Caffeine consumption and self-assessed stress, anxiety, and depression in secondary school children

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Abstract
Previous research suggests that effects of caffeine on behaviour are positive unless one is investigating sensitive groups or ingestion of large amounts. Children are a potentially sensitive subgroup, and especially so considering the high levels of caffeine currently found in energy drinks. The present study used data from the Cornish Academies Project to investigate associations between caffeine (both its total consumption, and that derived separately from energy drinks, cola, tea, and coffee) and single-item measures of stress, anxiety, and depression, in a large cohort of secondary school children from the South West of England. After adjusting for additional dietary, demographic, and lifestyle covariates, positive associations between total weekly caffeine intake and anxiety and depression remained significant, and the effects differed between males and females. Initially, effects were also observed in relation to caffeine consumed specifically from coffee. However, coffee was found to be the major contributor to high overall caffeine intake, providing explanation as to why effects relating to this source were also apparent. Findings from the current study increase our knowledge regarding associations between caffeine intake and stress, anxiety, and depression in secondary school children, though the cross-sectional nature of the research made it impossible to infer causality.

Introduction

Dose-dependent effects of caffeine on behaviour

Short-term effects of caffeine consumption include enhanced mood and alertness (Ferré, 2008; Kaplan et al., 1997; Lorist and Tops, 2003), improved exercise performance (Doherty and Smith, 2004), increased blood pressure (Riksen et al., 2009), improved ability to remain awake and mentally alert after fatigue (Smit and Rogers, 2002), faster information processing speed and reaction time, and heightened awareness and attention (Cysneiros et al., 2007). When consumed in moderation it appears that there are no serious adverse health effects associated with its use by adults (Nawrot et al., 2003) or children (Higdon and Frei, 2006; Mandel, 2002). However, it has been advised that those who are highly sensitive should not consume >400 mg/d, in order to avoid headaches, drowsiness, anxiety, and nausea (Nawrot et al., 2003). A sensitive individual might experience adverse effects at a lower dose than less sensitive individuals. Children are often considered as sensitive individuals because of their size and developing central nervous system. This is concerning because many children and adolescents are frequent caffeine consumers (for instance, a recent US study found 73% of children to consume caffeine on a given day; Branum et al., 2014). It is important, therefore, to identify thresholds above which negative effects might occur. In the context of the current study, the thresholds in question relate to the group as a whole, with potential sensitivity to caffeine being defined by the participants being children.

The relatively recent introduction of 'energy drinks' to the consumer market has been highlighted as a cause for concern (e.g. Reissig et al., 2009). Energy drinks are soft drinks that manufacturers claim boost performance and endurance (Meadows-Oliver and Ryan-Krause, 2007), with the main active ingredient being caffeine (McLellan and Lieberman, 2012). These products are often strategically marketed towards the young consumer (Reissig et al., 2009), with 30–50% of adolescents and young adults now known to consume them (Seifert et al., 2011). Energy drinks have also been associated with behavioural problems (Richards et al., 2015a), and a number of serious health complications (Reissig et al., 2009).

A potential avenue by which energy drink use may negatively affect health is through their association with risk-taking behaviours (see Arria et al., 2014). Miller (2008a), for instance, reported that the frequency of energy drink consumption in US

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undergraduates was positively associated with smoking, drinking, alcohol problems, use of illicit prescription drugs and marijuana, sexual risk-taking, fighting, seatbelt omission, and taking risks on a dare. However, it should be noted that such effects might also be explainable by personality characteristics of high users of energy drinks (for example, adherence to a 'toxic jock' identity; Miller, 2008b), rather than necessarily to the products themselves.

Another potential route that energy drinks may negatively affect health is through caffeine's capacity to disrupt sleep. Energy drink use has been associated with daytime sleepiness and weekly 'jolt and crash' episodes (Kristjánsson et al., 2011; Malinauskas et al., 2007), though the products also appear to be used to counter the effects of insufficient sleep (Malinauskas et al., 2007). Although findings such as these may implicate energy drinks in particular, Kristjánsson et al. (2013) have reported that caffeine consumption itself is positively associated with self-reported violent behaviour and conduct disorder. Furthermore, James et al. (2011) observed a strong inverse relationship between caffeine intake and academic attainment, 32% of which was explained by mediating effects of daytime sleepiness and other licit substance use. Due to findings such as these it is considered to be of particular importance to investigate the effects of caffeine from difference sources, as well as its overall intake.

Associations between caffeine intake and stress, anxiety, and depression

The consumption of caffeinated beverages is known to be a coping strategy used by college students in the management of stressful academic situations (Lazarus, 1993; Thoits, 1995), with 49% of a representative stratified sample of Puerto Rican students reporting caffeinated products to be useful for coping with stress (Ríos et al., 2013). Pettit and DeBarr (2011) have also reported a positive relationship between energy drink consumption and perceived stress levels in undergraduate students. Though the use of caffeine is moderately related to a range of psychiatric and substance use disorders in the general population, the relationships appear not to be causal (Kendler et al., 2006), and results between studies are equivocal (for a review of the area see Lara, 2010). Discerning the nature and direction of relationships between such variables becomes even more difficult when considering the self-medication hypothesis (e.g. Khantzian, 1997). The idea here is that people may self-medicate with legal and/or illicit substances, with evidence having already been provided to suggest that some individuals with mental health problems use caffeinated energy drinks for such purposes (Chelben et al., 2008).

In some cases positive effects of caffeine have been observed. For instance, low doses have been shown to reduce anxiety and elevate mood (Haskell et al., 2005; Lieberman et al., 1987, 2002; Smith, 2009a; Smith et al., 1999). Smith (2009b) also reported that caffeine consumption was associated with reduced risk of depression compared with non-consumption in a population study.

Negative effects of caffeine on stress and mental health have also been observed. Gilliland and Andress (1981), for instance, reported higher anxiety levels in moderate and high caffeine consumers compared with abstainers in a student sample. Case reports also suggest that mania can be induced by a high intake of caffeine (Ogawa and Ueki, 2003) or energy drinks (Sharma, 2010). These results are supported by the finding of Kaplan et al. (1997), that 250 mg of caffeine can increase elation in healthy volunteers, whereas 500 mg increases irritability. Other studies, however, have reported null findings. James et al. (1989), for instance, found no relationships between caffeine intake and anxiety or depression in medical students.

In the general population, negative effects of caffeine are usually observed in relation to excessive intake. At extremely high doses its consumption can induce a condition known as 'caffeinism'. Symptoms include anxiety, nervousness, restlessness, insomnia, excitement, psychomotor agitation, dysphoria, and a rambling flow of thoughts and speech (Gilliland and Andress, 1981; Greden, 1974), which have been considered to mimic a clinical picture known as 'mixed mood state' (Lara, 2010).

Larger effects of caffeine seem to occur in sensitive individuals, with psychiatric patients appearing to make up one such group. Higher sensitivity to the anxiogenic effects of high doses (typically >400 mg), for instance, has been observed in patients with panic disorder (Boulenger et al., 1984; Charney et al., 1985), generalised panic disorder (Bruce et al., 1992), and to a lesser extent, depression (Lee et al., 1988). Similar findings have also been made in patients with performance social anxiety disorder (though not generalised social anxiety disorder; Nardi et al., 2009), and excessive intake may interfere with the recovery of patients with bipolar disorder and manic-type mood episodes (Caykoylu et al., 2008; Dratcu et al., 2007; Tondo and Rudas, 1991).

Another potentially sensitive subgroup is that of young consumers. Certain psychiatric symptoms appear to occur at an alarming rate in this group. For example, the prevalence of major depressive disorder is known to range from 0.4% to 8% in adolescents (Birmaher et al., 1996; Fleming and Offord, 1990; Roberts et al., 1995), with approximately 30% reporting at least one current symptom of a major depressive episode (Roberts et al., 1995). Depressive symptoms have also been found to correlate positively with coffee consumption in middle- and high-school students (Fulkerson et al., 2004), and positive associations with the Children's Depression Inventory have been reported in both children and adolescents (Luebbe and Bell, 2009). However, as with research in adults, some studies have also reported null findings. Luebbe and Bell (2009), for instance, found no relationship between anxiety and caffeine in children and adolescents.

Aims of the current research

The general lack of research relating to the effects of caffeine on stress, anxiety, and depression in children is an area that the current paper will try to address. In order to do this, the Diet and Behaviour Scale (DABS; Richards et al., 2015b), a measure of intake of food and drinks (including caffeinated products) that may affect psychological outcomes, was administered to a large cohort of secondary school children from the South West of England. The current paper used the DABS for two purposes: (1) to provide estimates of weekly caffeine intake from energy drinks, cola, tea, and coffee, and (2) so that additional aspects of diet could be controlled for in multivariate analyses.

Along with the DABS, single-item measures of self-assessed stress, anxiety, and depression were administered. Single items were chosen as they have been shown to be valid and reliable,

allowing for the identification of overall risk whilst reducing the time costs associated with administering multi-item measures (Williams and Smith, 2012). The items themselves came from the Wellbeing Process Questionnaire (Williams, 2014), have been validated against full measures, demonstrated to correlate well, and appear to be as sensitive as the full-length measures with which they were compared (Williams, 2015; Williams and Smith, 2013).

It was hypothesised that high consumption of caffeine would be associated with high stress, anxiety, and depression, and that such relationships would not be dependent on the source from which caffeine was obtained. However, as no interventions were conducted, and data presented here are only cross-sectional in nature, it should be acknowledged that it is not possible to infer causality or the direction of relationships observed.

Method

The Cornish Academies Project was a large-scale longitudinal programme of research designed to investigate dietary effects on school performance, general health, and stress, anxiety, and depression in secondary school children. Two cross-sections of data were collected from three academies in the South West of England. The first cross-section (T1) was collected 6 months prior to the second (T2). The current paper presents analyses using data from the latter cross-section only, as information relating to stress, anxiety, and depression were not collected at the former.

Participants

In total, 3071 secondary school pupils were asked to take part in the Cornish Academies Project at T1; 2610 (85%) agreed to participate. At T2, the cohort consisted of 3323 pupils, and 2307 completed the questionnaires. A relatively balanced sex ratio (48.5% male, 51.5% female), and an age range of 11–17 (M = 13.6, SD = 1.49) were observed (for a more detailed description of the sample see Richards et al., 2015b).

Apparatus/materials

The DABS (Richards et al., 2015b) is a 29-item questionnaire developed for the purpose of assessing intake of common dietary variables with an onus on functional foods, and foods and drinks of current concern. The DABS contains 18 questions that assess frequency of consumption on a five-point scale (1 = never, 2 = once a month, 3 = once or twice a week, 4 = most days [3–6], 5 = every day), and 11 questions to assess amounts typically consumed. It has been associated with a four-factor structure in secondary school children labelled Junk Food, Caffeinated Soft Drinks/Gum, Healthy Foods, and Hot Caffeinated Beverages (see Richards et al., 2015b).

Because caffeine content is known to vary considerably between energy drink products (Reissig et al., 2009), participants were asked to state the brand names of those that they consumed. This measure was included in order to increase the accuracy of estimating caffeine consumption. In addition to this, as diet may reflect general lifestyle (e.g. Akbaraly, 2009), five further questions were administered. Three items were used to gauge exercise

frequency (mildly energetic, moderately energetic, and vigorous), with answers being given on a four-point scale (1 = three times a week or more, 2 = once or twice a week, 3 = about once to three times a month, 4 = never/hardly ever). In addition to this, participants were asked to state how many hours per night they typically spent asleep, and to give an indication of how good they perceived their general health to have been over the previous 6 months (1 = very good, 2 = good, 3 = fair, 4 = bad, 5 = very bad). Participants were then asked to state how frequently they had experienced stress, anxiety, and depression over the previous 6 months, on a five-point scale (1 = not at all, 2 = rarely, 3 = sometimes, 4 = frequently, 5 = very frequently), though no clinical evaluations were made. No further descriptions of 'stress', 'anxiety', or 'depression' were provided as it was assumed that participants would understand the concepts at hand.

Design and procedure

Schoolteachers administered the DABS as well as the lifestyle, stress, anxiety, and depression questions to the pupils at their respective academies. Demographic information was acquired through the School Information Management System (SIMS) and stored in a confidential database in Cardiff. This information included age, sex, school attendance, number of detentions/behavioural points received, English and maths attainment at Key Stage 3/Key Stage 4, school year, ethnicity, presence/absence of a special educational needs (SEN) status, eligibility/ineligibility to receive free school meals (FSM; a proxy indication of socioeconomic status; Shuttleworth, 1995), whether or not English was spoken as an additional language, and whether or not children were cared for by a non-parental guardian.

All questionnaire and demographic data were anonymised prior to being merged into a single database. Ethical clearance was granted by Cardiff University's School of Psychology Ethics Committee, and informed consent was acquired from all participants (as well as their parents) before data were collected. All data analysis was conducted using IBM SPSS Statistics Version 20.

Statistical analysis

The representativeness of the sample was investigated by comparing SIMS data for those who completed the questionnaires with that of those who did not, though frequency data relating to stress, anxiety, and depression are not provided here because they have already been reported elsewhere (see Richards and Smith, 2015). Weekly caffeine consumption was calculated from the DABS items used to measure the amount of consumption of energy drinks, cola, tea, and coffee. Linear-by-linear trends were then investigated between total weekly caffeine intake and stress, anxiety, and depression, and were followed up with binary logistic regression analyses (using the 'enter' method), so that additional variance from diet, demography, and lifestyle could be controlled for statistically. In order to investigate interactions between caffeine use and sex, multivariate analyses were conducted for males and females separately. It was also deemed important to examine the effects of each individual source of caffeine (i.e. that consumed specifically from energy drinks, cola, tea, and coffee). As with the analyses of total weekly caffeine intake, these effects were initially investigated using linear-by-linear trends, and then

with binary logistic regression to control for additional covariates (though in this instance separate analyses were not conducted for males and females).

Results

Demographic and lifestyle variables

Considerable variance in demographic background and lifestyle was observed within the sample; for frequency data, see Table 1. Participants' average number of sleep hours and frequency of exercise (a single-factor analysed variable derived from items measuring mild, moderate, and vigorous exercise) that are used as control variables in the current study have been described elsewhere (see Richards et al., 2015b).

Representativeness of the sample

A relatively high response rate of 88.4% was observed for completion of the DABS. To investigate how representative the sample was in reference to the academies from which it came, Chi-square tests were conducted to determine if SIMS data for those who completed the DABS differed from SIMS data of those that did not. It should be noted that a similar analysis presented in Richards et al. (2015b) relates to T1 from the Cornish Academies Project, whereas that presented here relates to T2.

It was found that the academy a pupil came from was significantly related to their likelihood of responding to the questionnaires, with Academy 1 and Academy 3 providing fewer respondents, and Academy 2 providing more respondents, than expected, $\chi2$ (2, N = 3323) = 241.172, p < .001. The school year that a participant came from was also related to their likelihood of completing the questionnaires, $\chi2$ (4, N = 3049) = 34.681, p < .001. A significant linear-by-linear association was observed, with the likelihood of responding being negatively associated with school year, $\chi2$ (1, N = 3049) = 30.245, p < .001. Children with a SEN status were also less likely to answer the questionnaire, $\chi2$ (1, N = 3083) = 23.142, p < .001, as were children who were eligible to receive FSM, $\chi2$ (1, N = 3049) = 25.116, p < .001.

Associations between total weekly caffeine intake and stress, anxiety, and depression

Univariate associations between total weekly caffeine intake and stress, anxiety, and depression. Single items from the DABS were used to estimate weekly caffeine intake, with the following values being assigned: cup of coffee (80 mg), cup of tea (40 mg), can of cola (25 mg), can of energy drink (133 mg). The values used for coffee, tea, and cola, were based on updated versions of those reported by Brice and Smith (2002), which were themselves based on values provided by Barone and Roberts (1996) and Scott et al. (1989); the value used for energy drinks was the mean caffeine content of the three brands most commonly reported by the current sample (which together accounted for 53.2% of all cases). Caffeine totals consumed from coffee, tea, energy drinks, and cola were then added together to create a variable for total weekly consumption. It was found that caffeine intake was higher in males than females, both in total amount, as well as in that consumed from energy drinks, cola,

Table 1. Frequency information for demographic variables.

		N	*%*
Academy	1	971	29.2%
	2	1375	41.4%
	3	977	29.4%
School year	7	573	18.8%
	8	602	19.7%
	9	618	20.3%
	10	616	20.2%
	11	640	21%
Sex	Male	1018	48.5%
	Female	1079	51.5%
SEN status	Yes	899	29.2%
	No	2184	70.8%
Eligible for FSM	Yes	398	13.1%
	No	2651	86.9%
Ethnicity	White	2946	97.2%
	Not white	84	2.8%
English as additional language	Yes	51	1.7%
	No	2868	98.3%
Non-parental guardian	Yes	17	.6%
	No	2909	99.4%

and coffee (though there was no difference regarding caffeine consumed from tea; for descriptive statistics, see Table 2). Total weekly caffeine was subsequently recoded into a categorical variable consisting of the following six consumption groups: 0 mg/w, 0.1–250 mg/w, 250.1–500 mg/w, 500.1–750 mg/w, 750.1–1000 mg/w, >1000 mg/w.

Self-assessed stress, anxiety, and depression were all found to be significantly higher in females compared with males (for descriptive statistics, see Table 2). The single-item measures were then dichotomised, with those answering with 1 or 2 ('not at all' or 'rarely' experienced stress, anxiety, or depression) making up the above average mental health group, and those answering with 3, 4, or 5 ('sometimes', 'frequently', or 'very frequently' experienced stress, anxiety, or depression) making up the below average mental health group.

Linear-by-linear associations were investigated between the dichotomous variables for stress, anxiety, and depression, and the categorical variable created from total weekly caffeine intake. The analysis found the >1000 mg/w condition to be associated with high stress, anxiety, and depression. In addition to this, consuming 0.1–250 mg/w was associated with low stress, and non-consumption was associated with low depression, though the latter effect was not significant. For linear-by-linear associations and cross-tabulations between total weekly caffeine intake and stress, anxiety, and depression, see Table 3.

Multivariate associations between total weekly caffeine intake and stress, anxiety, and depression. The analyses described in the previous section indicate that being a very high consumer of caffeine is a predictor of high levels of stress, anxiety, and depression. It was therefore deemed important to further investigate such effects at the multivariate level, so that additional variance could be controlled for statistically. In order to do this, binary logistic regression analyses (using the 'enter' method)

Table 2. Descriptive statistics and sex differences for self-reported stress, anxiety and depression, and weekly caffeine intake as calculated from the DABS.

		Overall			Males			Females			Sex difference		
		N	M	SD	N	M	SD	N	M	SD	t	df	p
Mental health	Stress	2249	2.88	1.08	984	2.67	1.07	1060	3.08	1.05	−8.7	2024.191	< .001
	Anxiety	2239	2.43	1.05	979	2.16	1	1058	2.66	1.05	−10.89	2033.779	< .001
	Depression	2237	2.17	1.15	980	1.97	1.06	1054	2.34	1.19	−7.411	2028.44	< .001
Caffeine intake (mg/w)	Total	2200	421.77	550	963	467.34	557.01	1033	364.99	512.84	4.262	1948.766	< .001
	Energy drinks	2254	123.74	246.99	989	158.69	270.54	1055	89.51	223.12	6.284	1918.455	< .001
	Cola	2253	36.7	55.52	991	41.45	60.31	1053	32	49.49	3.857	1917.632	< .001
	Coffee	2265	113.77	322.51	996	130.6	348.42	1061	92.97	278.13	2.696	1902.424	.007
	Tea	2267	152.32	261.65	996	142.49	241.87	1063	155.6	266.93	−1.165	2057	.244

Table 3. Cross-tabulations between total weekly caffeine intake and stress, anxiety, and depression.

			0 mg/w	0.1–250 mg/w	250.1–500 mg/w	500.1–750 mg/w	750.1–1000 mg/w	>1000 mg/w
Stress	Low	Count	81	342	165	89	42	66
		Expected count	81.6	318.5	166.9	88.2	44.8	84.9
		Column %	36.2%	39.1%	36%	36.8%	34.1%	28.3%
		Adjusted residual	−.1	2.1	−.2	.1	−.5	−2.7
	High	Count	143	532	293	153	81	167
		Expected count	142.4	555.5	291.1	153.8	78.2	148.1
		Column %	63.8%	60.9%	64%	63.2%	65.9%	71.7%
		Adjusted residual	.1	−2.1	.2	−.1	.5	2.7
		Linear-by-linear	6.599, p = .01					
Anxiety	Low	Count	134	519	258	143	75	110
		Expected count	128.7	502.9	262.7	139.1	71	134.5
		Column %	60.1%	59.6%	56.7%	59.3%	61%	47.2%
		Adjusted residual	.8	1.4	−.5	.5	.7	−3.4
	High	Count	89	352	197	98	48	123
		Expected count	94.3	368.1	192.3	101.9	52	98.5
		Column %	39.9%	40.4%	43.3%	40.7%	39%	52.8%
		Adjusted residual	−.8	−1.4	.5	−.5	−.7	3.4
		Linear-by-linear	6.976, p = .008					
Depression	Low	Count	158	574	308	157	77	131
		Expected count	146.1	569.5	300.1	157.3	80.6	151.4
		Column %	70.9%	66.1%	67.2%	65.4%	62.6%	56.7%
		Adjusted residual	1.8	.4	.9	.0	−.7	−3
	High	Count	65	295	150	83	46	100
		Expected count	76.9	299.5	157.9	82.7	42.4	79.6
		Column %	29.1%	33.9%	32.8%	34.6%	37.4%	43.3%
		Adjusted residual	−1.8	−.4	−.9	.0	.7	3
		Linear-by-linear	9.101, p = .003					

Note. Mean weekly caffeine intake for each consumption group was as follows: 0 mg M = 0 mg (SD = 0), 0.1–250 mg/w M = 117.83 (SD = 69.32), 250.1–500 mg/w M = 355.94 (SD = 70.61), 500.1–750 mg/w M = 616.37 (SD = 69.99), 750.1–1000 mg/w M = 865.09 (SD = 72.71), >1000 mg/w M = 1651.74 (SD = 750.33).

were conducted upon the dependent variables of stress, anxiety, and depression. The same categorical variable for total weekly caffeine intake described in the previous section was used, and the non-consumption group was set as the comparison. The additional covariates entered were diet (the DABS subscale scores for Junk Food and Healthy Foods; Caffeinated Soft Drinks/Gum and Hot Caffeinated Beverages were not entered as they were comprised of caffeinated products; for a description of these variables see Richards et al., 2015b), demography (sex, school, school year, presence/absence of a SEN status, and the eligibility/ineligibility to receive FSM), and lifestyle (sleep hours, exercise frequency, and school attendance). It was, however, deemed inappropriate to attempt to control for ethnicity, whether English was spoken as an additional language, and whether or not the child was cared for by a non-parental guardian, due to the numbers present in the minority groups being particularly small.

After controlling for covariates, the overall effect of caffeine on stress was not significant, Wald = 6.252, *p* = .283, and none of the consumption groups differed from the non-consumption group. However, total weekly caffeine intake remained a significant predictor of anxiety, Wald = 12.39, *p* = .03. This effect reflected increased risk of high anxiety occurring in the >1000 mg/w group, though none of the other conditions differed significantly from the non-consumers. For odds ratios and 95% confidence intervals for the multivariate association between total weekly caffeine intake and anxiety, see Figure 1.

The effect of caffeine on depression also remained significant after controlling for covariates, Wald = 14.682, *p* = .012. In this case increased risk was associated with each of the consumption groups compared with the non-consumers (though the effect relating to the 250.1–500 mg/w group was only marginally significant, and the effect relating to the 500.1–750 mg/w group was not significant). For odds ratios and 95% confidence intervals for the multivariate associations between caffeine and depression, see Figure 2.

Sex differences in associations between total weekly caffeine intake and stress, anxiety, and depression. Due to the large sample size available, and because sex differences in responses to caffeine in adolescents have been reported (e.g. Temple and Ziegler, 2011), it was deemed meritorious to investigate interactions between sex and caffeine intake. To do this, the same methodology outlined in the previous section was used (i.e. binary logistic regression analyses were conducted, and the same covariates were entered), except that the caffeine*sex interaction term was included instead of the main effects of caffeine and sex. Significant interactions were observed for each of the outcome variables: stress, Wald = 31.927, *p* < .001, anxiety, Wald = 50.341, *p* < .001, depression, Wald = 45.038, *p* < .001.

In order to further investigate the interactions between sex and caffeine intake on stress, anxiety, and depression, separate multivariate analyses were conducted in males and females. The overall effect of caffeine on stress was not significant in males, Wald = 5.193, *p* = .393, or females, Wald = 4.243, *p* = .515, though males who consumed >1000 mg/w were marginally more likely to report high stress compared with controls, OR = 1.891, 95% CI [.943, 3.792], *p* = .073. The effect of caffeine on anxiety was not significant in females, Wald = 8.307, *p* = .14, and none of the consumption groups differed significantly from the control. In males, however, the effect was significant, Wald = 13.186, *p* = .022. This reflected increased risk of high anxiety in the 0.1–250 mg/w, 250.1–500 mg/w, and >1000 mg/w conditions, with the effect being most apparent in the last condition. For odds ratios and 95% confidence intervals for the multivariate association between total weekly caffeine intake and anxiety in males see Figure 3.

The overall effect of caffeine on depression in males was not significant, Wald = 7.882, *p* = .163. However, each caffeine consumption group was associated with increased risk compared with the control (though the effect relating to the 500.1–750 mg/w group was only marginally significant, and the effect in the 750.1–1000 mg/w condition was not significant). The overall effect in females was significant, Wald = 13.137, *p* = .022, and reflected increased risk in both the 750.1–1000 mg/w and >1000 mg/w groups. For odds ratios and 95% confidence intervals for the multivariate associations between total weekly caffeine
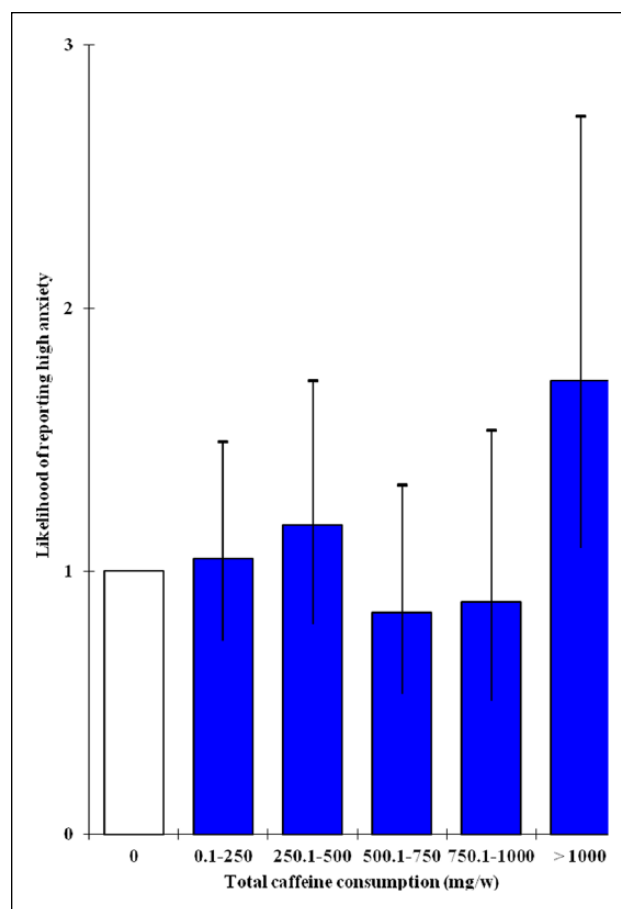

Figure 1. Odds ratios and 95% confidence intervals for multivariate associations between total weekly caffeine intake and anxiety.

intake and depression in males and females, see Figures 4 and 5, respectively.

Associations between individual caffeine sources and stress, anxiety, and depression

Univariate associations between individual caffeine sources and stress, anxiety, and depression. In order to determine whether the source of caffeine was important regarding the relationships reported in the previous section, caffeine from energy drinks, cola, tea, and coffee were recoded into three groups (non-consumption, low consumption, and high consumption), and linear-by-linear associations were investigated in relation to stress, anxiety, and depression. Because the distributions were skewed, the cut-off points to define what constituted 'low consumption' and 'high consumption' were determined in a manner that assigned relatively balanced numbers of participants to each group. These distinctions are shown in Table 4; essentially 'low consumption' related to one can of energy drink, one can of cola, two cups of coffee, and three cups of tea per week, and 'high consumption' related to any values in excess of these.

Caffeine consumed from energy drinks and tea was not associated with stress, anxiety, or depression. Interestingly, although
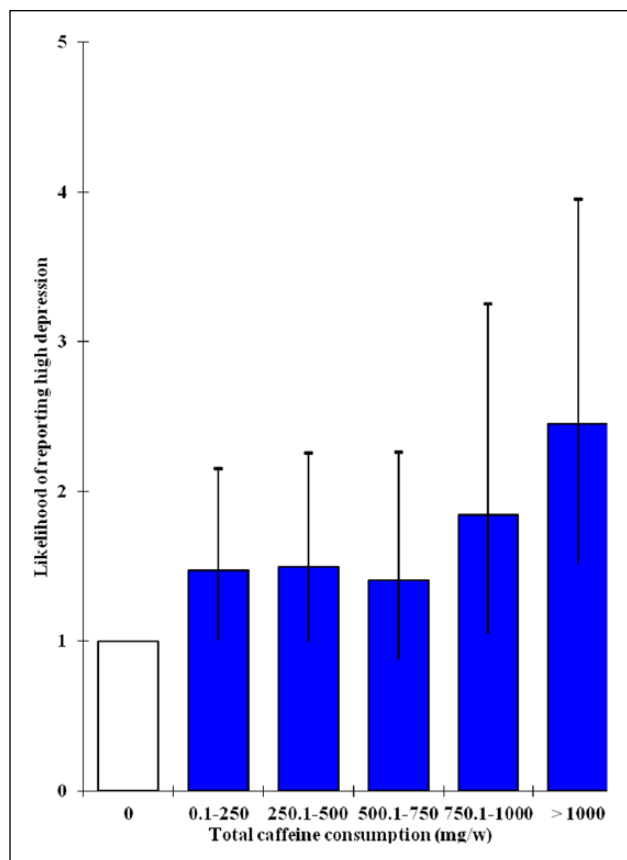
Figure 2. Odds ratios and 95% confidence intervals for multivariate associations between total weekly caffeine intake and depression.

Figure 3. Odds ratios and 95% confidence intervals for multivariate associations between total weekly caffeine intake and anxiety in males.

consumption of caffeine from cola was not associated with anxiety or depression, its non-consumption was associated with high stress levels, and being a low consumer was associated with low stress levels.

Positive linear relationships were observed between caffeine consumption from coffee and stress, anxiety, and depression (for linear-by-linear associations and cross-tabulations between stress, anxiety, and depression, and caffeine consumed from individual sources, see Table 4). However these associations are likely explained by coffee being the major contributor to high overall caffeine intake. This is reflected in the observation that those above the median for caffeine intake from coffee consumed more total caffeine than did those above the median for each of the other sources: caffeine from coffee low $M = 261.42$ ($SD = 331.82$), high $M = 827.65$ ($SD = 748.51$); caffeine from energy drinks low $M = 247.63$ ($SD = 382.38$), high $M = 674.24$ ($SD = 649.38$); caffeine from tea low $M = 225.97$ ($SD = 365.43$), high $M = 640.55$ ($SD = 633.11$); caffeine from cola low $M = 295.12$ ($SD = 448.63$), high $M = 486.88$ ($SD = 585$).

Multivariate associations between individual caffeine sources and stress, anxiety, and depression. In order to further investigate associations between caffeine from different sources and stress, anxiety, and depression, the non-consumption/low consumption/high consumption variables for caffeine from energy drinks, cola, tea, and coffee were entered together
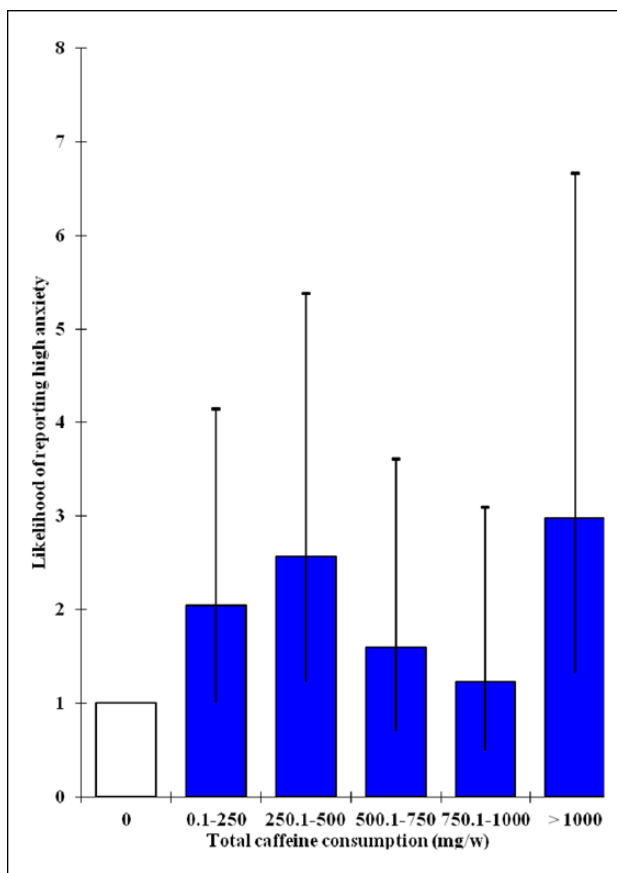
into binary logistic regression analyses using the 'enter' method. The same dietary, demographic, and lifestyle variables that were controlled for in the multivariate analyses of total weekly caffeine intake were again entered as covariates here.

Low consumption of caffeine from energy drinks was associated with high stress, though the overall effect was not significant. Both low and high consumption of caffeine from cola, on the other hand, were significantly associated with low stress. Low caffeine from energy drinks and high caffeine from coffee were both marginally associated with high anxiety, though neither effect was significant overall. Low consumption of caffeine from tea was associated with high depression, and the overall effect was significant. High caffeine consumption from coffee was also associated with high depression, though in this case the overall effect was not significant. For odds rations, 95% confidence intervals, and *p*-values for all multivariate level associations between individual caffeine sources and stress, anxiety, and depression, see Table 5.

Discussion

The current study aimed to present cross-sectional data from the Cornish Academies Project to investigate associations between caffeine consumption and stress, anxiety, and depression in secondary school children. Based on findings from the literature it was predicted that excessive caffeine intake would
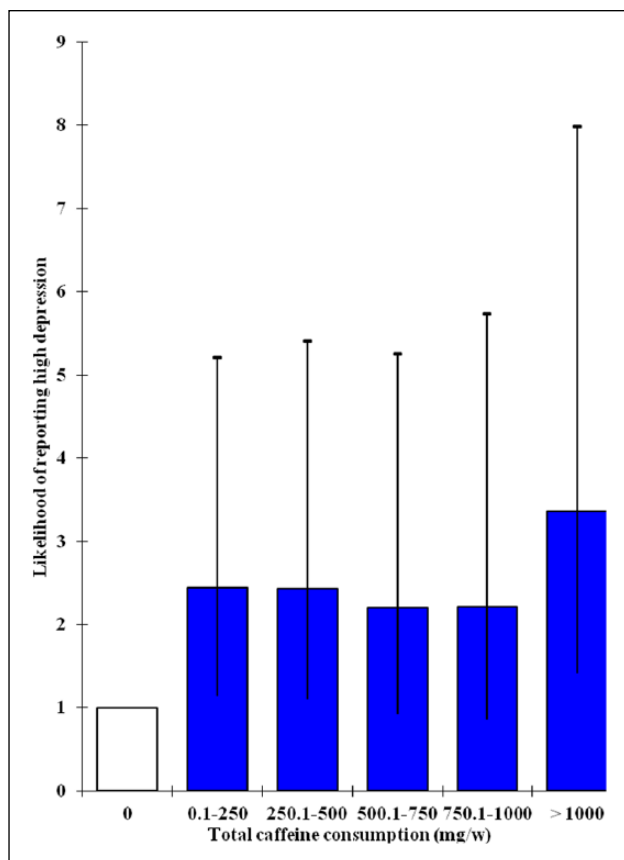
Figure 4. Odds ratios and 95% confidence intervals for multivariate associations between total weekly caffeine intake and depression in males.
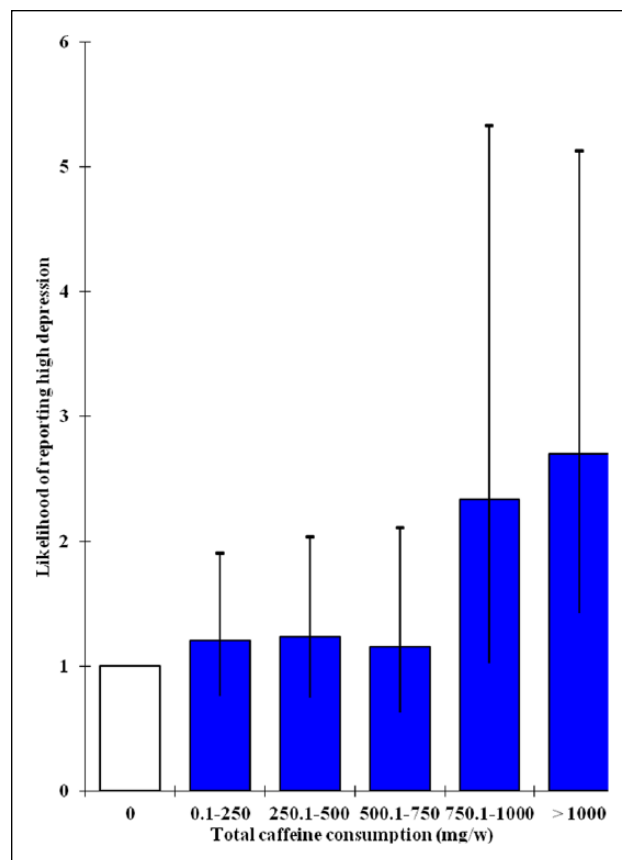

Figure 5. Odds ratios and 95% confidence intervals for multivariate associations between total weekly caffeine intake and depression in females.

be associated with high stress, anxiety, and depression, and that such effects would not be dependent on any particular source of caffeine. In addition to this, separate analyses were conducted in males and females in order to investigate interactions between caffeine and sex.

Relationships between total weekly caffeine intake and stress, anxiety, and depression

Initial positive relationships were observed between total weekly caffeine intake and stress, anxiety, and depression. After adjusting for dietary, demographic, and lifestyle covariates, the effect on stress disappeared. However, consuming >1000 mg/w remained a predictor of high anxiety, and caffeine consumption in general appeared to be associated with higher instances of depression compared with non-consumption (although the effect was also most pronounced in those who consumed >1000 mg/w).

Though the above findings mainly replicated those reported in adults (e.g. Gilliland and Andress, 1981; Pettit and DeBarr, 2011), the effects appeared to occur at lower doses, which is most likely a reflection of the lower bodyweight of children compared with adults. One finding that differed considerably from those made in adult populations was that of depression. Smith (2009b)

observed caffeine consumption to be beneficial compared with its abstinence, whereas the opposite pattern of results was observed here. This finding is therefore likely to highlight differences between the populations studied.

As significant interactions between total weekly caffeine intake and sex were observed in relation to each of the outcome variables, separate multivariate analyses were conducted for males and females. No association between caffeine and anxiety appeared in females; in males, higher instances of anxiety occurred in the 0.1–250 mg/w, 250.1–500 mg/w, and >1000 mg/w conditions, with the largest effect occurring in the last group. For depression, effects occurred in both males and females. In males, increased risk was associated with each group that consumed caffeine compared with non-consumers (though consuming 500.1–750 mg/w was only a marginally significant predictor, and consuming 750.1–1000 mg/w was not significantly related). In females, consuming either 750.1–1000 mg/w or >1000 mg/w was significantly associated with higher reporting of depression. These observations are consistent with other findings, such as caffeine having been shown to produce greater arousal effects in young males compared with females (Adan et al., 2008), and to have a higher propensity for reinforcement in adolescent males compared with females (Temple et al., 2009). Though it may be that male adolescents are more vulnerable to harmful effects of caffeine than are

Table 4. Cross-tabulations between weekly caffeine intake from energy drinks, cola, coffee, and tea, and stress, anxiety, and depression.

			Caffeine from energy drinks			Caffeine from cola			Caffeine from coffee			Caffeine from tea		
			0 mg	0.1–133 mg	>133 mg	0 mg	0.1–25 mg	>25 mg	0 mg	0.1–160 mg	>160 mg	0 mg	0.1–120 mg	>120 mg
Stress	Low	Count	493	164	145	245	295	266	602	110	94	333	227	248
		Expected count	476.6	175.6	149.8	275.7	272.4	257.8	576.3	110.5	119.2	335	216.3	256.7
		Column %	37.6%	34%	35.2%	32.5%	39.6%	37.7%	38%	36.2%	28.7%	36.2%	38.2%	35.2%
		Adjusted residual	1.5	–1.2	–.5	–2.9	2.1	.8	2.5	–.1	–3.1	–.2	1.1	–.8
	High	Count	818	319	267	509	450	439	984	194	234	587	367	457
		Expected count	834.4	307.4	262.2	478.3	472.6	447.2	1009.7	193.5	208.8	585	377.7	448.3
		Column %	62.4%	66%	64.8%	67.5%	60.4%	62.3%	62%	63.8%	71.3%	63.8%	61.8%	64.8%
		Adjusted residual	–1.5	1.2	.5	2.9	–2.1	–.8	–2.5	.1	3.1	.2	–1.1	.8
		Linear-by-linear	1.426, p = .232			4.477, p = .034			9.308, p = .002			.121, p = .728		
Anxiety	Low	Count	755	277	233	412	447	408	933	172	166	524	352	394
		Expected count	752.8	276.3	236	432.9	427.7	406.4	907.9	174.9	188.1	525.8	339.6	404.6
		Column %	57.7%	57.7%	56.8%	54.9%	60.3%	58%	59.1%	56.6%	50.8%	57.3%	59.6%	56%
		Adjusted residual	.2	.1	–.3	–1.9	1.8	.2	2.4	–.4	–2.7	–.2	1.2	–1
	High	Count	553	203	177	338	294	296	645	132	161	391	239	310
		Expected count	555.2	203.7	174	317.1	313.3	297.6	670.1	129.1	138.9	389.2	251.4	299.4
		Column %	42.3%	42.3%	43.2%	45.1%	39.7%	42%	40.9%	43.4%	49.2%	42.7%	40.4%	44%
		Adjusted residual	–.2	–.1	.3	1.9	–1.8	–.2	–2.4	.4	2.7	.2	–1.2	1
		Linear-by-linear	.081, p = .776			1.434, p = .231			7.62, p = .006			.196, p = .658		
Depression	Low	Count	864	316	255	497	491	447	1048	198	193	612	369	460
		Expected count	853.4	313.7	267.9	489.5	485.5	460	1029.5	197.6	211.9	597.8	384.4	458.8
		Column %	66.2%	65.8%	62.2%	66.4%	66.2%	63.6%	66.4%	65.3%	59.4%	66.8%	62.6%	65.4%
		Adjusted residual	1	.3	–1.5	.7	.5	–1.3	1.8	.1	–2.4	1.3	–1.6	.1
	High	Count	442	164	155	251	251	256	531	105	132	304	220	243
		Expected count	452.6	166.3	142.1	258.5	256.5	243	549.5	105.4	113.1	318.2	204.6	244.2
		Column %	33.8%	34.2%	37.8%	33.6%	33.8%	36.4%	33.6%	34.7%	40.6%	33.2%	37.4%	34.6%
		Adjusted residual	–1	–.3	1.5	–.7	–.5	1.3	–1.8	–.1	2.4	–1.3	1.6	–.1
		Linear-by-linear	1.805, p = .179			1.288, p = .257			5.164, p = .023			.465, p = .495		

Note. Caffeine amounts listed relate to weekly consumption.

Table 5. Multivariate associations between individual sources of caffeine and stress, anxiety, and depression.

	Caffeine source		OR	95% CI	p
Stress	Energy drinks	Low	1.377	1.051, 1.803	.02
		High	1.099	.804, 1.502	.555
		Wald	5.41, *p* = .067		
	Cola	Low	.721	.557, .935	.013
		High	.68	.517, .895	.006
		Wald	8.986, *p* = .011		
	Coffee	Low	.957	.705, 1.3	.779
		High	1.293	.93, 1.8	.127
		Wald	2.625, *p* = .269		
	Tea	Low	1.014	.784, 1.312	.915
		High	1.052	.818, 1.353	.693
		Wald	.159, *p* = .923		
Anxiety	Energy drinks	Low	1.259	.967, 1.638	.087
		High	1.05	.77, 1.43	.759
		Wald	3.008, *p* = .222		
	Cola	Low	.862	.669, 1.109	.248
		High	.83	.635, 1.085	.173
		Wald	2.151, *p* = .341		
	Coffee	Low	1.138	.842, 1.538	.401
		High	1.348	.988, 1.838	.059
		Wald	3.829, *p* = .147		
	Tea	Low	.944	.731, 1.217	.655
		High	.958	.75, 1.224	.731
		Wald	.231, *p* = .891		
Depression	Energy drinks	Low	.994	.756, 1.306	.964
		High	1.11	.811, 1.52	.516
		Wald	.449, .779		
	Cola	Low	1.184	.911, 1.539	.206
		High	1.227	.93, 1.619	.148
		Wald	2.443, *p* = .295		
	Coffee	Low	.931	.681, 1.273	.655
		High	1.369	1.001, 1.872	.049
		Wald	4.514, *p* = .105		
	Tea	Low	1.408	1.086, 1.825	.01
		High	1.104	.856, 1.422	.447
		Wald	6.809, *p* = .033		

females, these results may also reflect sexually dimorphic personality characteristics, or the observation that overall caffeine consumption in the current study was higher in males than in females.

When individual caffeine sources were investigated, negative effects were observed in relation to coffee, tea, and energy drinks, though they were not consistent across variables and often only marginally statistically significant. One relationship of particular interest was however observed: both low (0.1–25 mg/w) and high (>25 mg/w) levels of caffeine consumed from cola were associated with low stress. This finding may reflect reports of students using caffeinated products to cope with stress (e.g. Ríos et al., 2013). However, the general lack of consistent findings from this analysis as a whole suggests that, when investigating its effects on stress, anxiety, and depression, caffeine is best examined in terms of total intake rather than by differentiating between individual sources.

Methodological limitations and directions for future research

Though the current study has addressed a gap in the literature, several methodological limitations should be considered when interpreting the findings. One such limitation is that the participants who completed the questionnaires were not fully representative of the schools from which they came. However, taking a multivariate approach to data analysis in which demographic and lifestyle variables could be controlled for statistically is deemed to have been an effective method for addressing this issue. Nevertheless, as the population studied came from a very specific demographic group (i.e. 11–17-year-old White children from the South West of England), further research is needed that focuses on more representative samples.

Another limitation of the current research was that the chronicity of caffeine use was not taken into account. For instance, a

weekly cycle of caffeine use in adolescents was reported by Pollak and Bright (2003), in which consumption peaked during the weekend (Saturday), and was lowest in the middle of the week (Wednesday). Coupled with the observations that adolescents sometimes use caffeinated products to delay sleep onset (e.g. Calamaro et al., 2009) and to counteract the effects of sleepiness during the day (Malinauskas et al., 2007), it is possible that the timing of administration of the questionnaire may have been of importance.

A further limitation of the current study is that it utilised a cross-sectional design. This means that all effects observed here are correlational, and that causation cannot be inferred. Therefore the possibility of reverse-causation, or indeed bidirectionality, cannot be disregarded. For instance, high caffeine consumption may be a cause of high stress, anxiety, and depression, but suffering from such conditions may also lead towards the high consumption of caffeinated products as a coping strategy. Furthermore, it is possible that the effects observed here are attributable to personality characteristics associated with caffeine users, rather than to their use of caffeine. Future research should therefore aim to conduct intervention studies in order to investigate the nature of these relationships further.

Conclusions

The current study has presented results that suggest caffeine consumption may be associated with stress, anxiety, and depression in secondary school children, though the effect on stress disappeared after additional dietary, demographic, and lifestyle variance was controlled for statistically. The effects observed also appeared to differ between males and females. Though caffeine consumption was associated with anxiety in males at the multivariate level, no such observation was made in females. Furthermore, though the effects relating to depression occurred in both sexes, the threshold at which they appeared was lower in males than it was in females.

Initial analyses of individual caffeine sources implied that coffee may have been responsible for the effects observed in relation to total caffeine intake, but further investigations suggested this not to have been the case, and that they were likely attributable to caffeine consumption in general rather than to any particular source. The study also identified very high caffeine intake (>1000 mg/w) to be a risk factor associated with anxiety and depression, although effects were sometimes detected at lower doses. These findings may therefore be a concern for public health and school policy, and should be considered an important area for further investigation.

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