JOURNAL OF SCHOOL HEALTH
American School Health Association

RESEARCH ARTICLE

Mountain Dew® or Mountain Don't?: A Pilot Investigation of Caffeine Use Parameters and Relations to Depression and Anxiety Symptoms in 5th- and 10th-Grade Students

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ABSTRACT

BACKGROUND: Caffeine, the only licit psychoactive drug available to minors, may have a harmful impact on students' health and adjustment, yet little is known about its use or effects on students, especially from a developmental perspective. Caffeine use in 5th- and 10th-grade students was examined in a cross-sectional design, and relations and potential mediators of caffeine use to depression and anxiety symptoms were investigated.

METHODS: Children ($n = 135$) and adolescents ($n = 79$) completed a measure of naturalistic use of caffeinated and noncaffeinated beverages. Furthermore, daily availability, perceived benefits, and stimulating, psychological, and withdrawal effects of caffeinated and noncaffeinated beverages were assessed. Measures of depression and anxiety were also administered.

RESULTS: Fifth and 10th graders used caffeine frequently. Depression was positively related to caffeine use for both cohorts, though mediated by caffeine withdrawal effects. Surprisingly, anxiety was unrelated to use. Fifth graders reported less daily access to caffeine, but more psychological and stimulating effects of caffeine than 10th graders.

CONCLUSIONS: Although both children and adolescents experience negative caffeine-related outcomes, intake is seemingly not greatly limited in either cohort. In particular, youth appear vulnerable to increased depressive symptoms with increasing caffeine consumption. Implications for school policy regarding students' caffeine use are discussed.

Keywords: caffeine; depression; anxiety; school health; youth.

Citation: Luebbe AM, Bell DJ. Mountain Dew® or mountain don't?: A pilot investigation of caffeine use parameters and relations to depression and anxiety symptoms in 5th- and 10th-grade students. J Sch Health. 2009; 79: 380-387.

Accepted March 29, 2009

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Citing rising obesity rates, school districts are increasingly faced with decisions about limiting the sale of soft drinks to students. Recently, some national beverage companies have agreed to end sales of all sodas in elementary schools and limit sales in high schools to only diet sodas and other low-calorie beverages by the year 2010.[1] Yet, excessive consumption of certain sodas, including *diet* sodas, also means increased caffeine intake. Caffeine, the only licit psychoactive drug available to minors, may have a harmful impact on students' health, academic performance, and personal adjustment. This pilot study investigated naturalistic patterns of youth caffeine intake and potential negative psychological correlates (ie, depression, anxiety) of caffeine use. Both elementary and high school students were included to examine how caffeine use and its effects differed across ages that may have quite different levels of autonomy over and understanding of caffeine use.

Caffeine, a methylxanthine that works as a competitive antagonist at A_1 and A_{2a} adenosine receptors,[2] is frequently consumed by both children and adolescents (eg, at least weekly use in 75–98% of youth ages 2–18).[3,4] Most children receive caffeine in the form of soda typically containing 20 to 55 mg of caffeine per 12 oz can (cf. 80–120 mg per 8 oz cup of coffee) and consume, on average, approximately two 12 oz cans of caffeinated soda daily.[5–7] Additionally, newer energy drinks laden with more caffeine than typical sodas are rapidly entering the market, often with youth-directed advertising (eg, Kickstart SPARK).[8,9]

Certainly, youth who use caffeine report some benefits, including decreased self-reported sluggishness and improved attention and manual dexterity on performance tasks.[10–12] Yet, increased nervousness, jitteriness, and observer-rated fidgeting are also related to use, with deleterious side effects being especially prevalent at high doses.[12] Although 1 to 2 caffeinated beverages daily may not seem a considerable amount, youth may be ingesting more caffeine than adults on a mg/kg basis and enough to develop dependence. In adults, physical dependence can develop after brief daily exposure to as little as 100 mg of caffeine.[13] A 12-year-old child (weighing 30 kg [66 lbs]) who drinks a *single* 12 oz can of Diet Coke® (47 mg caffeine) receives a functionally equivalent dose to a 70 kg (144 lbs) adult who consumes 110 mg of caffeine.[14] Indeed, laboratory and survey studies have documented both physical dependence (eg, tolerance, cravings) and withdrawal symptoms after caffeine cessation (eg, headache, lack of concentration) in moderate to high caffeine-using adolescents and children.[14,15] Such symptoms may impair performance in several areas of youths' daily functioning (eg, school, sports).[16] Extensive caffeine use may also lead to disrupted sleep patterns which, in turn, are associated with academic and social adjustment problems.[17,18]

Theory and evidence suggest that negative affective experiences also may be of concern for caffeine-using youth. Symptoms of depression or anxiety could be causes or consequences of increased consumption. Just as some adults use substances to self-medicate for psychiatric symptoms,[19] depressed or anxious youth might ingest caffeine for temporary relief of affect-related apathy and lethargy or use it for its positive effects on attention and performance.[10–12] Then again, negative caffeine effects like increased state arousal and irritability may lead to more chronic anxious or depressive symptoms (eg, agitation, headache, lack of concentration), especially as a result of a cycle of high caffeine use and subsequent cessation.[16,20] Alternatively, any link between anxiety or depression and caffeine use may be an artifact of physiological symptom (eg, heart-rate acceleration) overlap.

Empirical links between caffeine use and youth depressive and anxious symptoms remain relatively unexplored, although a few studies support their existence. Youth diagnosed with major depressive disorder report more daily caffeine use than healthy controls,[20] and increased caffeine consumption has been linked to higher self-reported depressive symptoms in a community sample of adolescents.[21] In 2 additional studies, caffeine-dependent adolescents scored higher on depressive symptoms than those without dependence, though these differences did not reach significance in either study.[15,22] Regarding anxiety, while studies have found that children and adolescents experience increased *state* anxiety after consuming caffeine,[10,20] whether *trait* anxiety relates to caffeine use is less clear. To our knowledge, only 2 studies have examined this relation, and results were somewhat mixed. In one, caffeine-dependent adolescents scored significantly higher on trait anxiety than nondependent youth,[15] whereas in another, a nonsignificant trend emerged for higher trait anxiety among caffeine-dependent versus nondependent adolescents.[22] Clearly, additional work is needed to better understand the relations of caffeine to depression and anxiety symptoms.

The current pilot study had 2 purposes. First, in light of limited developmentally informed research, we examined naturalistic patterns of caffeine use in 2 developmentally distinct cohorts, 5th- and 10th-grade students. This is the first study to our knowledge to examine possible developmental differences in caffeine consumption. Similarly, unlike previous studies that focused on adolescents, this study included younger children. Given the widespread availability and high social acceptance of caffeine, 5th- and 10th-grade students might have similarly high rates of use. Yet, important differences between adolescents and younger children in autonomy over beverage consumption may mean that adolescents may have fewer restrictions on caffeine ingestion. As

such, we hypothesized that the younger cohort would demonstrate lower overall quantities of use and lower rates of symptoms associated with dependence.

Second, we examined correlates of caffeine use and its perceived positive and negative effects. We expected caffeine intake to be positively related to both depression and trait anxiety symptoms in our 2 samples. Because existing research has focused on bivariate relations of caffeine use to depression and anxiety symptoms, we conducted an initial exploration of potential mediators that may account for relations of caffeine use to mood. We expected perceived effects of caffeine (eg, withdrawal) to mediate relations of depression and anxiety to caffeine intake.

METHOD

Subjects

All 5th- and 10th-grade children from 3 rural Midwest school districts were invited to participate. Districts were chosen for this pilot study based on preexisting working relationships. They are representative with regard to enrollment as well as demographic and socioeconomic characteristics of other rural school districts in the state, but smaller and less ethnically diverse than the state's urban and suburban districts.[23] Parents' consent and child assent were obtained for 214 students, including 135 5th graders (60 boys, 75 girls; 76% consent rate) and 79 10th graders (39 boys, 39 girls, 1 unspecified gender; 55% consent rate). Fifth graders, referred to as *children*, were 10 to 12 years old (M = 10.98, SD = .44), and 10th graders, referred to as *adolescents*, were 15 to 17 years old (M = 15.90, SD = .50). Self-report ethnicity was unavailable for children, but was similar to the adolescent sample (ie, primarily Caucasian). For 10th graders, 88% reported their ethnicity as Caucasian, 3% Asian American, 3% Hispanic/Latino, 1% American Indian, and 5% multiracial or other. On average, 34% of students in the 3 school districts are enrolled in the free lunch program.[23]

Instruments

Caffeinated Beverage Use and Effects. To assess caffeine use, students first identified, from an inclusive list of caffeinated beverages (eg, Pepsi®, Mountain Dew®, different coffee drinks), beverages they drank at least weekly. Students who endorsed at least 1 beverage then selected the beverage they drank most often. Additional questions regarding days used per week, times used per day, and availability at home and school assessed usage patterns for their most consumed beverage. Children were also shown 6 typical beverage containers (eg, cups and bottles), sizes 8, 12, 16, 20, 32, and 64 oz, and asked to indicate their typical serving size. Pilot testing suggested that youth benefited from focusing on only 1 beverage at a time when describing their use and, especially, the effects of a particular beverage. Given time constraints of the data collection, caffeine use was assessed only for the most consumed beverage. Additionally, participants reported their height and weight to allow statistical control for body size. Notably, self-reported weight tends to be slightly underestimated and height overestimated in youth, but no more so than for what is observed in adults, and self-report, though less than ideal, is considered a valid estimate of body size.[24] Several students, however, were missing bodyweight data (25% of 5th graders, 13% of 10th graders). Because independent groups' *t* tests indicated no significant differences in caffeine intake or effects between individuals who did and did not provide weight data, we replaced missing weight data with gender- and grade-appropriate means from the remaining sample. Weekly caffeine use was calculated as the product of typical serving size, times used per day, days used per week, and amount of caffeine per ounce in the target beverage[6] and then divided by the youth's body mass.

Questions assessing caffeine effects were developed based on prior research assessing caffeine dependence in adults and adolescents, and pilot tested for clarity with a small sample of 5th-grade youth (Table 2 lists specific items).[16,25,26] Using a 5-point Likert-type scale (1 = ''Not true at all''; 5 = ''Always true''), youth answered 18 items representing 5 general levels of beverage use and perceived effects of the beverage. An exploratory factor analysis using maximum likelihood extraction and oblique rotation (promax)

Table 1. **Means and Standard Deviations for Caffeine and Affect Variables Compared Across Grade Level**

	5th Graders		10th Graders	
	M	SD	M	SD
Caffeine use variables				
Days per week beverage is consumed	3.69*	1.94	4.89†	1.92
Typical serving size (oz) of beverage	15.54	5.60	17.01	6.48
Typical number of servings daily	2.17	1.39	2.44	1.40
Mg/Kg of caffeine consumed per week	15.24	22.39	13.82	15.30
Diversity of beverages consumed per week	4.46	2.87	4.69	3.28
Caffeine effects variables				
Withdrawal effects	4.55	2.94	4.35	1.96
Perceived benefits	10.15	4.10	9.69	3.87
Daily presence	7.45*	2.29	9.53†	2.98
Psychological effects	11.36*	4.13	8.60†	2.91
Stimulating effects	7.79*	3.37	6.75†	2.87
Affective symptomatology				
Depressive symptoms‡	0.41	0.37	0.34	0.30
Trait anxiety‡	1.82*	0.41	1.64†	0.36

*† Means with different superscripts indicate significant mean differences between 5th- and 10th-grade students, $p < .01$.
‡ Mean item response is presented.

Table 2. **Rotated Factor Loadings and Communalities for the Perceived Caffeine Effects Items**

Item	Communalities	Caffeine Effects				
		F1	F2	F3	F4	F5
Withdrawal effects*						
When I do not get to have (beverage), I feel sick	.87	**.93**	−.01	−.01	.10	−.10
I have trouble concentrating at school when I do not have (beverage)	.66	**.63**	.26	−.02	.05	.03
I get a headache when I do not have (beverage)	.75	**.86**	−.10	.10	−.07	.10
Perceived benefits†						
Snacks taste better to me when I have them with (beverage) than without (beverage)	.44	−.15	**.57**	.07	.25	−.06
Homework is easier when I drink (beverage)	.68	.01	**.90**	−.13	−.05	−.03
I answer more questions in class after I drink (beverage)	.49	.25	**.63**	−.05	−.10	−.04
Daily presence‡						
We always have (beverage) at home	.32	.02	.05	**.56**	−.07	−.03
I drink (beverage) every day	.80	−.03	−.05	**.91**	.06	.00
I frequently buy (beverage) at school	.21	.12	−.07	**.45**	−.24	.02
Psychological effects§						
I would rather have (beverage) than any other beverage	.32	−.07	.25	.13	**.39**	−.02
I get a "buzz" from drinking (beverage)	.49	.22	−.03	−.23	**.58**	.11
If I drink too much (beverage) I feel jumpy	.48	−.02	−.03	−.12	**.63**	.19
I do not like to go one day without (beverage)	.61	.31	.15	.27	**.38**	−.09
Stimulating effects‖						
When I am tired, (beverage) helps me wake up¶	.61	.08	**.39**	.07	.00	**.49**
When I want to say up late studying, I drink (beverage)	.46	−.01	.27	.23	.09	**.37**
If I drink (beverage) before bed, I have trouble sleeping	.45	−.01	−.14	−.08	.16	**.63**

*Eigenvalue = 16.74 (61% of variance); $\alpha = .81$.
†Eigenvalue = 4.65 (17% of variance); $\alpha = .82$.
‡Eigenvalue = 3.21 (12% of variance); $\alpha = .71$.
§Eigenvalue = 1.89 (7% of variance); $\alpha = .58$.
‖Eigenvalue = .91 (2% of variance); $\alpha = .68$.
¶Item 16 loads highly on both the perceived benefits and stimulating effects factors. It is grouped with the latter because of its higher factor loading for the stimulating effects factor.
Boldface type represents factor loadings above .35. Three items (ie, *I like to have (beverage) first thing in the morning*, *I prefer (beverage) to milk*, and *Drinking (beverage) increases my heart rate)* were deleted because they failed to load highly on any factor.

suggested a 5-factor model best fit the perceived effects items (χ^2 (50) = 56.95, $p = .23$; Table 2 lists item communalities and factor loadings). Because of the smaller sample size for the 10th graders and to obtain more stable estimates, data were combined for the 2 cohorts prior to analysis. The 5 factors were labeled (a) *withdrawal effects*, (b) *perceived benefits*, (c) *daily presence*, (d) *psychological effects*, and (e) *stimulating effects*. Factors demonstrated moderate internal consistency (Table 2) and were moderately intercorrelated ($rs = .27–.49$, $p < .001$), with one exception: daily presence was unrelated to stimulating effects ($r = .06$).

To rule out the possibility that beverage consumption itself (with or without caffeine) may be correlated with affect, we also assessed noncaffeinated beverage use. Students answered a second set of items identical to those assessing caffeinated beverages but assessing use of noncaffeinated beverages (eg, milk, Sprite®).

Children's Depression Inventory. The Children's Depression Inventory (CDI) is a self-report, 27-item scale assessing symptoms of youth depression in the past 2 weeks.[27] Higher scores indicate higher levels of depressive symptoms. Upon request of local school boards, and as in prior studies,[28] we excluded the item assessing suicidal ideation, thereby yielding a possible range of scores between 0 and 52. The CDI is a reliable and valid measure of depressive symptoms in youth.[29,30] Coefficient alpha for the current sample was .92.

State-Trait Anxiety Inventory for Children-Trait Version. The State-Trait Anxiety Inventory for Children-Trait (STAIC-T) is a 20-item, self-report tool used to measure general trait anxiety in youth.[31] Scores range from 20 to 60, with higher scores indicating higher trait anxiety. The STAIC-T demonstrates adequate internal consistency, reliability, and convergent and discriminant validity.[30–32] For the current sample, coefficient alpha was .88.

Procedure

After receiving institutional review board (IRB) approval, data were collected during one 50-minute school period arranged to suit school schedules. Fifth-grade students completed data collection in their classrooms, while nonparticipants were allowed to read quietly at their desks. Tenth-grade participants completed data collection in small groups in the school auditorium, while nonparticipants continued their

typical curriculum. For all participants, youth provided assent and then were given questionnaire packets. Fifth-grade students filled in their responses as each question was read aloud by a trained research assistant who also clarified any confusing items. Tenth-grade students read and answered questionnaires silently to themselves. For participating, students received a university logo pencil and letter of appreciation.

Data Analysis

Developmental differences in caffeine use were examined with independent groups' *t* tests for continuous measures and chi-square tests of independence for categorical variables. Developmental differences were tested by comparing factor scores for the 2 cohorts via a series of Bonferroni-corrected ($\alpha = .05/5$ tests $= .01$) ANOVAs. Relations among caffeine prevalence, subjective effects factors, depression, and anxiety were examined with partial correlations, controlling for noncaffeinated beverage. A more conservative alpha level for significance (ie, $p < .01$) controlled Type I error inflation. Finally, for our exploratory analyses, hierarchical regressions were used to test whether reported effects of caffeine mediated relations between weekly caffeine intake and mood symptomatology.[33]

Given our assessment of beverages both with (eg, Coke®, Sprite®) and without (eg, Diet Coke®, milk) high sugar content, and given the rationale that sugar may be an influential confounding variable, analyses were conducted for all caffeinated and noncaffeinated beverages as a whole, as well as separately for beverages with and without sugar. Patterns of significance were identical and magnitude of relations similar for all analyses. As such, results are presented for both sugared and sugar-free beverages included together.

RESULTS

Parameters of Caffeine Use

Descriptive statistics for caffeine and affect variables are presented in Table 1. Nine participants were excluded because of either crucial missing data (one 5th grader and one 10th grader omitted items needed to compute weekly caffeine intake) or reports that they did not drink any caffeinated beverages in a typical week (four 5th graders and three 10th graders). Average weekly intake for youth's most frequently consumed beverage was 15.24 and 13.82 mg/kg for children and adolescents, respectively. For a typical 5th-grade child who weighs 40 kg (~88 lbs), this equates to approximately 16 12-oz cans of Pepsi® per week.

No significant differences emerged between grades for typical serving size, daily number of servings, weekly caffeine intake, diversity of use (ie, number of different types of caffeinated beverages consumed in a typical week), perceived consumption compared with peers, or availability of caffeine at home. Children reported drinking their favorite caffeinated beverage significantly fewer days per week on average than did adolescents, $t(204) = -4.28$, $p < .001$. Similarly, only 33% of 5th-grade students reported being allowed to drink caffeine at school compared with 73% of 10th graders (χ^2 (1) $= 30.89$, $p < .01$).

Caffeine Effects Domains

Children and adolescents did not differ on withdrawal effects, $F(1, 207) = .32$, $p = .57$, or perceived benefits, $F(1, 207) = .00$, $p = .98$. Children, however, scored significantly lower than adolescents regarding daily presence, $F(1, 207) = 16.51$, $p < .001$, and significantly higher than adolescents on the psychological $F(1, 207) = 33.64$, $p < .001$, and stimulating effects factors, $F(1, 207) = 17.44$, $p < .001$.

Correlates and Mechanisms of Caffeine Use

For children, weekly caffeine intake (controlling noncaffeinated beverage consumption) was positively associated with depression but not anxiety (Table 3; children are listed below the diagonal). Further, weekly intake was positively associated with reported levels of each of the subjective effects except stimulating effects. With 2 exceptions, there was a positive relation between each of the caffeine effect variables and both depression and anxiety. Neither depression nor anxiety was related to the perceived benefits or daily presence factors.

For adolescents, weekly caffeine intake (controlling noncaffeinated beverage consumption) was related to depression but not anxiety (Table 3; adolescents are listed above the diagonal). Additionally, weekly caffeine use was related positively to all perceived effects

Table 3. **Partial Correlations, Controlling for Noncaffeinated Use, Between Caffeine Use, Depression and Anxiety Symptoms, and Subjective Caffeine Effect Variables for 5th-Grade (Below Diagonal) and 10th-Grade (Above Diagonal) Students**

	CWK	DEP	ANX	WITH	PRES	BEN	PSYC	STIM
CWK	—	.35*	.22	.52**	.30*	.55**	.59**	.04
DEP	.36**	—	.77**	.37**	.26	.28	.25	.26
ANX	.09	.61**	—	.16	.10	.13	.19	.35*
WITH	.47**	.46**	.29**	—	.40**	.54**	.50**	.32*
PRES	.55**	.37**	.17	.58**	—	.61**	.57**	.56**
BEN	.53**	.16	.06	.37**	.56**	—	.60**	.22
PSYC	.33**	.35**	.34**	.49**	.55**	.49**	—	.41**
STIM	.20	.33**	.40**	.46**	.40**	.20	.58**	—

*$p < .05$; **$p < .01$.

Fifth-grade students, $n = 130$, tenth-grade students, $n = 75$. CWK, mg/kg of caffeine per week; DEP, depression score; ANX, anxiety score; WITH, withdrawal effects factor score; PRES, daily presence factor score; BEN, perceived benefits factor score; PSYC, psychological effects factor score; STIM, stimulating effects factor score.

factor scores except the stimulating effects factor. Finally, unlike children, depression was related only to the withdrawal effects factor score, whereas anxiety was related only to the stimulating effects score.

Exploratory Mediational Analyses

Given moderate to high intercorrelations among the 5 subjective effects factors, these potential mediators were entered simultaneously in analyses to examine their relative influence. For children, the withdrawal effects factor was the only significant mediator of the relation of weekly caffeine use to depression (Table 4). For adolescents, the stimulating effects factor was not significantly related to caffeine use so it was removed from the mediational model. Although no individual factor scores were significant mediators, the withdrawal factor was marginally significant. This finding is similar to that of children, and given additional power, would most likely reach significance.

DISCUSSION

The purposes of our study were to examine caffeine use and its perceived effects in 2 developmentally distinct cohorts of youth and to better understand the relation of caffeine use to symptoms of anxiety and depression. Overall, although both children and adolescents experience negative caffeine-related outcomes, intake is seemingly not greatly limited in either cohort. In light of this study's exploratory nature, however, these findings should be interpreted cautiously.

Table 4. **Regression Analyses Testing Mediation of the Relation of Caffeine Use to Depression Symptoms by Subjective Caffeine Effects**

Predictor	β	*t*	Sobel's Test
Predicting depression (5th grade)			
Step 1		$F(1, 128) = 16.38^{***}$	
Weekly intake	.34	4.05***	
Step 2		$F(6, 123) = 7.62^{***}$	
Weekly intake	.18	1.75	
Withdrawal	.28	2.73	2.48*
Daily presence	.10	0.91	0.90
Benefits	−.16	−1.53	1.36
Psychological effects	.12	1.06	1.03
Stimulating effects	.09	0.90	0.84
Predicting depression (10th grade)			
Step 1		$F(1, 73) = 4.46^{*}$	
Weekly intake	.52	2.11*	
Step 2		$F(1, 123) = 5.72^{***}$	
Weekly intake	.28	1.92†	
Withdrawal	.25	1.81†	1.71†
Daily presence	.15	1.08	1.00
Benefits	−.06	−0.41	0.41
Psychological effects	−.12	−0.79	0.78

*$p < .05$; **$p < .01$; ***$p < .001$; † $p < .10$.

Parameters of Caffeine Use

Caffeine use among children and adolescents in our sample was widely prevalent, frequent, and, with one exception,[15] occurred at levels higher than in other youth samples.[3] Interestingly, our estimates are likely conservative as we only assessed patterns of use for the participant's *most often consumed* caffeinated beverages. Only 2 developmental differences in the parameters of caffeine use between cohorts emerged: (a) children drank caffeine fewer days per week on average than adolescents and (b) significantly fewer children reported being allowed to drink caffeinated beverages at school than adolescents. Likely, both differences reflect dissimilar school policies between elementary and high schools concerning beverage sales and consumption. Policies limiting access to caffeine, however, seemingly do not deter use in younger children. Rather, the lack of mean differences in weekly intake between cohorts and between those with and without permission to drink caffeine at school suggest that children consume more caffeine in smaller time frames (eg, after school, weekends) than adolescents. For adults and adolescents, functional dosage (ie, amount per specific period of intake for a given body size) is more strongly related to the development of caffeine dependence than mean daily intake.[15,22] Thus, our results suggest that children, in particular, may be at increased risk for developing caffeine dependence.

Despite similar levels of use, the subjective experience of caffeine's effects may vary for children and adolescents. First, adolescents scored higher on the *daily presence* factor than did children, potentially indicating risk for habitual use. Second, children scored higher than adolescents on both the *psychological* and *stimulating effects* factors. Because children ingest caffeine in larger amounts in more condensed timeframes (ie, higher functional doses), they are potentially more likely to feel the psychological and stimulating effects than adolescents whose use is spread over a longer time frame. Alternatively, given similar levels of use, adolescents' reports of fewer stimulating and psychological symptoms (especially feeling a ''buzz'') may represent development of tolerance compared with children's more novel caffeine experiences.

Caffeine, Depression, and Anxiety

Weekly caffeine use was strongly related to depression symptoms in both cohorts, and our exploratory analyses suggest this association might be mediated by withdrawal effects (though marginally in the smaller adolescent sample). What is unclear from these findings is whether depression might be a manifestation of

withdrawal (ie, symptom overlap between withdrawal and depression), or if withdrawal symptoms contribute to the development of unique depressive symptoms. Alternatively, youth with depressive symptoms may be more sensitive to the negative effects of caffeine cessation. Regardless of causal direction, youth appear vulnerable to increased depressive symptoms with increasing caffeine consumption. In contrast, trait anxiety was not related to caffeine intake for either cohort. Although consistent with Oberstar's findings,[22] these findings conflict with evidence of a relation in older, caffeine-dependent adolescents[15] and in adults,[34,35] suggesting that this connection may be more likely to occur later in development vis-à-vis some change in response to caffeine, or more likely, increased exposure to and use of caffeine.

A developmentally distinct pattern of findings emerged from a group of mostly similar relations across cohorts that warrant attention. Specifically, both anxiety and depression were positively related to the withdrawal, psychological, and stimulating effects of caffeine for children. Of those same relations for adolescents, only withdrawal was related to depression, and only increased stimulating effects were related to anxiety. Our findings lead to some interesting, yet speculative, hypotheses that should be investigated in future research. Specifically, other evidence suggests that discrimination of internal states improves from childhood into early adolescence,[36,37] and knowledge and differentiation of drug effects also increases with age through childhood.[38] Compared with children, adolescents in our sample may have had valuable caffeine experience and the ability to report on finer distinctions in their internal experiences,[39] allowing them to link withdrawal effects (eg, feeling sick) specifically with depression, but stimulating effects (eg, feeling physiologically aroused) with anxiety. To the extent that they perceive links between caffeine effects and negative affective states, this may prompt adolescents to regulate use more than children. Differential use regulation could explain why, despite greater availability, adolescents did not consume more caffeine than children.

Limitations

Our findings must be considered in light of 4 limitations. First, the preliminary, cross-sectional, correlational design of our study limits the ability to interpret causality in links of depression and anxiety to caffeine. Prospective, longitudinal studies, examining relations between youth depression and caffeine are needed and should include additional mediators to those investigated in our study. Second, differential recruitment rates between cohorts may represent a potential selection bias in our study. Anecdotally, the likely reason for differential rates may be because of more frequent reminders about returning consent forms made from 5th-grade teachers to their students. Unfortunately, our data do not allow us to compare those students whose parents consented with those whose did not.

Third, given time constraints and because we wanted youth to focus on specific effects of their consumption, our caffeine measure only focused on youth's most consumed beverage. Again, this presents a conservative test of the relation between affect and caffeine consumption, and assessing all caffeine use may reveal stronger relations. Finally, although children and adolescents may have the best insight into their own caffeine usage patterns and negative affective states, our reliance on self-report for both does not rule out effects of mono-method bias. Similarly, many youth did not provide weight data, and these missing data were imputed. Research using varied methodology (eg, event sampling, researcher-collected body mass data) or additional reporters (eg, parents) can add to our understanding of these relations.

Applied Implications and Conclusions

Practically, our data highlight the importance for youth service providers to assess caffeine intake in routine evaluations of adjustment, particularly for youth presenting with depressive symptoms. Unlike alcohol and other illicit drug use, caffeine use is not included in typically used child assessment instruments, so relevant questions would need to be added to established assessments. More generally, despite caffeine's positive effects,[10–12] given the potential for negative consequences of increased use, parents, teachers, and school administrators may wish to regulate intake in the elementary and, potentially, high school students they nurture. Because most diet sodas contain as much or more caffeine than nondiet counterparts, limiting only regular soft drinks may not be wholly effective at reducing negative health consequences.

Given the seeming ''catch-up'' effect outside of school for children in our sample, parents in particular need to be informed of possible adverse effects of too much caffeine and provided with suggestions about healthy intake levels for youth of different ages and body size. Paradoxically, without regulating intake in nonschool settings, restricted caffeine access during school hours may actually initiate withdrawal symptoms, the mediator between use and depressive symptoms in our exploratory analyses. This in turn may impair academic and behavioral functioning while increasing depression and anxiety symptoms in students. Finally, recognizing adolescents' emerging autonomy, direct education about potential negative consequences associated with caffeine use may benefit these youth.

Overall, in our sample, youth consumed sufficient amounts of caffeine to develop dependence[13] and reported physiological and psychological effects of use that were related to depression and anxiety symptoms. Although we focused on the affective domain, caffeine's effect on other aspects of youth functioning such as sleep, academic, or social functioning should also be considered, both by adults in youths' lives and by researchers.

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