



Age of first use of energy beverages predicts future maximal consumption among naval pilot and flight officer candidates



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ARTICLE INFO

Article history:

Received 27 August 2015

Received in revised form 2 December 2015

Accepted 2 December 2015

Available online 4 December 2015

Keywords:

Energy drinks

Age of first use

Military

ABSTRACT

Background: Energy drinks are popular beverages that can have adverse long-term health effects when consumed by children and adolescents. This study sought to determine if the age of first energy drink use in a U.S. military population is predictive of the maximum number of energy drinks consumed during a single day and/or single occasion (operationally defined as a couple of hours; e.g., a night out, during studying or sport session).

Method: Student U.S. naval aviator and naval flight officers who reported past-year use of energy drinks ($N = 239$) were surveyed to determine various measures of energy drink consumption.

Results: Age of first consumption was predictive of the maximum number of energy drinks consumed during a single occasion within the past year. Within this sample, the age range between 13 and 16 years appeared to be a critical period with results indicating that people who began consuming energy drinks during this period were 4.88 times more likely to consume high quantities (four or more) of energy drinks during a single occasion when compared to those who started consuming energy drinks between the ages of 20–23. Likewise, persons who began to consume energy drinks between the ages of 13–16 are 2.48 times more likely to consume high quantities of energy drinks during a single occasion than those who started between the ages of 17–19. There was no difference between 17 and 19 year olds and 20–23 year olds. Age of first use was not correlated to daily average intake or daily maximal intake of energy drinks.

Conclusions: A lower age of first energy drink use suggests higher risk of single-occasion heavy episodic consumption in this military population. Researchers should further explore the relationship of early onset energy drink consumption and potential future health risks.

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1. Introduction

Energy drinks have become quite popular with adolescents and young adults. Among youths ages 12–17, the 2011 YouthStyles survey found that 8.5% of respondents reported consuming energy drinks on a weekly basis (Kumar et al., 2014). Results from the Monitoring the Future study found that among the 22,000 U.S. secondary school students surveyed, 30% reported using energy drinks (Terry-McElrath et al., 2014). Azagba et al. (2014) found that 62% of their surveyed respondents reported using energy drinks at least once in the last year, with approximately 20% stating that they used energy drinks once or more in the past month.

While consumption frequency is concerning, another concern is the quantity consumed during a single occasion. Given that energy drinks

are served cold, are sweet, and come enhanced with high levels of caffeine, energy drinks may pose a serious risk to consumers who drink these beverages akin to other soft drinks. Consuming multiple energy drinks over a short period as brief as only a few hours may cause caffeine intoxication resulting in heart palpitations, hypertension, nausea and vomiting, convulsions, psychosis, and in some rare cases, even death (Gunja & Brown, 2012; Trabulo, 2011; Winston et al., 2005). Research suggests that energy drinks pose a public health risk and may be linked to other substance use problems (Arria et al., 2011; Azagba, Langille, & Asbridge, 2014; Breda et al., 2014; Hamilton, Boak, Ilie, & Mann, 2013; Reissig et al., 2009; Terry-McElrath et al., 2014).

1.1. Energy drinks, caffeine, and herbal ingredients

Energy drinks are frequently marketed by highlighting potential health benefits of L-carnitine, taurine, and other herbal ingredients despite the lack of research on actual physiological benefits. Because

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of this lack of evidence and the potential risks of mixing various herbal ingredients, many countries have begun to restrict energy drink sales (Bradley, 2012). To date, the U.S. has not regulated energy drink production or sales despite growing concern among public health researchers and practitioners. Because of the potential health implications to consumers, researchers have called upon the U.S. Food and Drug Administration to regulate energy drinks with little success (Thorlton et al., 2014). While the consumption of various herbal ingredients in energy drinks are vague and relatively unstudied, the ingredient of caffeine has been studied extensively. While high levels of caffeine consumption are concerning to health researchers, it is the potential interactive or synergistic effects of caffeine and varying levels of herbal ingredients that are most concerning. The potential neurological effects from the mixing of ingredients such as ginseng, yohimbine HCL, and evodamine have been noted by Woolsey et al. (2014b).

Another issue of concern among public health professionals is the potential mislabeling of energy drink ingredients. Few have examined the actual amount of listed herbal ingredients; however, caffeine content has been examined. Because production and sales are unregulated in the U.S., caffeine content per serving of the available energy drink products ranges widely and is often not truly reflective of the labeled content amounts (Bailey, Saldanha, Gahche, & Dwyer, 2014; Consumer Reports, 2012). An examination of 27 different products indicated a wide range of caffeine concentration (6 mg to 242 mg) among energy drink products (Consumer Reports, 2012). Eleven of the studied products did not list caffeine level, while the actual caffeine level in five of the remaining sixteen products was 20% higher than the listed amount. This variation and uncertainty regarding energy drink products pose a risk to consumers who may not be informed on the actual ingredients being consumed.

1.2. Age of first use of energy drinks

Early-age consumption of drugs such as alcohol, tobacco, and marijuana has been studied extensively (Magid & Moreland, 2014). Findings consistently report that early onset of consumption increases future risk of various social, physical, and psychological health problems including illicit drug use, heavy alcohol use, and misuse of licit substances (Agle et al., 2015; Bergen-Cico & Lape, 2013; Falls et al., 2011; Liang & Chikritzhs, 2015; Magid & Moreland, 2014; Morean et al., 2014; Sullivan & Cosden, 2015). Additionally, early-age consumption of caffeine has been linked to increased risk of significant mental and behavioral health problems (Benko et al., 2011; Martin et al., 2008; Temple, 2009). What remains relatively unstudied is early consumption of energy drinks.

Two studies have documented a mean age of first use of 16 years; however, these researchers did not explore this variable as it relates to other behaviors (Alsunni & Badar, 2011; Ibrahim et al., 2014). In a study of 144 youth, Miyake and Marmorstein (2015) suggested that early adolescent use of energy drinks may increase risk of later alcohol use. As consumption of energy drinks continues to increase among adolescents and young adults, age of first use should be explored. Of particular concern is whether or not early onset of energy drink use may lead to increased future use of energy drinks.

1.3. Energy drink use among military populations

The majority of studies examining energy drink consumption focus on general college students; however, few studies explore military personnel. Schmidt et al. (2008) examined energy drink consumption among a U.S. Air Force sample and found that consumption prevalence was higher among military personnel than the comparable general population, despite lower consumption frequency. Also noted was the high availability of energy drinks on Air Force work installations and bases. Toblin, Clarke-Walper, Kok, Sipos, and Thomas (2012) indicated that 45% of deployed military service members (U.S. Army and Marine

combat platoons deployed to Afghanistan) reported daily energy drink use which is considerably higher than the civilian population (6%). Of these service members, 14% consumed three or more energy drinks per day. Another study examining active duty military personnel (Army, Navy, Air Force, Marine Corps, Coast Guard, Uniformed Public Health Service) reported that lower ranked military members were more likely to consume multiple energy drinks per day and more likely to think that energy drinks use was safe (Stephens, 2013). High military consumption rate may be linked to commonly self-reported side effects including increased pulse, restlessness, and inadequate sleep (Stephens et al., 2014; Toblin et al., 2012). The present study sought to examine energy drink consumption among military personnel, specifically to determine if age of first energy drink use is predictive of the maximum number of energy drinks consumed during a single day and/or single occasion. This allowed for exploration to determine if age at first use of energy drinks is a significant predictor of high rates of future energy drink consumption. For this study, "single occasion" was operationally defined as a couple of hours; e.g., a night out, during studying or sport session.

2. Methods

Human subjects approval was granted by the Navy Medical Operational Training Center Scientific and Ethical Review Committee and the IRB at the Naval Medical Research Unit – Dayton. An anonymous nutritional survey was presented to 302 student naval aviators and student naval flight officers undergoing Aviation Preflight Indoctrination training at a United States Navy base in Florida. Prior to the presentation of the survey, students were verbally informed as a group that an opportunity exists to participate in a study being conducted by Naval Aerospace Medical Institute (NAMI) researchers on energy drink consumption patterns. To minimize the possibility of coercion or undue influence, unit commanders were not present at the time of recruitment. Further, students were informed that their participation was voluntary, that there would be no penalty for not participating or for leaving the study early. No compensation was provided for participation in this study. They were informed that their decision to participate or not participate would in no way affect their class standing or final grade. Students were informed that their results would be reported in aggregate form so that individual results could not be tied back to any single participant, and that their participation would in no way affect their standing in naval aviation training or on their naval careers. The survey was available via pen and paper or by electronic web enabled device. The students were permitted to choose which version to use. Both versions of the survey were identical in all ways including programmed skipping of questions based on prior responses.

All 302 students recruited agreed to participate in the survey. This represented a response rate of 100%. All sampled personnel were college graduates and in good health and fitness.

Among those who completed the survey, 79% ($n = 239$) reported consuming energy drinks within the last year; therefore, this study focused on this sub-population of energy drink consumers. To assist participants in properly identifying energy drinks, this study utilized similar strategies used in prior energy drink studies (Woolsey et al., 2014b; Woolsey et al., 2015). The instrument identified examples of popular energy drinks and included pictures, serving sizes, and commonly sold product quantities. Age of first use was determined by asking the question "How old were you when you first started consuming energy drinks?"

In order to determine if the age of first use affected consumption patterns, the participants self-reported their age of first energy drink use, as well as items to determine frequency and quantities consumed. To measure how many energy drinks students consumed, ranged response scales were used. Because energy drinks are sold in varying sizes, content is unregulated by the U.S. Food and Drug Administration, and research has indicated the potential for mislabeling of ingredient

quantity (Bailey et al., 2014; Consumer Reports, 2012; Thorlton, Colby, & Devine, 2014), a standard energy drink quantity had to be operationalized for this study. To standardize the quantity of energy drinks, the researchers used quantity parameters as described in Woolsey et al. (2014b). One energy drink serving was defined as either a two ounce energy shot or eight ounce energy drink, which will typically contain caffeine concentrations ranging from 75 to 500 mg per container (Woolsey, et al., 2014b). While a standard serving size for energy drink consumption is eight ounces, a typical energy drink product is sold in a 24 to 32-oz. container (Webb, 2013); therefore, larger containers of energy drinks were computed as multiples of the eight ounce standard serving. To determine average daily usage, the values assigned to the answer choices were as follows: up to one per day (1), two per day (2), three per day (3), four per day (4), and more than four per day (5). This survey item asked participants to identify energy drink consumption “in an average day”. For maximal consumption, the numerical value assigned to the answer choices are as follows: none (0), up to one (1), two (2), three (3), four (4), five (5), and more than five (6). To assess the maximum number of energy drinks consumed in a day, the question “in the past 30 days, what was the maximum number of ENERGY DRINKS/SHOTS used in one day” was used. To assess the maximum number of energy drinks consumed during a single occasion, the question “over the LAST YEAR, what is the maximum number of ENERGY DRINKS/SHOTS you have consumed on a SINGLE OCCASION (time frame of a couple of hours; e.g., a night out, during studying or sport session)” was used.

3. Results

3.1. Sample characteristics

Participants' age ranged from 21 to 35 years ($M \pm SD = 23.68 \pm 1.99$). The energy drink consumer sample ($n = 239$) used for analyses consisted of 93.31% males ($n = 223$) and 6.69% females ($n = 16$). Among those who reported consuming energy drinks within the last year, 35.56% ($n = 85$) reported consuming energy drinks within the past 30 days. Males made up 94.12% of the past 30-day affirmative respondents ($n = 80$).

3.2. Energy drink consumption patterns

Based on the response scales for average daily energy drink use, the average response was 0.69 ± 0.49 indicating that the average maximum amount of energy drinks consumed per day was less than one. When asked about maximal number of energy drinks used in one day during the past 30 days, participants reported a mean score of 0.67 ± 0.87 indicating that the average maximum amount of energy drinks consumed in one day over the past 30 days was less than one standard serving. When asked about maximal number of energy drinks used in one day during the past year, participants reported a mean score of 1.95 ± 1.09 indicating that the average maximum quantity of energy drinks consumed on a single occasion over the last year was approximately two servings of energy drinks. Only 13.24% of energy drink users ($n = 27$) met the definition of high acute consumer by drinking four or more energy drink servings during a single occasion. Zucconi et al. (2013) defined “high acute consumer” as a person who consumes 11 (33.8-oz) of energy drink during a single session. Table 1 presents the consumption frequency trends among the sample. It should be noted that 98 subjects reported to not being regular users of energy drinks within the last year and were removed from the Table 1.

3.3. Age of first use and consumption patterns

In order to determine if a relationship exists between age of first use and average usage per day, the maximum quantity consumed in a day and on a single occasion, a bivariate correlation was initially used for

Table 1
Energy drink consumption patterns among study participants ($n = 204$).

	Frequency	Percent
In an average DAY, what best describes your consumption pattern of ENERGY DRINKS/SHOTS?		
Less than 1 per day	174	85.29
1 per day	26	12.75
2 per day	4	1.96
3 per day	0	0.0
4 per day	0	0.0
More than 4 per day	0	0.0
In the past 30 DAYS, what is the maximum number of ENERGY DRINKS/SHOTS consumed in ONE DAY?		
None	109	53.43
Less than 1	13	6.37
1	50	24.51
2	25	12.25
3	4	1.96
4	3	1.47
Over the LAST YEAR, what is the maximum number of ENERGY DRINKS/SHOTS you have consumed on a SINGLE OCCASION?		
Less than 1	8	3.92
1	79	38.73
2	73	35.78
3	17	8.33
4	23	11.27
5	3	1.47
More than 5	1	0.49

each query. The frequency distribution of age of first use is presented in Table 2. The mean age of first use was 17.8 ± 2.4 years of age (median and mode = 18) with the ages ranging from 10 to 26. The bivariate correlation for age of first use and reported average per day quantity consumed was not statistically significant at the 0.05 alpha level ($r(251) = -.02, p = 0.708$). The bivariate correlation for age of first use and maximum quantity consumed over the past 30 days was also not statistically significant ($r(202) = -.02, p = 0.790$). However, the bivariate correlation for age of first use and maximum quantity consumed on a single occasion was significant ($r(202) = -0.23, p = 0.001$).

In order to determine if the age of first use predicts maximum energy drink consumption on a single occasion, an ordinal logistic regression was employed. Despite small cell frequencies (Table 3), the basic assumptions for the ordinal logistic regression were met including no empty cells and at least 80% of cells with a frequency of five or more (Mertler & Vanatta, 2010). The predictive odds ratios from the ordinal logistic regression analysis used may be interpreted as the relative likelihood for increased energy drink consumption as participant age of first use increased. The ordinal logistic regression was applied as the factors

Table 2
Distribution of age of first use of energy drinks/shots.

Age of first use	N	Percent
10	1	0.3
12	1	0.3
13	4	1.3
14	14	4.6
15	22	7.3
16	41	13.6
17	24	7.9
18	64	21.2
19	21	7.0
20	28	9.3
21	19	6.3
22	8	2.6
23	2	0.7
24	3	1.0
26	1	0.3
Never used	49	16.2
Total	302	100.0

Table 3
Probability responses for max consumption of energy drinks (N = 204).

Age	N	Estimated cell probability for response category	Estimated probability by age	Cumulative probability by age
20+	28	Low	0.6222	0.6222
	17	Moderate	0.3223	0.9445
	1	High	0.0555	1.0000
17–19	43	Low	0.4554	0.4554
	36	Moderate	0.4408	0.8962
	12	High	0.1038	1.0000
13–16	16	Low	0.2523	0.2523
	37	Moderate	0.5247	0.7770
	14	High	0.2230	1.0000

were organized into categories instead of interval data. The assigned score of the question “over the LAST YEAR, what is the maximum number of ENERGY DRINKS/SHOTS you have consumed on a SINGLE OCCASION” by respondent was used to determine the quantity of energy drinks consumed on one occasion. The quantities consumed were divided into three categories. These were low (less than one and one energy drink), medium (two to three energy drinks), and high (four or more energy drinks). Age of first use was also grouped into three categories: 13–16, 17–19, and 20+ years of age. Table 3 presents the probability of the response data by the grouped age categories.

Results of a Pearson Chi-square ($X^2(2) = 2.655, p = 0.265$) and deviance-based goodness-of-fit model ($X^2(2) = 2.888, p = 0.236$) indicated that the data fits the model for the ordinal logistic regression analysis. The ordinal regression analysis indicated the following:

1. Participants who started consuming energy drinks during between the ages of 13–16 were 4.88 times (OR = 4.879, [95% CI, 2.28, 10.47]; $p < 0.001$; $R^2 = 0.104$) more likely to indicate a higher maximum amount of energy drinks consumed on one occasion when compared to those who began consuming energy drinks between the ages of 20–23. This statistically significant finding exhibits a strong odds ratio (OR > 3.0) association.
2. Participants who started consuming energy drinks during between the ages of 13–16 were 2.48 times (OR = 2.479, [95% CI, 1.34, 4.58]; $p = 0.004$; $R^2 = 0.104$) more likely to indicate a higher maximum amount of energy drinks consumed on one occasion when compared to those who began consuming energy drinks as a 17–19 year olds. This statistically significant finding exhibits a moderate odds ratio (OR = 1.6–3.0) association.
3. There was not a statistically significant difference when comparing 17–19 year old to 20–23 year olds with regard to the age of first energy drinks consumption to the maximum number of energy drinks consumed on one occasion (OR = 0.508, [95% CI, 0.25, 1.363]; $p = 0.061$).

4. Discussion

The present research study showed that age of first use, daily average quantity, and maximum quantity consumed during a day were not correlated. Results do indicate that age of first use was a significant predictor of the maximum quantity of energy drinks consumed on one occasion; however, this study did not explore potential explanations for this relationship. Future studies on a military population should examine potential reasons for this correlation. Further analysis showed that participants who started consuming energy drinks during the early ages of 13–16 were approximately five times more likely to indicate that they have consumed higher maximum numbers of energy drinks (four or more servings on a single occasion) than those who began consuming energy drinks after the age of 20. Additionally, the analysis showed that people who started consuming energy drinks as 13–16 year olds were almost 2.5 more likely to consume higher numbers of energy drinks on a single occasion in the future as an

adult when compared to those who began consuming energy drinks as at 17–19 years of age. This finding fits the hypothesis that age of first use is inversely related to the maximum number of energy drinks consumed on a single occasion.

This study suggests that the younger a person is when beginning to consume energy drinks, the greater the likelihood of consuming high quantities of energy drinks during a single occasion. Large quantities of energy drinks consumed during a single occasion increase the risks for serious health consequences (Arria et al., 2011; Gunja & Brown, 2012; O'Brien et al., 2013; Winston et al., 2005). Health officials, parents, teachers, and coaches need to be aware of the association between age of first energy drink use and quantity consumed for both health and safety reasons and as a potential preventative measure to avoid issues with other substances later in life.

Multivariate analyses research indicates that consumption of energy drinks is associated with increased risks of alcohol and drug use (Terry-McElrath et al., 2014). Arria et al. (2011) found that high frequency of energy drink consumption is associated with a greater risk of alcohol dependence. Research also indicates that the frequency of energy drink use is associated with the increased probability of illicit and licit prescription stimulant use and high-risk driving (Woolsey et al., 2014a; Woolsey et al., 2014b; Woolsey et al., 2015). Additionally, there is evidence to suggest that energy drinks may serve as a gateway product, which can lead to other forms of drug use (Reissig et al., 2009). Terry-McElrath et al. (2014) observed a positive association between energy drink consumption and past 30-day alcohol, cigarette, and illegal drug use among 8th, 10th, and 12th grade students. Among young adults, a high frequency of consumption of energy drinks has been associated with a greater risk of alcohol dependence (Arria et al., 2011). Results of these studies indicate that the regularity of energy drink use is associated with the increased likelihood of illicit and licit prescription stimulant use.

While early onset of energy drink consumption has yet to be fully explored, Magid and Moreland (2014) suggest that age of first use of other drugs may be an important predictor of future substance-related problems. Researchers have explored early-age consumption of other drugs including alcohol and marijuana with studies revealing a correlation between early onset of consumption and heavy alcohol use, non-social substance use, illicit drug use, and over-the-counter drug misuse (Agle et al., 2015; Bergen-Cico & Lape, 2013; Falls et al., 2011; Liang & Chikritzhs, 2015; Magid & Moreland, 2014; Morean et al., 2014; Sullivan & Cosden, 2015). The results of this study suggest that age at first use may be an important variable to explore as it could increase risk for future single-occasion heavy episodic use in a military population.

5. Limitations

This study is limited by the cross-sectional, retrospective design, as well as the reliance on self-reported data. The sample size was also a limitation, particularly the small number of participants reporting heavy episodic energy drink consumption during the past year. However, this study is one of the first to examine these behaviors in a highly specific military population; therefore, the results are useful to military health researchers and public health professionals working with this population. While this study found that age of first use was a significant predictor of energy drink consumption patterns, this variable is not the sole predictor for future use. Other factors such as impulsivity and sensation-seeking may serve as more predictive personality traits for future energy drink use (O'Brien et al., 2013); however, these traits may be more difficult to determine in public health practice. Age of first energy drink use presents as a relatively easy variable to determine; therefore, may allow for a more efficient predictive variable for prevention practitioners. Additionally, age of participants in this study may be confounder that serves as a potential limitation. Since the late 1990s, consumption of energy drinks has steadily increased among adolescents and young adults (Azagba, Langille, & Asbridge, 2014; Cotter et al., 2013;

O'Brien, McCoy, Rhodes, Wagoner, & Wolfson, 2008). Participants ranged in age from 21 to 35 years; therefore, younger participants may have been more likely to initiate energy drink consumption at an earlier age. Future studies should explore additional predictive variable including personality traits, as well as examine these relationships in non-military adult populations.

6. Conclusions

As the public health risks related to energy drink use are being discovered, it is important to expand research on the military population that has shown to exhibit high rates of energy drink consumption and unique health concerns (Stephens, 2013; Stephens et al., 2014; Toblin et al., 2012). This study serves as one of the first to explore possible predictors of energy drink behaviors among military personnel that may assist in developing effective prevention and intervention programs.

Role of funding sources

This study received no internal or external funding.

Contributors

TS served as the primary investigator for this project and was involved in all aspects including study design, data collection, statistical analysis, and manuscript preparation. CW, RW, ME, and FC assisted in statistical analysis, literature review, and manuscript preparation. All authors contributed to and have approved the final manuscript.

Conflict of interest

All authors declare that they have no conflicts of interest.

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