

A Brief Online Intervention for Sleep Problems and Heavy Drinking: Impacts on Alcohol- and Sleep-Related Problems

Cristina N. Abarno¹, Hannah M. Chapman¹, and Amy L. Copeland^{1, 2}

¹ Department of Psychology, Louisiana State University

² Division of Clinical Science, Pennington Biomedical Research Center

There is growing evidence that poor sleep contributes to increased alcohol use and related impairment among college students (DeMartini & Fucito, 2014), with heavy drinking exacerbating these effects. Efforts to reduce this impact via online personalized feedback interventions (PFIs) have had limited success, and there is a dearth of research on attempts to simultaneously address these concerns among college students using brief, web-based interventions. The present study assessed intervention efficacy in addition to the impact of sleep disturbance on alcohol outcomes using a novel, brief, online PFI for sleep problems among college students who drink heavily. Participants were randomly assigned to one of the three interventions: PFI-Alcohol ($n = 66$), PFI-Alcohol-Sleep ($n = 64$), or assessment-only control ($n = 66$). Alcohol use, related impairment, and sleep problems decreased from baseline to 1-month follow-up under all conditions. However, participants under the control condition endorsed greater alcohol use during follow-up compared with intervention conditions. Notably, baseline insomnia symptoms predicted follow-up alcohol problems (but not use) when accounting for variance attributable to baseline negative affect, condition, and sex. More work is needed to examine the impact of brief online PFIs that concurrently target alcohol use and sleep problems among college students to determine its impact on reducing related-problems in this population. Results highlight the need for further investigation of the incorporation of sleep components within online alcohol PFIs to reduce heavy drinking and sleep problems among college students.

Public Health Significance

The present study suggests that sleep may be a useful intervention target in brief online personalized feedback interventions among college students who drink heavily. Findings highlight the impact of insomnia symptoms at baseline predicting follow-up alcohol-related problems. It is important to further identify psychological variables that impact treatment outcomes to help inform efficacious interventions that target co-occurring sleep and alcohol problems among college students.

Keywords: personalized feedback intervention, alcohol use, sleep, college students, alcohol problems

Problematic alcohol use among college students is increasing as approximately 30% of college students endorse one or more episodes of heavy episodic drinking (HED; 4+ drinks per occasion for females and 5+ for males; Wechsler et al., 2002) every 2 weeks (Johnston et al., 2016). This is concerning given the array of problems associated with heavy drinking among college students including physical injury (Hingson et al., 2009), academic problems

and risky sexual behavior (Park, 2004), more alcohol-related problems than non-HED college students (Wechsler & Nelson, 2001), and sleep problems (Singleton & Wolfson, 2009). Approximately 60% of college students attain less than the recommended amount of sleep per night, with a majority endorsing poor subjective sleep quality (Lund et al., 2010), which is associated with alcohol-related problems (DeMartini & Fucito, 2014). Poor sleep quality is

This article was published Online First May 15, 2025.

Kelly E. Dunn served as action editor.

Amy L. Copeland  <https://orcid.org/0000-0002-2562-6195>

Data and ideas presented in this article have not been disseminated elsewhere prior to publication. Materials and analysis code for this study are not available. Portions of this were presented as a dissertation by one of the authors. The authors have no conflicts of interest to disclose. This research was supported in part by funding from the Department of Psychology at a large university. Funding was awarded to Cristina N. Abarno. The university's Department of Psychology had no other role than financial support. The funding source had no other role other than financial support. All authors contributed in a significant way to the article and all authors have read and approved the final article.

Cristina N. Abarno played a lead role in conceptualization, data curation, investigation, project administration, and writing—original draft and an equal role in formal analysis, methodology, and writing—review and editing. Hannah M. Chapman played a supporting role in data curation, investigation, project administration, writing—original draft, and writing—review and editing. Amy L. Copeland played a lead role in resources, software, supervision, validation, and writing—review and editing, a supporting role in conceptualization, data curation, investigation, project administration, and writing—original draft, and an equal role in formal analysis and methodology.

Correspondence concerning this article should be addressed to Amy L. Copeland, Department of Psychology, Louisiana State University, 215 Audubon Hall, Baton Rouge, LA 70803, United States. Email: copelan@lsu.edu

associated with adverse outcomes including negative mood (Taylor et al., 2013), increased alcohol use, and alcohol-related problems (DeMartini & Fucito, 2014). College students report using alcohol as a sleep aid (Goodhines, Gellis, et al., 2019), which is associated with increased frequency of HED, alcohol-related problems, and sleep problems. Emerging evidence suggests that alcohol- and sleep-related problems may be bidirectional in nature, in which alcohol use contributes to sleep disturbance (Chan et al., 2015) and poor sleep quality contributes to alcohol use (Haario et al., 2013).

Interventions Targeting Alcohol and Sleep

Online personalized feedback interventions (PFIs) may be one way to address heavy drinking and sleep problems among college students. Alcohol-focused online PFIs (Miller et al., 2013) and stand-alone personalized normative feedback (PNF) interventions (Miller et al., 2013; Riper et al., 2009) have been efficacious in reducing alcohol use and related problems among college students. While alcohol PFIs have been shown to reduce alcohol use, this is accompanied by small effect sizes on alcohol use outcomes, as their effects diminish over time (Carey et al., 2012; Dotson et al., 2015). Alcohol PFIs that incorporate sleep may be more effective, though their use has been limited given the inclusion of additional components (i.e., psychoeducation regarding the relationship between alcohol and sleep, Borsari & Carey, 2005; feedback on sleep under treatment conditions, Saitz et al., 2007; and provision of sleep psychoeducation under control conditions, Palfai et al., 2014).

Sleep interventions include psychoeducation regarding sleep stages, stress reduction, sleep hygiene, strategies to decrease maladaptive beliefs, and stimulus control (Brown et al., 2006; Kloss et al., 2011). Sleep interventions among college students have been shown to increase healthy sleep behaviors and improve overall sleep quality (Friedrich & Schlarb, 2018). There has been limited research on the incorporation of personalized feedback into sleep interventions among college students. Interestingly, when participants received psychoeducation on sleep hygiene and personalized feedback based on their sleep habits, those who endorsed sleeping less than 7 hr per night at baseline reported significant increases in sleep knowledge, duration (30 min), and efficiency (Levenson et al., 2016). However, this study did not have a control group nor did they assess outcomes over time, thus limiting its generalizability.

To date, there has been one web-based study that concurrently addressed heavy drinking (i.e., one or more HED episodes in past-month and alcohol-related problems) and sleep problems among college students. Participants were randomized to an intervention that included alcohol and sleep components or a control intervention (see Fucito et al., 2017 for more information on intervention components). At follow-up (5 weeks, 3 months), participants under both conditions reported reduced alcohol use, related problems, sleep problems, and improved sleep quality. However, limitations of this study can inform future work, most notably the lack of control conditions and brevity, as content was delivered weekly for 1 month.

Theoretical models of substance use and sleep posit that there are reciprocal associations between insomnia and alcohol use, such that the use of alcohol as a sleep aid contributes to both alcohol- and sleep-related problems (Brower, 2003). However, to date, there have been no studies examining the efficacy of a brief, one-session, web-based PFI in which sleep disturbance and alcohol use are concurrently targeted among college students who drink heavily.

Conducting this research is important given the high attrition rates in alcohol PFIs, college students preferences for web-based interventions (Buscemi et al., 2010; Epler et al., 2009), and improved sleep quality among young adults after participation in web-based sleep interventions (Tsai et al., 2022). The present study aimed to investigate the efficacy of a novel PFI (i.e., PFI-Alcohol-Sleep) by incorporating previous components of alcohol PFIs (Miller et al., 2013) and providing novel personalized feedback on sleep hygiene and insomnia (Fucito et al., 2017; Levenson et al., 2016). We hypothesized that participants under the intervention condition would report greater decreases in alcohol use, related problems, and sleep problems compared to participants in the alcohol PFI (PFI-Alcohol) or assessment-only control conditions.

Method

Participants

Participants were 196 (72.9% retention rate) predominantly non-Hispanic White females aged 18–25 years old. They were undergraduate students who met inclusion criteria of at least one episode of heavy drinking (i.e., five or more drinks per occasion for males, four or more for females; Wechsler et al., 2002), at least one past-month alcohol-related problem (Wagener et al., 2012), and past-month sleep problems. Participants were recruited through the psychology department research pool at a large southern university and completed the study between August 2022 and April 2023. The university's institutional review board approved the study (Protocol No. IRBAM-22-0754—*A Novel Personalized Feedback Intervention for Sleep Problems among College Students Who Drink Heavily*) and a certificate of confidentiality from the National Institutes of Health was obtained to further protect confidentiality.

Procedure

First, 430 participants completed a screener survey through the research participant pool system (Sona) to determine eligibility. We excluded 108 participants as follows: not current student ($n = 3$), not 18–25 years of age ($n = 2$), denied past-month alcohol use ($n = 7$), denied past-month HED ($n = 61$), denied sleep problems ($n = 21$), unwilling to complete follow-up survey ($n = 11$), or denied consent to participate ($n = 3$). Eligible participants ($n = 322$) were able to sign up and complete the baseline assessment through Qualtrics. Fifty-two of these participants did not complete the baseline survey so were excluded from randomization. Remaining participants ($n = 269$) were randomized as follows: 184 were allocated to intervention conditions (PFI-Alcohol $n = 91$; PFI-Alcohol-Sleep $n = 93$) and the control condition ($n = 85$). The intervention was provided online after completion of the baseline assessment. Participants spent an average of 49 min completing the entire survey, which included the baseline assessment and intervention. The follow-up survey was completed approximately 1 month after baseline. Demographic characteristics are in Table 1. Participants were compensated with research participation credits for completion of both baseline and follow-up surveys. All participants who finished both surveys were entered into a drawing to win one of ten \$50 cash prizes. Participant flow is depicted in a Consolidated Standards of Reporting Trials flow diagram in Figure 1.

Table 1*Participant Baseline Characteristics by Condition*

Participant characteristic	Total (N = 196)	PFI-A (n = 66)	PFI-A-S (n = 64)	Control (n = 66)	F or χ^2	p	d or Cramer's V
Age	19.64 (1.33)	19.41 (1.19)	19.92 (1.47)	19.59 (1.28)	2.53	.082	0.05
Sex (% female)	82.1%	83.3%	81.3%	81.8%	0.10	.950	0.23
Gender identity					11.18	.514	0.17
Cis-female	78.1%	78.8%	76.6%	78.8%			
Cis-male	17.3%	16.7%	17.2%	18.2%			
Gender fluid	1.5%	1.5%	3.1%	0			
Agender	1.0%	1.5%	0	1.5%			
Androgynous	0.5%	1.5%	0	0			
Genderqueer/gender nonconforming	0.5%	0	0	1.5%			
Not listed	1.0%	0	3.1%	0			
Race/ethnicity (White/non-Hispanic)	84.6%	85.9%	81.8%	85.7%	11.15	.346	0.18
White/Hispanic	0.07%	0.03%	0.08%	0.09			
Black/non-Hispanic	0.01%	0%	0.02%	0%			
Black/Hispanic	1%	0	1%	0			
Asian/Asian American	1.1%	0	1%	1%			
Asian Indian	1%	0	0	1%			
Multiracial	0.05%	0.08%	0.05%	0.02%			
Other	0.04%	0.02%	0.03%	0.06%			
Class standing					9.47	.304	0.16
First year	34.9%	36.4%	28.1%	34.8%			
Second year	20.9%	25.8%	17.2%	19.7%			
Third year	20.4%	13.6%	26.6%	21.2%			
Fourth year	23.5%	21.2%	25.0%	24.2%			
Fifth year	1.0%	0	3.1%	0			
Drinks per week	1.53 (1.05)	1.32 (0.83)	1.59 (0.95)	1.69 (1.29)	2.26	.107	0.23
Number of past-month alcohol-related problem	9.81 (7.47)	8.98 (7.77)	11.13 (7.30)	9.35 (7.27)	1.53	.219	0.09
ISI	13.47 (4.88)	13.52 (4.39)	12.92 (5.11)	13.95 (5.13)	0.73	.484	0.15
Positive affect	30.00 (8.67)	28.74 (7.98)	30.78 (8.32)	30.50 (9.57)	1.07	.346	0.09
Negative affect	22.57 (7.81)	22.47 (8.71)	22.44 (7.12)	22.80 (7.61)	0.04	.957	0.04

Note. PFI = personalized feedback intervention; PFI-A = PFI-Alcohol; PFI-A-S = PFI-Alcohol-Sleep; ISI = Insomnia Symptom Index.

Intervention Conditions

PFI-Alcohol Condition

Based on extant literature (Carey et al., 2007, 2012; Miller et al., 2013), PFI-Alcohol provided personalized feedback and psychoeducation on alcohol-related constructs based on responses from baseline data, including (a) drinking behaviors, such as the number of drinks consumed per week, weekend, and on heaviest day; (b) estimated blood alcohol concentration for typical and heaviest drinking day; (c) alcohol-related problems-based Rutgers alcohol problem index (RAPI) responses; (d) PNF on same-campus student drinking and actual drinking norms for drinks consumed per week and weekend; (e) strategies to moderate drinking; and (f) exercises exploring motivation to change alcohol use including feedback on money spent per month on alcohol. Consistent with previous work (Fucito et al., 2017) and to make the intervention comparable in length to PFI-Alcohol-Sleep (see below), participants received psychoeducation on diet and exercise.

PFI-Alcohol-Sleep Condition

This intervention contained same elements as PFI-Alcohol in addition to personalized feedback for insomnia (Levenson et al., 2016), comprised a graphical display of total time spent in bed, asleep, and total sleep efficiency for the previous week, including weekday/weekend averages. Participants were asked to recall the

past week's sleep at the initial assessment to account for the previous 7 days. Participants received PNF on total sleep time compared to others aged 18–25 for each day and weekday/weekend averages. Psychoeducation on sleep hygiene (American Sleep Association, 2020) including stimulus control, sleep environment, circadian rhythm, limiting use of caffeine before bed, and avoiding rigorous exercise before bed was provided. Additionally, the impact of alcohol on sleep, including adverse effects of sleep and drinking on functioning (Fucito et al., 2017), was provided.

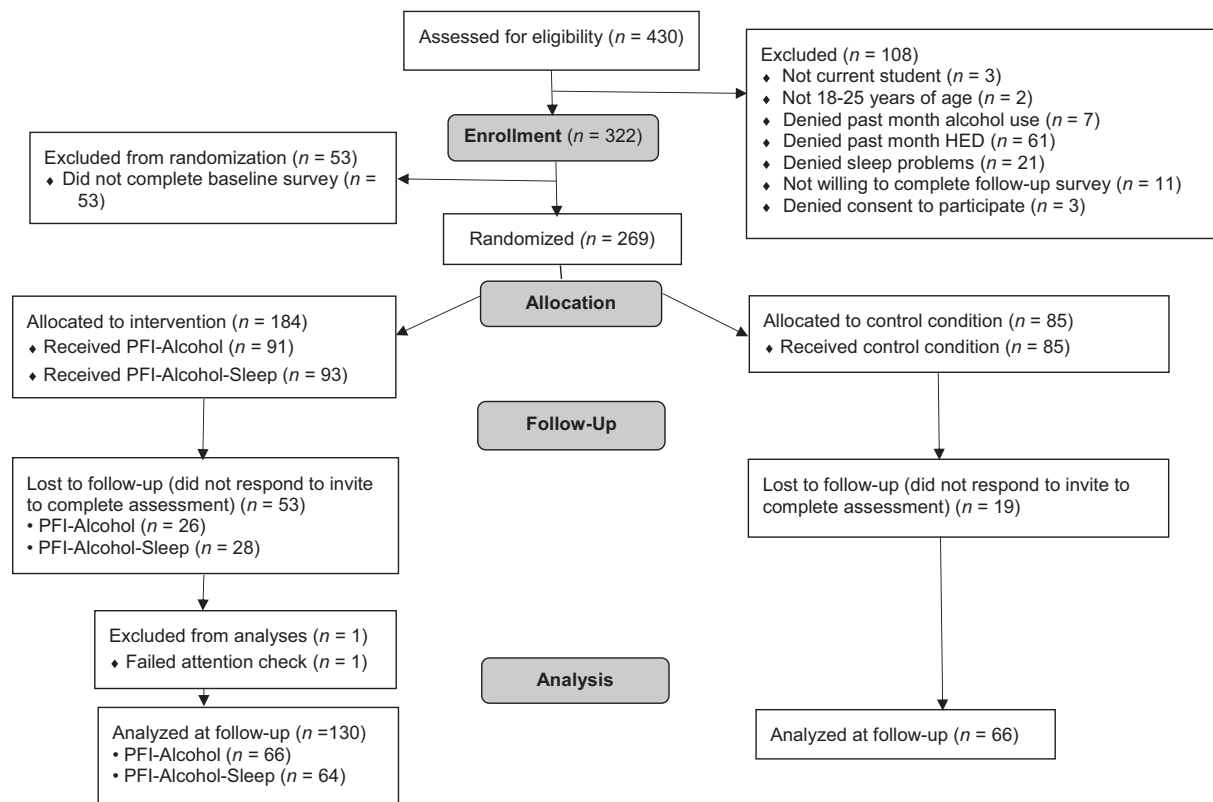
Assessment-Only Control Condition

Consistent with previous work on college drinkers (Leeman et al., 2015), participants under the control condition completed baseline and follow-up measures but did not receive personalized feedback or intervention content.

Measures

The Daily Drinking Questionnaire (Collins et al., 1985) was used to assess past-month typical and peak drinking quantity (number of drinks) at baseline and 1-month follow-up. Participants provided their number of daily drinks (0–31) and over how many hours drinks were consumed. This measure has demonstrated good convergent validity with other measures assessing alcohol frequency and quantity (Collins et al., 1985). Estimated blood alcohol concentration was calculated using a formula accounting for weight, sex,

Figure 1
Participant Flowchart



Note. PFI = personalized feedback intervention; HED = heavy episodic drinking.

time elapsed since drinking, and average metabolic rate (Matthews & Miller, 1979).

The RAPI (H. R. White & Labouvie, 1989) used 23 items to assess past-month alcohol related-problems at baseline and 1-month follow-up using 5-point Likert scale (0 = *never*, 4 = *more than 10 times*). Higher total scores indicate greater alcohol-related problems. The RAPI has demonstrated adequate psychometric properties including convergent validity with other measures assessing alcohol-related problems among college students (H. R. White & Labouvie, 1989). To assess alcohol-related problems, only students who endorsed at least one alcohol-related problem in the month preceding baseline were included. The measure demonstrated good internal consistency in this study (baseline $\alpha = .88$, follow-up $\alpha = .91$).

The Drinking Norms Rating Form (Baer et al., 1991) was used to assess normative beliefs at baseline and provide PNF. Participants estimated the number of alcoholic drinks a female, male, and typical student drinks on a typical weekend day and on their heaviest drinking day. Participants also estimated the number of days a female, male, and typical student drinks during an average week. This measure has demonstrated good test-retest validity (Neighbors et al., 2006).

The Positive and Negative Affect Scale (Watson et al., 1988) was used to assess state and trait negative and positive affect at baseline and 1-month follow-up. The Positive and Negative Affect Scale

consists of 20 items, two subscales, and uses a 5-point Likert scale (1 = *very slightly or not at all*, 5 = *extremely*). It has demonstrated good test-retest reliability and convergent validity among other measures assessing affect (Watson et al., 1988). At baseline and follow-up of the present study, the Positive and Negative Affect Scale demonstrated good internal consistency for both the total scale and subscales ($\alpha = .81-.91$).

The *Pittsburgh Sleep Diary* (Monk et al., 1994) was used to assess sleep behavior including sleep onset, time in bed, time to fall asleep, and wake up time over a 2-week period. It has demonstrated good test-retest reliability (Monk et al., 1994) and sensitivity to change following in a previous intervention targeting sleep and drinking among college students (Fucito et al., 2017). We utilized a modified version of this measure adapted from Levenson et al. (2016) to assess total time spent asleep and in bed during the week prior to baseline.

The Insomnia Severity Index (Bastien et al., 2001; Morin, 1993) used seven items to assess the severity, nature, and impact of insomnia at baseline and follow-up using a 5-point Likert scale (0 = *no problem* to 4 = *very severe problem*). Severity was determined using the following categories: absence of clinical insomnia (0–7), subthreshold insomnia (8–14), moderate clinical insomnia (15–21), and severe clinical insomnia (22–28). The Insomnia Severity Index demonstrates good internal consistency ($\alpha = .76-.78$) and concurrent validity with sleep diaries (Bastien et al., 2001). Based on

Table 2
Means, Standard Deviations, and Correlations Among Baseline Study Variables

Variable	<i>M</i>	<i>SD</i>	1	2	3	4	5	6	7	8
1. Sex	0.82	0.38	—							
2. Age	19.64	1.33	.10	—						
3. Race/ethnicity	5.67	1.53	-.03	-.03	—					
4. Typical weekly drinking	1.56	1.03	-.16**	.08	.06	—				
5. Alcohol-related problems	9.82	7.46	.004	.01	-.06	.42**	—			
6. Insomnia symptoms	13.47	4.88	.08	.04	-.04	.12*	.23**	—		
7. Positive affect	30.00	8.66	-.05	.02	.001	-.003	-.12*	-.20**	—	
8. Negative affect	22.57	7.81	.13	-.04	.04	.11	.30**	.30**	-.13*	—

* $p < .05$. ** $p < .01$.

previous research (Fucito et al., 2017), risky drinking college students with sleep problems were identified at baseline if they endorsed past-month sleep problems. The measure demonstrated adequate internal consistency in the present study (baseline $\alpha = .75$, follow-up $\alpha = .85$).

Four items from the *Infrequency Scale* (Chapman & Chapman, 1983) were used to identify inattentive or unreliable responders. Consistent with other online studies (A. S. Cohen et al., 2009), participants who incorrectly answered three or more questions were excluded at baseline and 1-month follow-up.

Data Analytic Strategy

First, bivariate correlations were conducted to examine relationships between baseline (see Table 2) and follow-up (see Table 3) study variables. Second, baseline differences in participants across the three conditions was assessed via Pearson's chi-square analyses for categorical data and one-way analyses of variances (ANOVAs) for continuous data. Given differences in alcohol use among males and females (Stanesby et al., 2019; A. M. White, 2020), sex was included as a covariate in study analyses.

To test the hypothesis that there will be a significant effect of condition on alcohol use, related problems, and sleep problems, three 3 (Experimental Condition: PFI-Alcohol, PFI-Alcohol-Sleep, assessment-only control) $\times$ 2 (Time: baseline, follow-up) mixed-model ANOVAs were conducted with condition as the between subjects' factor and time as the within-subject factor. Separate analyses were conducted for each dependent variable (Model 1: alcohol use, Model 2: alcohol-related problems, Model 3: sleep problems). Mauchley's Sphericity Test was not applicable to repeated-measures ANOVAs, as the data only assessed two time points. Interaction contrasts were examined following significant interactions to test differences in the slopes between conditions.

Transparency and Openness

We report how we determined our sample size based on all inclusion criteria, data exclusions, manipulations, and measures used. None of the work in this article was preregistered. Materials and analysis code for this study are not available.

Results

Conditions did not differ on demographic variables (Table 1). Completers (i.e., participants who completed baseline and follow-up) did not differ from noncompleters (i.e., participants who completed baseline only) on demographic variables (e.g., sex, race/ethnicity, gender) or outcome variables (e.g., alcohol use, alcohol-related problems, and insomnia symptoms) at baseline ($d_s = 0.05$ – 0.35).

Relationship Between Condition and Alcohol and Sleep Outcomes

There was a significant main effect of time on alcohol use, $F(1, 192) = 6.84, p = .010, \eta_p^2 = .034$, and related problems, $F(1, 192) = 4.82, p = .029, \eta_p^2 = .024$, such that alcohol use and related problems decreased across conditions from baseline to follow-up (see Table 4). The time by condition interaction approached significance for alcohol use, $F(2, 172) = 2.81, p = .063, \eta_p^2 = .028$, but not related problems, $F(2, 172) = 2.63, p = .075, \eta_p^2 = .027$. The time by sex interaction was not significant for alcohol use, $F(1, 192) = 0.65, p = .420, \eta_p^2 = .003$, or related problems, $F(1, 192) = 0.12, p = .733, \eta_p^2 = .001$. The main effect of condition approached significance for alcohol use, $F(2, 192) = 3.11, p = .047, \eta_p^2 = .031$ (see Figure 2 for interaction across conditions) but not for related problems (see Figure 3 for interaction across conditions on alcohol-related problems). Pairwise comparisons for the main effect of condition on

Table 3
Means, Standard Deviations, and Correlations Among Follow-Up Study Variables

Variable	<i>M</i>	<i>SD</i>	1	2	3	4	5
1. Typical weekly drinking	1.27	1.15	—				
2. Alcohol related problems	7.37	7.74	.42**	—			
3. Insomnia symptoms	11.63	5.85	.14*	.25**	—		
4. Positive affect	30.99	8.96	-.03	-.16*	-.21**	—	
5. Negative affect	22.79	8.86	.15*	.36**	.38**	-.14*	—

* $p < .05$. ** $p < .01$.

Table 4*Fixed-Effects Analysis of Variance Results Using Follow-Up Alcohol Outcomes as the Criterion*

Predictor	Baseline mean	Baseline SD	Follow-up mean	Follow-up SD	<i>p</i>	Partial η_p^2
DV: Follow-up alcohol use						
Time					.010	.034
Assessment-only control	1.71	1.28	1.56	1.44		
PFI-Alcohol	1.32	0.83	1.11	1.02		
PFI-Alcohol-Sleep	1.64	0.90	1.13	0.85		
Time $\times$ Sex					.420	.003
Time $\times$ Condition					.063	.028
DV: Follow-up alcohol-related problems						
Time					.029	.024
Assessment-only control	9.35	7.27	7.97	8.62		
PFI-Alcohol	9.00	7.75	7.24	7.65		
PFI-Alcohol-Sleep	11.14	7.27	6.89	6.92		
Time $\times$ Sex					.733	.001
Time $\times$ Condition					.075	.027

Note. η_p^2 = partial eta squared; PFI = personalized feedback intervention; DV = dependent variable.

alcohol use revealed that the difference between the assessment-only control and PFI-Alcohol groups was significant ($p = .043$).

There was a significant main effect of time on sleep problems, $F(1, 193) = 27.23$, $p \leq .001$, $\eta_p^2 = .124$, such that sleep problems decreased across conditions from baseline to follow-up (see Table 5). The time by condition interaction was not significant, $F(2, 193) = 0.32$, $p = .723$, $\eta_p^2 = .003$. There was not a significant main effect for condition on sleep problems, $F(2, 193) = 1.20$, $p = .302$, $\eta_p^2 = .012$ (see Figure 4 for interaction across conditions on insomnia symptoms).

Secondary Analyses

Several exploratory analyses were conducted to characterize associations between sleep problems at baseline and alcohol use and related problems at follow-up. Baseline alcohol use and related problems were significantly correlated with follow-up alcohol use ($rs = .30-.64$, $p < .001$). Baseline alcohol use, related problems, negative affect, and sleep problems were significantly correlated with

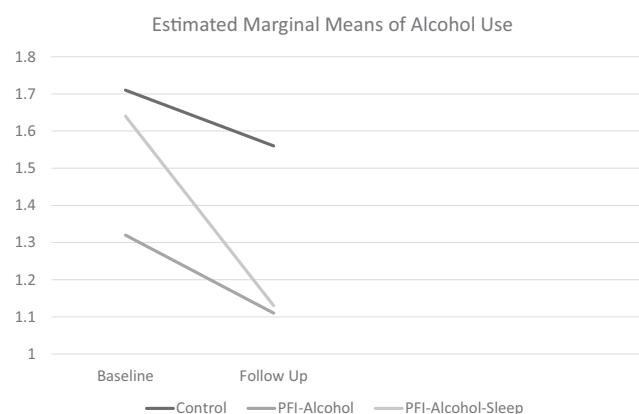
follow-up alcohol-related problems ($rs = .18-.48$, $p < .001$). One-way ANOVAs were run to examine differences in these variables by condition, and significant differences were only observed for follow-up alcohol use, $F(2, 195) = 3.36$, $p = .037$, $d = 0.39$. Post hoc analyses (Tukey) revealed that those under the control condition endorsed greater follow-up alcohol use ($M = 1.56$, $SD = 1.44$) compared to PFI-Alcohol ($M = 1.11$, $SD = 1.02$, $p = .058$) and PFI-Alcohol-Sleep ($M = 1.13$, $SD = 0.85$, $p = .078$). To assess sex differences in alcohol use (Stanesby et al., 2019; A. M. White, 2020), 3×2 mixed-model ANOVAs were conducted to examine sex differences on drinking outcome variables (follow-up alcohol use and related problems).¹

The relationship between alcohol- and sleep-related problems in the present study and prior research (Goodhines, Zaso, et al., 2019) warranted two linear regression models. Sex and condition were entered at Step 1, as the intervention condition appears to have impacted outcomes, and baseline sleep problems and negative affect were entered at Step 2. This approach ensures that observed effects at Step 2 cannot be attributed to variance shared with variables in Step 1 (J. Cohen & Cohen, 1983). The first model, which used follow-up alcohol use as the criterion variable, was not statistically significant (see Table 6). However, the second model, which used follow-up alcohol-related problems as the criterion variable, was statistically significant (see Table 6), such that baseline negative affect and sleep problems accounted for 4.7% of the variance in alcohol-related problems. Notably, baseline negative affect was not a significant predictor of alcohol-related problems when controlling for variance attributable to sleep problems, condition, and sex.

Discussion

The present study assessed the impact of a brief, online, PFI that provided PNF about problems and behaviors related to sleep and alcohol use on related outcomes among college students that endorsed HED and sleep problems. As alcohol use, related problems,

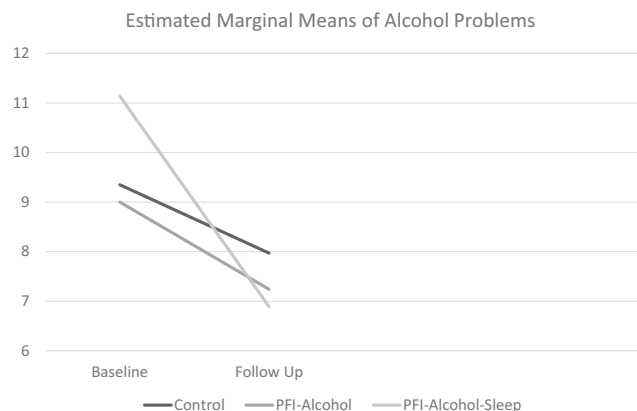
Figure 2
Time by Condition Interaction for Mixed Model Analysis of Variance With Alcohol Use as Dependent Variable



Note. PFI = personalized feedback intervention.

¹ Alcohol use decreased for males and females, but there were no significant main effects or time by condition interaction. For alcohol-related problems, there was a significant effect of time (not condition) for females only, $F(1, 158) = 17.83$, $p < .001$, $\eta_p^2 = .101$.

Figure 3
Time by Condition Interaction for Mixed Model Analysis of Variance With Alcohol Problems as Dependent Variable



Note. PFI = personalized feedback intervention.

and sleep problems decreased across conditions from baseline to follow-up, our first hypothesis (individuals in the PFI-Alcohol-Sleep condition would report greater decreases in these domains compared to those in PFI-Alcohol or control conditions) was not supported. However, the main effect of condition for alcohol use approached significance ($p = .047$) as there were significant differences between the control and PFI-Alcohol ($p = .047$) conditions, such that those under the PFI-Alcohol condition reported greater decreases in alcohol use at follow-up compared with those under the control condition. There are potential explanations why individuals under the PFI-Alcohol-Sleep condition did not show greater improvements in outcomes compared to those under PFI-Alcohol or control conditions. First, the exercise and diet component included under the PFI-Alcohol condition may have provided similar benefit to the insomnia component of the PFI-Alcohol-Sleep condition. Second, although the diet and exercise information was included in PFI-Alcohol to make the conditions comparable in length, the insomnia component required a greater level of engagement than the diet and exercise component. PFI-Alcohol-Sleep may have placed undue demand on participants, preventing them from fully benefiting from the combined intervention. Future studies should attempt to make conditions comparable in participant demand in addition to length.

Regarding our secondary analyses exploring outcomes among our primary study variables (follow-up alcohol use, alcohol-related problems, sleep problems), conditions only differed on follow-up alcohol use such that individuals under the control condition endorsed greater follow-up alcohol use compared to both treatment conditions. Sex differences on alcohol use and related problems indicated that both sexes decreased use from baseline to follow-up, but only females decreased the related problems. Notably, baseline sleep problems predicted follow-up alcohol-related problems (but not alcohol use) when accounting for the variance attributable to condition, baseline negative affect, and sex.

There are several possible explanations for the findings of the present study. First, although we had an adequate sample size ($n = 196$), our power analysis indicated that we needed 201 participants, and as such our study may be slightly underpowered and unable to detect significant effects. Second, there was no main effect of condition on alcohol use or related problems, as participants under all conditions decreased their drinking and alcohol-related problems from baseline to follow-up. Interestingly, participants in the assessment-only control condition drank significantly more at follow-up compared to participants under the two intervention conditions. Overall, participants endorsed low rates of past-month alcohol use at baseline ($M = 1.53$), but the overall sample endorsed high rates of alcohol-related problems ($M = 9.81$). Third, while participants reported decreased sleep problems over the course of the study, the sample endorsed subthreshold insomnia (8–14; Bastien et al., 2001) at both baseline ($M = 13.47$, $SD = 4.88$) and 1-month follow-up ($M = 11.63$, $SD = 5.85$). Fourth, we endorsed low retention rates, and it may be that participants did not immerse themselves in the intervention components despite implementation of attention check questions. Future work would benefit from incorporating additional strategies to engage participants in web-based interventions. Fifth, there may have been a ceiling effect among variables which led to restriction of range, inability to detect significant effects, and there could have been variable interactions that led to lack of significant findings.

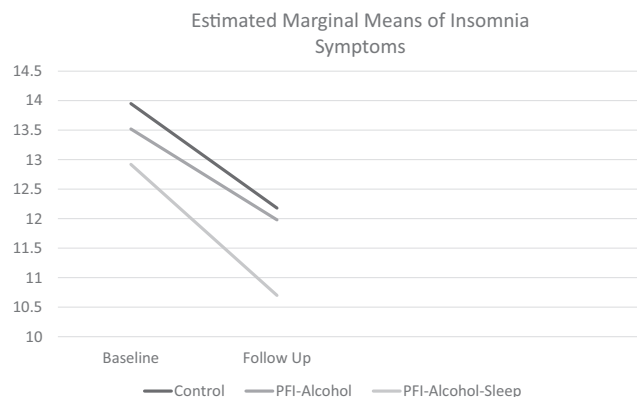
Furthermore, variable interactions may have contributed to lack of significant findings; therefore, the condition was included as a covariate in the exploratory regression analysis that assessed whether baseline sleep problems predicted follow-up alcohol-related problems. It may be that participants engaged in more episodes of HED than they reported or between baseline and follow-up, resulting in increased alcohol- and sleep-related problems. The RAPI has been successful in detecting alcohol use disorders among

Table 5
Fixed-Effects Analysis of Variance Results Using Follow-Up Insomnia Symptoms as the Criterion

Predictor	Baseline mean	Baseline SD	Follow-up mean	Follow-up SD	<i>p</i>	Partial η_p^2
Dependent variable: Follow-up insomnia symptoms						
Time					<.001	.124
Assessment-only control	13.95	5.13	12.18	6.03		
PFI-Alcohol	13.52	4.39	11.98	5.32		
PFI-Alcohol-Sleep	12.92	5.11	10.70	6.15		
Time $\times$ Condition					.723	.003

Note. η_p^2 = partial eta squared; PFI = personalized feedback intervention.

Figure 4
Time by Condition Interaction for Mixed Model Analysis of Variance With Insomnia Symptoms as Dependent Variable



Note. PFI = personalized feedback intervention.

college students (Hagman, 2017) using cutoff scores of 6 and 4 for males and females, respectively. Baseline ($M = 9.97$, $SD = 6.73$, $M = 9.78$, $SD = 7.62$, respectively) and follow-up ($M = 7.09$, $SD = 7.29$, $M = 7.43$, $SD = 7.86$) scores for males and females demonstrated that participants were above the cutoff. The bidirectional relationship between sleep and alcohol outcomes may help explain these findings, in which participants continued to experience alcohol problems despite reductions in alcohol use, related problems, and sleep impairment at follow-up. Although sleep problems reduced from baseline to follow-up, participants endorsed subthreshold insomnia at both time points.

Conclusion and Limitations

Results should be interpreted considering limitations. First, most of our sample was comprised of non-Hispanic White female college

students and, therefore, may not be generalizable to males or racial/ethnic minorities. For this reason, future studies could benefit from recruiting a more diverse sample. Second, data were collected via self-report measures and other methodologies (e.g., ecological momentary assessment) would be greatly beneficial in determining proximal predictors of alcohol use and related problems. Third, corrective normative feedback was not provided regarding the number of drinks consumed on the heaviest drinking day among typical same-campus students due to a lack of available data. Fourth, the sample size was slightly lower than expected results based on power analysis, which could have resulted in underpowered analyses and null findings. Despite contacting participants daily to complete the follow-up survey and entering participants into a cash drawing, the retention rate was low (72.9% retention rate). Future work would benefit from increased incentives and recruiting more participants. Fifth, follow-up outcomes were only assessed at 1-month, therefore future studies would benefit from assessing outcomes over a longer period. Sixth, we did not have a control PFI condition and future work would benefit from including one to help parse apart intervention effects.

There are several differences between the present study and the one previous web-based study that concurrently addressed alcohol and sleep among college students (Fucito et al., 2017): (a) this study's intervention was delivered over one session as opposed to 4 weeks and our participants did not wear sleep tracker device; (b) the prior study's control condition included feedback, where this study's did not; (c) this study's follow-up was 1 month compared to extended follow up in the previous study; and (d) this study's initial sleep assessment was conducted by way of past-week recall, instead of daily sleep diaries.

Despite the above limitations, this study identified sleep problems as a predictor of alcohol-related problems in a sample of college students after receiving a brief, online PFI targeting heavy drinking and sleep problems. Decreases observed across conditions on alcohol use, related problems, and sleep problems at follow-up,

Table 6

Linear Regression for Baseline Insomnia Symptoms Predicting Follow-Up Alcohol Use and Alcohol-Related Problems After Accounting for Baseline Negative Affect

Regression step	ΔR^2	ΔF	β	t	p	sr^2
Dependent variable: Follow-up alcohol use						
Step 1	.028	2.85			.060	
Sex			-.08	-1.18	.241	.01
Condition			-.14	-2.07	.050	.02
Step 2	.005	0.50			.605	
Sex			-.09	-1.29	.199	.01
Condition			-.14	-2.01	.046	.02
Baseline negative affect			.04	0.55	.582	.001
Baseline insomnia symptoms			.05	0.60	.552	.002
Dependent variable: Follow-up alcohol problems						
Step 1	.001	0.13			.880	
Sex			.02	0.31	.757	.0004
Condition			-.03	-0.40	.690	.001
Step 2	.065	6.85			.001	
Sex			-.01	-0.12	.903	.0001
Condition			-.01	-0.18	.855	.0002
Baseline negative affect			.13	1.76	.081	.02
Baseline insomnia symptoms			.18	2.45	.015	.03

highlights the importance of continuing to investigate potential effective treatment targets among college students with alcohol- and sleep-related problems. The impact of poor sleep quality on drinking outcomes may be explained by sleep-related functional impairment. Sleep-related functional impairment comprised sleep latency/duration, sleep efficiency, and impact of poor sleep quality (e.g., concentration and socialization difficulties, fatigue, mood-related problems, and sleepiness; Buysse et al., 1989; Ruiz et al., 2011). Given that sleep impairment contributes to alcohol-related problems irrespective of drinking frequency/quantity (Goodhines, Zaso, et al., 2019), it may be that college students are more likely to engage in HED in an attempt to alleviate sleep problems. However, individuals who endorse HED and sleep problems may require longer-term more intensive treatment. Poor sleep quality among college students is associated with adverse outcomes (e.g., negative mood, increased alcohol use and problems; DeMartini & Fucito, 2014; Lund et al., 2010; Taylor et al., 2013), and future work would benefit from developing interventions that concurrently target alcohol and sleep among college students.

References

- American Sleep Association. (2020). *Sleep hygiene tips*. <https://www.sleepassociation.org/about-sleep/sleep-hygiene-tips/>
- Baer, J. S., Stacy, A., & Larimer, M. (1991). Biases in the perception of drinking norms among college students. *Journal of Studies on Alcohol*, 52(6), 580–586. <https://doi.org/10.15288/jsa.1991.52.580>
- Bastien, C. H., Vallières, A., & Morin, C. M. (2001). Validation of the Insomnia Severity Index as an outcome measure for insomnia research. *Sleep Medicine*, 2(4), 297–307. [https://doi.org/10.1016/S1389-9457\(00\)00065-4](https://doi.org/10.1016/S1389-9457(00)00065-4)
- Borsari, B., & Carey, K. B. (2005). Two brief alcohol interventions for mandated college students. *Psychology of Addictive Behaviors*, 19(3), 296–302. <https://doi.org/10.1037/0893-164X.19.3.296>
- Brower, K. J. (2003). Insomnia, alcoholism and relapse. *Sleep Medicine Reviews*, 7(6), 523–539. [https://doi.org/10.1016/S1087-0792\(03\)90005-0](https://doi.org/10.1016/S1087-0792(03)90005-0)
- Brown, F. C., Buboltz, W. C., Jr., & Soper, B. (2006). Development and evaluation of the Sleep Treatment and Education Program for Students (STEPS). *Journal of American College Health*, 54(4), 231–237. <https://doi.org/10.3200/JACH.54.4.231-237>
- Buscemi, J., Murphy, J. G., Martens, M. P., McDevitt-Murphy, M. E., Dennhardt, A. A., & Skidmore, J. R. (2010). Help-seeking for alcohol-related problems in college students: Correlates and preferred resources. *Psychology of Addictive Behaviors*, 24(4), 571–580. <https://doi.org/10.1037/a0021122>
- Buysse, D. J., Reynolds, C. F., III, Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh Sleep Quality Index: A new instrument for psychiatric practice and research. *Psychiatry Research*, 28(2), 193–213. [https://doi.org/10.1016/0165-1781\(89\)90047-4](https://doi.org/10.1016/0165-1781(89)90047-4)
- Carey, K. B., Scott-Sheldon, L. A., Carey, M. P., & DeMartini, K. S. (2007). Individual-level interventions to reduce college student drinking: A meta-analytic review. *Addictive Behaviors*, 32(11), 2469–2494. <https://doi.org/10.1016/j.addbeh.2007.05.004>
- Carey, K. B., Scott-Sheldon, L. A., Elliott, J. C., Garey, L., & Carey, M. P. (2012). Face-to-face versus computer-delivered alcohol interventions for college drinkers: A meta-analytic review, 1998 to 2010. *Clinical Psychology Review*, 32(8), 690–703. <https://doi.org/10.1016/j.cpr.2012.08.001>
- Chan, J. K., Trinder, J., Colrain, I. M., & Nicholas, C. L. (2015). The acute effects of alcohol on sleep electroencephalogram power spectra in late adolescence. *Alcoholism: Clinical and Experimental Research*, 39(2), 291–299. <https://doi.org/10.1111/acer.12621>
- Chapman, L. J., & Chapman, J. P. (1983). *Infrequency Scale* [Unpublished test]. Department of Psychology, University of North Carolina at Greensboro.
- Cohen, A. S., Iglesias, B., & Minor, K. S. (2009). The neurocognitive underpinnings of diminished expressivity in schizotypy: What the voice reveals. *Schizophrenia Research*, 109(1–3), 38–45. <https://doi.org/10.1016/j.schres.2009.01.010>
- Cohen, J., & Cohen, P. (1983). *Applied multiple regression/correlation analysis for the behavioral sciences*. Lawrence Erlbaum.
- Collins, R. L., Parks, G. A., & Marlatt, G. A. (1985). Social determinants of alcohol consumption: The effects of social interaction and model status on the self-administration of alcohol. *Journal of Consulting and Clinical Psychology*, 53(2), 189–200. <https://doi.org/10.1037/0022-006X.53.2.189>
- DeMartini, K. S., & Fucito, L. M. (2014). Variations in sleep characteristics and sleep-related impairment in at-risk college drinkers: A latent profile analysis. *Health Psychology*, 33(10), 1164–1173. <https://doi.org/10.1037/hea0000115>
- Dotson, K. B., Dunn, M. E., & Bowers, C. A. (2015). Stand-alone personalized normative feedback for college student drinkers: A meta-analytic review, 2004 to 2014. *PLOS ONE*, 10(10), Article e0139518. <https://doi.org/10.1371/journal.pone.0139518>
- Epler, A. J., Sher, K. J., Loomis, T. B., & O'Malley, S. S. (2009). College student receptiveness to various alcohol treatment options. *Journal of American College Health*, 58(1), 26–32. <https://doi.org/10.3200/JACH.58.1.26-32>
- Friedrich, A., & Schlarb, A. A. (2018). Let's talk about sleep: A systematic review of psychological interventions to improve sleep in college students. *Journal of Sleep Research*, 27(1), 4–22. <https://doi.org/10.1111/jsr.12568>
- Fucito, L. M., DeMartini, K. S., Hanrahan, T. H., Yaggi, H. K., Heffern, C., & Redeker, N. S. (2017). Using sleep interventions to engage and treat heavy-drinking college students: A randomized pilot study. *Alcoholism: Clinical and Experimental Research*, 41(4), 798–809. <https://doi.org/10.1111/acer.13342>
- Goodhines, P. A., Gellis, L. A., Kim, J., Fucito, L. M., & Park, A. (2019). Self-medication for sleep in college students: Concurrent and prospective associations with sleep and alcohol behavior. *Behavioral Sleep Medicine*, 17(3), 327–341. <https://doi.org/10.1080/15402002.2017.1357119>
- Goodhines, P. A., Zaso, M. J., Gellis, L. A., & Park, A. (2019). Sleep-related functional impairment as a moderator of risky drinking and subsequent negative drinking consequences in college students. *Addictive Behaviors*, 93, 146–153. <https://doi.org/10.1016/j.addbeh.2019.01.042>
- Haario, P., Rahkonen, O., Laaksonen, M., Lahelma, E., & Lallukka, T. (2013). Bidirectional associations between insomnia symptoms and unhealthy behaviours. *Journal of Sleep Research*, 22(1), 89–95. <https://doi.org/10.1111/j.1365-2869.2012.01043.x>
- Hagman, B. (2017). Diagnostic performance of the Rutgers Alcohol Problem Index (RAPI) in detecting DSM-5 alcohol use disorders among college students. *Journal of Addiction & Prevention*, 5(2), 1–7. <https://doi.org/10.13188/2330-2178.1000039>
- Hingson, R. W., Zha, W., & Weitzman, E. R. (2009). Magnitude of and trends in alcohol-related mortality and morbidity among U.S. college students ages 18–24, 1998–2005. *Journal of Studies on Alcohol and Drugs, Supplement*, (S16), 12–20. <https://doi.org/10.15288/jsads.2009.s16.12>
- Johnston, L. D., O'Malley, P. M., Bachman, J. G., Schulenberg, J. E., & Miech, R. A. (2016). *Monitoring the Future national survey results on drug use, 1975–2015: Overview, key findings on adolescent drug use*. Institute for Social Research, The University of Michigan. <https://monitoringthefuture.org/wp-content/uploads/2022/08/mtf-overview2016.pdf>
- Kloss, J. D., Nash, C. O., Horsey, S. E., & Taylor, D. J. (2011). The delivery of behavioral sleep medicine to college students. *Journal of Adolescent Health*, 48(6), 553–561. <https://doi.org/10.1016/j.jadohealth.2010.09.023>
- Leeman, R. F., Perez, E., Nogueira, C., & DeMartini, K. S. (2015). Very-brief, web-based interventions for reducing alcohol use and related problems among college students: A review. *Frontiers in Psychiatry*, 6, Article 129. <https://doi.org/10.3389/fpsy.2015.00129>
- Levenson, J. C., Miller, E., Hafer, B., Reidell, M. F., Buysse, D. J., & Franzen, P. L. (2016). Pilot study of a sleep health promotion program for

- college students. *Sleep Health*, 2(2), 167–174. <https://doi.org/10.1016/j.sleh.2016.03.006>
- Lund, H. G., Reider, B. D., Whiting, A. B., & Prichard, J. R. (2010). Sleep patterns and predictors of disturbed sleep in a large population of college students. *Journal of Adolescent Health*, 46(2), 124–132. <https://doi.org/10.1016/j.jadohealth.2009.06.016>
- Matthews, D. B., & Miller, W. R. (1979). Estimating blood alcohol concentration: Two computer programs and their applications in therapy and research. *Addictive Behaviors*, 4(1), 55–60. [https://doi.org/10.1016/0306-4603\(79\)90021-2](https://doi.org/10.1016/0306-4603(79)90021-2)
- Miller, M. B., Leffingwell, T., Claborn, K., Meier, E., Walters, S., & Neighbors, C. (2013). Personalized feedback interventions for college alcohol misuse: An update of Walters & Neighbors (2005). *Psychology of Addictive Behaviors*, 27(4), 909–920. <https://doi.org/10.1037/a0031174>
- Monk, T. H., Reynolds, C. F., III, Kupfer, D. J., Buysse, D. J., Coble, P. A., Hayes, A. J., MacHen, M. A., Petrie, S. R., & Ritenour, A. M. (1994). The Pittsburgh sleep diary. *Journal of Sleep Research*, 3(2), 111–120. <https://doi.org/10.1111/j.1365-2869.1994.tb00114.x>
- Morin, C. M. (1993). *Insomnia: Psychological assessment and management*. Guilford Press.
- Neighbors, C., Dillard, A. J., Lewis, M. A., Bergstrom, R. L., & Neil, T. A. (2006). Normative misperceptions and temporal precedence of perceived norms and drinking. *Journal of Studies on Alcohol*, 67(2), 290–299. <https://doi.org/10.15288/jsa.2006.67.290>
- Palfai, T. P., Winter, M., Lu, J., Rosenbloom, D., & Saitz, R. (2014). Personalized feedback as a universal prevention approach for college drinking: A randomized trial of an e-mail linked universal web-based alcohol intervention. *The Journal of Primary Prevention*, 35(2), 75–84. <https://doi.org/10.1007/s10935-013-0337-9>
- Park, C. L. (2004). Positive and negative consequences of alcohol consumption in college students. *Addictive Behaviors*, 29(2), 311–321. <https://doi.org/10.1016/j.addbeh.2003.08.006>
- Riper, H., van Straten, A., Keuken, M., Smit, F., Schippers, G., & Cuijpers, P. (2009). Curbing problem drinking with personalized-feedback interventions: A meta-analysis. *American Journal of Preventive Medicine*, 36(3), 247–255. <https://doi.org/10.1016/j.amepre.2008.10.016>
- Ruiz, C., Guilera, G., & Gómez-Benito, J. (2011). Development of a scale to assess the diurnal impact of insomnia. *Psychiatry Research*, 190(2–3), 335–341. <https://doi.org/10.1016/j.psychres.2011.05.015>
- Saitz, R., Palfai, T. P., Freedner, N., Winter, M. R., Macdonald, A., Lu, J., Ozonoff, A., Rosenbloom, D. L., & Dejong, W. (2007). Screening and brief intervention online for college students: The ihealth study. *Alcohol and Alcoholism*, 42(1), 28–36. <https://doi.org/10.1093/alcac/agl092>
- Singleton, R. A., Jr., & Wolfson, A. R. (2009). Alcohol consumption, sleep, and academic performance among college students. *Journal of Studies on Alcohol and Drugs*, 70(3), 355–363. <https://doi.org/10.15288/jsad.2009.70.355>
- Stanesby, O., Labhart, F., Dietze, P., Wright, C. J. C., & Kuntsche, E. (2019). The contexts of heavy drinking: A systematic review of the combinations of context-related factors associated with heavy drinking occasions. *PLOS ONE*, 14(7), Article e0218465. <https://doi.org/10.1371/journal.pone.0218465>
- Taylor, D. J., Bramoweth, A. D., Grieser, E. A., Tatum, J. I., & Roane, B. M. (2013). Epidemiology of insomnia in college students: Relationship with mental health, quality of life, and substance use difficulties. *Behavior Therapy*, 44(3), 339–348. <https://doi.org/10.1016/j.beth.2012.12.001>
- Tsai, H. J., Yang, A. C., Zhu, J. D., Hsu, Y. Y., Hsu, T. F., & Tsai, S. J. (2022). Effectiveness of digital cognitive behavioral therapy for insomnia in young people: Preliminary findings from systematic review and meta-analysis. *Journal of Personalized Medicine*, 12(3), Article 481. <https://doi.org/10.3390/jpm12030481>
- Wagener, T. L., Leffingwell, T. R., Mignogna, J., Mignogna, M. R., Weaver, C. C., Cooney, N. J., & Claborn, K. R. (2012). Randomized trial comparing computer-delivered and face-to-face personalized feedback interventions for high-risk drinking among college students. *Journal of Substance Abuse Treatment*, 43(2), 260–267. <https://doi.org/10.1016/j.jsat.2011.11.001>
- Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*, 54(6), 1063–1070. <https://doi.org/10.1037/0022-3514.54.6.1063>
- Wechsler, H., Lee, J. E., Kuo, M., Seibring, M., Nelson, T. F., & Lee, H. (2002). Trends in college binge drinking during a period of increased prevention efforts. Findings from 4 Harvard School of Public Health College Alcohol Study surveys: 1993–2001. *Journal of American College Health*, 50(5), 203–217. <https://doi.org/10.1080/07448480209595713>
- Wechsler, H., & Nelson, T. F. (2001). Binge drinking and the American college student: What's five drinks? *Psychology of Addictive Behaviors*, 15(4), 287–291. <https://doi.org/10.1037/0893-164X.15.4.287>
- White, A. M. (2020). Gender differences in the epidemiology of alcohol use and related harms in the United States. *Alcohol Research*, 40(2), Article 01. <https://doi.org/10.35946/arcr.v40.2.01>
- White, H. R., & Labouvie, E. W. (1989). Towards the assessment of adolescent problem drinking. *Journal of Studies on Alcohol*, 50(1), 30–37. <https://doi.org/10.15288/jsa.1989.50.30>

Received October 10, 2024

Revision received April 1, 2025

Accepted April 7, 2025 ■