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Effects of Caffeinated vs. Non-Caffeinated Alcoholic Beverage on Next-day Hangover Incidence and Severity, Perceived Sleep Quality, and Alertness

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Abstract

Aims—Beliefs about the effects of mixing caffeine and alcohol on hangover or sleep may play a role in motivation to consume these mixtures; therefore, information is needed about actual effects. We investigated whether intoxication with caffeinated vs. non-caffeinated beer differentially affected perceived sleep quality, sleepiness, and hangover incidence and severity the next morning.

Methods—University students (89%) and recent graduate drinkers were randomized to receive: (1) beer with the equivalent of 69 mg caffeine/12 oz glass of regular beer (n = 28) or (2) beer without caffeine (n = 36), in sufficient quantity to attain a BrAC of 0.12 g%. After an 8-hour

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Contributors

Rohsenow, Howland and Arnedt designed the original study and Ms. Alvarez proposed the secondary analysis presented in this manuscript. Langlois, Verster, and Sherrard conducted literature reviews and contributed to the development of the Introduction and Discussion sections. Rohsenow, Nelson, and Langlois led or contributed to the statistical analyses. Howland and Rohsenow wrote the first draft of the manuscript and all authors have contributed to and have approved the final manuscript. Howland, Rohsenow and Alvarez presented portions of the results at the annual meeting of the Alcohol Hangover Research Group, Wolfeville, Nova Scotia, October 2012.

Author Disclosure

Conflict of Interest

Howland was the principal investigator on a contract between Boston Medical Center and Red Bull GmbH to conduct a student survey on AWC use that was not related to the preparation of this manuscript. Verster has received research support from Takeda Pharmaceuticals and Red Bull GmbH and has acted as scientific advisor for Takeda, Sanofi-Aventis, Transcept, Sepracor, Red Bull GmbH, Canadian Beverage Association, Trimbos Institute, Deenox, and CBD. Verster's funding was not related to the preparation of this manuscript. Rohsenow is funded by a Senior Research Career Scientist Award from the Department of Veterans Affairs. There are no other conflicts to report.

supervised sleep period, participants completed measures of hangover, sleep quality, sleep latency and time asleep, and sleepiness.

Results—While caffeinated beer improved perceived sleep quality, effect sizes were greater for morning alertness than for quality while sleeping, with no effect on sleep latency or total sleep time. No effects were seen on hangover incidence or severity.

Conclusions—Mixing caffeine and alcohol does not significantly impair amount of sleep or sleep latency, hangover, or sleepiness the morning after drinking to intoxication in this population.

Keywords

caffeine; alcohol; energy drinks; hangover; sleep quality

1. Introduction

Caffeinated alcoholic beverage (CAB) includes pre-mixed beverages, drinks mixed in bars or by oneself, or drinking a caffeinated beverage in temporal proximity to drinking alcohol (Howland et al., 2011; Howland et al. 2013). Consuming alcohol with caffeinated beverages such as energy drinks is increasingly popular among adolescents and young adults (O'Brien et al., 2008). While ingredients of energy drinks vary across brands, the primary active component is caffeine, most commonly with about 80 mg of caffeine per 8 ounce (250 ml) beverage (Reissig et al., 2009). Surveys of college students in Australia and the US indicate that 25–65% have consumed CABs in the last 30 days (Peacock et al., 2012; O'Brien et al., 2008).

Marketing targeting youth promotes beliefs that CABs increase energy while drinking and counteract unpleasant side effects (Howland et al., 2011). The belief that CAB mitigates hangover symptoms was endorsed by 3 -17% of student respondents in three US surveys (MacKillop et al., 2012; O'Brien et al., 2008; Malinauskas et al., 2007). This belief may also motivate CAB consumption. The only investigation of whether CAB actually affects hangover was a survey of 1503 Dutch university students; no significant differences were found in hangover severity between those who drank alcohol to intoxication with or without caffeine (Penning et al., 2011). No work has compared hangover when drinking to a controlled level of intoxication in the laboratory.

Sleep disruption is a common effect of caffeine (Brezinova 1974; Hindmarch et al. 2000; Karacan et al. 1976; Nicholson & Stone 1980). Some people believe that CAB counteracts the sedating effect of alcohol (Malinauskas et al., 2007; Marczinski et al., 2006; Mintel International Group, 2005). Due to caffeine content, CABs might result in worse sleep compared to the sleep disruption from the same quantity of alcohol, resulting in greater sleepiness and less alertness the next morning. One survey study reported a fourfold odds of having sleep difficulties with CAB (Peacock et al., 2012); focus groups also reported that CAB-related sleep disruptions (Pennay & Lubman, 2012); while another survey study found no effect on self-reported time spent asleep (Penning et al., 2011). Again, no controlled trial has compared the sleep effects of CAB vs. alcohol alone.

The present investigation analyzes data from a previous study of the acute effects of CAB vs. non-caffeinated alcohol (mean BrAC: .12 g%) on a simulated driving task (Howland et al., 2010). We added calibrated amounts of caffeine to beer to produce CAB without confounding caffeine effects with other ingredients often included in energy drinks (e.g., taurine, guarana, and sugar derivatives). W e hypothesized that CAB vs. non-caffeinated beer would worsen next-morning hangover incidence and severity, subjective sleep quality, and alertness. The present study is the first to use randomized alcohol administration to compare the effects of intoxication with CAB vs. noncaffeinated alcohol on hangover, sleep quality, and alertness.

2. Methods

2.1. Overview of study

We compared the two groups receiving alcohol (with and without caffeine) on measures the morning after intoxication and an 8-hour opportunity. (The placebo beer groups were not studied in the present analyses.)

2.2. Participants and Site

Participants were recruited from greater Boston, MA, USA. They were 21 and 30 years of age; had no current or history of drinking problems; and, had had ≥ 5 drinks on a single occasion (≥ 4 if female) at least once in the 30 days prior to screening. They were screened for health problems or medication use contraindicated for alcohol; sleep disorders; and pregnancy and nursing, if female. Regular tobacco users were excluded to avoid nicotine withdrawal. A prescribed sleep regimen for three nights prior to the experimental session was confirmed by daily sleep/wake diary and call-in to a time-stamped answering machine. Participants were required to abstain from alcohol, medications not approved by the study physician, sleep aids and recreational drugs for 24-hours, and caffeine for 8 hours, prior to their experimental session. (See Howland et al. 2010 for further details.)

Participants were paid $150. The study was conducted at the General Clinical Research Center (GCRC) at Boston Medical Center. Institutional Review Boards at Boston Medical Center, Brown University, and the University of Michigan approved this study.

2.3. Beverage administration procedures

Alcoholic beverage administration targeted 0.12 g% BrAC (1.068 g/kg body weight for men and .915 g/kg for women), adjusting for sex as per Friel et al. (1999). Hurricane High Gravity™ (8.1 % alcohol by volume) beer (Anheuser Busch, St Louis, MO) was used to reduce the volume required to attain the targeted dose.

Tasteless, anhydrous caffeine powder in solution was added to beer in a quantity equivalent to the caffeine content of a commercially available caffeinated beer (Moonshot ®) (69 ml of caffeine in each 12 ounce bottle),

Beverage administration began 3 hours after a standardized meal, served in the lab. Small groups (four to five) consumed beverages from 7:30 until approximately 8:30 p.m. Participants had an 8-hour sleep opportunity (11:00 p.m. to 7:00 a.m.), with safety monitoring by an Emergency Medical Technician. Self-report measures of hangover, sleep quality, and sleepiness were completed soon after awaking.

2.5. Measures

2.5.1. Last 30 days alcohol intake—Average daily volume (ADV) of alcohol intake was assessed with two questions: 1) “Considering all your drinking times in the past 30 days, about how often did you have any beer, wine or liquor?,” Likert-rated from 1 “once a day” to 7 “did not drink”; and 2) “In the past 30 days, on a typical day that you drank, about how much did you have to drink in one day?,” with their actual number of drinks specified. ADV was the product of the quantity by the weighted frequency score.

2.5.2. Subjective sleep quality measure—We used six items from a post-sleep sleep quality questionnaire (Roehrs et al., 1991). The scale provides a reliable and valid measure that was significantly lower on mornings after heavy alcohol consumption vs. placebo (Roehrs et al., 1991; Rohsenow et al., 2006).

2.5.3. Sleepiness—To measure morning alertness, the 7-item the Stanford Sleepiness Scale (SSS; Hoddes, et al. 1973) scale requires participants to rate their current sleepiness. It was completed three times, at 8:00, 8:30 and 9:00 a.m., with the average of the three ratings used as the dependent variable. (It was not completed in the first hour after waking to avoid sleep inertia effects.)

2.5.4. Acute Hangover Scale (AHS)—The AHS is a psychometrically validated measure of acute hangover symptoms (Rohsenow et al., 2007). The scale consists of self-rated severity of hangover and associated symptoms.

2.6. Data analysis approach

All measures were examined for normality and outliers. Hangover <u>incidence</u> was defined as rating one’s hangover as zero (none) vs. any other rating on the first AHS item, “hangover”. Hangover <u>severity</u> was the mean score from the nine AHS items. The groups receiving CAB vs. non-caffeinated alcohol were compared on continuous measures using between-groups t-tests to compare the differences between mean outcomes, and on dichotomous measures using chi-square tests. Since alcohol administration controlled for sex and weight and was designed to limit range of peak BrAC, and since age range was restricted, there was no need to control for these variables statistically. Alpha was set at .05. Due to the relatively small number of participants, effect sizes were examined to see if non-significance of results was likely due to small statistical effects as opposed to low power to detect medium effects (indicating a promising trend). We used d for t-tests and h for dichotomous variables (a value of .20 – .50 is small, and .50 – .79 is medium in effect size).

Results

2.4. Participant characteristics

Study completers included 28 participants randomized to CAB and 36 to non-caffeinated beer. The experimental groups were comparable with respect to race/ethnicity, mean age, average daily volume of alcohol consumption, and proportion enrolled in university (Table 1).

Participants received on average 44 ounces of beer (37 if female), the equivalent of 6.12 12-oz. cans of 4.8% alcohol (by volume) beer. Mean peak BrAC was 0.12 g% (range was 0.08–0.16 g%) (see Table 1), with no differences between the CAB and non-caffeinated alcohol groups. Those who received caffeine received on average 383 mgs of caffeine (338 if female).(A 7 ounce cup of coffee has from 100–200 mg of caffeine.)

2.5. Subjective Sleep Quality and Morning Sleepiness

The CAB group reported significantly better average perceived sleep quality than the non-caffeinated beer group, $t(62) = 2.49$, 95% confidence interval = 0.057 – 0.517, $p < .015$, with a medium effect size (Table 2). Since sleep quality during the night is conceptually different from alertness and concentration ability in the morning, and could be differentially affected in our study due to the half-life of caffeine, the mean of the two nighttime sleep quality ratings and the mean of the two morning alertness/concentration items were analyzed separately. A trend toward significance was found only for morning alertness/concentration, $t\ (62) = 1.66$, $p < .10$, M ± SD = 4.66 ± 0.82 for CAB, 4.29 ± 0.93 for non-CAB, with an effect size of $d = .42$ (high end of the small effect range). The effect size for the mean of the two within-sleep ratings was smaller, $d = .30$.

No significant group effects were found for time to fall asleep, amount of time asleep, or the Stanford Sleepiness Scale, with very small effect sizes.

Hangover—No significant differences between groups were found in hangover incidence or mean severity hangover scores (Table 2). All effects sizes were very small.

3. Discussion

Results indicate that perceived time to fall asleep and time spent sleeping were not affected by caffeine content of beer in this young population. While the perceived sleep quality index indicated better scores after CAB than non-caffeinated beer, post-hoc tests suggested that this was due more to better alertness on awakening after CAB than to perceived sleep quality during the night. Caffeinated and non-caffeinated alcoholic beverage did not affect the incidence or severity of hangover. The lack of significant effects could have been due to the low power. However, except possibly for the post-hoc test on morning alertness, effect sizes for all non-significant variables were quite small so would have required very large sample sizes for significance.

We believe that our findings generalize to other CAB consumption because caffeine is the main active ingredient in energy drinks and there is currently no evidence that taurine, guarana or sugar affect the variables we investigated. Moreover, our results were consistent with those of Penning et al. (2011) who asked students specifically about alcohol consumption with and without energy drinks on the night before their last hangover.

Our results could vary as a function of the amount of alcohol consumed. However, in the survey study by Penning et al. (2011), students with hangover consumed a mean (SD) of 11.10 (6.2) drinks, almost twice the number of drinks administered in our study. The consistency of results across our study and that by Penning et al. (2011) suggests that our findings may generalize to a broader range of heavy CAB consumption, though further study is needed to confirm this. It is also possible that results could differ as a function of the amount of caffeine, although we calibrated caffeine amount to a brand of caffeinated beer that was commercially available at the time of the study.

Since caffeine in the evening generally affects sleep onset (Brezinova 1974; Hindmarch et al. 2000; Karacan et al. 1976; Nicholson & Stone 1980), the lack of effect on sleep in this study could be due to the young age of the population, or due to alcohol’s effects on sleep in the first-half of the night when heavy drinking improves sleep onset and sleep consolidation (Arnedt et al., 2011), possibly counteracting caffeine’s short-lived effects on sleep. Results might be different with older populations.

Our findings, nonetheless, provide evidence that persons who believe that adding caffeine to alcohol affects the odds of hangover are likely misinformed. Public health efforts should provide corrective information to decrease these and any other beliefs that can motivate CAB use.

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Highlights

In a randomized trial, addition of caffeine to alcohol, vs. alcohol without caffeine, did not

- mitigate hangover after intoxication
- Affect self-reported sleep latency or total sleep time
- Affect next-day mood

Table 1

Comparison of participant characteristics by condition

	Beer with Caffeine M (SD) or %	Beer Alone M (SD) or %
Age	22.8 (2.3)	23.3 (2.1)
Male (%)	41.4	58.3
White (%)	78.6	83.3
Alcohol Daily Volume	1.49 (1.05)	1.79 (1.05)
Peak BrAC (g%)	0.12 (0.01)	0.12 (0.01)
Enrolled in university	96	83

Note: Alcohol Daily Volume is a product of average daily quantity and weighted frequency ratings, with higher numbers reflecting more drinking. All p values > .20.

BrAC = breath alcohol concentration. g% is also known as g/dL. N = 28 for beer with caffeine, n = 36 for beer without caffeine condition.

Table 2

Sleep quality, sleepiness, and hangover variables by condition

	Beer with Caffeine	Beer Alone	Effect size
	M (SD) or %	**M (SD) or %**	**D or h**
Minutes to fall asleep	36.5 (67.7)	23.2 (29.4)	.28
Minutes asleep	390.7 (73.8)	404.7 (62.5)	.21
Average sleep quality [a]	4.45 (0.41)	4.16 (0.49)	.64*
Stanford Sleepiness Scale [b]	2.52 (1.37)	2.78 (0.90)	.23
Acute Hangover Scale score	1.34 (0.84)	1.45 (0.89)	.13
Hangover incidence (% yes)	60.7	69.4	.19

Note: N = 28 for beer with caffeine, n = 36 for beer without caffeine condition.

[a] Higher score means better perceived sleep quality and morning alertness

[b] Mean of ratings at 8:00, 8:30, and 9:00 a.m.; higher scores are more sleepy

* $p < .02$.