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Trajectories of energy drink consumption and subsequent drug use during young adulthood



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ABSTRACT

Background: Highly caffeinated energy drinks (EDs) are popular with adolescents and young adults, but longitudinal consumption patterns are poorly understood especially in relation to other substance use.

Methods: ED and other substance use were assessed annually (modal ages 21–25) among a sample ($n = 1099$) who were originally recruited as first-year college students (modal age 18). Trajectory groups were derived based on probability of past-year use during ages 21–24, and compared for possible differences in substance use outcomes at age 25, holding constant demographics, sensation-seeking, other caffeine consumption, and age 21 substance use.

Results: From age 21–25, ED consumption declined in both annual prevalence [62.5%_{wt} to 49.1%_{wt} (_{wt} = weighted)] and frequency of use among consumers (35.2–26.3 days/year). Yet individuals exhibiting a Persistent trajectory (51.4%) of consumption outnumbered those with Non-Use (20.6%), Intermediate (17.4%), or Desisting (10.6%) trajectories. Age 25 cocaine use, nonmedical use of prescription stimulants (NPS), and alcohol use disorder (AUD) risk were significantly associated with trajectory group membership, with Persistent and Intermediate groups exhibiting the highest risk for such outcomes, even accounting for prior substance use and other risk factors. Neither marijuana nor tobacco use were associated with group membership.

Conclusions: The typical pattern of ED consumption among this sample was sustained use throughout young adulthood. Such individuals appear to be at high risk for adverse substance use outcomes, and results suggest possible specificity regarding cocaine use and NPS, and AUD risk. More research is needed to understand the mechanisms underlying the connection between ED and substance use.

1. Introduction

Energy drinks (EDs) and shots are highly caffeinated products marketed primarily to adolescents and young adults (Heckman et al., 2010; Reissig et al., 2009). Although caffeine is the most commonly used drug in the world (Juliano et al., 2009), the introduction of EDs to the marketplace—and the rapid growth in their popularity—have taken caffeine use in a new direction (Branum et al., 2014; Packaged Facts, 2013). EDs differ from traditional caffeinated beverages by typically containing higher doses and concentrations of added caffeine in the form of sweet, flavored beverages or shots designed to be ingested quickly (Juliano et al., 2009; Reissig et al., 2009; Seifert et al., 2011). Marketed primarily to youth (Heckman et al., 2010), some branding is related to risky behaviors (e.g., Rehab, Full Throttle, AMP Energy) and

their consumption has become intertwined with high-risk alcohol use (Arria et al., 2010; Arria et al., 2011a; O'Brien et al., 2013; O'Brien et al., 2008; Reissig et al., 2009).

Approximately one in three U.S. adolescents and young adults consume EDs and energy shots, with estimates as high as 50% for past-month use among college students (Arria et al., 2014; Miller, 2008b; Terry-McElrath et al., 2014; Velazquez et al., 2012; Woolsey et al., 2015). One study reported that 10% of college students consumed EDs at least weekly during the past year (Arria et al., 2011a). While White males are at highest risk for ED consumption among college students (Poulos and Pasch, 2015), other minority groups appear to be at risk among community samples (Arria et al., 2014; Berger et al., 2011).

Because of the high caffeine levels contained in most of these products, at least two major health concerns have been raised. First, acute

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cardiovascular effects have been discussed (Seifert et al., 2011); in particular, increased blood pressure (Franks et al., 2012; Phan and Shah, 2014; Shah et al., 2016), arrhythmias (Goldfarb et al., 2014), and increased platelet aggregation (Worthley et al., 2010) have been reported clinically. The second concern—and the focus of this paper—is the possible longer-term consequences of consuming highly caffeinated EDs, namely the increased potential for substance use and related problems. Significant cross-sectional associations between ED consumption and substance use (e.g., alcohol, tobacco, marijuana, non-medical use of prescription drugs) have been reported (Arria et al., 2011a; Miller, 2008a; Skewes et al., 2013; Terry-McElrath et al., 2014; Trapp et al., 2014; Woolsey et al., 2014). Research has focused on the interrelationships between ED consumption and high-risk drinking, as well as the consequences thereof. Almost one-quarter of college students have mixed an ED with alcohol (O'Brien et al., 2008), and cross-sectional evidence links this behavior to increased risk for alcohol-related problems such as alcohol dose escalation and heavy drinking patterns, subjective increases in alcohol desires and expectancies, injuries, and sexual consequences (Arria et al., 2010; Ferré and O'Brien, 2011; Ferreira et al., 2013; Mallett et al., 2014; Marcinski et al., 2013; Miller, 2012; O'Brien et al., 2013; , 2008). We previously reported that ED consumption is associated with an increased risk for alcohol dependence and more frequent drunk driving, even after adjustment for family history, conduct disorder, other caffeine consumption, and sensation-seeking (Arria et al., 2016b; Arria et al., 2011a).

Other research has observed a relationship between EDs and illicit substance use. From two waves of data from the study that is the focus of the present analysis, college students who consumed EDs were twice as likely to initiate nonmedical prescription stimulant use one year later compared with students who did not consume EDs, controlling for risk factors and other caffeine consumption (Arria et al., 2010). Other studies have also observed cross-sectional associations between ED consumption and other drug use (Kelly and Prichard, 2016; Kumar et al., 2015; Miller, 2008a; Miller and Quigley, 2011; Terry-McElrath et al., 2014; Trapp et al., 2014; Woolsey et al., 2014; Woolsey et al., 2015). At least three potential mechanisms exist to explain the association. First, ED consumers and individuals who use illicit substances might share a propensity for risk-taking. Problem behavior theory [PBT (Donovan and Jessor, 1985; Jessor, 1987)] would predict that ED consumers engage in substance use because they share many of the same characteristics as individuals with heavy substance use involvement [e.g., sensation-seeking, conduct problems (Kristjansson et al., 2013)]. Such commonalities point to a “third factor” hypothesis to explain the association between ED consumption and substance use.

Second, opportunities to be exposed to both EDs and other substances might overlap with each other. The social development model (Catalano and Hawkins, 1996) informs our understanding of the complex interplay of risk factors that might lead to high-risk substance use—and perhaps ED consumption—in that personal vulnerability to developing a substance use disorder (SUD) operates in the context of environmentally-driven opportunities to use a substance. ED consumption might increase an individual's interest in using illicit drugs (Reissig et al., 2009). If ED consumers are drawn to affiliate with each other, such a peer network might provide increased opportunities for and more accepting attitudes toward substance use.

Third, neurobiological evidence supports the possibility that frequent ED consumption might contribute to an increased risk for SUD due to caffeine's ability to potentiate the addictive properties of other substances (Ferré, 2016). Laboratory studies have shown that caffeine enhances nicotine's reinforcing and analgesic effects and potentiates the addictive properties of other stimulant drugs (Jones and Griffiths, 2003; O'Neill et al., 2015; Sigmon and Griffiths, 2011; Tanda and Goldberg, 2000). Furthermore, the rapid-onset stimulant effects of EDs—especially among younger consumers who have not yet developed tolerance to caffeine—might provoke some consumers to seek out similar or even more intense effects via other drugs (Reissig et al., 2009). Some have

argued that the high doses of caffeine in EDs might accelerate the development of caffeine dependence, which in turn could predict other SUDs (Meredith et al., 2013). If ED consumption contributes independently to intensification of substance use patterns, after accounting for shared risk factors, then prevention efforts could be targeted at ED consumption as a novel risk factor for substance use.

The purpose of this study is fourfold: (1) to describe the prevalence and frequency of ED consumption among a young adult sample throughout a five-year interval (ages 21–25); (2) to identify subsets of individuals who consume EDs with distinct trajectories of such use during the first four years of that interval (ages 21–24); (3) to describe the pattern of ED consumption within each trajectory group; and (4) to examine the relationship between ED trajectory group membership and subsequent alcohol use disorder (AUD) risk and other substance use at age 25, after accounting for variables that reflect the known shared propensity for risk-taking among individuals who consume EDs and individuals who use other substances. By taking these risk factors into account, we will be able to isolate the unique effect, if any, of trajectories of ED use on substance use, even in the context of the commonalities in their respective risk factors. This approach allows for simultaneous evaluation of two competing hypotheses that are both empirically and theoretically grounded: (1) a “third factor” hypothesis derived from PBT, and (2) a possible contributory relationship operating through neurobiological mechanisms. This component of the model reflects our hypothesis that EDs uniquely contribute to risk for AUD and other substance use.

2. Methods

2.1. Study design

Participants were enrolled in an ongoing longitudinal study that began at college entry in 2004 at one large public university (see Arria et al., 2008; Vincent et al., 2012). Recruitment occurred in two stages, beginning with a pre-college survey during summer orientation ($N = 3401$; 89% response rate), followed by a two-hour baseline assessment with a sample of screened students ($n = 1253$; 87% response rate). To ensure adequate statistical power for analyzing longitudinal drug use patterns, students who used illicit substances or prescription medications nonmedically at least once during high school were purposively oversampled with 100% probability, and all others with 40% probability. At baseline, participation was restricted to first-time college students ages 17–19. Data for the present analysis were collected during Years 4 through 8 of the study (76%–88% follow-up rates annually), and therefore encompass college graduation and the first few post-college years for most of the sample, although continued college attendance and graduation were not requirements for participation. The study was approved by the university's IRB, and written informed consent was obtained. Further protection was provided by a federal Certificate of Confidentiality. Participants were paid for each assessment.

2.2. Participants

For the present study, the analysis sample was 1099 individuals (54% women, 72% non-Hispanic White) who completed at least one of the annual assessments in which ED consumption patterns were assessed, that is Years 4 through 8, when modal ages were 21 through 25, respectively. Relative to the analysis sample, excluded individuals were over-representative of men (66% vs. 46%, $p < 0.001$) and slightly older at college entry (18.3 vs. 18.2 years, $p = 0.002$), but were similar with respect to race/ethnicity, parents' education, and prior ED consumption assessed during Years 2 and 3.

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