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Energy drink consumption and increased risk for alcohol dependence

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Abstract

Background—Energy drinks are highly caffeinated beverages that are increasingly consumed by young adults. Prior research has established associations between energy drink use and heavier drinking and alcohol-related problems among college students. This study investigated the extent to which energy drink use might pose additional risk for alcohol dependence over and above that from known risk factors.

Methods—Data were collected via personal interview from 1,097 fourth-year college students sampled from one large public university as part of an ongoing longitudinal study. Alcohol dependence was measured with DSM-IV criteria.

Results—After adjustment for the sampling design, 51.3%$_{wt}$ of students were classified as "low-frequency" energy drink users (1 to 51 days in the past year) and 10.1%$_{wt}$ as "high-frequency" users (≥52 days). Typical caffeine consumption varied widely depending on the brand consumed. Compared to the low-frequency group, high-frequency users drank alcohol more frequently (141.6 vs. 103.1 days) and in higher quantities (6.15 vs. 4.64 drinks/typical drinking day). High-frequency users were at significantly greater risk for alcohol dependence relative to both non-users (*AOR*=2.40, *95% CI*=1.27-4.56, *p*=.007) and low-frequency users (*AOR*=1.86, *95% CI*=1.10, 3.14, *p*=.020), even after holding constant demographics, typical alcohol consumption, fraternity/sorority involvement, depressive symptoms, parental history of alcohol/drug problems, and childhood conduct problems. Low-frequency energy drink users did not differ from non-users on their risk for alcohol dependence.

Conclusions—Weekly or daily energy drink consumption is strongly associated with alcohol dependence. Further research is warranted to understand the possible mechanisms underlying this association. College students who frequently consume energy drinks represent an important target population for alcohol prevention.

Keywords

alcohol dependence; caffeine; college students; energy drinks

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Introduction

Energy drinks are beverages that contain high levels of caffeine—usually much more than a can of cola—ranging from 50 mg to 500 mg or more per can (Reissig et al., 2009). The surge of energy drink sales in recent years (Heckman et al., 2010) has raised concerns among public health professionals because of both the possibility of adverse effects from caffeine intoxication, in addition to the potential health effects of the high calorie content from sugars in most of these products (Clauson et al., 2008). Moreover, energy drink consumption appears to be associated with an escalation of alcohol-related problems in young adults, and college students in particular. These populations are known to have high rates of alcohol use disorders (Caldeira et al., 2009; Knight et al., 2002; Wu et al., 2007) and represent the principal target of marketing efforts by energy drink manufacturers (Heckman et al., 2010). Not surprisingly, recent studies of college student samples have documented that the past-month prevalence of energy drink use ranges from 39% to 57% (Malinauskas et al., 2007; Miller, 2008b; Oteri et al., 2007).

Several potential mechanisms are plausible to explain the link between energy drinks and excessive alcohol consumption and alcohol use disorders. First, caffeine administered immediately prior to bedtime or throughout the day has been shown to delay sleep onset, reduce total sleep time, alter the normal stages of sleep, and decrease the reported quality of sleep (Alford et al., 1996; Hindmarch et al., 2000; Snel, 1993). Thus, caffeine may prolong drinking episodes by delaying the onset of normal sleepiness resulting in an increase in overall alcohol intake. Second, caffeine's neuropharmacological and behavioral effects are mediated through antagonism of the neuromodulator adenosine (Fredholm et al., 1999) which has a direct role in mediating many neuropharmacological and behavioral effects of alcohol (Mailliard and Diamond, 2004; Sharma et al., 2010). Preclinical studies have shown that caffeine and other adenosine antagonists may increase alcohol self-administration (Arolfo et al., 2004; Gilbert, 1976; Kunin et al., 2000). Importantly, human studies have shown that caffeine reduces the subjective feeling of drunkenness without reducing actual alcohol-related impairment (Ferreira et al., 2006; Marczinski and Fillmore, 2006). For example, one study showed that ingestion of a caffeinated energy drink with vodka reduced participants' perception of impairment of motor coordination relative to ingestion of vodka alone, but did not significantly reduce objective measures of alcohol-induced impairment of motor coordination or reaction time (Ferreira et al., 2006). Thus, in addition to a possible direct effect of caffeine on alcohol reinforcement, it is plausible that caffeine could reduce the subjective feelings of being drunk and therefore lead to dose escalation, with the drinker consuming more alcohol than they otherwise might. Third, because high levels of caffeine during a drinking session might exacerbate the normal disinhibiting effects of alcohol, co-ingestion of alcohol and energy drinks could lead to engagement in risky behaviors and physically hazardous activity. A serious related concern is that the drinker's reduced awareness of his or her level of impairment might lead him or her to misjudge his or her ability to safely engage in behaviors such as driving, with the eventual result being increases in alcohol-related injuries and deaths. Fourth, co-ingestion of "hard liquor" and sweet energy drinks might make the taste of such a mixed drink more palatable, thereby increasing the amount consumed. In summary, for these reasons, it is highly plausible that energy drink users might be more likely to endorse a greater number of dependence items (e.g., drinking more than intended, spending a lot of time drinking or obtaining alcohol, developing tolerance and withdrawal) and alcohol abuse items (e.g., driving after drinking, putting onself in physical danger) and therefore have a higher likelihood of meeting DSM-IV criteria for alcohol use disorders than individuals who do not consume energy drinks. In many cases, energy drinks are consumed on the same day or mixed directly with alcohol (e.g., "Jaegerbombs" are made from Jaegermeister®,[1] and Red Bull®,[2]). In one large college student sample, 24% of alcohol-using students mixed energy drinks and alcohol in

the past month (O'Brien et al., 2008). Given the mechanisms stated above, the co-ingestion of alcohol with energy drinks might arguably be even more risky than consuming energy drinks and alcohol concurrently simply because of the time-related dissipation of caffeine effects.

Indeed, survey and epidemiological studies also support the notion that energy drink users are at increased risk for heavier drinking, alcohol problems, illicit and nonmedical prescription drug use, and other risky behaviors (Arria et al., 2010; Miller, 2008a; Miller, 2008b). Support for caffeine-induced increases in both alcohol consumption and risky behavior was recently demonstrated using event-level drinking data collected in the field from college-aged bar patrons (Thombs et al., 2010). In that study, relative to patrons who consumed only alcohol, patrons who consumed alcohol mixed with energy drinks attained higher blood alcohol concentrations during that drinking session and were more likely to intend to drive when leaving the bar. These results strongly suggest that combined alcohol-energy drink users might be more likely to meet criteria for alcohol dependence. However, it is also possible that the observed associations between energy drink use and heavy drinking could be explained by the fact that these two behaviors share common risk factors. Prior studies have identified two such potential confounding factors: sensation-seeking and fraternity/sorority involvement. Energy drink users have higher levels of sensation-seeking (Arria et al., 2010), which has long been recognized as an important risk factor for substance use problems in adolescents as part of a broader high-risk phenotype characterized by disinhibition and undercontrol (Tarter et al., 1999). Sensation-seeking has been linked to binge drinking (Carlson et al., 2010), alcohol-related injury (Mundt et al., 2009), and alcohol-impaired driving (Zakletskaia et al., 2009). Similarly, involvement in fraternities and sororities is a well-established risk factor for alcohol problems in college students (Baer, 2002; McCabe et al., 2005; Wechsler et al., 2000) and has recently been found to have strong associations with energy drink use (O'Brien et al., 2008).

Three other risk factors for alcohol problems have been identified, but have not been investigated as possible confounders in the energy drink-alcohol association; namely, family history of alcoholism, depression, and conduct disorder. First, family history of alcoholism is regarded as one of the most robust predictors of alcohol problems, as it conveys both genetic and environmental vulnerabilities to alcohol problems. In college students, family history of alcoholism has been found to be significantly associated with greater risk of alcohol consumption and dependence symptoms (Sher et al., 1991), as well as with acceleration and continuation of problematic drinking over time (Jackson et al., 2001). Second, depression is strongly associated with alcohol use disorder in the general adult population, with, for example, 32% of alcohol-dependent individuals experiencing a major depressive episode at some point in their lifetime, often with depression preceding the onset of alcohol problems (Kessler et al., 1996). Some researchers have even speculated that depression and alcoholism might be two “manifestations of the same underlying disorder,” in light of strong familial associations between them (Grant et al., 1996). Third, conduct disorder is strongly correlated with alcohol use disorder in the general population (Kessler et al., 1996). In adolescents, conduct disorder appears to be the most common comorbid psychiatric disorder with substance use problems and is heavily implicated in the development of alcohol use disorder in later adolescence (Armstrong and Costello, 2002).

This study aimed to advance the current understanding of the association between energy drinks and heavy drinking. First, we were interested in the possible dose-response relationship between energy drink consumption and heavy drinking. We did not have a

[1]Mast-Jägermeister AG, Wolfenbüttel, Germany
[2]Red Bull GmbH, Fuschl am See, Austria

measure of co-ingestion of energy drinks with alcohol *per se*; we believed high frequency users might be more likely to have occasions of co-ingestion. Second, we were interested in whether energy drink consumption is related not only to heavy drinking, but to alcohol-related problems, and in particular, alcohol dependence as defined by the DSM-IV (American Psychiatric Association, 1994). Lastly, we focused our analyses on the unique relationship, if any, of energy drink use with alcohol dependence over and above the five known risk factors described above, as well as level of alcohol and caffeine consumption. In summary, the study objectives were to: (1) describe the patterns of energy drink use in a sample of fourth-year college students, (2) explore the possible associations between frequency of energy drink use and demographic characteristics, other caffeine consumption, alcohol use patterns, and alcohol-related consequences; and (3) develop an explanatory model predicting alcohol dependence on the basis of energy drink use, demographic characteristics, other caffeine consumption, alcohol use patterns, and other suspected risk factors for alcohol problems. We hypothesize that students who use energy drinks frequently will be at greater risk for alcohol dependence, independent of other risk factors for alcohol dependence.

Materials and Methods

Design

Data were derived from the College Life Study, an ongoing longitudinal study of a cohort of 1,253 young adults. The sample was ascertained in two stages at one large, public university in the mid-Atlantic region. First, all incoming first-time, first-year students, ages 17 to 19, were invited to participate in a brief computer-based screening survey during new-student orientation in the summer of 2004. The resulting screened sample (n=3,401) represented 81.8% of all eligible incoming first-year students. Next, a subset of screened students were recruited to participate in the longitudinal study, with purposive over-sampling of students who had used an illicit drug (or nonmedically used prescription drugs) at least once prior to college. The second-stage response rate was 86.5% yielding a sample of 1,253 students who completed an assessment at some time during the 2004-05 academic year, corresponding to their first year of college. The assessment consisted of a two-hour face-to-face interview and self-administered questionnaires. Annually thereafter, these 1,253 participants were assessed with follow-up rates ranging from 87.6% to 91.1%. Participants received $5 for the initial screening survey and $50 for each of the baseline and follow-up assessments, plus an additional $20 bonus for on-time completion of follow-up assessments. The study was approved by the university's Institutional Review Board and a federal Certificate of Confidentiality was obtained.

Participants

The present analyses were conducted on 1,097 individuals who completed the Year 4 assessment (for 87.7%, this corresponded to their fourth year of college as they were still enrolled at the same university). The age range of the sample was 20 to 23 years. Almost half were male (46%) and a majority (73%) were White. Participants were similar demographically to the general population of students at the university (Arria et al., 2008). With respect to attrition bias, males were slightly but significantly underrepresented in the analysis sample (46%) relative to the original sample (49%, p<.001); no race differences in attrition were observed.

Measures

Energy drink use—At Year 4, participants were asked a series of questions about their use of energy drinks in the past 12 months. The format of the questions was based on input from key informants and modeled after standard methods used with other substances.

Interviewers asked, "In the past 12 months, what energy drinks have you consumed?" and recorded the brand names verbatim. To assist with recall, participants were shown a card with photos depicting several popular energy drinks. Participants who used at least one energy drink were then asked to estimate, for each different beverage, the number of days they consumed it in the past 12 months and the quantity they typically consumed. Responses were coded verbatim (e.g., number of cans). To correct for the variability in volume and caffeine content of different energy drinks, we later converted these responses into fluid ounces and milligrams of caffeine, using industry data for each different product (Center for Science in the Public Interest, 2007). An overall measure of past-year frequency of energy drink use was computed as the sum of the number of days each different energy drink was consumed. No information about same-day use of multiple types of energyh drinks was obtained; therefore, days on which multiple types might have been used would have been counted more than once. Because this approach might overestimate the actual number of days energy drinks were used in the past year (i.e., valid values greater than 365 were possible), results should be interpreted as the number of instances of energy drink use (rather than number of days).

Demographics—Sex was recorded as observed at baseline. Race was captured via self-report data at Year 3, and confirmed via administrative data from the university. Socioeconomic status was approximated from the mean adjusted gross income for participants' home ZIP code from publicly available Internal Revenue Service data from 2003, the last year in which participants were living with their parents.[3]

Caffeine consumption—At Year 4, participants were asked about their consumption of caffeine in the form of coffee, tea, and soft drinks. For each type of beverage, responses were given as the number of fluid ounces they consumed on a typical day during the past year. Responses were later summed to produce an overall measure of typical caffeine consumption from beverages other than energy drinks.

Alcohol use patterns—Several standard interview questions assessed alcohol use patterns, including age at first intoxication (dichotomized for analytic purposes as 15 or younger versus later than 15 or never). Frequency of alcohol use was derived from questions asking about the number of days they drank any alcohol during the past 12 months, and quantity was assessed from questions about the typical, maximum, and minimum number of drinks they consumed per day, for each day of the week (i.e., Monday through Sunday). These data were later consolidated to compute two mean scores representing the typical and maximum number of drinks per drinking day. Means were rounded up to the nearest integer, and non-drinkers were coded as zero.

DSM-IV criteria for alcohol use disorders—A series of questions were asked that were adapted from the National Survey on Drug Use and Health (Substance Abuse and Mental Health Services Administration, 2003) that corresponded to the DSM-IV criteria for alcohol abuse and dependence. Consistent with the DSM-IV-TR (American Psychiatric Association, 1994), dependence was defined by meeting three or more of the following seven criteria: tolerance, withdrawal symptoms, often drinking more than intended, inability to cut down, spending a lot of time drinking or obtaining alcohol, giving up important activities because of drinking, and continuing to drink despite physical or mental health problems. Abuse was defined as non-dependent individuals endorsing one or more of the following four problems caused by drinking: serious problems at home, work or school;

[3]Obtained from http://www.melissadata.com/lookups/taxzip.asp

repeated trouble with the law; continued drinking despite problems with friends or family; and repeatedly putting oneself in physical danger (including driving after drinking).

Other alcohol-related consequences—To assess the possibility of physical harm resulting from alcohol use, participants were asked how many times they had visited an emergency department because of their own alcohol use. Participants were also asked if they had experienced any personal injuries during the past year, without specifying alcohol as the cause.

Fraternity/sorority involvement—The level of involvement in fraternities and sororities during the past year was assessed with the following response options: "None," "Irregular: Occasional/some of the time," and "Regular: Most of the time/frequently/kept to a schedule." Because very few individuals endorsed the "irregular" response (<4% of the sample), responses of irregular and regular were collapsed to create a dichotomous variable representing any involvement versus none.

Depressive symptoms—The Beck Depression Inventory (BDI) was self-administered at baseline (Beck et al., 1979). This 21-item survey assesses cognitive, emotional, and physical symptoms of depression during the past few days. The scale had high internal consistency in the present sample (Cronbach's α=.85).

Conduct problems—Although a clinical diagnosis of conduct disorder was not made, a Conduct Disorder Screener was administered at baseline, which asks about 18 different conduct problems experienced prior to age 18 (e.g., setting fires, lying, stealing, using a weapon in a fight). It was scored following published procedures that take into account varying degrees of severity of each conduct problem (Johnson et al., 1995). Reliability of the computed index was satisfactory in the present sample (Cronbach's α=.74).

Impulsive sensation-seeking—The Zuckerman-Kuhlman Personality Questionnaire Short Form (Zuckerman, 2002) was self-administered at baseline, and the seven-item subscale for impulsive sensation-seeking (ImpSS) subscale was used in the analyses as measure of sensation-seeking. The items had satisfactory reliability in the present sample (Cronbach's α=.74).

Parental history of alcohol or drug problems—Substance use problems among parents of participants were assessed in Year 2 via a self-administered family tree questionnaire (Mann et al., 1985). The presence of a parental history was coded when the participant reported that either of their biological parents had a "definite" or "possible" alcohol or drug problem. Responses of "don't know/don't remember" were coded as missing.

Statistical Analyses

To statistically correct for our sampling design, we computed sampling weights within each race-sex-drug use cell, such that each cell in the longitudinal sample represents the corresponding number of screened students. Thus, over-sampled participants were weighted to represent relatively fewer students, whereas under-sampled participants represent a greater number of students, thereby enabling us to estimate the prevalence among the entire class (Arria et al., 2008). Descriptive statistics were tabulated for the entire sample with and without sampling weights to describe the prevalence and patterns of energy drink use. To account for the variability across different energy drink products, data on frequency, quantity, and caffeine intake were further analyzed among users of each of the most commonly used products.

To find a satisfactory cut-off value to distinguish "high-frequency" from "low-frequency" energy drink users, we conducted a series of logistic regression models on alcohol dependence with, in turn, the linear, quadratic, and logarithmic functions of the variable on frequency of energy drink use (i.e., number of days), holding constant demographics, typical number of alcohol drinks per day, and baseline scores for BDI and conduct problems. Results ruled out the quadratic function but supported the presence of a logarithmic function (p=.001), which was further confirmed by a moderately high correlation between the log-frequency variable and the predicted probabilities (r=.52). Next, by inspecting the normalized residuals in relation to the predicted probabilities, we identified 31 days as the cutpoint at which the pattern of variation from the regression line became substantial. Finally, to verify and refine this cutpoint, we replicated the logistic regression model with a series of new three-level variables representing high-frequency, low-frequency, and non-users, based on cutpoints of 31, 45, 52, and 61 days. While each version of the variable was significant in the model, results supported 52 days as the strongest cutpoint.

For the remaining analyses, the sample was restricted to the 975 individuals who had complete data on all variables of interest for the analyses. The cutpoint described above was used to divide the sample into three groups based on frequency of energy drink consumption: non-users (used 0 days in the past year; n=338), low-frequency users (used 1 to 51 times in the past year; n=518), and high-frequency users (used 52 or more times in the past year; n=119). We then tabulated descriptive statistics for the three groups with respect to demographic characteristics, caffeine consumption, alcohol use patterns, and alcohol-related consequences including DSM-IV criteria for alcohol use disorders. Statistically significant differences between the high-frequency and low-frequency users of energy drinks were evaluated using χ^2 tests of independence for categorical variables and analysis of variance for continuous variables.

Finally, a series of logistic regression analyses were performed to test our hypothesis that high-frequency energy drink use would be associated with greater risk for alcohol dependence, independent of other factors. Thus, in addition to the three-level variable on energy drink use (non-user, low-frequency, high-frequency), we included the following other explanatory variables: demographics (i.e., sex, race, socioeconomic status), caffeine consumption, alcohol use patterns (typical number of alcohol drinks per drinking day, age of first intoxication), and the suspected risk factors for alcohol dependence (i.e., fraternity/sorority involvement, depressive symptoms at baseline, childhood conduct problems, parental history of alcohol/drug problems, impulsive sensation-seeking). Bivariate associations were evaluated for each variable, and then all explanatory variables (except energy drink use) were entered simultaneously in the model. To obtain a more parsimonious model, we adopted a model selection process in which variables were retained only if they approached statistical significance (setting α=.10). Non-significant variables were dropped from the model and then re-entered one at a time. Once we derived our "best" model from this process, we entered the three-level energy drink use variable to determine whether it could account for any additional variance in alcohol dependence. The three demographic variables were retained in every model, regardless of their statistical significance.

Results

Figure 1 displays the prevalence and frequency of energy drink use in the sample. One-third (34.5%) did not consume energy drinks. About half (52.6%) were low-frequency energy drink users and 13.0% were high-frequency users. Statistically adjusting for our sampling design, the corresponding prevalence estimates were similar (38.6%$_{wt}$, 51.3%$_{wt}$, and 10.1%$_{wt}$, respectively). For descriptive purposes, if we assume that energy drink use patterns were evenly distributed throughout the year, it is possible to further subdivide the sample

into occasional (25.0%), monthly (27.6%), weekly (10.4%), and daily or almost daily users (2.6%). Among all 719 energy drink users, the average frequency was 35.2 times/year (*SD*=51.0), with individual values ranging from 1 to 370 (The reader is reminded that frequencies were reported without regard to whether multiple types of energy drinks were consumed on the same day).

As seen in Table 1, Red Bull®,[4] was the brand most commonly and frequently consumed (82.3% of users; mean 24.5 days/year). Typical caffeine consumption from Red Bull (mean 93.2 mg per drinking day) was considerably lower on average relative to other products. More than half (57.3%) of users drank more than one type of energy drink in the past year.

Differences between high-frequency and low-frequency energy drink consumption groups

The high- and low-frequency groups did not differ significantly with respect to demographic characteristics (See Table 2). Aside from energy drinks, the high-frequency group consumed more caffeinated beverages on average than the low-frequency group (25.79 vs. 19.49 ounces/day). Several significant differences were observed regarding alcohol use patterns and consequences. Specifically, individuals in the high-frequency group were more likely to have gotten drunk at an early age (59.7% vs. 38.4%), drank alcohol more frequently in the past year (141.6 vs. 103.1 days), drank more alcohol drinks per day on both a typical drinking day (6.15 vs. 4.64) and a "maximum" drinking day (9.99 vs. 7.29), and were more likely to meet criteria for alcohol dependence (26.9% vs. 11.6%, all *p*s<.001). Of all the other alcohol-related consequences, three were significantly more prevalent in the high-frequency group relative to the low-frequency group; namely blacking out (59.7% vs. 40.2%), missing class due to hangover (59.7% vs. 39.2%), and hangover-related limitations in usual activities (75.6% vs. 56.8%, all *p*s<.001). Finally, with respect to the five suspected risk factors for alcohol dependence, compared to the low-frequency group, individuals in the high-frequency group were more likely to have sorority/fraternity involvement (45.4% vs. 27.0%, *p*<.001), but were similar with respect to all the other risk factors.

Differences between high-frequency energy drink users and non-users

Several differences existed between the high-frequency group and non-users; namely the high-frequency group was significantly more male (60.5% vs. 29.6%), more involved in sororities/fraternities (45.4% vs. 18.3%), more heavily involved in alcohol in every way measured, and more likely to meet criteria for alcohol dependence (26.9% vs. 7.7%), drive after drinking (44.5% vs. 21.0%), and place themselves in physical danger while drunk (29.4% vs. 10.4%). They also consumed more other caffeinated beverages (25.79 vs. 16.55 ounces/day). Individuals in the high-frequency group were also more likely than non-users to black out, miss class due to hangover, report activity limitations and concentration problems due to hangovers, and experience personal injury. The overall proportion meeting criteria for alcohol abuse did not differ among these groups. With respect to the suspected risk factors for alcohol dependence, the high-frequency group scored significantly higher than non-users on both childhood conduct problems (7.95 vs. 5.54) and impulsive sensation-seeking (3.87 vs. 3.12).

Differences between low-frequency energy drink users and non-users

Not surprisingly, in most comparisons the low-frequency group generally occupied an intermediate position between the high-frequency and non-user groups, and were therefore significantly different from non-users on several (but not all) of the same variables as in the above comparison of high-frequency users with non-users. These differences are shown in

[4]Red Bull GmbH, Fuschl am See, Austria

Table 2. The only variable that was uniquely associated with low-frequency but not high-frequency energy drink consumption was meeting criteria for alcohol abuse, which was significantly more prevalent in the low-frequency group than non-users (40.3% vs. 25.4%).

Lastly, it is noteworthy that race, socioeconomic status, depressive symptoms, and parental history of alcohol/drug problems were not associated with energy drink consumption in any of the above comparisons. Several other variables with extremely low sample prevalence also showed no association (i.e., problems at home, work, or school; trouble with the law; continued drinking despite problems with family/friends; and emergency department visits).

Association between energy drink consumption and alcohol dependence

As is evident from Table 3, three of the five suspected risk factors were significantly associated with alcohol dependence at the bivariate level (i.e., fraternity/sorority involvement, childhood conduct problems, impulsive sensation-seeking), but caffeine consumption was not. After the model selection process described above, Model 2 was deemed the "best" model to explain the relationship between all possible explanatory variables (with the exception of energy drink consumption) and alcohol dependence. Finally, Model 3 resulted when energy drink consumption was added to Model 2. In Model 3, high-frequency users were more than twice as likely as non-users (*AOR*=2.40, *95% CI*=1.27-4.56, p=.007) and almost twice as likely as low-frequency users (*AOR*=1.86, *95% CI*=1.10, 3.14, p=.020) to meet criteria for alcohol dependence, after holding constant other suspected risk factors. Low-frequency energy drink consumption (relative to non-use) was not independently associated with alcohol dependence (p>0.3).

Discussion

In this study of fourth-year college students at one large public university, energy drinks were consumed by nearly two-thirds of students (61.4%$_{wt}$) at some time in the past year, and 10.1%$_{wt}$ consumed these drinks on a weekly or daily basis. These high-frequency energy drink users had significantly heavier alcohol involvement, including drinking more often, drinking more heavily on days they drank, and having greater risk for alcohol-related problems such as blackouts, hangover-related impairments, and meeting DSM-IV criteria for alcohol dependence. Furthermore, multivariate analyses revealed that high-frequency energy drink users were twice as likely as low-frequency users—and more than twice as likely as non-users—to meet criteria for alcohol dependence, independent of demographics, typical quantity of alcohol consumed, fraternity/sorority involvement, depressive symptoms, parental history of alcohol/drug problems, and childhood conduct problems.

The present findings support and extend prior evidence that energy drink users are at increased risk for substance use problems (Miller, 2008a). To our knowledge, this study contributes new information regarding the association between energy drink consumption and alcohol dependence, and results support the expected dose-response relationship between energy drink consumption and heavy drinking. Specifically, high-frequency energy drink users were at increased risk for alcohol dependence, independent of several other risk factors. While low frequency consumption was not independently associated with increased risk for alcohol dependence, low frequency users experienced several more alcohol-related problems than non-users.

While this study confirmed the observations of other investigators (Miller, 2008a; Miller, 2008b; O'Brien et al., 2008) that energy drink users are different from non-users in a number of respects (i.e., higher risk-taking tendencies and substance involvement), it appears that these characteristics do not fully explain the increased risk for alcohol-related problems. Our

multivariate analyses confirmed that high-frequency energy drink consumption confers a risk over and above that of these confounding risk factors for alcohol dependence.

However, because the study was cross-sectional, the possibility cannot be ruled out that heavy drinkers rely on energy drinks to help them function normally throughout the day, as a way of compensating for alcohol-related hangover effects. For example, a college student might use energy drinks to get through classes on the day after a drinking binge, and if chronic partying interferes with their study habits they might consume energy drinks to pull "all-nighters" before exams. Future research is needed to clarify the mechanisms by which energy drink consumption might be related to increased risk for alcohol-related problems. For example, whether energy drink use increases the reinforcing effects of alcohol or the disinhibition typically associated with alcohol remains to be seen. Unfortunately, experimental studies might be limited in the extent to which they can model the extremely high levels of alcohol consumption that occur in naturalistic settings. Moreover, it will be important to understand the variety of contexts in which energy drinks are consumed and the differential risks between simultaneous versus concurrent ingestion of alcohol and energy drinks.

The findings must be interpreted in light of several limitations. Self-report studies are always subject to response bias, and while we have no indication that over- or under-reporting has occurred, we cannot rule out this possibility. Second, our measure of caffeine consumption relies on secondary data, albeit from a source we regard as reliable, but we did not conduct our own testing to confirm the caffeine concentrations of different products. Third, although we did not explicitly ask whether or not participants were co-ingesting energy drinks with alcohol, prior research evidence (Malinauskas et al., 2007; O'Brien et al., 2008) as well as anecdotal evidence from our participants indicates that consuming mixed drinks containing both alcohol and energy drinks is quite common, especially among high-frequency consumers. Lastly, the study ascertained young adults from one large public university, and thus we cannot generalize the findings to other settings.

This study's strengths include a large sample size and the breadth of domains assessed in this study, which provides a rare opportunity to compare the statistical effect of energy drinks with that of several other important indicators of risk. In many ways college students are an ideal population in which to study the association of energy drinks and alcohol use, due to the popularity therein of both beverages and the high prevalence of alcohol-related problems. Moreover, this study demonstrates a new methodology for measuring energy drink consumption in a more fine-grained manner than prior studies. One unique contribution of this study is the use of an empirically-derived cutpoint characterizing a high-risk pattern of energy drink consumption, on the basis of risk for alcohol dependence. Interestingly, certain other alcohol-related consequences did not correlate as well with this definition of high-risk energy drink consumption, notably drunk driving and personal injury, raising the possibility that lower thresholds might better distinguish energy-drink consumption patterns that confer high risk for these consequences.

In this study we focused our analyses on alcohol dependence rather than alcohol use disorders and chose not to consider alcohol abuse as a main outcome. This decision was made in light of the body of evidence cited by the Substance Use Disorders Workgroup for the development of the DSM-5, which has concluded that the diagnostic distinction between abuse and dependence is questionable and recommends the transition to a single diagnosis of substance use disorder that would be graded according to levels of severity (American Psychiatric Association, 2010). Not surprisingly, in our sample, there is considerable overlap between individuals meeting criteria for abuse and dependence over time, for example, with 57.5% (data not presented in a table) of our alcohol dependence cases in Year 4 having

already met criteria for alcohol abuse in one of the three prior interviews. An examination of all four annual assessments revealed that 41.8% of abuse cases also met dependence criteria at some point. Therefore, we regard alcohol dependence as defined in the DSM-IV (American Psychiatric Association, 1994) as the more severe manifestation of alcohol use disorder and a more reliable indicator of serious alcohol problems in our sample.

The present findings have important implications for researchers, policymakers, and the general public. Researchers should be aware of the fact that many young adults consume alcohol in the context of energy drinks and should add questions about energy drink consumption to their assessment instruments. Given the mounting public health concern regarding how co-ingestion of energy drinks with alcohol might exacerbate aggressive and dangerous behaviors by creating a state of “wide-awake drunkenness” (Arria and O'Brien, 2009), more research is needed to understand the nature and extent of this problem.

The present finding that frequent consumption of energy drinks—but not other caffeinated beverages—contributes to increased risk for alcohol dependence adds more urgency for policymakers to adopt and enforce measures that would separate the consumption of these two beverages. If our findings are replicated, labeling of energy drink products that caution against mixing alcohol and energy drinks might be warranted, and vendors could be required to limit sales of energy drinks and cocktails made with them to patrons who are intoxicated.

It is troubling that there are no requirements for disclosing the caffeine content of energy drinks on the product label. We observed considerable variability in how much caffeine users are consuming from different energy drinks, and therefore find it plausible that, when consuming one of the more concentrated energy drinks, some users might be ingesting much more caffeine than they realize. Individuals who typically consume an energy drink with lower caffeine content might inadvertently ingest more caffeine than intended if under the incorrect assumption that they are “all the same.” We strongly encourage policymakers to require explicit labeling of energy drinks, so that consumers can have accurate information regarding caffeine content.

Lastly, with respect to the general public, parents and peers could play a valuable role in monitoring risk for alcohol related consequences among energy drink users. Parents should regard frequent energy drink consumption as a red flag for heavy drinking in their college-aged children, and discourage mixing alcohol and energy drinks. Young adults should be educated about the risks of this behavior and encouraged to exercise vigilance and intervene appropriately when they observe their peers consuming energy drinks in risky situations. For example, they should be educated to understand the difference between someone who is impaired but wide awake and someone who is safe to drive. This could be a natural extension of highly successful past campaigns that have made the concept of a “designated driver” second nature for many young adults.

Further study is certainly warranted to understand how patterns of co-ingestion of alcohol and energy drinks relate to the risk for serious alcohol problems. Strong evidence now exists supporting the notion that mixing energy drinks with alcohol leads to greater alcohol consumption and therefore more dangerous blood alcohol levels (Thombs et al., 2010). Moreover, in light of the commonalities between the characteristics of energy drink users and heavy drinkers, future studies should strive to account for multiple risk factors and any multicollinearity between them.

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References

Alford C, Bhatti J, Leigh T, Jamieson A, Hindmarch I. Caffeine-induced sleep disruption: Effects on waking the following day and its reversal with a hypnotic. Hum Psychopharmacol. 1996; 11(3): 185–198.

American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders: DSM-IV. 4th ed.. American Psychiatric Press; Washington, DC: 1994.

American Psychiatric Association. DSM-5 Development. 2010. http://www.dsm5.org/

Armstrong TD, Costello EJ. Community studies on adolescent substance use, abuse, or dependence and psychiatric comorbidity. J Consult Clin Psychol. 2002; 70(6):1224–1239. [PubMed: 12472299]

Arolfo M, Yao L, Gordon AS, Diamond I, Janak PH. Ethanol operant self-administration in rats is regulated by adenosine A2 receptors. Alcohol Clin Exp Res. 2004; 28(9):1308–1316. [PubMed: 15365300]

Arria AM, Caldeira KM, Kasperski SJ, O'Grady KE, Vincent KB, Griffiths RR, Wish ED. Increased alcohol consumption, nonmedical prescription drug use, and illicit drug use are associated with energy drink consumption among college students. J Addict Med. 2010; 4(2):74–80. [PubMed: 20729975]

Arria AM, Caldeira KM, O'Grady KE, Vincent KB, Fitzelle DB, Johnson EP, Wish ED. Drug exposure opportunities and use patterns among college students: Results of a longitudinal prospective cohort study. Subst Abus. 2008; 29(4):19–38. [PubMed: 19042196]

ArriaAMO'BrienMC2009Available at: http://www.fda.gov/downloads/Food/FoodIngredientsPackaging/UCM190372.pdf.April 1, 2010 Letter to Attorneys General Blumenthal, Shurtleff, and Limtiaco RE: The use of caffeine in alcoholic beverages

Baer JS. Student factors: Understanding individual variation in college drinking. J Stud Alcohol Suppl. 2002; 14:40–53. [PubMed: 12022729]

Beck, AT.; Rush, AJ.; Shaw, BF.; Emery, G. Cognitive therapy of depression. The Guilford Press; New York: 1979.

Caldeira KM, Kasperski SJ, Sharma E, Vincent KB, O'Grady KE, Wish ED, Arria AM. College students rarely seek help despite serious substance use problems. J Subst Abuse Treat. 2009; 37(4):368–378. [PubMed: 19553064]

Carlson SR, Johnson SC, Jacobs P,C. Disinhibited characteristics and binge drinking among university student drinkers. Addict Behav. 2010; 35(3):242–251. [PubMed: 19926401]

Center for Science in the Public Interest. Caffeine content of food and drugs. 2007. http://www.cspinet.org/new/cafchart.htm

Clauson KA, Shields KM, McQueen CE, Persad N. Safety issues associated with commercially available energy drinks. J Am Pharm Assoc. 2008; 48(3):e55–e63.

Ferreira SE, de Mello MT, Pompeia S, de Souza-Formigoni ML. Effects of energy drink ingestion on alcohol intoxication. Alcohol Clin Exp Res. 2006; 30(4):598–605. [PubMed: 16573577]

Fredholm BB, Battig K, Holmen J, Nehlig A, Zvartau EE. Actions of caffeine in the brain with special reference to factors that contribute to its widespread use. Pharmacol Rev. 1999; 51(1):83–133. [PubMed: 10049999]

Gilbert RM. Dietary caffeine and alcohol consumption by rats. J Stud Alcohol. 1976; 37(1):11–18. [PubMed: 2809]

Grant BF, Hasin DS, Dawson DA. The relationship between DSM-IV alcohol use disorders and DSM-IV major depression: Examination of the primary-secondary distinction in a general population sample. J Affect Disord. 1996; 36:113–128. [PubMed: 8791180]

Heckman MA, Sherry K, Gonzalez de Mejia E. Energy drinks: An assessment of their market size, consumer demographics, ingredient profile, functionality, and regulations in the United States. Compr Rev Food Sci Food Saf. 2010; 9:303–317.

Hindmarch I, Rigney U, Stanley N, Quinlan P, Rycroft J, Lane J. A naturalistic investigation of the effects of day-long consumption of tea, coffee and water on alertness, sleep onset and sleep quality. Psychopharmacology. 2000; 149(3):203–216. [PubMed: 10823400]

Jackson KM, Sher KJ, Gotham HJ, Wood PK. Transitioning into and out of large-effect drinking in young adulthood. J Abnorm Psychol. 2001; 110(3):378–391. [PubMed: 11502081]

Johnson EO, Arria AM, Borges G, Ialongo N. The growth of conduct problem behaviors from middle childhood to early adolescence: Sex differences and the suspected influence of early alcohol use. J Stud Alcohol. 1995; 56(6):661–671. [PubMed: 8558898]

Kessler RC, Nelson CB, McGonagle KA, Edlund MJ, Frank RG, Leaf PJ. The epidemiology of co-occurring addictive and mental disorders: Implications for prevention and service utilization. Am J Orthopsychiatry. 1996; 66(1):17–31. [PubMed: 8720638]

Knight JR, Wechsler H, Meichun K, Seibring M, Weitzman ER, Schuckit MA. Alcohol abuse and dependence among U.S. college students. J Stud Alcohol. 2002; 63(3):263–270. [PubMed: 12086126]

Kunin D, Gaskin S, Rogan F, Smith B, Amit Z. Caffeine promotes ethanol drinking in rats: Examination using a limited-access free choice paradigm. Alcohol. 2000; 21(3):271–277. [PubMed: 11091031]

Mailliard WS, Diamond I. Recent advances in the neurobiology of alcoholism: The role of adenosine. Pharmacol Ther. 2004; 101(1):39–46. [PubMed: 14729391]

Malinauskas BM, Aeby VG, Overton RF, Carpenter-Aeby T, Barber-Heidal K. A survey of energy drink consumption patterns among college students. Nutr J. 2007; 6:35–41. [PubMed: 17974021]

Mann RE, Sobell LC, Sobell MB, Pavan D. Reliability of a family tree questionnaire for assessing family history of alcohol problems. Drug Alcohol Depend. 1985; 15(1-2):61–67. [PubMed: 4017879]

Marczinski CA, Fillmore MT. Clubgoers and their trendy cocktails: Implications of mixing caffeine into alcohol on information processing and subjective reports of intoxication. Exp Clin Psychopharmacol. 2006; 14(4):450–458. [PubMed: 17115872]

McCabe SE, Schulenberg JE, Johnston LD, O'Malley PM, Bachman JG, Kloska DD. Selection and socialization effects of fraternities and sororities on US college student substance use: A multi-cohort national longitudinal study. Addiction. 2005; 100(4):512–524. [PubMed: 15784066]

Miller KE. Energy drinks, race, and problem behaviors among college students. J Adolesc Health. 2008a; 43(5):490–497. [PubMed: 18848678]

Miller KE. Wired: Energy drinks, jock identity, masculine norms, and risk taking. J Am Coll Health. 2008b; 56(5):481–490. [PubMed: 18400659]

Mundt MP, Zakletskaia LI, Fleming MF. Extreme college drinking and alcohol-related injury risk. Alcohol Clin Exp Res. 2009; 33(1):1532–1538. [PubMed: 19485974]

O'Brien MC, McCoy TP, Rhodes SD, Wagoner A, Wolfson M. Caffeinated cocktails: Energy drink consumption, high-risk drinking, and alcohol- related consequences among college students. Acad Emerg Med. 2008; 15(5):453–460. [PubMed: 18439201]

Oteri A, Salvo F, Caputi AP, Calapai G. Intake of energy drinks in association with alcoholic beverages in a cohort of students of the school of medicine of the University of Messina. Alcohol Clin Exp Res. 2007; 31(10):1677–1680. [PubMed: 17651468]

Reissig CJ, Strain EC, Griffiths RR. Caffeinated energy drinks—A growing problem. Drug Alcohol Depend. 2009; 99(1-3):1–10. [PubMed: 18809264]

Sharma R, Engemann SC, Sahota P, Thakkar MM. Effects of ethanol on extracellular levels of adenosine in the basal forebrain: An in vivo microdialysis study in freely behaving rats. Alcohol Clin Exp Res. 2010; 34(5):813–818. [PubMed: 20184564]

Sher KJ, Walitzer KS, Wood PK, Brent EE. Characteristics of children of alcoholics: Putative risk factors, substance use and abuse, and psychopathology. J Abnorm Psychol. 1991; 100(4):427–448. [PubMed: 1757657]

Snel, J. Coffee and caffeine: sleep and wakefulness. In: Garattini, S., editor. Caffeine, coffee, and health. Raven Press; New York: 1993. p. 255-290.

Substance Abuse and Mental Health Services Administration. 2002 National Survey on Drug Use and Health Questionnaire. 2003. http://www.drugabusestatistics.samhsa.gov/nhsda/2k2MRB/2k2CAISpecs.pdf

Tarter R, Vanyukov M, Giancola P, Dawes M, Blackson T, Mezzich A, Clark DB. Etiology of early age onset substance use disorder: A maturational perspective. Dev Psychopathol. 1999; 11(4):657–683. [PubMed: 10624720]

Thombs DL, O'Mara RJ, Tsukamoto M, Rossheim ME, Weiler RM, Merves ML, Goldberger BA. Event-level analyses of energy drink consumption and alcohol intoxication in bar patrons. Addict Behav. 2010; 35:325–330. [PubMed: 19954894]

Wechsler H, Lee JE, Kuo M, Lee H. College binge drinking in the 1990s: A continuing problem: Results of the Harvard School of Public Health 1999 College Alcohol Study. J Am Coll Health. 2000; 48(5):199–210. [PubMed: 10778020]

Wu L, Pilowsky DJ, Schlenger WE, Hasin D. Alcohol use disorders and the use of treatment services among college-age young adults. Psychiatric Services. 2007; 58(2):192–200. [PubMed: 17287375]

Zakletskaia LI, Mundt MP, Balousek SL, Wilson EL, Fleming MF. Alcohol-impaired driving behavior and sensation-seeking disposition in a college population receiving routine care at campus health services centers. Accid Anal Prev. 2009; 41(3):380–386. [PubMed: 19393782]

Zuckerman, M. Zuckerman-Kuhlman Personality Questionnaire (ZKPQ): An alternative five-factorial model. In: de Raad, B.; Perugini, M., editors. Big Five Assessment. Hogrefe & Huber; Seattle: 2002. p. 377-396.

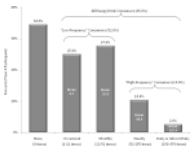

Figure 1.
Frequency of energy drink consumption in the past 12 months, among 1,097 fourth-year college students

Table 1

Patterns of energy drink consumption and caffeine intake, by brand of energy drink, among 719 past-year energy drink users.

	Product information			Summary of Participant Responses			
Brand Name	**Volume (oz)**	**Caffeine content (mg/can)[a]**	**Caffeine concentration (mg/oz)**	**Number (%) who consumed this beverage ≥1 time in past 12 months[b]**	**Mean number of days beverage was consumed**	**Typical quantity consumed per drinking day (oz)[c]**	**Typical caffeine consumption from this beverage per drinking day (mg)**
Red Bull®,[d]	8.3	80	9.64	592 (82.3%)	24.50	9.67	93.19
Monster®,[e]	16	160	10.00	242 (33.7%)	11.94	21.53	215.33
Amp®,[f]	8.4	74	8.81	157 (21.8%)	9.68	9.73	85.74
Rockstar®,[g]	8	80	10.00	132 (18.4%)	17.15	15.31	153.13
SoBe Essential Energy®,[h]	8	83	10.38	84 (11.7%)	18.79	19.05	197.67
Other	n/a	n/a	--	138 (19.2%)	16.28	11.80	--

[a] Data on caffeine content were obtained as mg/can from the Center for Science in the Public Interest (http://www.cspinet.org/new/cafchart.htm) and used to compute mg/oz.

[b] Numbers do not sum to 719 (100%) because multiple responses were allowed.

[c] Typical quantity consumed was missing for one user of Red Bull and three users of "other" energy drinks. Caffeine concentration per ounce and typical caffeine consumption were not computed since "other" is composed of several different types of energy drinks.

[d] Red Bull GmbH, Fuschl am See, Austria

[e] Hansen Natural Corporation, Corona, California

[f] PepsiCo, Purchase, New York

[g] Rockstar, Inc., Las Vegas, Nevada

[h] PepsiCo, Purchase, New York

Table 2

Sample characteristics and comparisons between non-users of energy drinks, low-frequency users, and high-frequency users with respect to demographics, other caffeine consumption, alcohol drinking patterns, alcohol-related consequences, and suspected risk factors for alcohol-related problems.

	Total Sample[d] (*n*=975) % or *Mean (SD)*	**High-Frequency Energy Drink Users (*n*=119) % or *Mean (SD)***	**Low-Frequency Energy Drink Users (*n*=518) % or *Mean (SD)***	**Non-Users of Energy Drinks (*n*=338) % or *Mean (SD)***	***Sig.***
Demographic Characteristics					
Male[b,c]	46.1%	60.5%	53.5%	29.6%	***
White	74.2%	77.3%	75.7%	70.7%	
Socioeconomic status[e]	7.36 (3.36)	7.60 (3.44)	7.33 (3.37)	7.33 (3.32)	
Caffeine Consumption (typical number of ounces/day)[a,b,c]	19.24 (14.82)	25.79 (15.66)	19.49 (14.59)	16.55 (14.15)	***
Alcohol Use Patterns					
Age 15 or younger at first alcohol intoxication[a,b,c]	36.4%	59.7%	38.4%	25.1%	***
Drinking frequency in past year (number of days)[a,b,c]	97.5 (71.6)	141.6 (70.8)	103.1 (69.2)	73.5 (66.3)	***
Typical number of drinks/drinking day[a,b,c]	4.30 (3.02)	6.15 (3.12)	4.64 (2.92)	3.13 (2.68)	***
Maximum number of drinks/drinking day[a,b,c]	6.86 (4.38)	9.99 (5.48)	7.29 (4.03)	5.09 (3.63)	***
DSM-IV Criteria for Alcohol Use Disorders					
Alcohol dependence[a,b]	12.1%	26.9%	11.6%	7.7%	***
Individual criteria for alcohol dependence					
Tolerance[b,c]	24.7%	35.3%	26.1%	18.9%	**
Withdrawal[b]	2.6%	6.7%	2.5%	1.2%	**
Drank more than intended[a,b]	9.1%	21.0%	8.9%	5.3%	***
Unable to cut down[a,b]	9.8%	16.8%	9.3%	8.3%	*
Spent a lot of time drinking or obtaining alcohol[a,b,c]	33.6%	50.4%	36.1%	24.0%	***
Gave up important activities[b]	9.3%	14.3%	10.4%	5.9%	*
Continued drinking despite health problems[b]	11.7%	19.5%	12.0%	8.6%	**
Alcohol abuse[c]	34.7%	36.1%	40.3%	25.4%	***
Individual criteria for alcohol abuse					
Serious problems at home, work, or school	2.4%	4.2%	2.1%	2.1%	

	Total Sample[d] (*n*=975) % or *Mean (SD)*	High-Frequency Energy Drink Users (*n*=119) % or *Mean (SD)*	Low-Frequency Energy Drink Users (*n*=518) % or *Mean (SD)*	Non-Users of Energy Drinks (*n*=338) % or *Mean (SD)*	*Sig.*
Repeatedly in trouble with the law	0.8%	0.0%	1.2%	0.6%	
Continued drinking despite problems with family/friends	5.4%	7.6%	5.6%	4.4%	
Drove after drinking (sometimes or regularly)[b,c]	32.6%	44.5%	37.5%	21.0%	***
Put self in physical danger while drunk (sometimes or regularly)[b,c]	17.5%	29.4%	19.5%	10.4%	***
Other consequences					
ER visit due to alcohol use	1.2%	3.4%	1.0%	0.9%	
Personal injury (any cause)[b]	19.0%	24.6%	20.6%	14.7%	*
Blacked out from drinking alcohol[a,b,c]	37.7%	59.7%	40.2%	26.3%	***
Missed class due to alcohol hangover[a,b,c]	35.8%	59.7%	39.2%	22.2%	***
Concentration problems due to alcohol hangover[b,c]	46.4%	60.5%	50.8%	34.6%	***
Usual activities were limited due to alcohol hangover[a,b,c]	51.9%	75.6%	56.8%	36.1%	***
Suspected risk factors for alcohol-related problems					
Fraternity/Sorority involvement (Year 4)[a,b,c]	26.3%	45.4%	27.0%	18.3%	***
Beck Depression Inventory (Year 1)	5.29 (5.05)	5.30 (4.40)	5.11 (4.64)	5.56 (5.81)	
Conduct problems[b,c]	6.55 (4.70)	7.95 (4.88)	6.88 (4.67)	5.54 (4.49)	***
Parental history of alcohol/drug problems	24.5%	27.7%	23.0%	25.7%	
Impulsive sensation-seeking[b,c]	3.51 (2.16)	3.87 (2.12)	3.68 (2.12)	3.12 (2.2)	***

Statistical significance of overall Chi-square tests (for categorical variables) and ANOVA (for continuous variables) is denoted as follows:

* $p<.05$

** $p<.01$

*** $p<.001$.

[a] Denotes significant difference between high-frequency and low-frequency groups.

[b] Denotes significant difference between high-frequency and non-user groups.

[c] Denotes significant difference between low-frequency and non-user groups.

[d] Results are presented for 975 individuals with non-missing data, with the following exceptions: 2 cases missing "continued drinking despite health problems," 1 case missing "continued drinking despite problems with friends/family," and 9 cases missing "personal injury."

[e]Socioeconomic status was approximated from the mean adjusted gross income for participants' home ZIP code from publicly available IRS data from 2003, the last year in which participants were living with their parents.

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Table 3

Results of logistic regression on alcohol dependence (*n*=975).

	Bivariate Results		Model 1		Model 2		Model 3	
	OR (95% CI)	*p*	*AOR (95% CI)*	*p*	*AOR (95% CI)*	*p*	*AOR (95% CI)*	*p*
Demographics								
Sex = Male	1.15 (.78, 1.69)	.471	.57 (.35, .93)	.024	.55 (.34, .89)	.015	.51 (.31, .83)	.007
Race = White	1.08 (.69, 1.69)	.737	.57 (.35, .95)	.030	.60 (.37, .99)	.045	.61 (.37, 1.01)	.053
Socioeconomic status[a]	1.06 (1.01, 1.11)	.022	1.05 (.99, 1.11)	.097	1.05 (1.00, 1.11)	.071	1.05 (1.00, 1.11)	.067
Caffeine Consumption	1.01 (1.00, 1.02)	.192	1.00 (.99, 1.02)	.707				
Alcohol Use Patterns								
Typical number of drinks/drinking day	1.26 (1.19, 1.35)	<.001	1.30 (1.20, 1.41)	<.001	1.31 (1.22, 1.42)	<.001	1.29 (1.19, 1.39)	<.001
Age 15 or younger at first alcohol intoxication	2.22 (1.50, 3.27)	<.001	.25 (.83, 2.05)	.248				
Suspected risk factors for alcohol-related problems								
Fraternity/Sorority involvement (Year 4)	2.14 (1.44, 3.19)	<.001	1.69 (1.10, 2.61)	.018	1.71 (1.11, 2.63)	.016	1.56 (1.00, 2.43)	.048
Beck Depression Inventory (Year 1)	1.03 (1.00, 1.07)	.071	1.04 (1.00, 1.08)	.072	1.04 (1.00, 1.08)	.072	1.04 (1.00, 1.08)	.073
Conduct problems	1.08 (1.04, 1.13)	<.001	1.07 (1.02, 1.12)	.006	1.07 (1.02, 1.12)	.002	1.07 (1.02, 1.12)	.003
Parental history of alcohol/drug problems	1.41 (.93, 2.16)	.108	1.68 (1.05, 2.68)	.029	1.68 (1.05, 2.66)	.029	1.62 (1.01, 2.58)	.044
Impulsive sensation-seeking	1.12 (1.02, 1.22)	.017	1.00 (.90, 1.10)	.908				
Energy Drink Consumption (Year 4)								
High Frequency vs. None	4.41 (2.50, 7.80)	<.001					2.40 (1.27, 4.56)	.007
High Frequency vs. Low Frequency	2.81 (1.73, 4.57)	<.001					1.86 (1.10, 3.14)	.020
Low Frequency vs. None	1.57 (.97, 2.55)	.066					1.29 (.76, 2.19)	.328
Nagelkerke R Square	n/a		.18		.18		.19	

[a]Socioeconomic status was approximated from the mean adjusted gross income for participants' home ZIP code from publicly available IRS data from 2003, the last year in which participants were living with their parents.