Caffeinated Alcohol, Sensation Seeking, and Injury Risk

Mary Claire O'Brien,^{1,2} Thomas P. McCoy,³ Kathleen L. Egan,² Shoshanna Goldin,⁴
Scott D. Rhodes,² and Mark Wolfson²

Background: College students who consume caffeinated alcoholic beverages (CaffAlc) are at increased injury risk. This study examines the extent to which a sensation-seeking personality accounts for the relationship between consumption of CaffAlc and negative outcomes.

Methods: A Web-based survey was administered to stratified random samples of 4907 college students from eight North Carolina universities in Fall 2009. Sensation seeking was assessed using the Brief Sensation-Seeking Scale (BSSS) ($\alpha=0.81$). Data were analyzed using linear and logistic regression.

Results: 3390 students (71.2%) reported past 30-day drinking, of whom 786 (23.2%) consumed CaffAlc. CaffAlc past 30-day drinkers had higher BSSS scores (3.8 vs. 3.4; $p<0.001$), compared to non-CaffAlc drinkers. Consumption of CaffAlc was associated with more frequent binge drinking ($p<0.001$) and drunken days in a typical week ($p<0.001$), even after adjusting for the BSSS score. CaffAlc students were more likely to be taken advantage of sexually (adjusted odds ratio [AOR]=1.70, $p=0.012$), drive under the influence of alcohol (AOR=2.00, $p<0.001$), and ride with a driver under the influence of alcohol (AOR=1.87, $p<0.001$). Injury requiring medical treatment was more prevalent among CaffAlc students with higher BSSS-8 scores (interaction $p=0.024$), even after adjustment for drinking levels and student characteristics.

Conclusions: Sensation seeking does not fully account for the increase in risky drinking among college students who consume CaffAlc, nor does it moderate the relationship between CaffAlc and drinking behaviors. Sensation seeking moderates the risk of alcohol-associated injury requiring medical treatment among college students who consume CaffAlc. Those with strong sensation-seeking dispositions are at the highest risk of alcohol-associated injury requiring medical treatment.

Introduction

ENERGY DRINKS ARE FLAVORED BEVERAGES containing variable amounts of caffeine, sugars, amino acids, vitamins, and herbal supplements.¹ They are aggressively marketed to youths, with advertising that suggests mental and physical benefits, including increased energy and enhanced physical performance.^{2,3} It is estimated that 30%–50% of adolescents and young adults in the United States consume caffeinated energy drinks.⁴ Among adults 21 years of age and older, 28% report using energy drinks to mix with an alcoholic beverage.⁵ One survey reports that 54% of college students use caffeinated energy drinks to mix with alcohol while partying.⁶

A growing body of scientific evidence documents the risk of serious adverse effects among individuals who consume highly caffeinated energy drinks, either alone or in combination with alcohol.^{7,8} According to the United States Substance

Abuse and Mental Health Services Administration, emergency department visits involving energy drinks have doubled in number from 2007 to 2011 (10,068 to 20,783); about 13 percent of these visits involved energy drinks and alcohol.⁷ In response to serious concerns raised by scientists, law enforcement officials, and public health advocates in 2010, the United States Food and Drug Administration (FDA) determined that the addition of caffeine to manufactured alcoholic beverages is not generally recognized as safe.^{9–12} While this action effectively bans the addition of caffeine to manufactured alcohol in the United States, the practice of mixing alcohol with energy drinks remains popular, particularly among young people.¹³

The consumption of caffeinated alcohol (CaffAlc) has been found to be significantly associated with increased frequency of high-risk drinking behaviors in college students, including heavy episodic drinking and weekly drunkenness.¹⁴ A study

Departments of ¹Emergency Medicine and ²Social Sciences & Health Policy, Wake Forest School of Medicine, Winston-Salem, North Carolina.

³School of Nursing, The University of North Carolina Greensboro, Greensboro, North Carolina.

⁴Wake Forest University, Winston-Salem, North Carolina.

of patrons exiting a U.S. college bar district found individuals who consumed CaffAlc to be three times more likely to be legally intoxicated than individuals who consumed alcohol alone,¹⁵ and four times more likely to report intention of driving, compared to patrons who consumed only alcohol.¹⁵ Even after adjusting for the increased alcohol consumed, college students who drank CaffAlc beverages reported significantly higher prevalence of serious alcohol-related consequences, including alcohol-related illness or injury, sexual assault, and riding with a drunken driver.¹⁴

Several mechanisms have been suggested to explain the observed association between CaffAlc, risky drinking, and alcohol-related harms. Drinkers who believe that caffeine neutralizes the depressive effects of alcohol may expect that by consuming CaffAlc, they can safely tolerate greater quantities of alcohol without impairment. Individuals who consume CaffAlc may have difficulty judging their level of intoxication,^{16,17} leading them to drink more alcohol and to engage in more risky behaviors (e.g., driving under the influence).

Personality factors may play a part in the relationship between the consumption of CaffAlc and negative alcohol-related consequences. Individuals with stronger sensation-seeking dispositions, who enjoy heightened levels of physical and psychological excitement, may be preferentially enticed by the buzz drunk state that is reportedly associated with the excessive consumption of CaffAlc. These same individuals may have risk-taking tendencies, independent of their ability to estimate correctly their level of intoxication.

Sensation seeking is a normal personality attribute characterized by the need for stimulation and the willingness to take risks for the sake of it. It comprises the desire for new sensations, susceptibility to boredom, thrill and adventure seeking (including the pursuit of physical speed and danger), and disinhibition.¹⁸ Previous studies indicate that individuals who are high-sensation seekers tend to be drawn to high-risk activities, including the use of alcohol and illicit drugs.^{19–27} High-sensation seekers may have an increased susceptibility to the subjective rewarding effects of alcohol.²⁸ Among college students, higher levels of sensation seeking have been linked to binge drinking.²¹

To date, very little research has examined the relationship between personality, CaffAlc, and negative alcohol-related consequences. In a Web-based survey of students attending university in Western Canada ($n = 465$),²⁹ there was a significant association between the risk-taking tendency (measured with a 14-item scale that included behavioral and nonbehavioral constructs) and the likelihood of consuming CaffAlc. After controlling for risk-taking propensity, the consumption of CaffAlc was associated with heavier and more frequent drinking. After additionally controlling for heavy episodic drinking, students who consumed CaffAlc were more likely to drive after drinking, ride with an intoxicated driver, and have been hurt or injured.

This study expands on the current literature, examining the extent to which a sensation-seeking (based on the 8-item Brief Sensation-Seeking Scale [BSSS]³⁰) disposition accounts for the association between the consumption of CaffAlc and negative alcohol-related consequences in a large sample of undergraduate students from multiple academic institutions located in the southeastern portion of the United States.

Materials and Methods

In the Fall of 2009, a stratified random sample of 4907 undergraduate students from eight North Carolina universities in the United States (one private and seven public) completed an anonymous Web-based survey. This survey was developed as part of a randomized community trial to prevent high-risk drinking and alcohol-related consequences among college students ("The Study to Prevent Alcohol-Related Consequences among college students," "SPARC").³¹ Students were offered \$15.00 in Paypal® money for completing the survey. From the completed surveys, one student at each university was randomly selected to receive \$100.00 in Paypal money. The survey took ~30 minutes to complete, depending on the skip patterns of the respondent. The survey measured demographic variables, attitudes about drinking, alcohol consumption behaviors, beliefs or attitudes about policies and enforcement of policies concerning alcohol consumption, campus norms concerning alcohol consumption, consequences experienced as a result of one's own drinking, consequences experienced as a result of someone else's drinking, and other health risk behaviors.

High-risk drinking questions included (1) the typical number of drinks in a drinking episode; (2) the number of days drunk in a typical week (range 0–7 days), where drunk was defined for students as "dizzy, unsteady, or sick to your stomach"³²; (3) the number of heavy episodic (binge) drinking days in the past 30 days (range 0–30 days), where binge was defined by the gender-specific measure of four or more drinks in a row for a female and five or more drinks in a row for a male³³; and (4) the greatest number of alcoholic drinks consumed in a single episode the past 30 days. Students were asked, "In the past 30 days, have you consumed premixed alcoholic energy drinks (e.g., Jooze®, Four®, Torque®, Liquid Charge®), or energy drinks mixed with alcohol (e.g., Jagerbombs; Red Bull® and vodka)?" No specific information about the quantity or ratio of caffeine to alcohol was obtained. This study was conducted before the FDA ban on the addition of caffeine to manufactured alcoholic beverages in December 2010.

A sensation-seeking personality was assessed using the 8-item BSSS-8.^{30,34} The BSSS-8 contained two questions for each of the 4 content domains of sensation seeking: experience seeking (*I would like to explore new places; I would like to take off on a trip with no preplanned routes or timetables*), thrill and adventure seeking (*I like to do frightening things; I would like to try bungee jumping*); disinhibition (*I like wild parties; I would love to have new and exciting experiences, even if I have to break the rules*); and boredom susceptibility (*I get restless when I spend too much time at home; I prefer friends who are exciting and unpredictable*). Students indicated their response to each item using a 5-point scale anchored by strongly disagree (1) and strongly agree (5). The average of the eight items was used as an overall score for sensation seeking.^{30,34,35} Higher BSSS-8 mean scores indicated a greater agreement with seeking sensation.

Students were asked whether in the past 30 days, they had experienced any of the following as a result of their drinking or the drinking of others: (1) were taken advantage of sexually, (2) took advantage of another sexually, (3) drove under the influence of alcohol, or (4) rode with a driver who was under the influence of alcohol. In addition, they were asked

TABLE 1. CHARACTERISTICS OF STUDENTS BY REPORTING OF MIXING ALCOHOL AND ENERGY DRINKS (CAFFALC) (N=4761)

Characteristic	Overall n=4761	Nonpast 30-day drinkers n=1371 (28.8%)	Past 30-day drinkers n=3390 (71.2%)	
			Non-CaffAlc, n=2604 (76.8%)	CaffAlc, n=786 (23.2%)
Gender, n (%) ^a				
Male	1787 (38)	418 (30)	1015 (39)	354 (45)
Female	2951 (62)	945 (69)	1583 (61)	423 (54)
No response	23 (<1)	8 (<1)	6 (<1)	9 (1)
Academic classification, n (%)				
Freshman	1264 (27)	470 (34)	584 (22)	213 (27)
Sophomore	1107 (23)	361 (26)	584 (22)	162 (21)
Junior	1216 (26)	317 (23)	693 (27)	206 (26)
Senior	974 (20)	188 (14)	614 (24)	172 (22)
Other	193 (4)	31 (2)	129 (5)	33 (4)
No response	4 (<1)	4 (<1)	0	0
Age, mean±SD ^b	20.5±2.9	20.3±3.3	20.6±2.7	20.3±2.3
Under 21 years old, n (%)				
Yes	3020 (63)	1029 (75)	1526 (59)	465 (59)
No	1735 (36)	338 (25)	1076 (41)	321 (41)
No response	6 (<1)	4 (<1)	2 (<1)	0
Race, n (%)				
Non-Hispanic white	3768 (79)	971 (71)	2146 (82)	651 (83)
African-American	381 (8)	185 (13)	152 (6)	44 (6)
Hispanic	163 (3)	41 (3)	91 (3)	31 (4)
Asian/Pacific Islander	135 (3)	64 (5)	50 (2)	21 (3)
Other	214 (4)	80 (6)	110 (4)	24 (3)
No response	100 (2)	30 (2)	55 (2)	15 (2)
Average sensation-seeking score (BSSS-8), mean±SD ^a	3.4±0.8	3.1±0.7	3.4±0.7	3.8±0.7
Fraternity/sorority status, n (%) ^c				
Pledge or Member	697 (15)	82 (6)	454 (17)	161 (20)
Neither	3790 (80)	1205 (88)	2004 (77)	581 (74)
No response	274 (6)	84 (6)	146 (6)	44 (6)
Athletic status, n (%) ^b				
Intramural	1136 (24)	253 (18)	642 (25)	241 (31)
Varsity	247 (5)	64 (5)	142 (5)	41 (5)
Nonathlete	3118 (65)	984 (72)	1677 (64)	457 (58)
No response	260 (5)	70 (5)	143 (5)	47 (6)
Campus residence, n (%)				
On-campus	2229 (47)	810 (59)	1081 (42)	338 (43)
Off-campus	1827 (38)	449 (33)	1041 (40)	337 (43)
No response	705 (15)	112 (8)	482 (19)	111 (14)

^a $p < 0.001$, ^b $p < 0.01$, and ^c $p < 0.05$ from mixed-effects logistic regression comparing CaffAlc vs. non-CaffAlc only.

Nondrinkers mean did not consume alcohol in the past 30 days.

CaffAlc, caffeinated alcoholic beverages; BSSS, Brief sensation-seeking scale.

whether they had experienced an alcohol-related injury requiring medical treatment in the past 12 months and in the past 30 days (e.g., automobile accident, fall from a height, sexual assault). These alcohol-related consequences were chosen to remain consistent with those examined in the overall SPARC trial.³¹

The number of full-time undergraduates at the study campuses ranged from 3132 to 17,275. A target response quota of 33% over a 5-week fielding period was set, based on power calculations for the overall SPARC trial.^{14,31,36} The survey procedures have been described in detail previously.^{14,31,36} The survey site was shut down shortly after the required number of surveys was received; the final response rate was 34.8%.

The Wake Forest University Health Sciences (WFUHS) Institutional Review Board (IRB) provided human subject re-

view and oversight. The review boards of other universities participating in this study either approved this study or chose to fall under the WFUHS IRB.

Data analysis

The goals of the statistical analyses were to (1) estimate the prevalence of CaffAlc use among past 30-day drinkers, (2) compare sensation-seeking scores between past 30-day drinkers by their CaffAlc use status, and (3) examine the association of CaffAlc use with drinking behaviors and with alcohol-related consequences, after adjusting for sensation-seeking scores.

Mixed-effects logistic regression was used to assess associations of student demographic characteristics with CaffAlc use, after adjusting for within campus clustering. Campus was used

TABLE 2. DRINKING BEHAVIORS BY REPORTING OF MIXING ALCOHOL AND ENERGY DRINKS (CAFFALC)^a

Drinking behavior	Without sensation seeking			With sensation seeking				
	Typical no. of drinks in single episode ^b	No. of days with 5/4 heavy episodic drinking in past 30 days ^b	No. of days drunk in a typical week ^b	Most no. of drinks in single episode ^b in past 30 days ^b	Typical no. of drinks in single episode ^c	No. of days with 5/4 heavy episodic drinking in past 30 days ^c	No. of days drunk in a typical week ^c	Most no. of drinks in single episode ^c in past 30 days ^c
Non-CaffAlc	4.2±0.12	2.0±0.18	0.60±0.05	5.4±0.16	4.2±0.13	2.1±0.16	0.61±0.05	5.5±0.14
CaffAlc	5.4±0.15	4.1±0.22	1.16±0.06	7.4±0.19	5.2±0.15	3.8±0.21	1.07±0.06	7.0±0.18
95% CI for b ^d	1.2 (1.0, 1.4)	2.1 (1.7, 2.4)	0.56 (0.47, 0.64)	2.0 (1.7, 2.3)	1.0 (0.8, 1.2)	1.7 (1.4, 2.1)	0.46 (0.37, 0.54)	1.5 (1.2, 1.8)
t statistic	10.87	12.09	13.04	13.02	8.85	9.33	10.20	9.41
p-Value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
R _β ²	0.19	0.08	0.11	0.21	0.23	0.11	0.14	0.27

Numbers in first two rows are adjusted means±SE.

^aStudents who reported drinking in the past 30 days only (*n*=3390).

^bAdjusted for student gender, age, race, fraternity or sorority status, athlete status, and within-campus clustering;

^cAdditionally adjusted for sensation seeking using BSSS-8 scores; no interaction effects (all *p*>0.10).

^db is the regression coefficient of the indicator variables comparing CaffAlc to non-CaffAlc drinkers from multivariable linear mixed-effects regression modeling.

as a random effect (random intercept) in all regression modeling to account for within-campus clustering.³⁷ Multivariable mixed-effects linear regression was used to assess whether CaffAlc use was associated with drinking behavior outcomes after adjusting for student characteristics, sensation seeking, and within-campus clustering. Model specification was based on the covariates used previously in O'Brien *et al.*¹⁴ (student gender, age, race, fraternity or sorority status, athlete status, typical number of drinks consumed). R-square statistics (R^2) were estimated for these linear mixed models using the methods from Edwards *et al.*³⁸ Multivariable mixed-effects logistic regression was used to assess whether the CaffAlc group was associated with alcohol-related consequences and injury outcomes, adjusting for student characteristics, within campus clustering, typical number of drinks consumed, and sensation seeking. A single mean scale score for sensation seeking using the BSSS-8 using the mean of all 8 items was used in all subsequent analyses (Cronbach's α =0.81). This is consistent with the approach used by Hoyle *et al.*,³⁰ Stephenson *et al.*,³⁴ and Eachus.³⁵ Regression assumptions were assessed with residual analyses, and influence diagnostics were explored. Multicollinearity was checked with variance inflation factors (VIFs), and modeling adequacy supported (all VIFs <2).³⁹ All analyses were performed using SAS v9.2 (SAS Institute, Cary, NC). A two-sided *p*-value <0.05 was considered statistically significant.

Results

A total of 4907 students completed the survey. Of these, 4761 students answered questions about the past 30-day drinking (97%). Reflecting the enrollment at the study schools and at 4-year colleges nationally, 62% of these students were female. The average age of students was 20.5 years (SD=2.9). Descriptive statistics on student characteristics are provided in Table 1. Of the 4761 students with a known past 30-day drinking status, past 30-day drinking was reported by 3390 students (71.2%). Among drinkers, 786 (23.2%) reported consuming CaffAlc at least 1 day in the past 30 days (95% CI=[21.8%, 24.6%]). All subsequent analyses are restricted to past 30-day drinkers.

In bivariate analyses, male students had 34% higher odds of consuming CaffAlc compared to female students [odds ratio (OR) 1.34; 95% confidence interval (CI)=(1.14, 1.58); *p*<0.001]. Younger students were more likely to drink CaffAlc [OR 0.95; 95% CI=(0.92, 0.98); *p*=0.003] Fraternity or sorority pledges and members had 28% higher odds of reporting consuming CaffAlc, compared to all other past 30-day drinkers [OR 1.28; 95% CI=(1.03, 1.58); *p*=0.027]. Intramural athletes (*p*<0.001) were more likely to report the consumption of CaffAlc, compared to all other past 30-day drinkers [OR 1.43; 95% CI=(1.18, 1.73); *p*<0.001].

Race, academic classification (class year), varsity athlete status, and campus residence (i.e., on-campus, off-campus) were not statistically significant predictors of CaffAlc consumption.

The average BSSS score for students who consumed CaffAlc was 3.8, compared to 3.4 for students who did not report the consumption of CaffAlc (*p*<0.001).

The consumption of CaffAlc was strongly associated with high-risk drinking behaviors (see Table 2). After adjusting for the sensation-seeking score, students who reported drinking CaffAlc had a greater number of drinks in a typical episode

TABLE 3. ALCOHOL-RELATED CONSEQUENCES AND CAFFALC^a

Alcohol-related consequence	Without sensation seeking				With sensation-seeking			
	Was taken advantage of sexually ^b	Took advantage of another sexually ^b	Drove under the influence of alcohol ^b	Rode with a driver who was under the influence of alcohol ^b	Received a ticket for DUI/DWI ^b	Was hurt or injured ^b	Was taken advantage of sexually ^c	Took advantage of another sexually ^c
AOR	1.95	2.12	2.15	2.14	2.18	2.14	1.70	1.56
AOR 95% CI	1.33, 2.86	1.22, 3.68	1.71, 2.70	1.74, 2.64	1.15, 4.16	1.56, 2.94	1.12, 2.56	0.86, 2.83
t statistic	3.44	2.68	6.57	7.16	2.38	4.72	2.52	1.46
p-Value	<0.001	0.008	<0.001	<0.001	0.018	<0.001	0.012	0.143

^aUsing students who reported drinking in the past 30 days only ($n = 3390$).^bAdjusted for student gender, age, race, fraternity or sorority status, athlete status, typical number of drinks in an episode, and within-campus clustering.^cAdditionally adjusted for the BSSS-8 sensation-seeking score.

AOR is the adjusted odds ratio for the indicator variable comparing CaffAlc to non-CaffAlc drinkers from multivariable logistic mixed-effects regression modeling. DUI/DWI, driving under the influence/driving while intoxicated.

(5.2 vs. 4.2 drinks; $p < 0.001$), more heavy episodic (binge) drinking days per month (3.8 days vs. 2.1 days; $p < 0.001$), and more drunken days per typical week (1.1 days/week vs. 0.61 days/week; $p < 0.001$), on average. Students who consumed CaffAlc had a significantly higher greatest number of drinks in a single episode, compared to students who did not report consuming CaffAlc (7.0 drinks vs. 5.5 drinks; $p < 0.001$). There were no significant interactions of CaffAlc reporting with the BSSS score for any drinking behavior outcome (all $p > 0.10$). Increases in R^2 from models unadjusted, and then adjusted for sensation seeking were minimal, and not considered to be substantial. CaffAlc remained significant before and after adjustment of BSSS-8 sensation-seeking scores. Thus, sensation seeking did not account for the observed increases in high-risk drinking behaviors for CaffAlc vs. non-CaffAlc.

Prevalence of serious alcohol-related consequences for past 30-day student drinkers were as follows: 5.2% reported "Was taken advantage of sexually," 2.4% reported "Took advantage of another sexually," 17.9% reported "Drove under the influence of alcohol," 23.9% reported "Rode with a driver who was under the influence of alcohol," 1.7% reported "Received a ticket for driving under the influence (DUI)/driving while intoxicated (DWI)," 7.5% reported "Was hurt or injured as a result of drinking," and 6.8% reported "injury requiring medical treatment."

Students who reported consuming CaffAlc had a higher predicted prevalence of serious alcohol-related consequences in the past 30 days, even after adjusting for the typical amount of alcohol consumed in an episode and sensation-seeking score (see Table 3). Students who drank CaffAlc were more likely to be taken advantage of sexually (adjusted odds ratio [AOR]=1.70, $p = 0.012$), drive under the influence of alcohol (AOR=2.00, $p < 0.001$), ride with a driver under the influence of alcohol (AOR=1.87, $p < 0.001$), and report being hurt or injured (AOR=1.71, $p = 0.002$). The predicted prevalence of injury requiring medical treatment was significantly higher among students who drank CaffAlc, even after adjustment for a typical drinking level, but the effect was moderated by sensation seeking ($p = 0.024$) (Fig. 1).

The models for alcohol-related consequences and injury outcomes unadjusted and adjusted for sensation seeking (adjusting for the previously described model covariates) showed significant differences between CaffAlc and non-CaffAlc, except for two cases. The exceptions were for "Took advantage of another sexually" ($p = 0.008$ unadjusted and $p = 0.143$ after adjusting for sensation seeking) and "Received a ticket for DUI/DWI" ($p = 0.018$ unadjusted and $p = 0.162$ BSSS adjusted).

There was a significant interaction between CaffAlc and sensation seeking for injuries requiring medical treatment ($p = 0.024$). Thus, sensation seeking did not account for injury risk, but rather the effects of CaffAlc were dependent upon the sensation-seeking score (and vice versa). As shown in Figure 1, higher sensation seeking was synergistic with the risk from CaffAlc, in that it increased the odds of injuries requiring medical treatment above and beyond that from CaffAlc alone.

Discussion

The consumption of CaffAlc has been found to be significantly associated with increased frequency of high-risk drinking behaviors and adverse alcohol-related consequences

FIG. 1. Association of consuming alcohol mixed with energy drinks (CaffAlc), sensation seeking, and a past 30-day injury requiring medical treatment.

among college students.¹⁴ This study examined the extent to which a sensation-seeking personality accounted for the relationship between consumption of CaffAlc and negative alcohol-related outcomes.

The mean BSSS-8 score for CaffAlc students in this study was 3.8 and was 3.4 for non-CaffAlc students. In Hoyle *et al.*, the overall mean BSSS-8 score was 3.74 ± 0.71 . Hoyle and colleagues describe gender differences by ethnicity whereby no difference in mean scores exceeded 0.20 in absolute value (e.g., mean was 3.34 for African-American females, while this was 3.41 for African-American males). Stephenson *et al.* also describe gender differences (mean 3.24 for males, 3.07 for females). The magnitude of these differences does not exceed 0.17. A mean difference of 0.40 is statistically significant, compared to what has been observed in previous studies; the clinical significance of this finding is less clear.

Males in our study were more likely to consume CaffAlc, and our results suggest that the association between sensation seeking and drinking is higher among males than females. It has been previously proposed that this relationship is due to males having higher circulating levels of gonadal hormones, in particular, testosterone compared to females.⁴⁰ Early socialization patterns and tendency to conform to gender-based stereotypes may also account for the greater effect in males. Intervention programs may benefit from deconstructing stereotypes about gender roles.⁴¹ Although these types of interventions are being explored to change men's behavior in other health domains, a more effective approach in this context might be to focus on correcting popular misconceptions about CaffAlc, and helping college men better understand the risks associated with mixing alcohol and energy drinks.

Cyders *et al.*⁴² found that personality dispositions predicted drinking among first-year college students. We found that younger students are significantly more likely to consume CaffAlc. For individuals in transition (e.g., college freshmen), personality may play an especially important role in influencing behavior, particularly when the new social context involves higher levels of freedom. We suggest that first-year college students should be specifically targeted with information about the risks of energy drinks mixed with alcohol.

The sensation-seeking personality significantly predicted the consumption of CaffAlc among our sample of college students. Previous studies indicate that individuals who are high-sensation seekers tend to be drawn to high-risk activities, including the use of alcohol and illicit drugs.^{19–23,27,24–26} Previous research suggests that both CaffAlc^{14,43–45} and sensation seeking^{46–49} predict the likelihood of experiencing adverse consequences.

Our results suggest that for the majority of consequences, sensation seeking only partially accounts for the relationship between CaffAlc and negative alcohol-related consequences. Being taken advantage of sexually, driving under the influence, riding with a driver under the influence, and getting hurt or injured were consequences that remained statistically significant after adjusting for sensation seeking, although effect sizes (ORs) lessened after adjustment. Thus, although causality was not established by this study, the consumption of CaffAlc was associated with increased predicted prevalence of adverse consequences.

Furthermore, sensation seeking does appear to influence the relationship between CaffAlc and injuries requiring medical treatment. Among drinkers who consumed CaffAlc, students with the highest sensation-seeking scores were more likely to suffer from an injury requiring medical treatment. High-sensation seekers may be more willing than their peers to engage in physically risky activities, such as riding in a car with an intoxicated driver. By placing themselves in situations where risk is prominent, students with stronger sensation-seeking personalities may increase their chance of injury, independent of the type or amount of alcohol they consume.

The study has several important limitations. Due to the cross-sectional nature of the study, causal relationships and directionality of the relationship between CaffAlc and adverse alcohol-related consequences cannot be determined. Prospective empirical investigations are needed to establish whether a functional relationship exists between the consumption of CaffAlc and alcohol-related consequences. Further studies are also needed to explore any differences in perceived or actual intoxication that might be related to the concentration of caffeine, the timing of caffeine and alcohol

ingestion, the presence of natural (or artificial) sweeteners, and other potential confounders. This study relies on self-reported data on potentially sensitive topics. However, the use of a Web-based survey, as well as the fact that the survey was confidential, should have minimized social desirability bias.⁵⁰ A final caveat is that the students in our sample were surveyed before the 2010 United States Food and Drug Administration (FDA) ban on the addition of caffeine to manufactured alcoholic beverages. Further studies should examine if consumers' characteristics remain the same.

Conclusions

This study was the first to examine the extent to which the sensation-seeking disposition accounts for the association between the consumption of CaffAlc and the negative alcohol-related consequences in a large sample of undergraduate students from multiple academic institutions located in the southeastern part of the United States. Sensation seeking only partially accounts for the increase in risky drinking behavior or adverse alcohol-related consequences among college students who consume CaffAlc. However, sensation seeking does moderate the increased risk of alcohol-associated injury requiring medical treatment among college students who consume CaffAlc. Individuals with strong sensation-seeking personalities are at the highest risk of alcohol-associated injury requiring medical treatment.

Acknowledgment

The research reported in this publication was supported by the National Institute on Alcohol Abuse and Alcoholism (NIAAA) of the National Institutes of Health, under award number R01AA014007. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institute on Alcohol Abuse and Alcoholism or the National Institutes of Health.

Author Disclosure Statement

No competing financial interests exist.

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Address correspondence to:

Mary Claire O'Brien, MD

Department of Emergency Medicine

Wake Forest School of Medicine

Winston-Salem, NC 27157

E-mail: mobrien@wakehealth.edu