



Original article

Intake of caffeine from all sources and reasons for use by college students



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ARTICLE INFO

Article history:

Received 27 February 2018

Accepted 3 April 2018

Keywords:

Coffee

Energy drinks

Caffeine

College students

SUMMARY

Background & aims: Caffeine intake in a convenience sample of U.S. college students (N = 1248) was surveyed at five geographically-dispersed United States (U.S.) universities.

Methods: Intake from coffee, tea, soft drinks, energy drinks, gums, and medications was assessed. Associations between caffeine intake and demographic variables including sex, age, race/ethnicity, family income, general health, exercise, weight variables and tobacco use were examined. Reasons for use of caffeine-containing products were assessed.

Results: Caffeine, in any form, was consumed by 92% of students in the past year. Mean daily caffeine consumption for all students, including non-consumers, was 159 mg/d with a mean intake of 173 mg/d among caffeine users. Coffee was the main source of caffeine intake in male (120 mg/d) and female (111 mg/d) consumers. Male and female students consumed 53 vs. 30 mg/d of caffeine in energy drinks, respectively, and 28% consumed energy drinks with alcohol on at least one occasion. Students provided multiple reasons for caffeine use including: to feel awake (79%); enjoy the taste (68%); the social aspects of consumption (39%); improve concentration (31%); increase physical energy (27%); improve mood (18%); and alleviate stress (9%).

Conclusions: As in the general U.S. population, coffee is the primary source of caffeine intake among the college students surveyed. Energy drinks provide less than half of total daily caffeine intake but more than among the general population. Students, especially women, consume somewhat more caffeine than the general population of individuals aged 19–30 y but less than individuals aged 31–50 y.

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1. Introduction

Eighty-nine percent of the United States (U.S.) population regularly consumes caffeine [1]. Coffee is the primary source of caffeine in the U.S. diet, but tea, carbonated soft drinks, hot cocoa,

chocolate milk and chocolate candy, energy drinks and some dietary supplements also contain caffeine and the caffeine content of these products varies considerably [1–3].

A number of surveys have quantified caffeine intake in the United States. The USDA Continuing Surveys of Food Intakes by Individuals (CSFII) conducted in 1994–1996 and 1998 sampled approximately 18,000 individuals in the U.S. [4]. Eighty-seven percent of respondents consumed caffeine, and average intake of consumers was 193 mg/day. The major source of caffeine was coffee followed by soft drinks and tea. In the 1999 Share of Intake Panel (SIP) survey, coffee, soft drinks and tea provided the largest

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amounts of caffeine in the diet [5]. The Kantar Worldpanel (KWP) Beverage Consumption Panel survey (formerly the SIP) quantified caffeine intake from beverages in the U.S. between October 2010 and September 2011 [3]. Consistent with previous findings, approximately 85% of respondents consumed some type of caffeine-containing beverage, and 98% of all caffeine was consumed in the form of coffee, tea, carbonated soft drinks and energy drinks. A recent report based on data collected from 2001 to 2010 in a large, nationally-representative U.S. survey, the National Health and Nutrition Examination Survey (NHANES), found that 89% of U.S. adults regularly consume caffeine with usual intake by caffeine consumers being 211 mg/d [1]. Coffee (64%), soft drinks (18%) and tea (16%) were the main sources of caffeine in the diet [1].

A variety of reasons for use of caffeine have been reported in the literature. Surgeons have been reported to use caffeine to reduce fatigue [6]. Athletes report using caffeine to enhance their physical performance [7]. Adolescents state they use caffeine to provide more energy, for the taste of the product and for image enhancement [8].

Energy drinks are a relatively new source of caffeine on the market and are popular among young people, especially young males. They are controversial with some scientists expressing concern regarding their safety although others disagree [9,10]. One component of energy drinks that is known to affect behavior is caffeine so their use should be considered in the context of consumption of all caffeine-containing products [11]. Energy drinks also usually contain many other ingredients such as taurine, various vitamins and carbohydrates that may be bioactive [11]. Other caffeine-containing products such as coffee, tea and cola drinks also contain a variety of other potentially bioactive compounds. A survey of energy drink intake, conducted with a representative U.S. sample, reported 4% of individuals consumed caffeine in energy drinks [3]. Recent NHANES findings indicate only 1%–2% of total caffeine intake in the adult U.S. population was from energy drinks [1,12]. Energy drink consumption appears to be particularly common among college students [13–16] but accounted for less than 9% of total caffeine consumed by U.S. adults aged 18–24 y [17]. About one-third of college students surveyed reported consuming at least one energy drink over the previous 30 days [14].

1.2. Present study

Given the rapid growth of the energy drink industry, whose marketing is often geared toward young adults [18], quantification of caffeine intake and its sources by U.S. college students warrants additional investigation. National surveys such as the Kantar Worldpanel and NHANES have not typically examined college students as a subgroup of the population. Previous research in this area has suggested use of energy drinks by college students could contribute to a number of adverse outcomes. For example, it has been suggested energy drink consumption by college students is associated with lower sleep quantity and quality as well as next day sleepiness [19]. It has also been suggested that episodic (binge) alcohol use is associated with energy drink consumption among college students [15]. In addition, it has been reported that undergraduates who are attempting to lose weight are more likely to use energy drinks [14]. Therefore, this study assessed caffeine intake from a wide variety of caffeinated products including coffee, tea, colas and other soft drinks, energy drinks, gums and medications among a convenience sample of college students at 5 geographically-dispersed U.S. universities. The reasons college students reported using caffeine-containing products were also assessed. In addition, associations between caffeine intake and demographic variables such as sex, age, race/ethnicity, family

income, general health, exercise and weight variables and tobacco use were examined.

2. Methods

For this study, a total of 1248 students from five U.S. universities were sampled in 2009 and 2010: Louisiana State University in Louisiana (LSU; N = 301); Kent State University in Ohio (Kent State; N = 286); University of Massachusetts Amherst in Massachusetts (UMASS; N = 238); California State University Fullerton in California (Cal State; N = 212); and Tufts University in Massachusetts (Tufts; N = 211). The schools were chosen to be representative of the major types of American 4-year colleges and universities, including public and private institutions, residential and commuter schools, and various geographic regions of the U.S. A convenience sample of college students were recruited through an information booth (UMASS), online (Cal State and Tufts), or in the classroom (Cal State, Kent State and LSU). Students at UMASS and Tufts were given an incentive of \$10 to complete the survey and students at LSU were provided with classroom-based extra credit incentive. The study was approved by the USARIEM Human Subjects Institutional Review Board and the review boards of the colleges surveyed. The data collected in this survey were also used to assess dietary supplement intake of college students [20]. Similar surveys of U.S. Army, Air Force and Coast Guard populations have been conducted and, like this survey, also concurrently assessed intake of dietary supplements [21–24].

2.1. Variables

The self-report survey instrument included detailed questions on types of caffeine-containing beverages, gums and medications consumed, and the amount and frequency of consumption. A diverse variety of 31 specific caffeine-containing products were included as response options in the survey instrument. Respondents were asked to indicate serving size and frequency of use (number of times consumed per day, week, month, or year) for each product they regularly consumed. Participants were asked to write in caffeine-containing beverages they used that were not specifically identified in the questions on the survey. For data analysis, individual caffeine beverage types were grouped into the following categories: coffee, tea, sodas (regular and diet), energy drinks and other. All categories were combined to arrive at aggregate caffeine intake for the total sample including students who were not caffeine consumers and identify regular users of caffeine-containing products. Aggregate use was calculated as average daily intake for all students surveyed. Regular users were defined as those consuming any caffeine-containing products at least once a week. Identical procedures were employed to analyze data collected from U.S. Army soldiers and Air Force personnel who completed a nearly-identical survey [24,25].

As described previously, the survey collected data on a number of sociodemographic and lifestyle factors including: sex, age, race/ethnicity, family income, general health, aerobic exercise duration, whether the individual exercised with a team, whether the individual was attempting to gain or lose weight, and tobacco use [20]. Self-reported height and weight were collected and body mass index (BMI) was calculated (BMI = mass in kilograms divided by squared height in meters, rounded to the nearest tenth). Individuals with BMI <18.5 were considered underweight, individuals with BMI ≥18.5 and <24.9 were considered in the normal weight range, while a BMI ≥25.0–29.9 was considered overweight and individuals with BMI ≥30.0 were classified as obese [26–28]. To assess reasons for general caffeine consumption (not use of any specific beverage), a question listing nine possible reasons was

included in the survey. Participants could specify other reasons as well (see [Table 4](#)).

2.2. Survey administration

The survey was administered on-site by project staff at participating universities. Completed surveys were returned to the project team who scanned and tabulated responses using ScanTools® Plus with ScanFlex™ (version 6.301, 2006, Scantron Corporation, Eagan, Minnesota).

2.3. Calculation of daily caffeine intake

Based on information reported on product type, size and frequency of use, daily caffeine consumption was calculated using data on the amount of caffeine in specific product types. Sources of caffeine content in specific products included company websites and a database compiled by the authors on caffeine content of various brands and types of soda, coffee and energy drinks based on product labels, product websites, and other reliable online sources of caffeine contents [29,30]. Based on response distribution and inconsistent reporting, individuals reporting total caffeine consumption >2000 mg/day were excluded; this corresponded to less than 1% of the sample [24].

2.4. Statistics

The SAS (Version 9.2, 2008, SAS Institute, Cary, NC) statistical software program was used for data analysis (SAS Institute Inc. 2004). Pearson chi-square tests were used to assess the association between respondent sociodemographic characteristics and overall caffeine intake from all sources assessed, as well as from specific sources of caffeine. For caffeine users, analysis of variance (ANOVA) was used to assess the association between student sociodemographic and lifestyle characteristics and amount of caffeine consumed, overall from all sources and for specific caffeine sources; these ANOVA models were adjusted for survey site. Based on these results, multiple linear regression was used to examine the independent effects of student characteristics on caffeine consumption among caffeine users.

3. Results

The sociodemographic and lifestyle characteristics of respondents and intake of caffeine products as related to sociodemographic and lifestyle characteristics as totaled across the five universities are presented in [Table 1](#). A majority of the respondents were female (64.2%), 20–22 years old (52.2%), non-Hispanic whites (69.4%), and nearly half reported family income \$25,000 – \$99,999 (49.0%). In comparison, the majority of the general U.S. post-secondary education population at the time were female (57%), 24 yrs old or less (57%), and white (61%) [31]. The majority of volunteers in this study had a “normal” BMI of 18.5–24.9 (68.2%). A large percentage of participants exercised more than 300 min/wk (30.3%) and over a third exercised in an intramural or extramural team setting (41.1%). Most students were trying to maintain weight (46.5%) and had never used tobacco products (71.6%).

More females than males reported using any caffeine ($P < 0.001$), coffee ($P < 0.001$) and tea ($P < 0.001$) ([Table 1](#)). Older (23+ years) students were less likely to drink tea ($P = 0.002$), while African-Americans were less likely to drink coffee ($P < 0.001$) ([Table 1](#)). Individuals trying to gain weight, were less likely to drink coffee ($P < 0.001$) or tea ($P = 0.002$), while obese respondents (BMI ≥ 30) were more likely to consume caffeine in tea ($P = 0.001$) ([Table 1](#)). Those reporting comparatively better general health were

less likely to drink soda ($P = 0.003$) or energy drinks ($P = 0.023$) containing caffeine. Significantly fewer persons who exercised regularly with a team reported drinking coffee (68.0% vs. 74.7%, $P = 0.01$), however more reported drinking energy drinks (40.2% vs. 33.7%, $P = 0.02$) ([Table 1](#)). Non-smokers were less likely to drink energy drinks ($P < 0.001$) ([Table 1](#)).

Mean daily caffeine intake for all students surveyed, including non-consumers, was 159 mg/d. The average intake (mg/d) of caffeine among self-reported caffeine consumers with respect to sociodemographic and lifestyle characteristics is shown in [Table 2](#). Mean intake was 120 mg/d (males) and 111 mg/d (females) for coffee; 61 mg/d (males) and 50 mg/d (females) for tea; 38 mg/d (males) and 36 mg/d (females) for soda; 53 mg/d (males) and 30 mg/d (females) for energy drinks; and 25 mg/d (males) and 48 mg/d (females) for other ([Table 2](#)). Overall, no difference in amount of caffeine consumed from all sources was found between male and female college students (males: 173.9 mg/d; females: 173.4 mg/d; $P = 0.61$). However, males reported consuming significantly more caffeine from energy beverages than did females (males: 53.2 mg/d; females: 30.0 mg/d, $P = 0.02$). Older students (23+ years) consumed the most total caffeine 234.3 mg/d and caffeine from coffee 147.3 mg/d, tea 83.2 mg/d and energy drinks 81.8 mg/d (all $P < 0.001$) compared to other age groups. Those who reported poorer health consumed significantly more caffeine from all sources ($P < 0.001$) and specifically from sodas ($P < 0.001$) compared to those reporting better health status. Students currently using tobacco products had a higher intake of caffeine in general ($P < 0.001$), as well as coffee ($P < 0.001$), tea ($P = 0.014$), soda ($P = 0.021$) and energy drinks ($P < 0.001$) compared to non-smokers. As would be expected, those spending more on caffeine-containing products consumed more caffeine in general ($P < 0.001$), as well as coffee ($P < 0.001$), tea ($P < 0.001$), soda ($P = 0.033$) and energy drinks ($P = 0.02$) ([Table 2](#)). Students who reported never mixing energy drinks with alcohol consumed the least caffeine overall ($P < 0.001$) and the least caffeine from energy drinks ($P = 0.04$).

Multiple linear regression models for caffeine overall intake from all sources and for specific products, with the sample for each model being those reporting any consumption of that product, are presented in [Table 3](#). The coefficients estimate the difference in caffeine intake (mg/d) among caffeine users associated with each independent variable, holding other factors in the model constant. No significant difference was found in total caffeine consumption between males and females. Mean caffeine intake for older students (23+ years old) was about 95 mg/d more than for 18–19 year-olds ($P < 0.001$). Tobacco users consumed approximately 97 mg/d more caffeine than non-smokers ($P < 0.001$). Race/ethnicity, family income, general health and weight gain/loss were not independently associated with overall caffeine intake from all sources.

In columns 3–6 of [Table 3](#) the results of regression models computed individually for the four major sources of caffeine intake in college students' diets: coffee, tea, soda and energy drinks are presented. Coffee consumption was higher among older students 23+ years old, who consumed an average of 63 mg/d more caffeine from coffee than younger students ($P < 0.001$) and among smokers, who consumed an average of 53 mg/d more than non-smokers ($P < 0.01$). Older age ($P = 0.003$) and current smoking ($P = 0.018$) were independently associated with greater intake of caffeine from tea. Those reporting fair/poor health ($P < 0.001$) and smokers ($P = 0.050$) consumed more caffeine from soda. Older students ($P = 0.004$), current smokers ($P = 0.037$) and former smokers ($P = 0.025$) consumed more caffeine from energy drinks than their younger, non-smoking counterparts.

[Table 4](#) provides the reasons college students reported they used caffeine. The most common cited were: to feel more awake (79%);

Table 1

Sample size and intake of caffeine in any form and in specific products over the past year, according to selected sociodemographic and lifestyle characteristics.

	N ^a	%	Any caffeine		Coffee		Tea		Soda		Energy Drinks		Other	
			% ^b	P ^c	%	P	%	P	%	P	%	P	%	P
Overall	1248		91.7%		72.0%		61.4%		68.8%		36.4%		12.2%	
Sex														
Male	447	35.8%	87.2%	<0.001	61.1%	<0.001	48.3%	<0.001	67.8%	0.552	39.4%	0.100	7.8%	<0.001
Female	801	64.2%	94.3%		78.0%		68.7%		69.4%		34.7%		14.6%	
Age years														
16 to 19	401	32.1%	93.5%	0.091	73.6%	0.658	67.6%	0.002	71.1%	0.500	37.2%	0.248	12.7%	0.236
20 to 22	651	52.2%	91.7%		71.4%		59.9%		67.7%		37.5%		10.9%	
23+	196	15.7%	88.3%		70.4%		53.6%		67.9%		31.1%		15.3%	
Race/ethnicity														
Non-hispanic white	866	69.4%	92.0%	0.476	72.9%	<0.001	59.7%	0.176	70.1%	0.209	36.5%	0.209	12.8%	0.245
Non-hispanic black	88	7.1%	90.9%		51.1%		69.3%		71.6%		34.1%		13.6%	
Hispanic/Latino	124	9.9%	93.5%		79.0%		59.7%		68.5%		34.7%		12.9%	
Asian	112	9.0%	87.5%		71.4%		65.2%		62.5%		32.1%		5.4%	
Other	58	4.6%	93.1%		75.9%		70.7%		58.6%		50.0%		12.1%	
Family income														
< \$25,000	93	9.0%	88.2%	0.667	66.7%	0.718	58.1%	0.911	64.5%	0.062	39.8%	0.547	16.1%	0.751
\$25k – \$99,999	506	49.0%	91.3%		72.1%		60.5%		66.6%		34.0%		12.8%	
\$100k – \$200k	313	30.3%	92.0%		72.5%		61.3%		70.3%		37.7%		11.8%	
>\$200,000	120	11.6%	92.5%		72.5%		58.3%		78.3%		38.3%		13.3%	
General health														
Excellent	436	34.9%	91.3%	0.568	70.2%	0.593	62.6%	0.215	63.1%	0.003	31.4%	0.023	10.6%	0.020
Good	734	58.8%	91.7%		72.9%		59.8%		71.4%		38.7%		12.1%	
Fair/poor	78	6.3%	94.9%		73.1%		69.2%		76.9%		42.3%		21.8%	
Body mass index														
<18.5	48	3.9%	97.9%	0.021	77.1%	0.297	68.8%	0.001	68.8%	0.085	37.5%	0.067	16.7%	0.001
18.5–24.9	833	68.2%	92.8%		73.6%		63.1%		68.4%		35.7%		12.1%	
25.0–29.9	259	21.2%	88.0%		68.0%		51.7%		66.8%		36.3%		7.7%	
≥ 30.0	81	6.6%	95.1%		72.8%		71.6%		81.5%		50.6%		23.5%	
Exercise minutes/wk														
≤30	121	9.7%	95.9%	0.157	72.7%	0.136	65.3%	0.590	74.4%	0.017	31.4%	0.360	12.4%	0.004
31 – 150	381	30.8%	91.6%		72.4%		61.7%		71.1%		36.0%		8.9%	
151 – 300	366	29.4%	92.6%		75.7%		62.6%		71.0%		39.6%		17.2%	
>300	378	30.3%	89.7%		68.0%		59.0%		62.7%		35.2%		10.6%	
Exercises with team														
Yes	513	41.1%	90.8%	0.330	68.0%	0.010	60.2%	0.488	69.2%	0.813	40.2%	0.020	12.7%	0.658
No	735	58.9%	92.4%		74.7%		62.2%		68.6%		33.7%		11.8%	
Weight gain/lose														
Trying to lose weight	548	44.0%	91.4%	0.214	74.1%	<0.001	62.8%	0.002	70.1%	0.639	37.8%	0.634	14.6%	0.030
Trying to gain weight	119	9.6%	88.2%		54.6%		46.2%		69.7%		37.0%		6.7%	
Maintaining weight	579	46.5%	92.9%		73.7%		63.4%		67.5%		35.1%		11.1%	
Tobacco use														
Never	893	71.6%	91.8%	0.634	70.2%	0.093	62.2%	0.328	68.6%	0.599	33.0%	<0.001	10.5%	0.018
Former	149	11.9%	89.9%		75.8%		63.1%		66.4%		43.6%		16.8%	
Current	206	16.5%	92.7%		76.7%		56.8%		71.4%		45.6%		16.0%	

The bolded P values identify them as statistically significant ($P \leq 0.05$) values.^a The total number of respondents with the given characteristic in the row, i.e. the denominator for all the percentages in that row.^b The percent of respondents with the given characteristic in the row who indicated any consumption of caffeine from the source shown in the column i.e. row percents.^c Pearson chi-square statistic for overall association between given row characteristic and any consumption of caffeine from the source shown in the column.

enjoy the taste (68%); due to the social aspects of having coffee with friends or family (39%); to improve concentration (31%); to increase physical energy (27%); to improve mood (18%); and to alleviate stress (9%).

4. Discussion

The present study quantifies caffeine use by college undergraduates using data from a convenience sample of over 1200 students at five universities. It is based on a detailed survey that examined the quantity and frequency of consumption of a range of caffeinated products as well as sociodemographic and lifestyle factors of the volunteers. Over 90% of students reported consuming caffeine at least once in the past year, with the majority regularly consuming coffee, tea and soda. Total mean caffeine consumption per capita (for the whole student population surveyed) was 159 mg/d. Among regular caffeine users, total mean caffeine consumption from all reported sources was approximately 173 mg per day for both men and women. This is consistent with other recent

estimates of caffeine intake of the U.S. population, although somewhat higher than individuals of the same age as the students we studied [1,3,17]. Individual caffeine intake varied considerably in this population as it does in the general population and was not normally distributed [1,12]. Total caffeine intake of U.S. college students who consume caffeine appears similar, but slightly higher, than the intake of Dutch students, who consume on average 144 mg/d, although direct comparison of these studies is not possible due to procedural differences [32].

The demographic composition of students sampled in this study was quite similar to the U.S. college population [31]. Like the overall population of college students, more females than males were sampled in this survey. Our student sample was predominately white, like the general student population, although also like the overall population there were a number of blacks, Hispanics and Asian individuals in our sample. Overall, the size of the minority population sample who participated in this survey was approximately the same as the general student population. Our sample was also similar in age to the overall college population, with the largest

Table 2
Average consumption (mg/d) of caffeine, overall from all sources and for specific caffeine-containing products, according to selected sociodemographic characteristics and lifestyle factors, among consumers of caffeine and specific caffeine products.

	All caffeine (N = 1,145)			Coffee (N = 898)			Tea (N = 766)			Soda (N = 859)			Energy drinks (N = 454)			Other ^a (N = 152)		
	Mean	(SEM)	P ^b	Mean	(SEM)	P	Mean	(SEM)	P	Mean	(SEM)	P	Mean	(SEM)	P	Mean	(SEM)	P
Sex																		
Male	173.9	(10.6)	0.609	120.3	(9.4)	0.359	60.9	(8.1)	0.091	38.3	(3.0)	0.439	53.2	(8.2)	0.018	24.8	(7.3)	0.305
Female	173.4	(6.9)		111.0	(5.8)		50.1	(3.0)		36.0	(3.3)		30.0	(3.9)		48.3	(8.8)	
Age (years)																		
18–19	163.4	(9.0)	<0.001	105.6	(8.9)	<0.001	52.7	(4.3)	<0.001	32.9	(2.7)	0.610	30.2	(5.8)	0.001	38.3	(10.0)	0.891
20–22	162.3	(7.5)		109.1	(6.5)		45.3	(3.5)		38.7	(4.0)		33.7	(4.2)		45.5	(9.7)	
23+	234.3	(20.0)		147.3	(14.0)		83.2	(15.0)		38.7	(5.1)		81.8	(19.6)		44.5	(21.8)	
Race/ethnicity																		
Non-hispanic white	178.3	(7.1)	0.550	122.3	(6.1)	0.113	47.6	(3.2)	0.011	37.7	(3.1)	0.758	39.1	(5.0)	0.842	45.9	(9.1)	0.625
Non-hispanic black	165.0	(20.1)		81.3	(16.8)		74.1	(12.6)		47.4	(8.2)		41.7	(19.2)		65.3	(24.1)	
Hispanic/latino	170.1	(16.5)		98.7	(13.9)		63.8	(9.4)		33.1	(4.3)		48.5	(13.8)		27.7	(9.9)	
Asian	144.1	(18.3)		93.4	(16.5)		44.9	(8.6)		28.8	(6.4)		34.3	(9.0)		20.5	(12.2)	
Other	177.6	(30.0)		96.6	(19.7)		87.3	(30.5)		27.0	(5.3)		26.7	(6.4)		10.4	(3.9)	
Family income																		
<\$25K	164.0	(22.3)	0.976	81.5	(13.7)	0.013	73.6	(23.5)	0.122	41.9	(7.4)	0.075	41.7	(17.1)	0.968	24.1	(11.6)	0.746
\$25K – \$99,999	167.4	(9.3)		96.9	(7.2)		52.5	(4.5)		45.9	(5.1)		41.9	(6.9)		49.3	(10.1)	
\$100K – \$200K	177.0	(10.6)		132.1	(10.6)		44.6	(4.2)		32.5	(3.5)		34.3	(5.3)		33.1	(10.8)	
>\$200K	186.2	(19.0)		134.0	(15.7)		61.2	(10.7)		27.8	(3.3)		27.6	(10.0)		53.0	(39.2)	
General health																		
Excellent	150.1	(8.5)	0.001	114.3	(7.7)	0.413	47.2	(5.7)	0.210	25.3	(2.4)	<0.001	28.8	(7.2)	0.116	21.0	(6.2)	0.209
Good	183.0	(7.9)		116.2	(6.9)		54.6	(3.9)		39.4	(2.5)		41.4	(4.9)		52.3	(11.2)	
Fair/Poor	214.0	(25.2)		89.1	(12.5)		71.2	(12.6)		67.1	(23.1)		60.2	(19.1)		52.9	(13.6)	
Body mass index																		
<18.5	171.7	(25.8)	0.652	117.9	(25.7)	0.575	54.6	(9.9)	0.682	39.6	(8.9)	0.343	28.7	(10.6)	0.203	10.4	(2.5)	0.535
18.5–24.9	171.0	(6.9)		116.4	(6.0)		50.9	(3.9)		33.9	(2.2)		34.6	(4.6)		43.5	(9.3)	
25.0–29.9	178.1	(14.0)		116.5	(12.4)		56.6	(7.3)		45.1	(8.7)		39.1	(6.9)		52.4	(21.8)	
≥ 30.0	193.8	(21.7)		87.7	(13.4)		64.5	(10.8)		41.9	(6.4)		64.4	(20.7)		31.9	(10.2)	
Weight gain/lose																		
Trying to lose wt.	187.2	(9.2)	0.050	107.4	(7.6)	0.377	61.5	(5.5)	0.060	41.3	(4.4)	0.091	42.5	(6.3)	0.119	54.7	(10.1)	0.339
Trying to gain wt.	168.0	(20.9)		130.9	(21.1)		40.7	(7.1)		46.2	(5.9)		62.6	(18.6)		38.2	(17.7)	
Maintain weight	162.3	(7.9)		117.3	(6.9)		47.2	(3.9)		30.5	(2.5)		30.3	(4.7)		28.8	(10.6)	
Exercise (min/wk)																		
≤30	176.8	(22.6)	0.181	123.9	(21.0)	0.329	49.1	(10.6)	0.941	40.9	(6.8)	0.215	43.3	(10.5)	0.902	27.2	(10.4)	0.792
31–150	173.2	(9.6)		106.6	(7.8)		56.0	(6.6)		40.1	(3.4)		42.0	(7.7)		37.0	(9.1)	
151–300	191.7	(11.1)		123.1	(9.0)		53.6	(5.0)		39.7	(5.9)		36.3	(7.1)		48.0	(13.6)	
>300	155.6	(10.0)		108.0	(9.2)		51.1	(5.3)		28.4	(2.9)		37.7	(7.6)		45.7	(13.7)	
Exercises with team																		
Yes	155.6	(8.5)	0.119	102.5	(7.7)	0.131	54.1	(5.7)	0.895	32.7	(2.5)	0.143	37.3	(5.6)	0.655	66.0	(14.1)	0.011
No	180.7	(7.5)		121.0	(6.5)		52.5	(3.6)		39.7	(3.6)		40.4	(5.7)		25.7	(5.7)	
Tobacco use																		
Never	151.1	(6.0)	<0.001	103.4	(5.7)	<0.001	48.0	(2.9)	0.014	33.5	(3.0)	0.021	27.3	(3.4)	<0.001	41.1	(8.4)	0.216
Former	203.5	(18.8)		120.3	(12.8)		58.2	(13.7)		34.5	(3.9)		66.2	(18.0)		19.1	(5.7)	
Current	249.0	(17.9)		150.6	(13.8)		73.4	(10.6)		52.1	(5.1)		56.9	(9.9)		66.0	(21.1)	
Average monthly expenditure on caffeine products																		
None	108.8	(12.4)	<0.001	57.8	(9.7)	<0.001	54.9	(7.6)	<0.001	46.1	(14.1)	0.033	16.0	(4.8)	0.020	71.2	(29.4)	0.410
<\$30/month	114.5	(7.2)		73.8	(6.0)		39.0	(3.6)		26.8	(2.9)		29.1	(6.6)		26.1	(8.1)	
\$30–59/month	197.7	(10.2)		119.7	(8.6)		45.0	(4.0)		40.7	(3.4)		50.2	(8.3)		49.8	(11.5)	
\$60–99/month	268.9	(23.3)		166.9	(20.0)		76.8	(14.2)		43.4	(6.0)		34.3	(7.3)		27.9	(8.7)	
≥ \$100/month	297.7	(24.4)		194.1	(18.7)		95.2	(17.0)		47.2	(5.7)		47.5	(13.6)		44.8	(25.4)	
% of Energy drinks with alcohol																		
0% (none)	176.0	(11.4)	<0.001	108.5	(10.5)	0.188	51.2	(5.3)	0.087	38.1	(3.6)	0.595	28.4	(3.9)	0.040	30.8	(7.6)	0.825
1%–24%	228.7	(15.9)		125.2	(11.9)		56.8	(6.5)		39.7	(4.1)		57.1	(9.9)		54.5	(17.4)	
25–49%	239.9	(31.7)		154.0	(28.2)		27.3	(4.0)		53.6	(15.0)		44.1	(10.1)		49.9	(28.2)	
50%–100%	197.3	(25.2)		108.0	(13.9)		79.1	(22.1)		42.0	(7.2)		44.1	(15.4)		47.5	(18.8)	
Does not consume energy drinks	139.4	(6.3)		107.8	(6.2)		48.8	(3.6)		32.9	(3.9)		0	NA		44.5	(13.6)	

The bolded P values identify them as statistically significant ($P \leq 0.05$) values.

^a Includes hot cocoa and other caffeine-containing milk products, as well as gum, candy or medication.

^b P-values are for an overall Type 3 F-statistic derived from ANOVA with consumption of the given type of caffeine-containing product (in mg) as the dependent variable and the characteristic in the first column as a categorical independent variable. The sample for each model includes only those with some consumption of the specified type of caffeine, and each model is adjusted only for survey location (College 1 – College 5).

group of students in our survey composed of those aged 24 or less, like the general college population.

The current study is one of the first and largest to examine the relationship of caffeine intake from caffeine-containing products including energy drinks with a comprehensive set of demographic and lifestyle variables among U.S. college students. Like Dutch students [32], U.S. students surveyed consumed most of their

caffeine from coffee (males = 120.3 mg/d, females = 111.0 mg/d) and tea (males = 60.9 mg/d; females = 50.1 mg/d). Student daily consumption of caffeine from energy beverages was 53.2 mg/d for males and 30.0 mg/d for females. Soda was a significant source of caffeine (38.3 mg/d for males and 36.0 mg/d for females). The aggregate mean intake of caffeine from all sources by college students was well within levels considered to be acceptable by U.S.

Table 3

Multiple linear regression models to examine the association of daily caffeine consumption (mg/day) with selected sociodemographic and lifestyle factors, among consumers of caffeine and specified caffeine products.^a

Variable	All caffeine (N = 1130)		Coffee (N = 887)		Tea (N = 756)		Soda (N = 846)		Energy drinks (n = 449)	
	Estimate ^a (SE)	P	Estimate (SE)	P	Estimate (SE)	P	Estimate (SE)	P	Estimate (SE)	P
Male gender	-13.68 (13.27)	0.303	-10.11 (11.82)	0.393	12.23 (7.61)	0.108	2.44 (5.54)	0.659	10.25 (9.33)	0.273
Age (years)										
23+	95.35 (18.97)	<0.001	62.99 (16.32)	<0.001	32.18 (10.64)	0.003	1.90 (7.97)	0.811	40.03 (13.81)	0.004
20 to 22	10.26 (12.95)	0.428	12.64 (11.22)	0.260	-6.74 (7.05)	0.339	2.27 (5.44)	0.676	-3.21 (9.04)	0.723
18–19	Reference		Reference		Reference		Reference		Reference	
Race/ethnicity										
Non-hispanic black	-11.20 (23.20)	0.629	-30.91 (23.38)	0.186	29.25 (12.26)	0.017	3.23 (9.51)	0.734	3.54 (16.82)	0.833
Hispanic/latino	9.26 (20.98)	0.659	0.59 (17.70)	0.973	17.12 (11.76)	0.146	-6.74 (8.83)	0.446	10.76 (15.24)	0.481
Asian	-21.22 (21.41)	0.322	-28.85 (17.99)	0.109	2.48 (11.38)	0.828	-6.54 (9.20)	0.477	-2.98 (15.82)	0.851
Other	1.08 (27.50)	0.969	-16.55 (23.16)	0.475	38.65 (14.33)	0.007	-13.77 (12.54)	0.273	-15.42 (16.74)	0.358
Non-hispanic white	Reference		Reference		Reference		Reference		Reference	
Family income										
\$100,000 – \$200,000	-5.09 (21.29)	0.811	0.42 (18.38)	0.982	-20.17 (12.09)	0.096	2.83 (8.56)	0.741	-4.53 (14.93)	0.762
\$25,000 – \$99,999	-10.66 (20.59)	0.605	-29.71 (17.71)	0.094	-13.69 (11.76)	0.245	15.13 (8.29)	0.068	-2.97 (14.55)	0.838
< \$25,000	-19.04 (28.31)	0.501	-43.77 (24.67)	0.076	4.29 (16.01)	0.789	11.87 (11.74)	0.312	-3.88 (19.26)	0.840
>\$200,000	Reference		Reference		Reference		Reference		Reference	
General health										
Fair/poor	50.11 (25.59)	0.051	-9.83 (22.39)	0.661	6.74 (13.95)	0.629	37.64 (10.57)	<0.001	28.76 (17.90)	0.109
Good	26.33 (12.79)	0.040	12.51 (11.15)	0.262	3.09 (7.15)	0.665	10.98 (5.47)	0.045	6.95 (9.54)	0.467
Excellent	Reference		Reference		Reference		Reference		Reference	
Weight gain/lose										
Trying to lose wt.	13.67 (12.69)	0.282	-5.70 (10.96)	0.603	9.80 (7.04)	0.164	4.36 (5.35)	0.415	8.49 (9.03)	0.348
Trying to gain wt.	22.70 (21.75)	0.297	25.10 (20.41)	0.219	-16.97 (13.39)	0.206	12.62 (8.99)	0.161	23.56 (15.17)	0.121
Maintaining weight	Reference		Reference		Reference		Reference		Reference	
Tobacco use										
Current	96.72 (16.01)	<0.001	52.92 (13.69)	<0.001	21.90 (9.21)	0.018	13.10 (6.68)	0.050	22.01 (10.51)	0.037
Former	39.23 (18.19)	0.031	14.22 (15.33)	0.354	3.52 (9.88)	0.722	-2.80 (7.72)	0.717	26.79 (11.93)	0.025
Never	Reference		Reference		Reference		Reference		Reference	

The bolded P values identify them as statistically significant ($P \leq 0.05$) values.

^a All estimates are adjusted for the other variables shown in the table. Additionally, estimates are adjusted for site (college 1–5) and an indicator for those with unknown income.

Table 4

Reasons for caffeine use, caffeine users only (N = 1145).

Reason(s) for caffeine use ^a	Total N (%)
To feel more awake and alert	872 (78.5)
Enjoy the taste	752 (67.7)
Social aspects	434 (39.1)
To improve concentration	342 (30.8)
Increase physical energy	294 (26.5)
To improve mood	202 (18.2)
Alleviate Stress	102 (9.2)
Other Reason(s) ^b	46 (4.1)
To help lose weight	34 (3.1)
To improve creativity	28 (2.5)

^a Reasons are not mutually exclusive; therefore, percentages may add up to more than 100.

^b Other reasons given included “To get rid of headaches”, “Just happens to be in the drinks that I consume”, and “Morning ritual”.

government recommendations [33]. However, like the general population, some students consume more caffeine (over 400 mg per day) than has been advised by some authors [33–35]. Levels of safe or ‘optimal’ caffeine intake remain controversial, due to limited safety data and because research indicates consumption of caffeine may be beneficial both acutely and chronically [34–39]. A recent comprehensive systematic review of possible adverse effects of caffeine in all forms on the cardiovascular system, bone status, reproductive health and development, as well as behavior concluded that, for adults, caffeine intake of up to 400 mg per day did not pose any risk [35]. Wikoff and colleagues also concluded that consumption of up to 2.5 mg/kg per day of caffeine was safe for adolescent populations [35].

Energy drinks were first marketed in the U.S. in 1997, and recent data indicate annual energy drink and energy shot sales increased from approximately \$8 billion in 2011 to over \$13 billion in 2015

[40]. Common reasons reported by college students for seeking caffeine from energy drinks include increasing energy or counteracting insufficient sleep, to improve exercise performance and to study [41,42]. However, in this study we assessed reasons for use of caffeine in general not energy drinks alone. Several recent papers have addressed the safety of energy drinks and raised concerns regarding excessive consumption of these products by adolescents and adults [43,44].

Although the age range in the present sample was small, caffeine use significantly increased with age, consistent with reports that caffeine consumption is greatest amongst individuals 45–60 years of age [17]. In this study, women consumed more caffeine from ‘other’ products such as cocoa than men, while men consumed more caffeine from energy drinks, coffee and tea. Despite gender differences in consumption of these sources of caffeine, men and women did not differ in total daily caffeine intake. Norton and colleagues [13] also did not find gender difference in caffeine consumption among college students.

Smokers reported consuming more caffeine in general, as well as coffee, soda and energy drinks than non-smokers. Higher caffeine intake among smokers than non-smokers is well-documented [45–47]. Physiological, cognitive and environmental factors all may contribute to the association between smoking and caffeine intake. Nicotine use increases the rate of caffeine metabolism; as a consequence, smokers must consume caffeine more frequently than non-smokers to maintain the same internal (e.g. plasma) levels. Other factors, such as stress, could have similar effects on use of both caffeine and nicotine leading to increased use of both [48].

A variety of other factors may also be associated with caffeine intake. For example, in the general population race is strongly associated with overall caffeine intake, with non-Hispanic Whites consuming the most caffeine and non-Hispanic Blacks consuming

the least [1,12,49]. Among the college students we studied non-Hispanic Blacks did consume less caffeine than whites but the difference was smaller than is observed in the general population and not statistically significant.

Limited data are available on the reasons individuals choose to use caffeine-containing products. Among the college students we surveyed, many reported using caffeine-containing products to enhance some aspect of mood or performance such as to feel more awake (79%), improve concentration (31%), increase physical energy (27%), improve mood (18%) and alleviate stress (9%). Numerous research studies assessing cognitive performance, physical performance and mood after caffeine administration corroborate these self-reported observations [2, 50, 51]. Jeffers et al. [14] reported that energy drink users were more likely to be attempting to lose weight. However, we found that aggregate use of caffeine was significantly associated with weight loss but not specifically energy drink use.

There are some limitations to this study. Self-reported data are always subject to various types of biases, such as recall bias. In addition, this study was limited to five colleges, although previous studies typically only survey one [41]. The survey is based on a convenience sample that, while similar, was not representative of the U.S. college population. It should also be noted that due to the methods used to recruit volunteers it was not possible to calculate response rate.

5. Conclusions

Among all the college undergraduates surveyed, per capita caffeine consumption averaged 159 mg/d and was 173 mg/d for individuals who were regular users of caffeine. Most consumers of caffeine-containing products reported using them to enhance mood and performance. Most caffeine was consumed in the form of coffee and tea, not energy drinks. Thirty-six percent of students reported consuming energy drinks, with non-smokers, women and individuals who perceive themselves to be in better health consuming fewer energy drinks than smokers, men and those perceiving themselves to be in poorer health.

Conflict of interest

None.

Acknowledgements

The views, opinions and findings in this report are those of the authors and should not be construed as an official Department of Defense policy, or decision, unless so designated by other official documentation. Citations of commercial organizations and trade names in this report do not constitute an official Department of the Army endorsement or approval of the products or services of these organizations. The investigators have adhered to the policies for protection of human subjects as prescribed in DOD Instruction 3216.02 and the project was conducted in adherence with the provisions of 32 CFR Part 219. This work was supported by the Defense Medical Research and Development Program (DMRDP) and US Army Medical Research and Materiel Command (USAMRMC). The authors have no conflicts of interest to declare.

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