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Sleep-Related Functional Impairment as a Moderator of Risky Drinking and Subsequent Negative Drinking Consequences in College Students

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Abstract

Objective: Poor sleep quality and insufficient total sleep time have been shown to modify the relationship between college drinking and negative drinking consequences. This study aimed to examine whether prospective associations between risky drinking and negative drinking consequences similarly differ by sleep-related functional impairment, which is novel to the literature.

Method: Data were obtained from a 2-month prospective study of 157 college drinkers (mean age = 19 years [*SD* = 1.11], 30% male, 76% White). Online questionnaires were administered at both Time 1 (T1) and Time 2 (T2) to measure sleep-related functional impairment (assessed by Insomnia Diurnal Impact Scale; Ruiz et al., 2011), and drinking behaviors and negative drinking consequences (assessed retrospectively over the past 2 months).

Results: Prospective negative binomial regression analyses demonstrated that associations of both maximum drinks and binge drinking frequency at T1 with negative drinking consequences at T2 differed by T1 sleep-related functional impairment after controlling for covariates (sex, negative mood, total sleep time, insomnia symptoms, morning preference, and negative drinking consequences at T1). Students reporting lower sleep-related functional impairment experienced high levels of negative drinking consequences only at high levels of risky drinking, whereas students reporting higher sleep-related functional impairment experienced consistently high levels of negative drinking consequences regardless of their risky drinking levels.

Conclusion: Findings indicate that sleep-related functional impairment may exacerbate negative drinking consequences of risky drinking. Thus, sleep-related functional impairment helps to explain individual differences in the association between risky drinking and negative drinking consequences in college students.

Keywords

sleep; functional impairment; alcohol; consequences; college students

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1. Introduction

Risky college drinking remains highly prevalent and associated with substantial negative consequences, including academic and cognitive impairment, assault, injury, and death (for a review, see Merrill & Carey, 2016). Poor sleep quality and insufficient total sleep time have been shown to exacerbate associations between college drinking and negative drinking consequences. In a cross-sectional study, weekly drinking quantity was positively associated with negative drinking consequences only among college drinkers who reported poor sleep quality; in contrast, among students reporting better sleep quality, weekly alcohol consumption was not associated with experience of negative drinking consequences (Kenney et al., 2012). In a longitudinal study, drinking quantity was more positively associated with negative drinking consequences among college drinkers who reported subjective inadequate total sleep time concurrently and at one, three, and five month follow-ups (Miller et al., 2016).

A growing literature further indicates reciprocal associations between sleep and alcohol behaviors among college drinkers. For example, a daily study of heavy-drinking college students found that students that were more alert upon waking drank more heavily and heavier drinkers reported shorter sleep durations on average (Fucito et al., 2018). Further, intervention research suggests that targeting sleep problems among college drinkers may result in decreased alcohol use and related consequences (Fucito et al., 2015; Fucito et al., 2017). However, there remains a paucity of research considering the unique moderating role of sleep-related functional impairment on college drinking and negative drinking consequences.

The role of poor sleep quality and insufficient sleep duration in the association of college drinking with negative drinking consequences may actually be driven by sleep-related functional impairment. Sleep-related functional impairment is a sub-component of “sleep quality,” which is a complex construct encompassing both quantitative (e.g., total sleep time) and subjective (e.g., daytime impairment) aspects of sleep (Buysse et al., 1989). Sleep-related functional impairment represents the diverse daytime consequences of poor sleep, including sleepiness, irritability, and difficulties with concentration and socializing (Ruiz, Guilera, & Gomez-Benito, 2011). Sleep-related functional impairment may reduce one’s capacity to make safe decisions and avoid impulsive behaviors, such as risky drinking (Kenney et al., 2012). Thus, college students with high sleep-related functional impairment may be more susceptible to the impairing effects of alcohol (e.g., disinhibition) and experience more negative drinking consequences than peers with lower sleep-related functional impairment.

Sleep-related functional impairment may be a prime contributor to exacerbations of the college drinking and subsequent negative drinking consequences relationship given its striking prevalence among college students. Up to 71% of college students report falling asleep in class (DeMartini & Fucito, 2014) and 40 – 50% report frequent irritability, excessive drowsiness, and concentration problems due to insufficient sleep (Oginska & Pokorski, 2006). Further, college students who report difficulty initiating or maintaining sleep have reported daytime fatigue and concentration difficulties due to lack of sleep on at

least four days per week (Alapin et al., 2000). However, sleep-related functional impairment overlaps considerably with other sleep constructs and sleep-related correlates. Specifically, sleep-related functional impairment has demonstrated moderate to high correlations with nighttime sleep difficulty (i.e., Athens Insomnia Scale, $r = .65$; Ruiz, Guilera, & Gomez-Benito, 2011). Thus, existing research on the moderating influences of poor sleep quality and insufficient sleep time on the college drinking and subsequent negative drinking consequences relationship (Kenney et al., 2012; Miller et al., 2016) may be due, at least in part, to sleep-related functional impairment. Research is needed to examine the unique moderating role of sleep-related functional impairment on college drinking and negative drinking consequences, after controlling for the influences of poor sleep, total sleep time, and other sleep-related constructs.

The current prospective study examined whether associations of college drinking with negative drinking consequences differed as a function of sleep-related functional impairment, after controlling for other aspects of sleep (i.e., insomnia symptoms, total sleep time, morning preference) and well-established sleep-related correlates (e.g., male sex and negative affect; Galambos et al., 2013; Taylor et al., 2013). This conservative approach allowed for isolation of the unique association of sleep-related functional impairment with drinking and negative drinking consequences. Based on previous findings (Kenney et al., 2012; Miller et al., 2016), it was hypothesized that drinking would be more strongly and positively associated with subsequent negative drinking consequences among college students with high levels of sleep-related functional impairment.

2. Materials and Methods

2.1 Participants and Procedure

Data were drawn from a two-wave longitudinal study of 171 college drinkers at a four-year university in the northeastern United States (Gellis et al., 2014; Goodhines et al., 2017). Participants were recruited from introductory psychology classes and compensated with credit for the course research component. Students who were at least 18 years of age and endorsed consuming one or more alcoholic drinks in the past 30 days were eligible to participate. This drinking-related eligibility criteria is consistent with a previous study validating a drinking consequences measure among college students (Earleywine, LaBrie, & Pedersen, 2008). Recruitment of a broad range of college drinkers (rather than exclusively heavy drinkers) was necessary given that even low-risk college drinkers have been shown to experience negative drinking consequences (Read et al., 2016) and as little as one drink can result in exacerbated insomnia symptoms during the night (Ebrahim et al., 2013) due to toxicity on sleep-related brain systems. The current sampling criteria was intended to capture a naturally-occurring cross-section of college sleepers, and thus sleep-related eligibility criteria was not implemented.

Participants completed two online surveys with an average interval of 68 days ($SD = 10.22$) between Time 1 (T1) and Time 2 (T2). Of the 171 participants at T1, 157 (92%) also participated at T2. Data from non-attriters who completed both T1 and T2 assessments ($n =$ 157 students) were used for analyses. The final sample was, on average, 19 years old ($SD =$ 1.11, range = 18 to 23) and 30% male. Students were 76% White, 10% Asian, 6% Black or

African American, 6% multiracial, and 1% American Indian or Alaska Native. Multiple logistic regression demonstrated attrition was predicted only by T1 insomnia severity (*OR* = 1.19; 95% CI [1.03, 1.38]), suggesting that the current results based on complete data may slightly underestimate the effects of insomnia severity. All study procedures were approved by the university's institutional review board.

2.2 Measures

2.2.1 Sleep-related functional impairment—The 6-item Insomnia Diurnal Impact Scale (Ruiz, Guilera, & Gomez-Benito, 2011) assessed the negative daytime effects of nighttime sleep difficulty over the "past month or longer" at T1 and T2. Participants indicated the degree to which they agreed with statements regarding daytime dysfunction (e.g., "I have generally felt sleepy throughout the day," "I have found it difficult to concentrate during the day") using a 4-point Likert scale ranging from 0 (*totally disagree*) to 3 (*totally agree*). Sum scores (possible range = 0 – 18; Cronbach's $\alpha = 0.84$) were used for analyses, with higher scores indicating greater sleep-related functional impairment.

This measure was selected in order to assess the varying domains of daytime functional impairment resulting from sleep problems. These sleep-related daytime functional impairments may result from an array of nighttime sleep symptoms, including but not limited to clinical insomnia or circadian rhythm sleep-wake disorders (American Psychiatric Association, 2013). This scale covers the broad range of sleep-related functional impairment relative to (a) measures of sleep problems which do not comprehensively assess the varied domains of daytime functional impairment (e.g., Pittsburgh Sleep Quality Index; Buysse et al., 1989) and (b) other measures assessing one specific domain such as fatigue (e.g., Fatigue Severity Scale, Krupp et al., 1989).

2.2.2 Drinking patterns—Four items were used at T1 and T2 to capture both typical drinking (i.e., alcohol use frequency and quantity) and risky drinking (i.e., maximum drinks and binge drinking frequency; Goodhines et al., 2017). The past-2-month timeframe was used to accommodate the 2-month time lapse between T1 and T2 assessments. For alcohol use and binge drinking frequency, students responded to "In the past 2 months, how often did you usually have any kind of drink containing alcohol?" and "In the past 2 months, how often did you have 5 (males) or 4 (females) or more drinks containing any kind of alcohol in within a two-hour period?" respectively, using a 9-point Likert scale ranging from 0 (*I did not drink any alcohol in the past 2 months*) to 8 (*Every day*). For alcohol quantity and maximum drinks consumed, students responded to "In the past 2 months, how many alcoholic drinks did you have on a typical day when you drank alcohol?" and "In the past 2 months, what is the largest number of drinks containing alcohol that you drank within a 24-hour period?" respectively, using an 11-point Likert scale ranging from 0 (*I did not drink any alcohol in the past 2 months*) to 10 (*Twenty-five or more drinks*). Items used to retrospectively report drinking are consistent with recommendations from the National Institute on Alcohol Abuse and Alcoholism (2003) and similar methodology is commonly used in college drinking studies (e.g., Keough, O'Connor, & Read, 2016), including national studies (e.g., Johnston et al., 2015).

2.2.3 Negative drinking consequences—The 23-item Rutgers Alcohol Problem Index assessed experience of diverse negative drinking consequences at T1 and T2 (White & Labouvie, 1989), such as “get into fights,” “have a bad time,” “neglect responsibilities,” and “black out.” The timeframe was modified from the past 12 months to accommodate the 2-month time lapse between T1 and T2 assessments. Participants responded to each item on a modified 7-point Likert scale ranging from 0 (*Never in the past 2 months*) to 6 (Six times or more in the past 2 months; Park et al., 2014). A sum score (possible range = 0 – 138; Cronbach’s α = .87) was used for analyses.

2.2.4 Insomnia severity—The 7-item Insomnia Severity Index assessed severity of insomnia symptoms at T1 and T2 (Bastien, Vallieres, & Morin, 2001). Participants indicated perceived severity of insomnia symptoms (e.g., difficulty falling asleep, waking up too early) using a 5-point Likert scale ranging from 0 (*None*) to 4 (*Very severe*). Sum scores (possible range = 0 – 28; Cronbach’s α = .86) were included as a covariate in all analyses, with scores ranging from 0 – 7 indicating no clinically significant insomnia, 8 – 14 indicating sub-threshold insomnia, 15 – 21 indicating moderate clinical insomnia, and 22 – 28 indicating severe clinical insomnia (Buysse et al., 2006; Smith & Wegener, 2003).

2.2.5 Total sleep time—Two investigator-developed items assessed average sleep duration in the past two weeks at T1 and T2. Participants identified times they typically went to bed or woke up on weekdays and weekends. Typical weekday and weekend sleep durations were calculated as the time elapsed between bed and wake times. By averaging typical weekday sleep duration (multiplied by five days) and weekend sleep duration (multiplied by two days) over a seven-day period, participants’ weighted average sleep duration (hours) was calculated and used as a covariate. While items are investigator-developed, this methodology and item wording is consistent with many past studies of college sleep (Singleton & Wolfson, 2009; Tavernier & Willoughby, 2015), as well as recommendations for sleep research (see Buysse et al., 2006).

2.2.6 Morning/evening preference—The 19-item Morningness-Eveningness Questionnaire assessed circadian preference at T1 (Horne & Ostberg, 1976). Participants identified their preferred sleep/wake times (e.g., “What time would you go to bed if you were entirely free to plan your evening?”) and functioning during the day (e.g., “How alert do you feel during the first half hour after you wake up in the morning?”). A sum score was used as a covariate in all analyses (possible range = 16 – 86; Cronbach’s α = .72), with higher scores indicating a morning (versus evening) preference.

2.2.7 Depression/anxiety—The 4-item Patient Health Questionnaire, which has demonstrated reliability and validity among college students (Khubchandani et al., 2016), assessed subjective depression and anxiety symptoms at T1 and T2 (Kroenke et al., 2009). Participants indicated how often during the past two weeks they experienced each symptom (e.g., “feeling nervous, anxious, or on edge,” “feeling down, depressed, or hopeless”) using a 4-point Likert scale ranging from 0 (*not at all*) to 3 (*nearly every day*). A sum score (possible range = 0 – 12; Cronbach’s α = .79) was used as a covariate in all analyses, given well-

established associations of depression and anxiety with both sleep and drinking in college students (Kenney et al., 2013; Taylor et al., 2013).

2.2.8 Demographics—Participant age and sex (0 = female, 1 = male) were assessed at T1 and included as covariates in all analyses, given demonstrated associations with college drinking (LaBrie et al., 2011) and sleep (Lund et al., 2010).

2.3 Data Analytic Strategy

Data analyses were computed in *SPSS* Version 23. Univariate outliers on negative drinking consequences at T1 (i.e., scores greater than 42; $n = 6$) and T2 (i.e., scores greater than 45; $n = 8$) were winsorized (Hoaglin & Iglewicz, 1987), consistent with recommendations for handling over-dispersed data when logical cut-offs are not indicated (Spiegelhalter, 2005). No univariate outliers were detected on other study variables. Descriptive statistics and bivariate Pearson correlations were computed for all study variables.

Negative binomial regression was used to examine the moderating effect of T1 sleep-related functional impairment on prospective relationships between T1 drinking and T2 negative drinking consequences. Separate models were estimated for each of the four drinking predictors. The negative binomial distribution accounted for over-dispersion (i.e., variance > mean; Hilbe, 2011) in T2 negative drinking consequences (mean = 11.11; variance = 150.06; dispersion parameter = 0.67 – 0.70; skewness = 1.58; kurtosis = 1.76; observed range = 0 – 45). Incidence rate ratios (IRR) and 95% confidence intervals were used for an effect-size measure of predictors and covariates. Participant sex, T1 depression/anxiety symptoms, T1 insomnia severity, T1 total sleep time, T1 morning/evening preference, and T1 negative drinking consequences were included as covariates. For significant interactions, simple slopes analyses were conducted to examine associations of T1 drinking and T2 negative drinking consequences at low and high levels (±1 *SD*) of T1 sleep-related functional impairment.

Ancillary analyses were conducted to test the moderating effect of T1 sleep-related functional impairment on the cross-sectional (rather than prospective) relationships of T1 drinking with T1 negative drinking consequences using full data at T1 ($N = 171$).

3. Results

3.1 Descriptive Analyses

Descriptive statistics and bivariate correlation coefficients for all study variables are presented in Table 1. On average, participants reported moderate levels of sleep-related functional impairment ($M = 7.82$; $SD = 3.37$), sub-threshold insomnia ($M = 8.57$; $SD = 5.37$), eight hours ($SD = 1.17$) of sleep per night, and an evening (versus morning) circadian preference ($M = 46.90$; $SD = 7.59$) at T1. These mean levels of sleep-related variables are comparable to those in a prior college study (Ruiz, Guilera, & Gomez-Benito, 2011). Among this sample, 21 students (13%) screened positive for clinical insomnia at T1 according to the Insomnia Severity Index standard threshold (Bastien, Vallieres, & Morin, 2001; Buysse et al., 2006). Further, on average, participants reported drinking alcohol once or twice a week ($M = 3.87$; $SD = 0.99$), consuming 5 – 6 drinks on a typical drinking day (M

= 3.75; *SD* = 1.59), consuming a maximum of 5 – 7 drinks within a 24-hour period (*M* = 5.04; *SD* = 1.85), and binge drinking two or three times per month (*M* = 2.68; *SD* = 1.72) at T1. Both T1 sleep-related functional impairment (*r*'s = .25; *p*'s < .01) and alcohol variables (*r*'s = .21 – .41; *p*'s < .01) were significantly and positively associated with negative drinking consequences at T1 and T2. Sleep-related functional impairment was significantly, negatively associated with total sleep time at T1 (*r* = −.22; *p* = .01), but T1 total sleep time was not significantly associated with negative drinking consequences at T1 or T2 (*r*'s = −.15 – −.11; *p*'s = .07 – .20).

3.2 Prospective Analyses Predicting T2 Negative Drinking Consequences

Results from main negative binomial regression analyses predicting T2 negative drinking consequences are presented in Table 2. There was a significant interaction between T1 maximum drinks and T1 sleep-related functional impairment on T2 negative drinking consequences (*IRR* = 0.98, 95% CI [0.96, 0.996], *p* = .02) after controlling for covariates. Likewise, there was a significant interaction between T1 binge drinking frequency and T1 sleep-related functional impairment on T2 negative drinking consequences (*IRR* = 0.97, 95% CI [0.95, .996], *p* = .03) after controlling for covariates. In contrast, T1 sleep-related functional impairment did not significantly moderate prospective associations of T1 drinking frequency (*p* = .09) or drinking quantity (*p* = .45) with T2 negative drinking consequences. Notably, significant moderation effects remained consistent when main analyses were re-run without the T1 insomnia severity covariate, thus illustrating that sleep-related functional impairment is responsible for observed moderation *even after* controlling for previously-identified moderators (i.e., nighttime sleep problems; Kenney et al., 2012; Miller et al., 2016).

As shown in Figure 1, T1 maximum drinks and T1 binge drinking frequency were more strongly positively associated with T2 negative drinking consequences at lower levels of T1 sleep-related functional impairment (*IRR* = 1.10, 95% CI [0.99, 1.23], *p* = .08; *IRR* = 1.15, 95% CI [1.02, 1.31], *p* = .03) as compared to higher levels of T1 sleep-related functional impairment (*IRR* = 0.93, 95% CI [0.83, 1.05], *p* = .26; *IRR* = 0.94, 95% CI [0.82, 1.09], *p* = .43). Specifically, among students reporting lower (−1 *SD*) levels of T1 sleep-related functional impairment, greater T1 maximum drinks and binge drinking frequency was associated with greater T2 negative drinking consequences. However, among students reporting higher (+1 *SD*) levels of T1 sleep-related functional impairment, T2 negative drinking consequences were consistently high regardless of T1 maximum drinks and binge drinking frequency.

3.3 Ancillary Analyses Predicting T1 Negative Drinking Consequences

Consistent with prospective results, ancillary analyses using full cross-sectional data at T1 (*N* = 171) revealed a significant interaction between T1 maximum drinks and T1 sleep-related functional impairment on T1 negative drinking consequences (*IRR* = 0.98, 95% CI [0.96, 0.99], *p* = .01) after controlling for covariates. Simple slopes analyses also indicated that T1 maximum drinks was more strongly, positively associated with T1 negative drinking consequences at lower (*IRR* = 1.36, 95% CI [1.23, 1.49], *p* < .001) as compared to higher (*IRR* = 1.15, 95% CI [1.04, 1.27], *p* = .01) levels of T1 sleep-related functional impairment.

No significant interactions of T1 alcohol frequency (*IRR* = 0.99, 95% CI [0.94, 1.03], $p = .55$), alcohol quantity (*IRR* = 0.98, 95% CI [0.96, 1.01], $p = .20$), or binge drinking frequency (*IRR* = 0.99, 95% CI [0.96, 1.01], $p = .23$) with T1 sleep-related functional impairment on T1 negative drinking consequences were found. Cross-sectional ancillary analyses highlight consistency of the observed moderation pattern both concurrently and prospectively, thereby increasing confidence in prospective findings.

4. Discussion

It is well-established that college students experience substantial sleep-related functional impairment and also frequently engage in risky drinking that leads to negative drinking consequences. The current two-month prospective study examined whether sleep-related functional impairment modified associations of T1 college drinking with T2 negative drinking consequences after accounting for T1 negative drinking consequences, depression/anxiety symptoms, sleep-related variables (i.e., insomnia severity, total sleep time, morning/evening preference) and sex. Students reporting higher sleep-related functional impairment experienced high levels of negative drinking consequences even at low levels of risky drinking. In contrast, students reporting lower sleep-related functional impairment experienced high levels of negative drinking consequences (at levels comparable to peers with higher sleep-related functional impairment) only at high levels of risky drinking. Thus, findings highlight sleep-related functional impairment as an important source of individual differences in the college drinking and negative drinking consequences relationship, over and above the effects of additional sleep constructs and sleep-related correlates.

Current results highlight college drinkers reporting higher sleep-related functional impairment as a high-risk group for unforeseen levels of negative drinking consequences, as these students experience consistently high levels of negative drinking consequences regardless of their drinking levels. In the presence of high sleep-related functional impairment, as opposed to nighttime sleep problems, failures in self-regulation resulting in negative drinking consequences may occur even at lower levels of risky drinking. For example, sleep-related functional impairment in young adults includes impulsive responding to negative stimuli (Anderson & Platten, 2011), weakened ability to inhibit aggression (Kahn-Greene et al., 2006), and impaired decision-making (Schnyer, Zeithamova, & Williams, 2009). Thus, sleep-related functional impairment may increase high-risk behavior and decrease protective behavior (e.g., pacing drinks) while drinking, resulting in greater experience of negative drinking consequences.

Previous research suggests students with poor sleep quality and subjective insufficient total sleep time experience greater negative drinking consequences only at high drinking quantity levels (Kenney et al., 2012; Miller et al., 2016). In contrast, the current study investigated associations of both general alcohol consumption (i.e., frequency, quantity) and risky drinking (i.e., maximum drinks, binge drinking frequency) with negative drinking consequences. Results indicate that sleep-related functional impairment may prospectively influence associations of risky drinking (but not general alcohol consumption) with negative drinking consequences, after accounting for insomnia severity, total sleep time, and morning/evening preference. This result may be explained by previous findings that risky

drinking and general alcohol consumption are differentially associated with the impairing effects of alcohol (and by extension negative drinking consequences). For example, binge drinkers aged 16 – 20 years experienced more negative drinking consequences than their non-binge drinking peers, regardless of drinking frequency (Reboussin et al., 2006).

4.1. Clinical Implications

Current findings suggest college drinkers may benefit from integrated interventions targeting sleep and drinking. Evidence-based sleep interventions for college students include cognitive-behavioral therapy and sleep hygiene (for a review, see Friedrich & Schlarb, 2017), which might expand upon alcohol-specific content (Fucito et al., 2015). For example, limiting alcohol use before bed is recommended as a standard component of sleep hygiene education (Stepanski & Wyatt, 2003). Integrated interventions should include personalized feedback on drinking, moderate drinking recommendations, and drinking reduction strategies (Fucito et al., 2015). Findings also indicate specific targeting of sleep-related functional impairment within integrated interventions, such as monitoring of next-day functioning (as in cognitive therapy for insomnia; Harvey, 2005).

4.2. Limitations and Future Directions

Findings must be interpreted with regard to several limitations. First, data were drawn from a predominantly White, female, first-year sample of students recruited from psychology classes at a northeastern United States private university. Because drinking and sleep patterns vary by diverse individual and school characteristics (Johnston et al., 2015; Lichstein et al., 2004), replication in samples with greater heterogeneity is needed to investigate generalizability of our findings. Further, eligibility criteria required that all participants endorse alcohol use at least once in the past 30 days, so findings may not generalize to infrequent drinkers; however, 83% of students in a comparable sample without this eligibility criteria endorsed alcohol use in the past 30 days (Lowery, Merrill, & Carey, 2018), suggesting such sampling bias may be minimal. Likewise, findings might not generalize to heavy-drinking or clinical samples of young adults. Additionally, the current study did not assess specific sleep disorders that may cause functional impairment (e.g., insomnia disorder, circadian rhythm sleep-wake disorders, obstructive sleep apnea, etc.) and subjective retrospective assessments may have been vulnerable to self-reporting biases and memory errors. Lastly, although this prospective design allows for superior assessment of temporal relationships relative to cross-sectional designs, the current study remains correlational in nature and causal inferences are speculative.

Results of the current study have the potential to inform future research. Because this is the first study testing the moderating role of sleep-related functional impairment in associations of both risky and general alcohol use behaviors with negative consequences, replication is necessary among both general college samples and specific sub-samples of heavy-drinkers and poor sleepers. In order to optimize reporting accuracy, future investigations should use measures robust to retrospective reporting error for drinking (e.g., Timeline Follow-Back; Sobell & Sobell, 1992) and daily sleep behaviors (e.g., Consensus Sleep Diary; Carney et al., 2012). Further, in order to reconcile the current findings with previous findings (Kenney et al., 2012; Miller et al., 2016), research is needed to examine how roles of poor sleep

quality and subjective total sleep time inadequacy in risky drinking and negative drinking consequences differ from the role of sleep-related functional impairment. Continued investigation might also assess specific factors (e.g., compromised decision making) that may mediate the relationship between sleep-related functional impairment and negative drinking consequences. Lastly, clinical research may investigate efficacy of integrating sleep-related functional impairment into college alcohol and sleep intervention programs (e.g., Fucito et al., 2015).

4.3. Conclusion

Despite these limitations, the current findings indicate that sleep-related functional impairment may exacerbate negative drinking consequences of risky drinking. Thus, sleep-related functional impairment helps to explain individual differences in the association between risky drinking and negative drinking consequences in college students.

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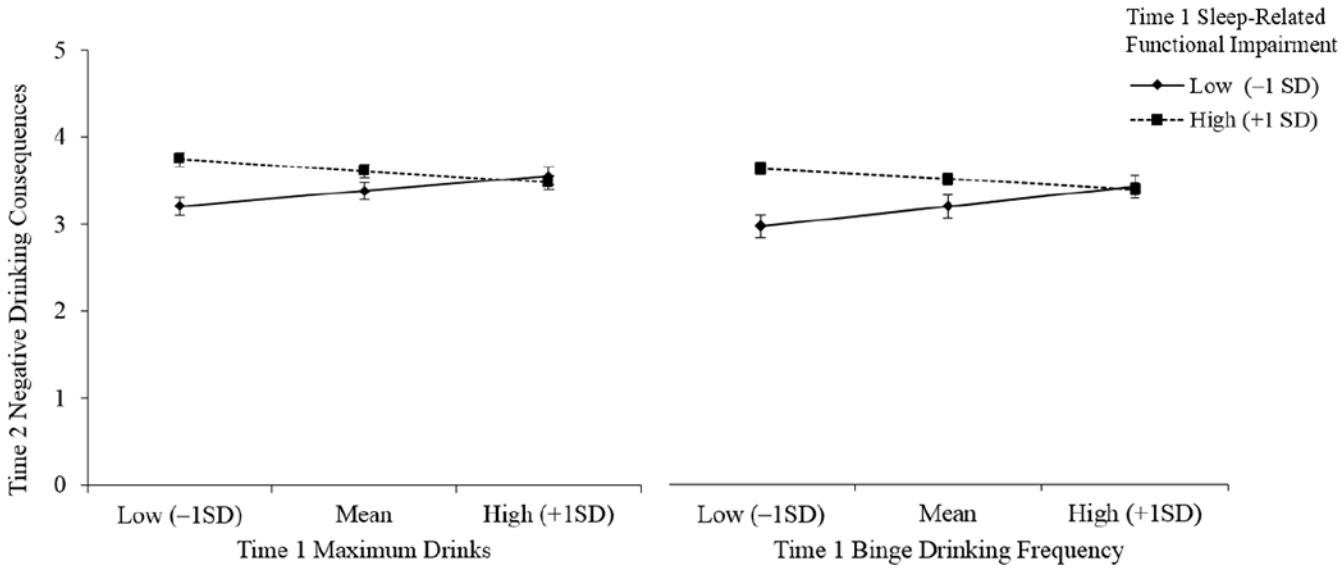

Figure 1.

n = 157. Simple slopes for associations of Time 1 maximum drinks and binge drinking frequency with Time 2 negative drinking consequences, by Time 1 sleep-related functional impairment.

Table 1

Correlation Coefficients among Study Variables at Time 1 and Time 2

		r																			
	% or *M* (*SD*)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Time 1 Variables																					
1. Male Sex (vs. Female)	30%	—																			
2. Age	18.87 (1.11)	**.17**	—																		
3. Sleep-Related Impairment	7.82 (3.37)	**−.17**	−.11	—																	
4. Alcohol Frequency	3.87 (0.99)	.15	−.03	.03	—																
5. Alcohol Quantity	3.75 (1.59)	**.37**	−.06	−.05	**.51**	—															
6. Maximum Drinks	5.04 (1.85)	**.30**	−.10	.07	**.62**	**.79**	—														
7. Binge Drinking Frequency	2.68 (1.72)	.12	.03	.08	**.65**	**.69**	**.67**	—													
8. Depression/Anxiety	3.58 (2.72)	−.07	−.02	**.49**	−.03	.01	.09	.06	—												
9. Insomnia Severity	8.57 (5.37)	−.14	.02	**.62**	.05	.00	.05	.13	**.42**	—											
10. Total Sleep Time (hours)	8.04 (1.17)	.09	−.01	**−.22**	.09	−.13	**−.17**	−.09	**−.18**	**−.31**	—										
11. Morning Preference	46.90 (7.59)	−.02	**.19**	−.12	−.11	−.13	−.15	−.15	−.06	−.04	−.03	—									
12. Negative Drinking Consequences	10.82 (10.75)	.09	−.11	**.25**	**.36**	**.33**	**.32**	**.41**	**.33**	**.32**	−.15	−.04	—								
Time 2 Variables																					
13. Sleep-related impairment	7.11 (3.62)	−.10	.02	**.57**	−.00	−.07	−.02	.02	**.34**	**.44**	−.13	−.09	**.20**	—							
14. Alcohol Frequency	3.71 (1.06)	**.18**	−.02	−.05	**.55**	**.34**	**.40**	**.39**	−.11	−.03	.10	−.12	**.17**	−.10	—						
15. Alcohol Quantity	3.84 (1.72)	**.22**	**−.18**	−.08	**.41**	**.60**	**.58**	**.43**	−.15	−.07	−.12	**−.30**	**.19**	−.10	**.41**	—					
16. Maximum Drinks	4.96 (1.70)	**.27**	−.15	.00	**.41**	**.58**	**.70**	**.39**	.04	−.01	−.15	−.16	**.25**	−.10	**.42**	**.60**	—				
17. Binge Drinking Frequency	2.50 (1.50)	.15	−.12	.01	**.49**	**.51**	**.57**	**.55**	−.02	.01	−.05	−.14	**.24**	−.01	**.54**	**.57**	**.57**	—			
18. Depression/Anxiety	2.55 (2.69)	−.08	−.00	**.31**	−.06	−.13	−.02	−.03	**.42**	**.33**	−.14	−.04	**.22**	**.53**	−.07	−.09	.03	−.02	—		
19. Insomnia Severity	7.39 (5.30)	−.08	.00	**.48**	**.20**	.01	.06	.13	**.34**	**.55**	−.13	−.12	**.29**	**.62**	.02	.00	−.05	.04	**.51**	—	
20. Total Sleep Time (hours)	8.38 (1.19)	−.10	**−.21**	−.07	−.04	−.07	−.02	−.15	−.14	**−.24**	**.40**	.01	**−.17**	**−.19**	−.10	−.06	.05	−.09	−.15	**−.25**	—
21. Negative Drinking Consequences	11.11 (12.25)	.13	−.09	**.25**	**.25**	**.21**	**.22**	**.27**	**.26**	**.21**	−.11	**−.19**	**.52**	**.27**	**.20**	**.31**	.15	**.28**	**.33**	**.43**	−.14

Note. n = 157. Pearson's correlation coefficient are reported for two continuous variables; Spearman's coefficients are reported for continuous and dichotomous (i.e., Male Sex) variables. Significant correlation coefficients at $p < .05$ are highlighted in bold font.

Table 2

Results from Negative Binomial Regression Analyses Predicting T2 Negative Drinking Consequences

	IRR (95% CI) Predicting T2 Negative Drinking Consequences			
Predictors and Covariates	**T1 Alcohol Frequency**	**T1 Alcohol Quantity**	**T1 Maximum Drinks**	**T1 Binge Drinking**
Male Sex	1.66 (1.21, 2.29) **	1.64 (1.16, 2.33) **	1.62 (1.17, 2.25) **	1.58 (1.14, 2.18) **
T1 Depression/Anxiety	1.02 (0.96, 1.10)	1.03 (0.96, 1.10)	1.04 (0.97, 1.11)	1.03 (0.96, 1.10)
T1 Insomnia Severity	1.02 (0.98, 1.05)	1.01 (0.98, 1.05)	1.02 (0.98, 1.05)	1.01 (0.98, 1.05)
T1 Total Sleep Time	0.97 (0.85, 1.11)	0.96 (0.84, 1.10)	0.94 (0.82, 1.08)	0.96 (0.84, 1.09)
T1 Morning Preference	0.97 (0.95, 0.99) ***	0.97 (0.95, 0.99) **	0.97 (0.95, 0.99) ***	0.97 (0.95, 0.99) **
T1 Negative Drinking Consequences	1.05 (1.03, 1.06) ***	1.05 (1.03, 1.06) ***	1.04 (1.03, 1.06) ***	1.04 (1.03, 1.06) ***
T1 Alcohol Frequency, Quantity, Maximum, or Binge Drinking	1.02 (0.85, 1.22)	1.01 (0.89, 1.15)	1.01 (0.92, 1.11)	1.04 (0.94, 1.16)
T1 Sleep-related Functional Impairment	1.04 (0.98, 1.11)	1.05 (0.98, 1.11)	1.04 (0.97, 1.10)	1.05 (0.99, 1.11)
T1 Alcohol * T1 Sleep-related Functional Impairment	0.96 (0.91, 1.01)	0.99 (0.96, 1.02)	0.98 (0.96, 1.00) *	0.97 (0.95, 1.00) *

Note. n = 157. IRR = incidence rate ratio; CI = confidence interval; T1 = Time 1; T2 = Time 2.

* $p < .05$.

** $p < .01$.

*** $p < .001$.