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Sleep and Alcohol Use among Young Adult Drinkers with Insomnia: A Daily Process Model

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Abstract

Background: Previous studies examining associations between sleep and alcohol use have done so primarily at the aggregate (between-person) level and primarily among healthy young adults. This study aimed to examine reciprocal, within-person associations between sleep and alcohol use among young adult drinkers with insomnia.

Methods: Young adults who engaged in past-month binge drinking and met diagnostic criteria for insomnia (*N*=56) wore wrist actigraphy and completed online daily diaries assessing sleep and drinking for an average of 8.52 days (*SD*=2.31), resulting in 477 reports. Multilevel models were used to examine within- and between-person effects of sleep quality and efficiency on alcohol use and vice versa. Bedtime and waketime were included as secondary sleep parameters.

Results: Participants reported drinking on 231 days (48%). Participants did not report significantly different sleep quality on heavier-drinking days, nor did they demonstrate significant changes in actigraphy-measured sleep efficiency. However, they self-reported better sleep efficiency on heavier-drinking days (driven primarily by improvements in sleep onset latency), and they reported heavier drinking following days of better sleep efficiency (driven by improvements in total sleep time). Drinking was also associated with later bedtimes and waketimes.

Conclusions: Young adult drinkers with insomnia report reciprocal associations between subjective sleep efficiency and alcohol use, but these results were not replicated using objective measures. Providers may need to challenge the belief that there is a positive association between alcohol use and sleep among young adults who drink and have insomnia.

Keywords

alcohol; insomnia; sleep; heavy-drinking; college

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1.1 Introduction

Heavy alcohol use is prevalent in the United States, with one in four 18- to 30-year-olds reporting binge drinking (defined as 4/5+ drinks for women/men)[1] in the past year and one in two young adults reporting past-year problems related to use.[2] These problematic forms of alcohol use often co-occur with other mental health problems,[3] including insomnia. Approximately half of heavy drinkers report clinically significant sleep disturbances,[4,5] and this rate of sleep disturbance is even higher among those with Alcohol Use Disorder (AUD).[6] This may be due in part to the belief that alcohol will help with sleep, particularly falling asleep. Approximately 50-60% of those in treatment for AUD report regular use of alcohol as a sleep aid.[7,8] Use of alcohol as a sleep aid is much less prevalent among drinkers without AUD; however, 28% of those with insomnia also report using alcohol to help with sleep.[9] Importantly, sleep problems have also been linked to subsequent alcohol use and alcohol-related problems.[10-12] Therefore, trouble with either of these health domains may create an ongoing, negative feedback loop of sleep to alcohol problems and vice versa.

A number of daily, longitudinal, and experimental studies have examined associations between sleep and alcohol use in healthy adults. Among healthy (primarily young) adults, a moderate to heavy dose of alcohol before bedtime tends to induce sleepiness and decrease time to sleep onset, if sleep is attempted on the descending versus ascending limb of the BAC curve.[13-16] However, such doses of alcohol have also been linked to increased light sleep and/or wakefulness, at least in the second half of the night; and they tend to be associated with worse sleep quality and daytime fatigue.[13-19] Survey research also suggests reliable concurrent and prospective associations between alcohol use and difficulty falling or staying asleep in large samples of adolescents and adults.[4,20-22] Based on these data, alcohol use seems to have more negative than positive effects on sleep in otherwise healthy adults.

In contrast to the range of studies examining associations between sleep and alcohol use among healthy adults, few studies have examined this association among individuals who tend to have below-average levels of slow-wave sleep, such as those with insomnia or AUD.[23-26] We highlight this distinction because at least one study has found that consumption of 0.5g/kg of alcohol (~3 standard drinks) one hour before bedtime brings the deeper, slower-wave sleep of individuals with insomnia closer to the levels of individuals without insomnia.[23] Individuals with insomnia tend to develop a tolerance to this effect within six nights of drinking.[27] However, if they initially experience a beneficial effect on sleep, then they may be more likely than healthy populations to perceive a positive association between alcohol use and sleep. Indeed, in at least one study of young adults with sleep complaints, the negative daily association between alcohol use and subsequent sleep quality that is documented in otherwise healthy adults was not evident.[28]

This study tested the daily association between alcohol use and sleep among young adult drinkers with insomnia. Sleep quality (one's subjective rating of sleep from 'very poor' to 'very good') and sleep efficiency (the percentage of time spent in bed that is actually spent sleeping) were identified as primary sleep variables because subjective sleep disturbance and unconsolidated ("inefficient") sleep are central to the diagnosis and maintenance of insomnia.[29,30] Based on research indicating that one in four individuals with insomnia uses

alcohol to help with sleep,[9] we hypothesized that participants would self-report better sleep quality and efficiency after drinking. We also included objective (actigraphy) measures of sleep efficiency. In an effort to replicate and extend previous findings,[28,31] we also examined daily associations between alcohol use and bedtime/waketime. Finally, to rule out alternative temporal ordering – and to replicate previously-documented daily associations between sleep and subsequent alcohol use[28] – we examined the impact of sleep parameters on alcohol use the next day.

2.1 Materials and methods

2.1.1 Participants and procedure

Participants were recruited from the community (e.g., flyers, social media) to participate in an insomnia treatment study for heavy-drinking young adults with insomnia.[32] After providing written informed consent, participants completed self-report measures and a semi-structured clinical interview assessing DSM-5 criteria for sleep and psychiatric disorders with a trained research assistant. They were then asked to complete a brief online survey every day until their next research appointment, which was scheduled at least 7 days later. Eligibility criteria included ages 18-30 years, 1+ binge drinking episode (4/5+ drinks for women/men) in the past 30 days, and diagnostic criteria for insomnia. Criteria for insomnia included >30 minutes falling/staying asleep on 3+ nights per week for 3+ months, plus daytime impairment.[33] Data were collected between August 2018 and June 2019. All procedures were approved by the Institutional Review Board. Data for this study were derived solely from the baseline assessment. Sample demographics are presented in Table 1.

2.1.2 Measures

2.1.2.1 Sleep parameters—Daily online sleep diaries assessed what time participants got into bed, what time they tried to go to sleep (bedtime), how long it took them to fall asleep (sleep onset latency), how much time they spent awake during the night (wake after sleep onset), what time they woke up (waketime), and what time they got out of bed for the day.[34] Sleep efficiency was calculated by dividing the amount of time spent sleeping by the amount of time spent in bed (range 0-100%). Participants also rated their subjective sleep quality on a scale from 0 (*very poor*) to 4 (*very good*). Although self-report is the recommended method for assessment of insomnia in adults,[30] actigraphy (Actiwatch Spectrum Plus, Philips Respironics) was also used to measure sleep objectively. Actigraphy data were analyzed in 30-second epochs using medium sensitivity settings. Software algorithms were used to estimate actigraphy sleep variables, using self-reported start/end times for the sleep period because actigraphy is less reliable in estimating these parameters for individuals with insomnia.[35]

2.1.2.2 Alcohol use—Daily standard drinking quantity was also assessed on daily diaries. Participants reviewed definitions of a standard drink (e.g., 12oz regular beer) before indicating how many standard drinks they consumed, approximately what time they started drinking, what time they finished their last drink, and whether or not they were drinking specifically to help with sleep.

2.1.2.3 Demographic information and covariates—

Participants reported age, sex, race/ethnicity, and college enrollment. They provided inlab measures of height and weight to aid in calculation of body mass index (BMI). Insomnia severity was assessed using the 7-item Insomnia Severity Index (ISI), which asks participants how severe their problems staying or falling asleep are on a scale from 0 (*none*) to 4 (*very severe*).[36] In community samples, a cut-off score ≥10 demonstrated 86% sensitivity and 88% specificity in identifying cases of insomnia.[36] Hazardous drinking was assessed using the 10-item Alcohol Use Disorders Identification Test (AUDIT).[37] Among young adults, a cut-off score ≥8 demonstrates 75% sensitivity and 82% specificity in identifying at-risk drinking.[38] Participants reported cannabis use (yes/no) on diary reports, and diaries were also used to estimate time elapsed between drinking cessation and bedtime.

2.1.3 Data Screening and Analysis

Participants (N=56) completed an average of 8.52 diaries (SD=2.31, range=1-15; 477 data points) and reported an average of 4.13 drinking days (SD=2.19, range=0-10; 231 data points). Multilevel modeling (MLM) was used to examine within- and between-person effects of alcohol variables on sleep parameters and vice versa. Sleep and alcohol variables were each missing on ≤0.1% of data points. All available data were utilized.

Analyses were conducted in IBM SPSS Statistics 26. Unconditional models were conducted to determine the intraclass correlation coefficient (ICC) for each outcome. ICCs indicated that 22% of the variance in sleep quality, 37% of variance in self-reported sleep efficiency, 31% in actigraphy sleep efficiency, 26% in bedtime, 26% in waketime, and 5% in drinking quantity occurred between individuals (at level 2). Remaining variance occurred within individuals over time (at level 1).

In full models, Level 1 (L1) variables were centered by person means to capture within-person variability over time, and continuous level 2 (L2) variables were centered by grand means to capture between-person variability at baseline.[39] In models examining alcohol effects on sleep parameters, alcohol use was assumed to precede sleep. In models examining sleep effects on drinking, alcohol use was lagged so that sleep parameters would predict alcohol the following day. For all models, between-person (level 2) covariates included sex (0=female, 1=male), college status (0=non-college, 1=college), body mass index, frequency of cannabis use over baseline, average drinking quantity, and average insomnia severity (ISI score). Within-person (level 1) covariates included weekend versus weekday report (0=Sunday to Thursday, 1=Friday or Saturday), prior day's value of the outcome, and day-level cannabis use (0=no, 1=yes). In models predicting sleep outcomes, time between drinking cessation and bedtime was also included as a covariate. When model convergence allowed, intercepts were specified as random to allow for individual differences in baseline levels of each outcome and slopes were specified as random to allow for individual differences in change in outcomes over time. An autoregressive covariance structure (assuming smaller correlations over time) was specified for repeated effects. Cohen's f^2 values of 0.02, 0.15, and 0.35 indicate small, medium, and large effect sizes, respectively.[40]

3.1 Results

3.1.1 Primary Models: Alcohol Use Predicting Change in Same-Day Sleep

3.1.1.1 Self-reported outcomes—Inferential statistics for primary models are presented in Table 2. Drinking quantity was not significantly associated with sleep quality at the between- or within-person level. At the between-person level, individuals reporting more severe insomnia reported worse sleep quality than those reporting less severe insomnia. At the day-/within-person level, participants reported better sleep quality on weekends than on weekdays, and they reported worse sleep quality (closer to their personal average) if they had experienced above-average sleep quality the night before (see Table 2).

In contrast to the model for sleep quality, participants reported ~1% better sleep efficiency (on a scale from 0-100%) on days that they consumed 1 standard deviation more than their personal drinking quantity average f^2=.01; see Table 2). Participants also reported worse sleep efficiency if they had experienced above-average sleep efficiency the night before, and they reported better sleep efficiency on nights that they drank closer to bedtime.

Given the association between alcohol use and self-reported sleep efficiency, follow-up analyses were conducted to determine which aspect of sleep efficiency (sleep onset latency, wake after sleep onset, or total sleep time) drove this effect. The ICC for each outcome was 0.33, 0.30, and 0.29, respectively. For every 1 standard deviation increase in drinks consumed, participants reported falling asleep about 2 minutes faster (B=−1.83, p=.001; 95% CI=−2.93, −0.73; f^2=.03) and waking up about 1 minute less in the middle of the night (B=−1.17, p=.005; 95% CI=−1.98, −0.35; f^2=.01). Drinking quantity was not significantly associated with total sleep time (B=−0.001, p=.96; 95% CI=−0.06, 0.06) at the within-person level, and between-person differences in drinking quantity were not associated with any of these outcomes. Notably, individuals with more severe insomnia reported longer time to sleep onset than those with less severe insomnia (B=2.25, p=.02; 95% CI=0.36, 4.13), college students reported less wake after sleep onset than non-college participants (B= −15.55, p=.01; 95% CI=−26.71, −4.39), and individuals with higher BMIs reported less total sleep time than those with lower BMIs (B=−0.05, p=.03; 95% CI=−0.10, −0.01). Participants also reported significantly longer total sleep time on weekends than weekdays (B=0.43, p=.02; 95% CI=0.07, 0.79) and on nights that they drank closer to bedtime (B=0.15, p=.003; 95% CI=0.05, 0.24).

3.1.1.2 Actigraphy outcomes—Drinking quantity was not associated with actigraphy sleep efficiency at the between- or within-person level (see Table 2). College students (vs non-college participants) and more frequent (vs less frequent) cannabis users demonstrated worse actigraphy-based sleep efficiency than non-college participants. Other covariates are listed in Table 2.

3.1.2 Secondary Models: Alcohol Use Predicting Change in Bedtime/Waketime

Secondary analyses examined drinking as a predictor of change in bedtime/waketime. For every 1 standard deviation increase in drinking quantity, participants reported going to bed ~7 minutes later (B=0.12, p<.001; 95% CI=0.08, 0.17; f^2=.07) and waking up 3-4 minutes

later (*B*=0.06, *p*=.01; 95% CI=0.01, 0.12; f^2=.02). Notably, college students reported later bedtimes (*B*=0.90, *p*=.01; 95% CI=0.23, 1.56) and waketimes (*B*=1.03, *p*=.003; 95% CI=0.36, 1.70) than non-college participants. Participants also reported going to bed (*B*=0.38, *p*=.01; 95% CI=0.10, 0.67) and waking up (*B*=0.65, *p*<.001; 95% CI=0.31, 0.98) later on weekends than weeknights. Again, in both models, participants reported later bedtimes/waketimes if they had gone to bed or woken up earlier than normal the night before (*p*<.001). There were no other between- or within-person correlates of bedtime or waketime.

3.1.3 Alternative Models: Sleep Predicting Change in Next-Day Alcohol Use

Inferential statistics examining sleep quality and efficiency as predictors of alcohol use are presented in Table 3. Participants reported drinking significantly more following nights of better self-reported sleep efficiency (f^2=.05). In contrast, neither sleep quality nor actigraphy sleep efficiency was associated with drinking quantity the following day (see Table 3). Bedtime (*B*=−0.04, *p*=.70; 95% CI=−0.27, 0.18), waketime (*B*=0.18, *p*=.10; 95% CI=−0.03, 0.38), and sleep onset latency (*B*=−0.001, *p*=.89; 95% CI=−0.01, 0.01) were also not associated with change in drinking quantity; and participants reported drinking less (not more) following nights of above-average wake after sleep onset (*B*=−0.02, *p*=.01; 95% CI= −0.03, −0.01;f^2=.02). However, they reported drinking significantly more following nights of above-average total sleep time (*B*=0.34, *p*<.001; 95% CI=0.16, 0.52; f^2=.06). The only other significant correlate of daily drinking quantity was between-person drinking quantity; specifically, heavier drinkers reported significantly greater drinking quantities than lighter drinkers on any given day (see Table 3).

3.1.4 Supplementary Analyses

Based on research indicating that individuals with insomnia develop a tolerance to the sleep-promoting effects of alcohol within a few days,[27] we examined “number of consecutive drinking days” (see Table 4) as a covariate in primary sleep outcome models. Inclusion of this variable did not change the pattern of results described above, and it was not significantly associated with sleep parameters at the between- or within-person levels (all *p*>.05). Because it was also highly correlated with drinking quantity (*r*=0.49, *p*<.001), we did not include it in final models.

4.1 Discussion

This study adds to a growing literature documenting daily, within-person associations between alcohol use and sleep. It extends previous studies by documenting that these associations may seem more positive for young adults who meet diagnostic criteria for insomnia. This subpopulation is important because sleep complaints are prevalent among heavy-drinking young adults and seem to confer additional risk for alcohol-related problems.[12,41]

Participants in this study reported small but significant improvements in sleep efficiency on drinking days – attributable primarily to improvements in sleep onset latency. While this self-reported change in sleep onset was not replicated using objective (actigraphy) measures,

the finding that participants perceived a reliable improvement in their ability to fall asleep is important for at least two reasons. First, perceptions of improved sleep after drinking may lead to reliance on alcohol to help with sleep. Second, among individuals in treatment for AUD, subjective sleep parameters are more strongly associated with future drinking than corresponding objective (polysomnography) measures.[42] Thus, the perception of alcohol-related sleep improvement is likely more powerful and clinically meaningful than any objective change, or lack thereof.

It is notable that this self-reported improvement in ability to fall asleep did not translate to improvements in sleep quality. Although the lack of association between drinking and sleep quality documented in this sample differs from several studies with healthy adults,[16-19] it is consistent with research among young adults with sleep complaints.[28] The lack of effect for sleep quality seems counterintuitive because participants reported less time awake at night on drinking days. However, polysomnographic studies suggest that moderate to heavy alcohol use before bedtime may increase objective measures of wakefulness in the second half of the night.[13,15] This pattern is also evident, but was not significant, in adults with insomnia.[23] If this is the case, then participants may not experience improved quality of sleep, even if they are falling asleep more quickly. Notably, the association between drinking and sleep quality may also differ for individuals who drink regularly. Indeed, Geoghegan and colleagues[16] found that the negative impact of alcohol on sleep may be more evident in lighter-drinking samples.

In contrast to previous research,[27] consecutive days of drinking did not have a significant impact on sleep-related outcomes in this study. At least one experimental study found that individuals with insomnia build a tolerance to the sleep-promoting effects of alcohol within six days.[27] However, the majority of participants in this sample did not drink for more than two days in a row. Thus, future research examining the impact of consecutive drinking days on sleep among more frequent drinkers, such as those with moderate to severe AUD, is encouraged.

Consistent with previous studies,[28] young adult drinkers with insomnia also reported going to bed and waking up later after drinking, perhaps because they stay up later socializing on nights of alcohol use.[28] These later bedtimes may account in part for the shorter self-reported time to sleep onset and wake after sleep onset on drinking days. Specifically, going to bed later than one's typical time may result in greater propensity for sleep, which may also make it easier to fall and stay asleep.[29]

Data from this study also suggest that, among young adult drinkers with insomnia, sleep may also have reciprocal effects on alcohol use the following day. Specifically, participants reported heavier drinking following nights of better self-reported sleep efficiency, and this effect seems to be driven by longer total sleep time prior to drinking nights. One may speculate that participants drank more because they slept longer and, ostensibly, felt more rested the following day. However, previous research has not found significant associations between alertness and drinking at the within-person level,[28] and we did not find a significant within-person association between sleep quality (which one might expect to be correlated with "restful" sleep) and subsequent drinking. Alternatively, it is possible that participants

went to sleep in anticipation of a drinking day and, in order to prepare for that day, made it a priority to get more sleep. Given discrepancies between findings, additional research in this area seems warranted.

4.1.1 Clinical Implications

The potential for alcohol use to influence sleep (and vice versa) has important implications for alcohol prevention and intervention efforts, as young adults are interested in feedback on their sleep[43-45] and may be more motivated to change their drinking if it impacts broad health outcomes. Unfortunately, data from this study suggest that young adult drinkers with insomnia report more efficient sleep on days of heavier drinking. In treatments such as Cognitive Behavioral Therapy for Insomnia, where daily sleep patterns are often reviewed as part of treatment, it seems important to address and explore these associations. Although only a small proportion of young adults in this study reported using alcohol to help with sleep, it may still be important to challenge the idea that alcohol helps with sleep – specifically pointing out the lack of association between drinking and sleep quality and the possibility that alcohol use leads to disrupted sleep physiology throughout the course of the night.[13,15] Alternatively, if young adults fixate on a positive association between alcohol use and sleep onset latency, it may be helpful to point out the relatively small magnitude of this effect (in this study, an improvement of only ~2 minutes per standard deviation increase in drinking) and to discuss research indicating that individuals tend to build a tolerance to the sleep-promoting effects of alcohol within a few days.[27]

4.1.2 Limitations

This study is one of the few to examine daily associations between alcohol use and sleep among individuals with insomnia, and generalizability is strengthened by the inclusion of young adults who were not in college. However, there were limitations that should be considered. Our sample was primarily white and female, which may restrict generalizability of findings. This may be explained in part by higher rates of insomnia among both of these populations,[46] but research in more diverse samples is needed. We also reported data for a relatively small number of participants, in which case it is important to replicate these findings in larger samples. However, Level 2 samples of 30+ tend to have minimal impact on estimated fixed effects and standard errors at Level 1 in multilevel models.[47] Finally, temporally-ordered associations cannot determine causal effects, so conclusions drawn should be considerate of extraneous influences.

4.1.3 Conclusion

Research has documented longitudinal, bidirectional associations between sleep and alcohol use at the between-person level. This study is among the few to examine these associations within persons and is the first to examine these associations among drinkers with insomnia. Young adult drinkers with insomnia self-reported small but significant improvements in sleep efficiency on days of heavier drinking, and they reported heavier drinking following days of better self-reported sleep efficiency. However, results were not replicated using objective measures. The potential for alcohol use to impact young adults' perceptions of their sleep is important for alcohol prevention and treatment efforts, as young adults with

insomnia may be less motivated to change drinking behaviors that they believe positively influence their sleep.

Author Agreement

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Highlights

- Most variance in sleep and drinking occurred within (not between) individuals.
- Drinking quantity did not significantly impact sleep quality.
- Participants self-reported more efficient sleep after drinking, and vice versa.
- Subjective findings were not replicated using objective measures.

Table 1

Baseline characteristics of young adult drinkers with insomnia (N=56).

Demographics	***M* (*SD*) or *n* (%)**
Age	22.4 (2.7)
Female (vs. male)	42 (75%)
Race	---
European American alone	46 (82%)
African American alone	3 (5%)
Asian American alone	0 (0%)
Native American or Native Alaskan alone	1 (2%)
Native Hawaiian or Pacific Islander alone	0 (0%)
Two or more races	6 (11%)
Hispanic/Latinx	2 (4%)
Current college enrollment	41 (73%)
Alcohol Use and Sleep	*M (SD)* or *n* (%)
Number of drinking days (diary reports)	4.13 (2.19)
Drinks per drinking day (diary reports)	4.17 (3.01)
Hazardous drinking (AUDIT total score)	9.54 (4.34)
Positive screen (AUDIT score ≥ 8)	37 (66%)
Use of alcohol as a sleep aid (diary reports)	7 (13%)
Insomnia severity (ISI total score)	16.18 (3.51)
Positive insomnia screen (ISI score ≥ 10)	56 (100%)
Sleep quality (0-4; diary reports)	1.92 (0.57)
Sleep efficiency (0-100%; diary reports)	---
Diary self-reports	76.63 (10.41)
Actigraphy	76.94 (6.45)
Bedtime (military time; diary reports)	24.42 (1.02)
Waketime (military time; diary reports)	8.49 (1.11)
Total sleep time (hours; diary reports)	7.03 (1.17)

Note. AUDIT=Alcohol Use Disorders Identification Test. ISI=Insomnia Severity Index.

Table 2.

Drinking quantity predicting change in self-reported sleep parameters that evening (N=56).

	Outcome: Sleep Quality (self-report)			Outcome: Sleep Efficiency (self-report)			Outcome: Sleep Efficiency (actigraphy)		
Parameter	**Estimate**	***p***	**95% CI**	**Estimate**	***p***	**95% CI**	**Estimate**	***p***	**95% CI**
Intercept	1.67	<.001	1.28, 2.07	69.39	<.001	63.85, 74.94	78.91	<.001	73.69, 84.12
Time	0.05	.03	0.01, 0.10	1.04	.002	0.39, 1.69	0.12	.75	−0.61, 0.85
L2 male (Y/N)	−0.35	.07	−0.73, 0.03	0.47	.86	−4.78, 5.73	−0.54	.83	−5.68, 4.60
L2 college student (Y/N)	0.05	.77	−0.31, 0.42	3.51	.17	−1.49, 8.51	−5.32	.03	−9.99, −0.65
L2 BMI (gmc)	−0.02	.16	−0.04, 0.01	−0.31	.08	−0.66, 0.03	−0.13	.43	−0.47, 0.20
L2 insomnia severity (gmc)	−0.06	.02	−0.10, −0.01	−0.58	.07	−1.22, 0.05	−0.64	.06	−1.30, 0.02
L2 days of cannabis use (gmc)	0.10	.06	−0.002, 0.21	1.23	.10	−0.23, 2.70	−1.55	.03	−2.93, −0.18
L2 drink-to-bed timing (gmc)	0.11	.08	−0.01, 0.24	0.48	.58	−1.26, 2.23	−0.86	.32	−2.58, 0.85
L2 drinking quantity (gmc)	−0.07	.41	−0.21, 0.09	0.60	.56	−1.46, 2.66	0.57	.59	−1.54, 2.68
L1 weekend (Y/N)	0.25	.02	0.05, 0.45	2.64	.06	−0.15, 5.43	1.51	.36	−1.76, 4.79
L1 prior day outcome (pmc)	−0.34	<.001	−0.44, −0.24	−0.40	<.001	−0.50, −0.30	−0.34	<.001	−0.49, −0.19
L1 cannabis use (Y/N)	0.12	.50	−0.22, 0.46	−4.13	.08	−8.81, 0.56	4.15	.08	−0.46, 8.77
L1 drink-to-bed timing (pmc)	−0.02	.56	−0.07, 0.04	1.07	.004	0.35, 1.78	−0.89	.12	−2.01, 0.23
L1 drinking quantity (pmc)	−0.004	.80	−0.03, 0.03	0.80	<.001	0.37, 1.23	−0.13	.63	−0.68, 0.41

Note. Shading indicates significant values. BMI=body mass index. CI=95% confidence interval. Drink-to-bed timing=time between drinking cessation and bedtime (positive values indicate drinking closer to bedtime). GMC=grand-mean centered. L1=level 1 (day-level or within-person) effects. L2=level 2 (between-person) effects. PMC=person-mean centered. Y/N=coded yes (1) or no (0).

Table 3.

Self-reported sleep parameters predicting change in drinking quantity the following day (N=56).

	Outcome: Drinking Quantity								
	Predictor: Sleep Quality			Predictor: SE (self-report)			Predictor: SE (actigraphy)		
Parameter	**Estimate**	***p***	**95% CI**	**Estimate**	***p***	**95% CI**	**Estimate**	***p***	**95% CI**
Intercept	1.85	<.001	1.09, 2.60	1.84	<.001	1.07, 2.60	2.36	.34	−2.52, 7.23
Time	−0.03	.61	−0.13, 0.07	−0.03	.56	−0.13, 0.07	−0.05	.49	−0.18, 0.08
L2 male (Y/N)	0.13	.73	−0.63, 0.89	0.28	.44	−0.44, 0.99	0.40	.35	−0.44, 1.25
L2 college student (Y/N)	−0.04	.91	−0.71, 0.63	−0.10	.77	−0.80, 0.59	−0.22	.59	−1.04, 0.60
L2 BMI (gmc)	0.004	.88	−0.04, 0.05	−0.01	.78	−0.05, 0.04	−0.03	.23	−0.09, 0.02
L2 insomnia severity (gmc)	−0.01	.80	−0.10, 0.08	−0.03	.44	−0.12, 0.05	0.02	.69	−0.09, 0.13
L2 drinking quantity (gmc)	1.03	<.001	0.76, 1.30	0.99	<.001	0.72, 1.26	0.74	<.001	0.43, 1.04
L2 days of cannabis use (gmc)	−0.01	.92	−0.25, 0.22	−0.02	.87	−0.24, 0.20	−0.14	.32	−0.41, 0.13
L2 sleep quality (gmc)	−0.03	.93	−0.63, 0.58	---	---	---	---	---	---
L2 self-reported SE (gmc)	---	---	---	−0.01	.80	−0.06, 0.05	---	---	---
L2 actigraphy SE (gmc)	---	---	---	---	---	---	−0.005	.88	−0.06, 0.05
L1 weekend (Y/N)	0.45	.16	−0.17, 1.07	0.44	.16	−0.17, 1.04	0.33	.38	−0.41, 1.08
L1 prior day drinking (pmc)	−0.03	.52	−0.14, 0.07	−0.07	.19	−0.17, 0.03	−0.10	.11	−0.23, 0.02
L1 cannabis use (Y/N)	−0.13	.81	−1.24, 0.97	−0.01	.98	−1.08, 1.06	−0.47	.49	−1.81, 0.87
L1 sleep quality (pmc)	0.15	.38	−0.19, 0.49	---	---	---	---	---	---
L1 self-reported SE (pmc)	---	---	---	0.03	.02	0.01, 0.05	---	---	---
L1 actigraphy SE (pmc)	---	---	---	---	---	---	0.01	.50	−0.03, 0.06

Note. Shading indicates significant values. CI=95% confidence interval. GMC=grand-mean centered. L1=level 1 (daily within-person) effects. L2=level 2 (between-person) effects. OR=odds ratio. PMC=person-mean centered. SE=sleep efficiency. Y/N=coded yes (1) or no (0).

Table 4

Maximum number of consecutive drinking days among heavy-drinking young adults with insomnia (N=56).

Days	Frequency	Percent	Cumulative Percent
0 days	1	1.8	1.8
1 day	8	14.3	16.1
2 days	20	35.7	51.8
3 days	9	16.1	67.9
4 days	12	21.4	89.3
5 days	1	1.8	91.1
6 days	1	1.8	92.9
7 days	2	3.6	96.4
8 days	1	1.8	98.2
9 days	0	0.0	98.2
10 days	1	1.8	100.0