Concurrent Validity of Caffeine Problems and Diagnostic Criteria for Substance Use Disorders

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Background: The DSM-5 proposes caffeine use disorder (CUD) as a condition for further study. The objective of this study was to report on the prevalence of CUD and rates of endorsement for each substance use disorder (SUD) criterion in relation to caffeine compared to alcohol and marijuana in a sample of adolescents presenting for medical care in the primary, adolescent, and substance use clinics at an academic medical center.

Methods: A convenience sample of patients ($N=213$; 66.7% female) aged 12–17 presenting for medical care completed the Composite Diagnostic Interview-Substance Abuse Module questionnaire, with questions regarding use of caffeine, alcohol, and marijuana. Descriptive analyses were used to determine prevalence of CUD and frequency of each endorsed SUD criterion as applied to caffeine versus alcohol or marijuana. Comparative Fit Index (CFI) and Tucker–Lewis Index (TLI) were used to determine psychometric properties for CUD.

Results: The majority of subjects ($N=153$) reported past 30-day caffeine use and of these, six (4%) met criteria for CUD. All six also met criteria for either alcohol and/or marijuana use disorders. Of the three essential CUD criteria (failure to quit, use despite harm, and withdrawal), both harm and withdrawal were endorsed significantly more often in relation to caffeine versus alcohol. Descriptive fit indices for the CUD model were excellent ($CFI=0.994$, $TLI=0.991$).

Conclusions: In our sample, the proportion of adolescents that met proposed CUD criteria was low, suggesting that the proposed criteria would not lead to overdiagnosis of CUD. CUD was highly correlated with other SUDs.

Keywords: caffeine use disorder, DSM-5, adolescents

Introduction

CAFFEINE USE BY CHILDREN and adolescents is common. On any given day, ~75% of children aged 6 and older in the United States consume caffeine¹; this rate has been stable for the past decade.¹ Caffeine is a nonselective adenosine receptor antagonist that produces many of its effects by releasing the pre- and postsynaptic brakes that adenosine imposes on striatal dopaminergic transmission.²

Although caffeine intake is generally considered safe, large doses in children can result in tachycardia, gastrointestinal distress, irregular heart rhythms, hallucinations, and seizures.³ Caffeinated beverage consumption by adolescents is frequently associated with physical and emotional symptoms and problems, such as sleep disruption,

stomach discomfort, and withdrawal symptoms (e.g., headache).⁴ While many of these symptoms are typically considered more of a nuisance than a serious threat to health, they may impact functioning. For example, frequent urination associated with caffeine use may be disruptive to learning in a classroom, headaches from withdrawal could result in decreased concentration, and sleep problems can cause poor memory and attention during the day.

Although the Diagnostic and Statistical Manual of Mental Disorders-Fourth Edition (DSM-IV)⁵ did not specifically recognize Substance Dependence as applied to caffeine, several research studies did apply the Substance Dependence criteria to caffeine, which was defined as meeting at least three of the following criteria: tolerance, withdrawal, taking larger amounts than intended, failure

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to quit, great deal of time spent obtaining or recovering from caffeine, important activities reduced/given up because of caffeine, and continued use despite a problem.⁶ Among 36 daily caffeine consumers aged 13–17 years old who reported one or more criteria of caffeine dependence, 22% met the DSM-IV criteria for Substance Dependence as applied to caffeine.⁷

Within the Diagnostic and Statistical Manual of Mental Disorders-Fifth Edition (DSM-5), “Caffeine Use Disorder” (CUD) is described within the “Conditions for Further Study” section.⁸ There are nine proposed criteria of CUD, all of which are also included in alcohol, marijuana, and “other specific substance use disorders” described in DSM-5 (Table 1).

The first three essential criteria (persistent desire or efforts to cut down or quit use, continued caffeine use despite having a problem caused by caffeine, and withdrawal) must all be endorsed to meet proposed diagnostic criteria for CUD. The six other criteria, which are not

necessary for making a diagnosis according to the proposed definition in DSM-5, are caffeine taken in longer or larger amounts than intended; recurrent caffeine use results in inability to fulfill obligations; continued use despite social or interpersonal problems caused by use; tolerance; great deal of time spent on obtaining, using, or recovering from caffeine use; and craving or strong desire to use caffeine. Given the ubiquity of legal caffeinated products and minimal impact on sensorium, it is unclear how applicable some of these criteria are for caffeine.

In a comprehensive review article of CUD, Meredith *et al.*⁶ show that there is a wide range of reported frequency for each of these criteria within available research. The authors of DSM-5 stress the need for further study of CUD,⁸ and previous literature has discussed the need for more clinical research on CUD⁶ and the concern about potential overdiagnosis if CUD was included as a disorder within the DSM.⁹

TABLE 1. DESCRIPTION OF DSM-5 CRITERIA FOR CUD AND OTHER SPECIFIC SUDs, AS WELL AS AVAILABLE DATA FOR THIS STUDY

<i>DSM-5 diagnostic criteria</i>	<i>CUD</i>	<i>Alcohol and marijuana SUDs</i>	<i>Data available for both caffeine and other substances</i>
1. Persistent desire or unsuccessful efforts to cut down or control substance use (Failing to quit)	X	X	X
2. Continued substance use despite knowledge of having a persistent or recurrent physical or psychological problem that is likely to have been caused or exacerbated by substance (Harm)	X	X	X
3. Withdrawal, as manifested by either of the following: (Withdrawal) (a) The characteristic withdrawal syndrome for substance (b) Substance (or a closely related substance) is taken to relieve or avoid withdrawal symptoms.	X	X	X
4. Substance is often taken in larger amounts or over a longer period than was intended (Intend)	X	X	X
5. Recurrent substance use resulting in a failure to fulfill major role obligations at work, school, or home (e.g., repeated tardiness or absences from work or school related to substance use or withdrawal).	X	X	
6. Continued substance use despite having persistent or recurrent social or interpersonal problems caused or exacerbated by the effects of substance (e.g., arguments with spouse about consequences of use, medical problems, and cost).	X	X	
7. Tolerance, as defined by either of the following: (Tolerance) (a) A need for markedly increased amounts of substance to achieve desired effect (b) Markedly diminished effect with continued use of the same amount of substance	X	X	X
8. A great deal of time is spent in activities necessary to obtain substance, use substance, or recover from its effects (Time)	X	X	X
9. Craving or a strong desire or urge to use substance (Crave)	X	X	X
10. Important social, occupational, or recreational activities are given up or reduced because of substance use		X	X
11. Recurrent substance use in situations in which it is physically hazardous		X	

The shaded boxes represent the diagnostic criteria that had available data for this study and were included in both CUD and alcohol and marijuana SUD definitions, and thus, these criteria were used in the analyses.

CUD, caffeine use disorder; SUD, substance use disorder.

In this exploratory study, we examined the prevalence of CUD using seven of the nine proposed criteria in DSM-5 (the other two were not asked about in this dataset) in a sample of adolescents aged 12–17 presenting for medical care. We calculated the rate of endorsement for each criterion and compared them to rates of endorsement for the criteria as applied to alcohol and marijuana. We also assessed the correlation between CUD and both alcohol and marijuana substance use disorders (SUDs).

Methods

Study setting and subjects

We conducted a secondary analysis of data from a study designed to validate an electronic screen against a criterion standard diagnostic interview for SUDs in adolescents presenting for routine medical care.¹⁰ The parent study recruited a convenience sample of assented patients ($N=213$) aged 12–17 years presenting for a medical clinic appointment at one of three sites in a tertiary care pediatric hospital: (1) an adolescent primary care clinic, (2) a pediatric primary care clinic, and (3) an outpatient subspecialty treatment program for adolescent SUDs. Patients were excluded if they were non-English speaking, medically or emotionally unstable on the day of their appointment, or had been in a residential treatment for a SUD in the past 3 months.

This study was approved with a waiver of parental permission by the hospital institutional review board and granted a Certificate of Confidentiality from the National Institutes of Health. A detailed description of the study methods has previously been published.¹⁰

Measures

The assessment battery included demographic information, including age, gender, race/ethnicity, numbers of parents in household, and highest level of parent education as markers of socioeconomic status, and the criterion standard Composite International Diagnostic Interview-Substance Abuse Module (CIDI-SAM).¹¹ The CIDI-SAM is a structured diagnostic interview for lifetime history of psychoactive SUDs among those reporting past-year use of substances, including caffeine, alcohol, and other drugs (amphetamines and other stimulants, cannabinoids, cocaine, PCP and other hallucinogens, inhalants, heroin and other opiates, barbiturates, and other sedatives and tranquilizers). Questions are asked about problems related to use of each substance for which use is endorsed.

For caffeine, CIDI-SAM included seven of the nine DSM-5 criteria for the proposed CUD (recurrent substance use resulting in failure to fulfill major role obligations and continued substance use despite persistent problems were not included as they are not asked about within the CIDI-SAM). Table 1 shows the diagnostic criteria used for CUD versus other specific SUD criteria in DSM-5.

Data analysis

We used descriptive analyses to summarize demographic data about subjects, caffeine use, and associated symptoms, as well as alcohol, marijuana, and other drug use. We calculated prevalence rates for CUD, alcohol use disorder, and marijuana use disorder. We reported frequencies for endorsement of individual SUD criteria for caffeine, alcohol, and marijuana. We used chi-square analyses and simple linear regression to determine if significant differences were present in rates of endorsement across substances.

Before evaluating rates of endorsement of CUD by gender and age, we fit a one-dimensional simple structure to the seven diagnostic criteria to determine the fit indices for the DSM-5 criteria for substance abuse. We reported the Comparative Fit Index (CFI) and the Tucker–Lewis Index (TLI) as the descriptive fit indices. For these indices, values greater than 0.950 are considered adequate.¹² In addition, we used the root mean squared error of approximation (RMSEA) among residual-based fit indices and values ≤ 0.08 signify adequate fit.¹³

After model fit was assessed, to determine whether rates of endorsement of CUD diagnostic criteria differed by gender or age, we ran a latent mean Confirmatory Factor Analysis model. Gender comprised a dummy variable with 0 = females and 1 = males. We used age as a continuous variable measured in years and months. We evaluated the significance of the predictors using a z-test, but those findings were also contingent on overall model fit (i.e., the measurement of substance abuse criteria was mostly free of measurement error).

Results

Sample description

Of the total sample of 213 subjects, the mean age was 15.4 years and 33.3% were male. The sample was nearly evenly split between white (31.9%), black (31.9%), and nonwhite Hispanic (27.2%) participants. Just over half the sample had two parents in the home and a parent who was a college graduate (55.9% and 56.3%, respectively; Table 2). Subjects were recruited primarily from the adolescent (73.7%) and pediatric (10.3%) primary care clinics, with 16.0% recruited from the outpatient subspecialty treatment program for adolescent SUDs.

There were no differences between the clinics in terms of age ($\chi^2=16.30$, $N=213$, and $p=0.091$) or having two parents in the home ($\chi^2=5.182$, $N=213$, and $p=0.075$). The adolescent primary care clinic ($\chi^2=4.87$, $N=213$, and $p=0.027$) and the outpatient treatment program for adolescent substance use ($\chi^2=15.91$, $N=213$, and $p<0.001$) had a significantly higher rate of at least one parent who was a college graduate compared to the pediatric primary care clinic. The substance use clinic also had a significantly higher rate of a parent who was a

TABLE 2. DEMOGRAPHICS OF TOTAL SAMPLE AND THOSE REPORTING PAST CAFFEINE, ALCOHOL, OR MARIJUANA USE

Demographics	Total sample, N (%)	Past 30-day caffeine use, N (%)	CUD ^a , N (%)
Total (N)	213	153	6
Mean age (years)	15.4	15.6*	16.2
Male	71 (33.3)	52 (34.0)	1 (16.7)
Black	68 (32)	53 (34.6)	2 (33.3)
White	68 (32)	51 (33.3)	4 (66.7)
Nonwhite Hispanic	58 (27.2)	34 (22.2)	0
Two-parent home	119 (55.9)	88 (57.5)	4 (66.7)
Parent college graduate	117 (56.3)	88 (57.5)	3 (50)
Past-year alcohol use	79 (37.1)	67 (43.8)**	6 (100)**
Alcohol use disorder ^a	29 (13.6)	27 (17.6)*	4 (66.7)**
Past-year marijuana use	74 (34.7)	63 (41.2)**	6 (100)**
Marijuana use disorder ^a	29 (13.6)	26 (17.0)*	4 (66.7)**

^aSUDs were defined according to DSM-5 diagnostic criteria.

* $p < 0.05$ for chi-square analyses showing relationship between column and corresponding row (e.g., of those who endorsed caffeine use within the past 30 days, 17.6% have an alcohol disorder, which is more than expected by chance).

** $p < 0.01$ for chi-square analyses showing relationship between column and corresponding row (e.g., of those who endorsed caffeine use within the past 30 days, 43.8% report past-year alcohol use, which is more than expected by chance).

college graduate than the adolescent primary care clinic ($\chi^2 = 9.11$, $N = 213$, and $p = 0.003$).

Caffeine use disorder

The majority ($n = 153$, 71.83%) of the total sample reported past 30-day caffeine use. Sixty-four percent ($n = 100$), 91% ($n = 20$), and 97% ($n = 33$) of participants in the adolescent, primary care, and outpatient substance use clinics, respectively, reported caffeine use. Of those reporting past 30-day caffeine use, six participants (3.9%) endorsed all three essential criteria needed to make the diagnosis of CUD. Four participants had presented for care at the outpatient substance use clinic, and two had presented for care at the primary care clinic. All of these six also met DSM-5 criteria for either alcohol use disorder ($N = 4$), marijuana use disorder ($N = 4$), or both ($N = 2$). Prevalence of CUD among all subjects in this study was 2.8%.

Of those reporting past 30-day caffeine use, 87 participants (58.2%) reported one or more of seven criteria listed as proposed criteria for CUD in the DSM-5. Forty-two percent of caffeine users did not endorse any CUD criteria, 23% reported one criterion, 11% reported two criteria, 7% reported three criteria, 9% reported four criteria, and 7% reported five criteria. The maximum number of criteria endorsed was six (3% of caffeine users). The six participants who met criteria for a CUD met a total of five (four participants) or six (two participants) criteria.

Of the 38 subjects who endorsed three or more CUD criteria, six were diagnosed with CUD based on requiring

the essential three CUD criteria to be fulfilled. Of the remaining 32 subjects, 11 met criteria for alcohol use disorder only ($N = 4$), marijuana use disorder only ($N = 4$), or both alcohol and marijuana use disorders ($N = 3$).

Older adolescents were more likely than younger adolescents to report caffeine use ($B = 0.069$, $B = 0.221$, and $p = 0.001$); there was no difference in the rate of caffeine use between boys and girls, by race/ethnicity or socioeconomic status (Table 2). As seen in Table 2, chi-square analyses revealed that both past 30-day caffeine use and having a CUD were significantly associated with past alcohol and marijuana use and alcohol and marijuana use disorders.

Rates of criterion endorsement

Table 3 shows the rates of endorsement of each individual SUD criterion separately for caffeine, alcohol, and marijuana. There were significant bivariate differences in endorsement for each criterion. Each of the substances of caffeine, alcohol, and marijuana was denoted with subscripts a, b, and c, respectively, with the presence of two subscripts a and b or c showing significant differences between caffeine (a) and either alcohol (b) or marijuana (c). Significant differences are only shown with regard to caffeine in relation to the other two substances, but not between alcohol and marijuana because these comparisons were beyond the scope of the present study.

“Failing to Quit” showed significantly lower endorsement rates for caffeine compared to alcohol. “Harm,” “Time,” and “Crave” criteria were all endorsed significantly more frequently in relation to caffeine compared to either alcohol or marijuana. “Withdrawal” was endorsed more frequently in relation to caffeine than

TABLE 3. DISTRIBUTION OF DSM-5 CRITERIA ENDORSEMENT FOR CAFFEINE, ALCOHOL, AND MARIJUANA

DSM-5 criteria	Distribution of item responses (%)			Chi-square
	Caffeine _a	Alcohol _b	Marijuana _c	
Failing to quit	4.2 _{a,b}	11.3 _{b,a}	7.7 _c	6.003 ^a
Harm	29.8 _{a,b,c}	4.8 _{b,a}	12.5 _{c,a}	41.641***
Withdrawal	19.0 _{a,b}	3.0 _{b,a}	11.3 _c	21.978***
Intend	14.3 _{a,c}	16.7 _b	7.7 _{c,a}	6.394*
Tolerance	13.7 _a	10.7 _b	8.3 _c	2.490
Time	32.1 _{a,b,c}	10.1 _{b,a}	11.3 _{c,a}	35.142***
Crave	17.3 _{a,b,c}	6.0 _{b,a}	9.5 _{c,a}	11.551**

The subscripts a, b, and c indicate mean levels for caffeine, alcohol, and marijuana, respectively. The presence of two subscripts suggests significant differences between the endorsement levels for two substances. For example, for failing to quit a substance, there are significant differences between caffeine and alcohol (denoted with subscripts a,b and b,a), that is, differences between 4.2 and 11.3, but no differences related to marijuana (c subscript is by itself).

* $p < 0.05$, ** $p < 0.01$, and *** $p < 0.001$.

^aEffect at exactly $p = 0.05$.

alcohol, and “Intend” was endorsed more frequently in relation to caffeine than marijuana.

Rates of endorsement of CUD criteria by gender and age

Descriptive fit indices for the CUD model were excellent (CFI=0.994, TLI=0.991, with recommended acceptable values being greater than 0.950). Unstandardized residuals (i.e., RMSEA) had a mean of 4.2% with 95% confidence interval (CI) 1.5–6.6%, all within acceptable limits.

Results for the latent mean model with gender and age suggest that the data fit the model well with excellent descriptive fit indices (i.e., CFI=0.962) and RMSEA (0.063, 95% CI 0.026–0.095). The regression of gender and age on the latent factor resulted in null effects ($b_{\text{Gender}} = -0.066$, $p = 0.493$; $b_{\text{Age}} = -0.017$, $p = 0.854$). Thus, gender and age were not influential in predicting substance abuse criteria for caffeine (i.e., the criteria were not different for males vs. females or younger vs. older individuals).

Discussion

In our sample of adolescents aged 12–17 years old presenting for a medical appointment, the prevalence of CUD using proposed criteria was 2.8% in the total sample and 3.9% among those who reported past 30-day caffeine use ($N = 153$). These estimates are lower than previous research on caffeine dependence in adolescents; prevalence of caffeine dependence was reported to be 23.8% among 21 adolescents with past-year daily caffeine use.¹⁴ The difference in prevalence could be affected by the difference in diagnostic criteria between CUD and caffeine dependence.

In our study, every adolescent who met proposed criteria for CUD also met criteria for either alcohol or marijuana use disorder, suggesting that individuals predisposed to other SUDs may also be more likely to develop problems related to caffeine use. The likelihood of meeting criteria for CUD was not significantly affected by the adolescent’s age or gender in this sample. The clustering of CUD with other SUDs may represent an underlying physiologic tendency toward disordered substance use in some people. Risk taking behavior is associated with increased activity in the nucleus accumbens, and research has shown that there is individual variation in levels of activation of the nucleus accumbens according to anticipated positive or negative consequences of behaviors.¹⁵

Thus, some individuals may be predisposed to develop disordered use across a variety of substances. Common genetic factors shared between caffeine, alcohol, and tobacco may also explain the likelihood for comorbidity¹⁶ in that some individuals may be more susceptible to developing problematic use based more on their genetics than on the actual type of substance used.

Another possible explanation for the comorbidity of caffeine use and other substance use is that caffeine

may facilitate the use of other drugs. For example, combining alcoholic drinks with caffeine may offset the subjective intoxicating effects of alcohol,^{17,18} contributing to increased intake. It is also possible that adolescents with alcohol or marijuana problems cannot distinguish which substance is causing a problem (such as withdrawal symptoms) and they may incorrectly attribute. However, the CIDI-SAM used in this study to ascertain symptoms and problems related to substance use asks about each specific substance, and its potentially related problems, separately in an effort to classify problems as they relate to a specific substance.

Our findings suggest that the model for CUD is psychometrically robust. With acceptable values between 5% and 8% for RMSEA values, we conclude that the seven criteria defined well a unidimensional hypothetical structure of SUD. Face validity also supports the essential inclusion of failure to quit, harm from substance, and withdrawal as supportive of disordered use. Caffeine can be associated with physical and emotional problems⁴ and if an individual continues caffeine use despite these problems, then it is reasonable to consider use as disordered.

In this sample, less than 3% of adolescents met criteria for CUD, despite 71.8% reporting caffeine use in the past 30 days. The relatively high threshold of criteria needed to meet definition for disordered use (three criteria must be met vs. two for other substances)⁸ may help to prevent overdiagnosis of CUD, given the widespread use of caffeine. In this study, 21 subjects (9.8% of total sample) endorsed three or more CUD criteria, but did not meet criteria for any SUD. It is possible that the three essential criteria alone miss some individuals with CUD. A future qualitative study could assess in greater depth whether this group experiences functional impairment due to caffeine use and, thus, should be captured by the diagnosis of a CUD.

Of the three CUD criteria essential for the diagnosis (failure to quit, use despite harm, and withdrawal), both harm and withdrawal were endorsed significantly more often in relation to caffeine compared to alcohol. The concept of harm from substance use may be very different in relation to different substances. Some of the adverse effects of caffeine include increase in blood pressure, palpitations, sleep problems, headaches, and increase in urinary frequency.² These harms are quite different from those associated with alcohol or marijuana use, such as blackouts and memory problems.

Furthermore, it is unclear how to interpret the differences in withdrawal criteria reported across substances. Caffeine withdrawal can occur after abstinence from a dose as low as 100 mg/day,¹⁹ which could be consumed through normative use (a 12-ounce cup of coffee = 200 mg caffeine). Thus, the physiological properties of caffeine may increase the likelihood of withdrawal symptoms. In this study, the criterion of failure to quit was rarely endorsed in relation to caffeine (4.2%). In comparison, it

was endorsed significantly more frequently in relation to alcohol (11.3%). Including “failure to quit” as an essential criterion for CUD may minimize overdiagnosis of CUD.

It is unclear how the other nonessential criteria for CUD should be used clinically. In our study, time spent to obtain substance and craving of substance were both reported more frequently in relation to caffeine compared to either alcohol or marijuana. Given the cultural acceptance and even promotion of caffeine in our society, it is not clear that time spent related to obtaining caffeine indicates problematic use; it may be a social phenomenon rather than a preoccupation. The notion of “craving” caffeine may also be difficult to compare to other substances given that it is readily available with widespread advertisements and marketing supporting the notion that caffeinated drinks should be sought.

Among adolescents in our study, the criterion of “substance taken in larger amounts or over a longer period than intended” was endorsed more frequently for caffeine compared to marijuana. Given the ubiquitous nature of caffeine in beverages and food, it is unclear whether respondents were indicating that they cannot stop themselves from seeking out caffeine, or they simply have difficulty avoiding it, and whether this would indicate problematic use. Future studies could further explore the clinical utility of these nonessential criteria for CUD.

The findings of this study must be interpreted in the context of a number of potential limitations. The data for this study were collected before DSM-5 was released. Therefore, only seven out of the nine criteria for the proposed CUD were included in the assessment battery in this study and we cannot comment on the other two criteria. However, the essential three criteria were all included, thus it was possible to determine how many subjects met criteria for CUD.

A minority of the subjects in this study (16.0%) were recruited from an outpatient subspecialty treatment program for adolescent SUDs, making this sample distinct from the sample in a previous report evaluating the prevalence of problems related to caffeine use among adolescents presenting for routine medical care,⁴ in which this subsample was not included. The oversampling of adolescents with SUDs limits generalizability of the findings to primary care samples. However, we note that even with the inclusion of the subsample with SUD, only 3% of participants met criteria for CUD.

Conclusions

We conclude that the proposed DSM-5 criteria for CUD form a well-defined, unidimensional hypothetical structure of SUD. In our sample, despite common use of caffeine among adolescents, relatively few met criteria for CUD. These findings suggest that the DSM-5 proposed CUD will avoid overdiagnosis of CUD. In addition, CUD was

highly correlated with both alcohol and marijuana use disorders, thus supporting that CUD may accurately capture those with addictive and/or problematic use of caffeine.

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Author Disclosure Statement

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