

Are energy drinks scapegoats? Decomposing teenagers' caffeine intake from energy drinks and soda beverages

Short title: Decomposing teenagers' caffeine intake

Conflict of Interest: There is no conflict of interest relevant to this article to disclose.

ABSTRACT

Background: Energy drinks have been repeatedly blamed for contributing to caffeine intake among teenagers.

Objectives: This study aimed to estimate and compare the caffeine intake of US teenagers from soda drinks versus energy drinks and shots.

Methods: Data were taken from a 2015 nationally representative survey (Monitoring the Future) of 8th and 10th graders in the US (47.2% 8th grade; 51.1% female). Participants reported their numbers of consumed sodas, diet sodas, energy drinks, and energy shots per day. These were converted into mg caffeine/day and were contrasted with common guidelines for healthy caffeine intake, stratified by age group and sex. Error-bar charts, ANOVA and ROC curves were used for contrasting caffeine intake from soda drinks and energy drinks, as well as their contribution to exceeding recommended caffeine intake cutoffs.

Results: First, in both sexes and grades the intake from soda drinks was significantly higher than the intake from energy drinks. The soda and energy drink intake for males was higher than the intake for females; intake for 8th graders was higher than this of 10th graders. Second, caffeine intake from soda drinks was significantly higher even in those who exceeded the recommended maximum caffeine intake. Third, caffeine intakes from soda and energy drinks were efficacious in explaining the exceeding of the recommended threshold for daily caffeine intake, but the explanatory power of soda drinks was larger.

Conclusions: From a caffeine consumption standpoint, health professionals should emphasize reduction in both soda and energy drinks.

KEYWORDS: Energy drinks, Soda drinks, Caffeine, Teenagers, Adolescents

Energy drinks are beverages that contain large amounts of caffeine, sometimes combined with other stimulants (e.g., taurine), as well as sugars and sweeteners. Their consumptions by children and adolescents is a topic of interest for the pediatrics community because (1) they are unregulated and can be freely consumed by many adolescents (over 60% of 7-12 grade student consumed at least once in the last year, and about 20% consumed at least once a month) (Azagba, Langille, & Asbridge, 2014), and (2) given their excessive caffeine content, they can adversely affect adolescents, especially those who are diabetic, have seizures, cardiac, behavioral and mood abnormalities (Seifert, Schaechter, Hershorin, & Lipshultz, 2011). These adverse effects can include dehydration, heart complications, anxiety, insomnia, bone, calcium and reproduction issues (Wikoff et al., 2017). Moreover, energy drinks are often mixed with alcohol and this is associated with increased drunkenness among 16-17 years old adolescents (Kristjansson, Mann, Sigfusdottir, & James, 2015). Such drinks provide high dosages and concentration of caffeine at a given time; given that the half-life of caffeine is between 2-9 hours, this may explain the increase in emergency department visits of US adolescents attributed to adverse reactions to energy drinks (Mattson, 2013).

The reported caffeine content (which is the main stimulant they typically contain) in a typical 8-12 oz energy drink is 70-80 mg and can be 2-5 times higher in energy shots (condensed in 0.8-3 oz of liquid) (Seifert et al., 2011). Independent lab studies regarding popular energy drinks, energy shots and soda drinks provide more precise insights regarding these amounts. These are given in Table 1. These findings imply that energy drinks and shots are financially accessible by many and can contain large amounts of caffeine, compared to soda drinks.

The recommended caffeine consumption limits for adolescents vary between studies (often 50-200 mg/day), but a commonly used limit is 2.5 mg/kg per day (Wikoff et al., 2017). Employing the 2.5 mg/kg per day criteria, the upper recommended limits for typical 8th grade boys and girls (50th percentile, based on Center for Disease Control and Prevention [CDC] growth charts) are calculated to be 121.25 and 118.75 mg/day, respectively. Similarly, the upper recommended limits for typical 10th grade boys and girls (50th percentile, based on CDC growth charts) are calculated to be 147.5 and 132.5 mg/day, respectively.

While energy drinks can be unhealthy along many dimensions (e.g., sugar content, unknown effects of ingredients), their high caffeine content have raised major concerns in the pediatrics community (Seifert et al., 2011), as well as in popular media, given that such drinks are marketed for young adults as a means to stay attentive and awake (Pomeranz, Munsell, & Harris, 2013). Nevertheless, adolescents can consume caffeine from multiple sources, including foods and other beverages (e.g., carbonated soda, tea). Hence, it is not clear how much of the caffeine overconsumption in US teenagers, should be attributed to energy drinks vs. other sources. I ventured to address this issue by examining calculated caffeine consumption from two main sources: energy drinks (regular and shots) vs. soda (regular and diet). While acknowledging that there are other caffeine sources, these two sources seem to be main ones, and can suffice to show that from a caffeine consumption standpoint, energy drinks may be a scapegoat in the big picture that includes multiple caffeine sources. Note that I do not suggest that energy drinks and shots are healthy; rather, this study argues that from a caffeine consumption standpoint we may have "barked at one tree", while there may be bigger trees around.

Method

Participants

The study uses the 2015 Monitoring the Future Dataset of 8th and 10th grade students in the US (Johnston, Jerald G., Patrick M., John E., & Richard A., 2016) to run analyses. It contained 9,687 records (4,569 8th graders; 4,807 female) that reported on average daily energy and soda drink consumption. Response rates were 89% and 87% for 8th and 10th grade students, correspondingly (Johnston, Bachman, O'Malley, Schulenberg, & Miech, 2016).

Measures

Four questions asked individuals to report an approximate average number of drinks (energy, energy shots, soda, and diet soda) per day. Most scale points included exact numbers of drinks/day; exceptions included "<1", "5-6" and " ≥ 7 ", which were treated as 0.5, 5.5 and 7, respectively. Using the averages in Table 1, the number of units was converted into estimated mg of caffeine per day. Demographic information included grade (8th or 10th) and sex.

Results and Discussion

The following average mg/day of caffeine, standard deviations, and bias-corrected bootstrapping-based 95% confidence intervals were obtained: Energy drinks [27.46, 82.55, 25.82-29.04], Energy Shots [16.17, 90.05, 14.32-18.03], Soda [44.37, 59.47, 43.19-45.55], diet soda [19.56, 44.03, 18.65-20.49], and total caffeine intake from such beverages [107.56, 207.90, 103.34-111.78]. Comparisons of caffeine intake from soda and energy drink sources are visualized in Figure 1, which also provides the statistical results of within- and between-group comparisons.

Panel A supports the findings of prior research (e.g., Temple, Dewey, & Briatico, 2010) by showing that, on average; males consume more caffeine from beverages than females do; across caffeine sources. Panel A also shows that caffeine intake from soda is significantly higher than this from energy drinks, across the sexes. This is consistent with older nationally representative samples that used 7-day diaries and examined caffeine consumption by sources, in the 13-17 age group (Mitchell, Knight, Hockenberry, Teplansky, & Hartman, 2014). It is interesting to see that in the mentioned study the ratio between caffeine intakes from soda to energy drinks in the 13-17 age group was 6.1. In our study it was 1.5. This may reflect differences in measurement approaches, but may also reflect changes from 2010-11 to 2015 in terms of replacement by some consumers of soda with energy drinks.

Panel B demonstrates that 8th graders consume more caffeine from both sources compared to 10th graders. This is also true in terms of caffeinated drink units [8th grade: energy drinks=0.31, energy shots=0.15, soda=1.20, diet soda=0.53; 10th grade: energy drinks=0.20, energy shots=0.07, soda=0.89, diet soda=0.39]. This finding is interesting and counterintuitive as normally, there is a positive association between age and caffeine intake (Ahluwalia & Herrick, 2015). Nevertheless prior research has often lumped together 8th and 10th grade students into one group (e.g., Mitchell et al., 2014). Reasons for the reduction from 8th to 10th grade should be explored in future research.

Panel C shows that this does not change if we look separately on those who exceed the recommended upper limit of daily caffeine intake; the proportion of caffeine from energy drinks in this segment, though, is higher than this of those who do not exceed the recommended daily caffeine limit. This implies that energy drinks contribute to presumed to -be unhealthy caffeine intake levels, but still, the majority of the "blame" should be on soda drinks. Panel D shows that

both caffeine sources predict exceeding the recommended caffeine intake and that soda is more instrumental in this determination, compared to energy drinks.

These findings, however, should be interpreted with caution. First, the sample is US-based and included limited age ranges. Second, this study used estimates of caffeinated drink unit consumption and translated them into mg/day using averages. While this is not accurate, it is reasonable especially given that other measurement approaches also have limitations (e.g., diaries may modify a person's behavior). Third, the study excluded decaffeinated drinks from the calculated averages and assumed that all soda drinks are caffeinated. There are, however, many non-caffeinated soda beverages on the market, including Sprite, 7-UP, Grape Soda, Cream Soda, many brands of root beer and orange soda, as well as decaffeinated version of many colas. Hence, our estimates of caffeine intake from soda may be upward biased. Last, the study accounted for just two sources of caffeine intake, and ignored other possibly important sources, such as coffee and tea.

Overall, the results demonstrate that from a caffeine consumption standpoint, health professionals, regulators and families should emphasize reduction in both soda and energy drinks. While reduction of soda consumption may better serve an overall objective of caffeine intake reduction than reduction in energy drink intake; energy drink intake reduction can too serve this purpose and should also be sought given the risks of high caffeine intake at once. Such efforts should be directed at students at grades below the 8th grade, as consumption at the 8th grade already reaches, for some, possibly unhealthy levels. The content of energy drinks (i.e., its other ingredients), beyond caffeine, may dictate different priorities, but at least from a caffeine standpoint, soda drinks are an equally important threat. Media mentions of energy drinks and

their aversive effects should not detract from parents', health professionals' and educators' effort to reduce soda consumption in teenagers.

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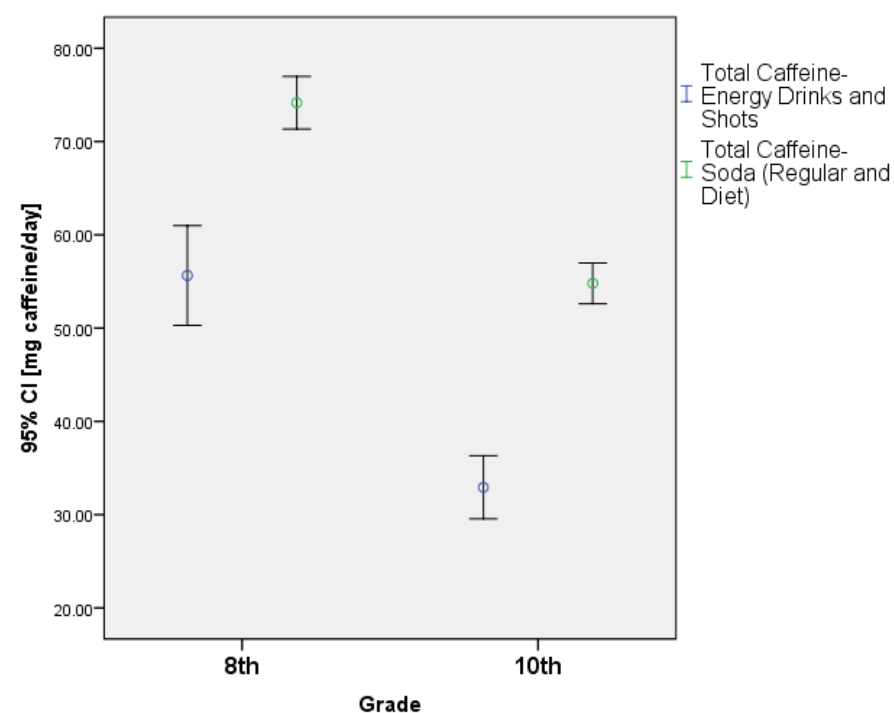
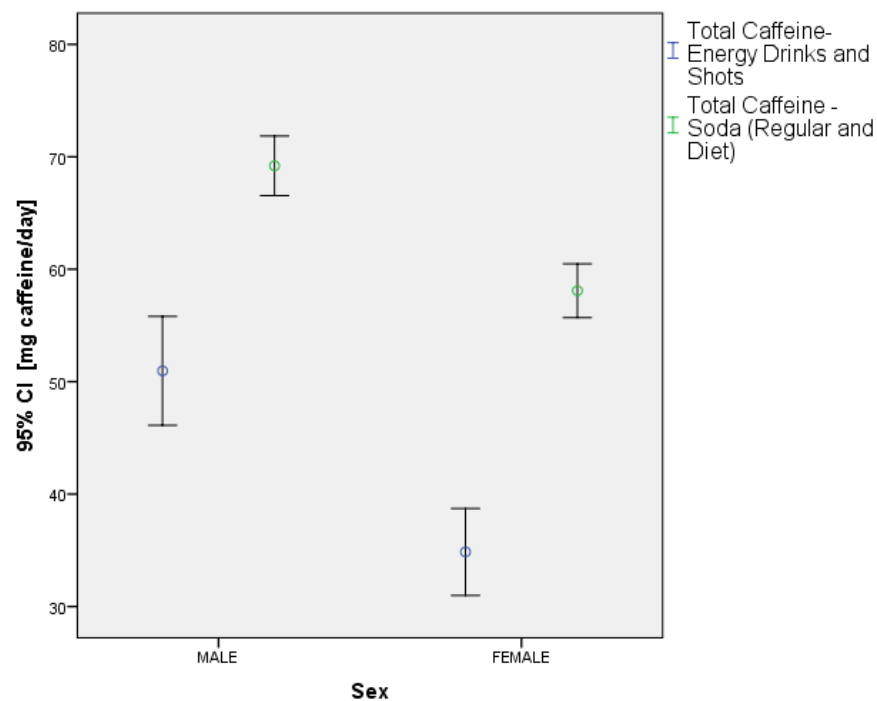
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Table 1: Drink Type Statistics Based on Lab Testing

	Energy Drinks [†]	Energy Shots [†]	Soda (Regular and Diet) ^{††}
n (drinks analyzed)	20	7	72
Typical content [fluid oz]	6.8-16	1.2-2.5	12
Cost [\$]	0.5-2.5	1-3	-
Calories	0-220	0-110	-
Sugar [g]	0-58	0-12	-
Caffeine range [mg]	17-224	6-242	10.3-74
Average Caffeine content [mg]	110.05 (SD=59.48)	150.29 (SD=86.74)	42.97 (SD=11.66)

[†] Based on Consumer Reports study (<https://www.consumerreports.org/cro/magazine/2012/12/the-buzz-on-energy-drink-caffeine/index.htm>). Extracted in Oct. 2017.

^{††} Based on Caffeine Informer study (<https://www.caffeineinformer.com/caffeine-amounts-in-soda-every-kind-of-cola-you-can-think-of>). Extracted in Oct. 2017

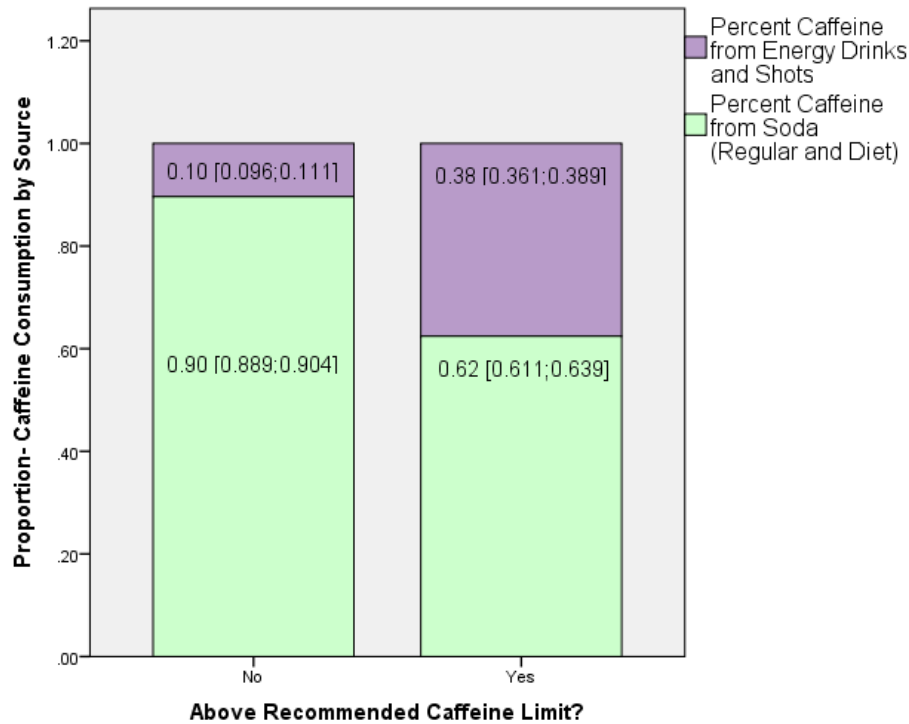


Panel A: 95% confidence intervals for the mean intake of caffeine per day from the two sources, grouped by sex.

In both sexes the intake from soda drinks was significantly higher than the intake from energy drinks ($p < 0.001$). The soda and energy drink intake for males was higher than the intake for females ($p < 0.001$).

Panel B: 95% confidence intervals for the mean intake of caffeine per day from the two sources, grouped by school grade.

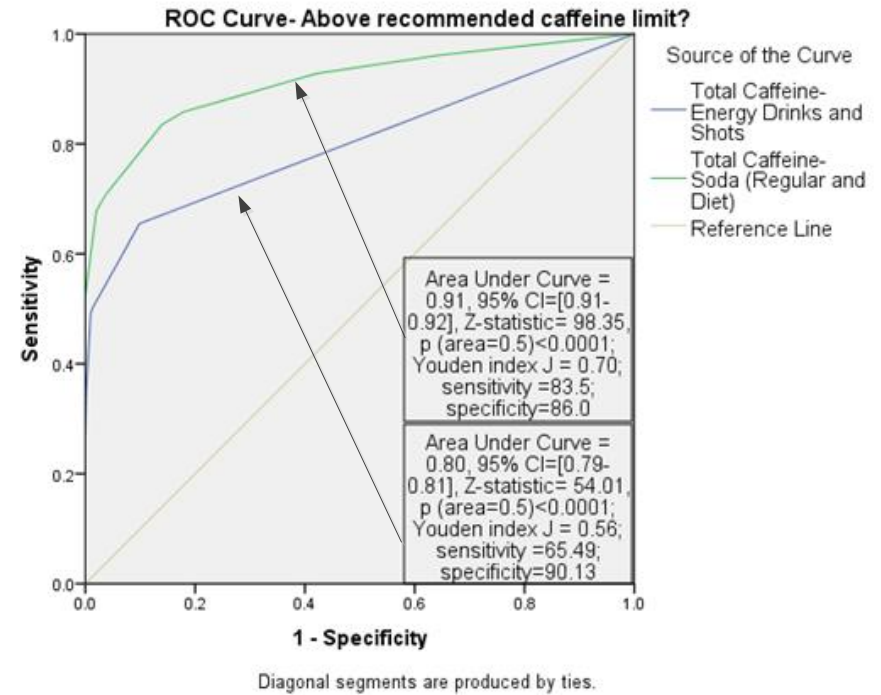
In both grades the intake from soda drinks was significantly higher than the intake from energy drinks ($p < 0.001$). The soda and energy drink intake for 8th graders was higher than the intake for 10th graders ($p < 0.001$).



Panel C: Mean proportions of caffeine sources [95% confidence Intervals] for those who are above vs. below the recommended maximum caffeine intake; for participants who reported >0 caffeine intake from beverages.

In both groups the intake from soda drinks was significantly higher ($p < 0.001$). The proportion of intake from soda was higher in the "No" group compared to the "Yes" group ($p < 0.001$); the proportion of intake from energy drinks was higher in the "Yes" group compared to the "No" group ($p < 0.001$).

Figure 1: Comparisons of caffeine intake from soda and energy drinks, by (A) sex, (B) Grade, (C) exceeding or not the recommended caffeine intake amount, and (D) in terms of effect on whether one exceeds or not the recommended daily caffeine intake



Panel D: ROC curve expressing the sensitivity and specificity of caffeine intake from (1) Energy drinks and shots [blue line], and (2) soda drinks (regular and diet) [green line], in explaining whether an adolescent exceeds (or not) the recommended threshold for daily caffeine intake. It shows that both forms of caffeine intake are efficacious in explaining exceeding the recommended threshold for daily caffeine intake. It also shows, consistent with panels A and B, that the area under the curve for caffeine from soda sources is larger than this from energy drink sources. The 95% confidence intervals indicate that this difference is statistically significant.