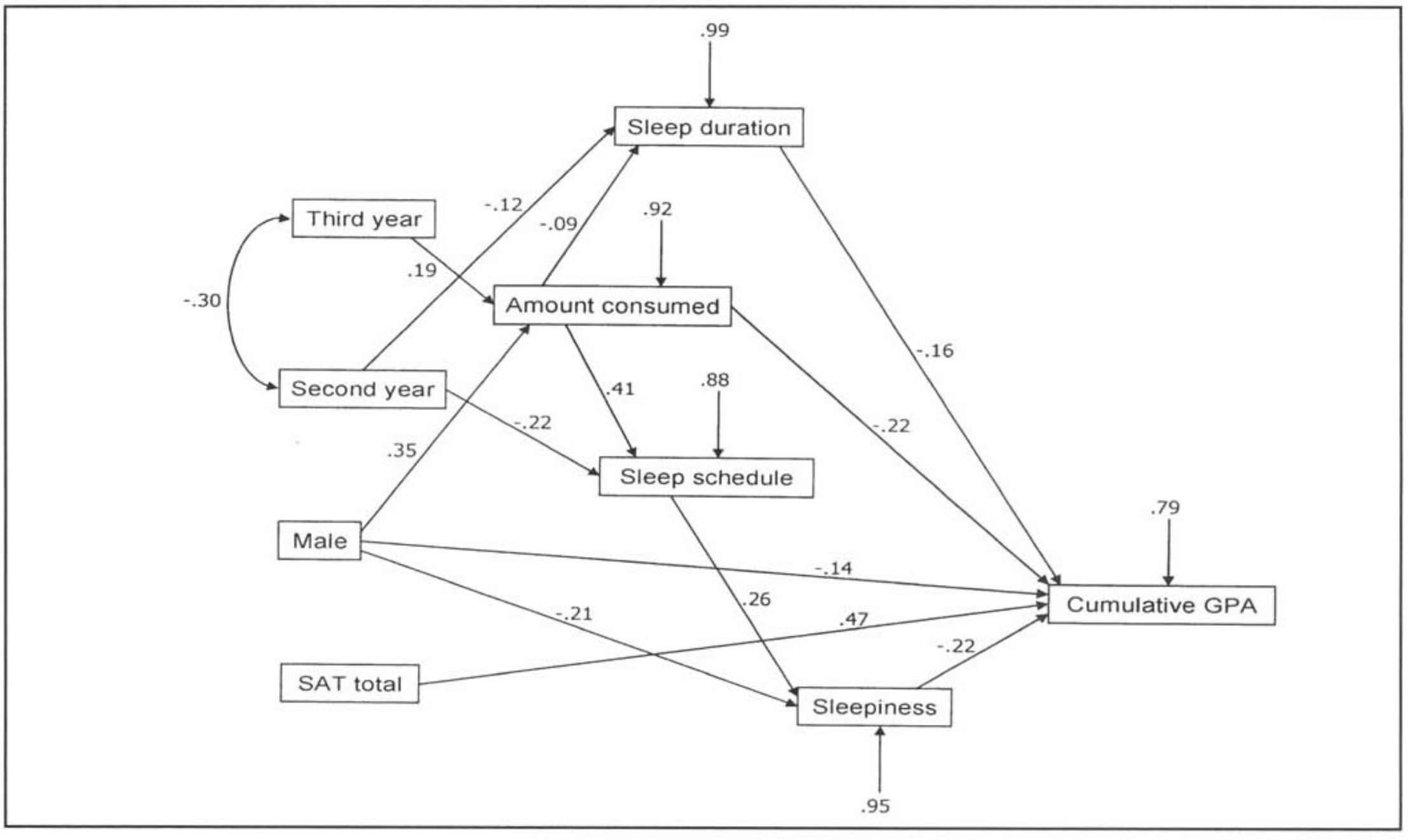


FIGURE 1. Path diagram of regressions of cumulative grade-point average (GPA), sleepiness, sleep duration, sleep schedule, and amount consumed; SAT = Scholastic Aptitude Test

cohol use, with the strongest association between volume of alcohol consumed and lateness of sleep schedule.

As expected, alcohol consumption was associated with academic performance when controls were introduced for academic aptitude, gender, and class year. The results further showed that this association was attenuated when sleep measures were added to the model and that part of alcohol's association with academic performance was mediated by students' sleep habits. Specifically, drinking was associated with a later sleep–wake schedule, which in turn was associated with an increase in daytime sleepiness and decrement in academic performance. Thus, the present study strengthens the inference that alcohol use undermines academic performance by demonstrating one means—poor sleep habits—by which this occurs.

An unexpected finding was the weak negative association between sleep duration and academic performance. This seems counterintuitive because sleep deprivation has been shown to diminish cognitive functioning. However, even relatively short nocturnal sleep in the present sample, as measured by average sleep time during the course of the week, would not constitute deprivation. Other research has found, moreover, that quality rather than quantity of students' sleep is more strongly associated with sleepiness and with a variety of health indicators (Pilcher et al., 1997). In fact, sleep quality may account for why the lateness of a student's sleep is associated with daytime sleepiness. Students who tend to go to bed later drink more alcohol, and alcohol use has been shown to disrupt nighttime sleep (Roehrs and Roth, 2001).

That students who reported more daytime sleepiness tended to get lower grades is contrary to one prior study showing no association between sleepiness and grades (Howell et al., 2004). However, several differences between these studies could account for this disparity, and the current finding is consistent with other research indicating that sleepy students were less able to solve mathematical problems (Campos-Morales et al., 2005). Overall, the results suggest the need to further clarify how sleep schedules, quantity, and quality affect excessive sleepiness and academic performance.

One limitation of the present study was the reliance on retrospective student reports as measures of sleep patterns. Sleep–wake diaries, sleep laboratory measurements, or actigraphy measurements possibly would provide more valid assessments. Studies of high school students indicate that self-reported data are valid, particularly when schedules are consistent (Wolfson et al., 2003). However, this may not be true of college students, who tend to have more irregular weekly schedules. Calculations of total sleep time from self-reports also vary from study to study. In this study, total sleep referred to the time in bed from bedtime to rise time, whereas in other studies, total sleep has been estimated by

the respondent. Neither of these measurements is optimal, but estimations of total sleep based on time in bed may be longer than the direct estimates reported in other surveys of college students.

Future research should examine more precisely the day-to-day alcohol consumption, sleep–wake schedules, and academic demands of college students. We suspect that the weak to moderate connections among alcohol, sleep, and academic performance observed in the present study would be stronger if these variables were assessed more proximately, such as by measuring alcohol consumption and sleep–wake schedules the night before—and daytime alertness the same day as—an examination.

It is also difficult to evaluate the generalizability of the findings. Whether similar results would be obtained for college students drawn from a wider socioeconomic/cultural background and nonresidential university setting is an empirical question. Unlike the present research, studies at large public universities have found an association between prior academic aptitude and alcohol use (Paschall and Freisthler, 2003; Wood et al., 1997). As Singleton (2007) has pointed out, the effects of such personal factors may be muted at small liberal arts colleges by a more unified and dominant student culture. At more elite schools, there also may be insufficient variation in SAT scores or similar measures to account for differences in alcohol consumption.

Although we are reasonably confident about time precedence among the variables, causal interpretations of these data should be made with caution. It is plausible that doing poorly in coursework leads to alcohol use and that poor sleep quality and excessive daytime sleepiness encourage alcohol use. It also is likely that we have omitted other causes of academic performance, and it is possible that some of these may be confounded with alcohol use and/or sleep. For example, students' level of interest in (or enthusiasm about) their coursework, living situation, or involvement in athletics may influence both alcohol use and academic performance. Future studies should take potential confounds such as these into account. Finally, although the academic consequences of sleep–wake patterns and alcohol consumption are important, there may be other effects as well. Future research also should evaluate the conjoint effects of sleep problems and alcohol consumption on mood, physical health, exercise, interpersonal relations, and other aspects of college students' lives.

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