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Examining Associations Between Cannabis Use Disorder and Measures of Weekly and Within-Day Cannabis Frequency, Quantity, and Potency in College Students

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Abstract

Background: College student cannabis use has increased significantly in recent years, and individuals aged 18–25 are at elevated risk for development of cannabis use disorder (CUD). While weekly cannabis use frequency is a commonly used measure of cannabis consumption, there is increasing scientific interest in exploring more nuanced measures of cannabis use. Currently, limited research exists examining the clinical utility of cannabis quantity, within-day frequency, and potency variables.

Methods: We used cross-sectional survey data from a sample of 617 undergraduate students in the state of Colorado. A two-part model-building approach was leveraged to examine whether within-session cannabis quantity and within-day cannabis use frequency were associated with odds of experiencing any CUD symptoms and total number of CUD symptoms endorsed. We also examined whether cannabis flower potency was associated with odds of experiencing any CUD symptoms and total number of CUD symptoms endorsed among a subset ($N = 288$) of the sample who reported knowledge of the cannabinoid content of their most frequently used products.

Results: Weekly flower use frequency (odds ratio [OR] = 1.27, $p < 0.001$) and weekly concentrate use frequency (OR = 1.10, $p = 0.044$) were positively associated with increased odds of experiencing any CUD symptoms, but cannabis quantity and within-day frequency variables were not. In addition, no association was found between flower potency and odds of endorsing any CUD symptoms. Among individuals endorsing at least one symptom, weekly flower use frequency (incident rate ratio [IRR] = 1.06, $p < 0.001$) was positively associated with total symptom count, but weekly concentrate use frequency, cannabis quantity variables, and within-day frequency variables were not. Among individuals endorsing symptoms, a positive association was found between flower potency and total symptom count (IRR = 1.01, $p = 0.008$).

Conclusion: Current methods of assessing within-session cannabis quantity and within-day cannabis use frequency may lack clinical utility in examining college student CUD symptoms over and above weekly cannabis use frequency. Cannabis flower potency may prove useful in assessment of CUD symptom severity, but further research is warranted.

Keywords: cannabis; tetrahydrocannabinol; cannabis quantity; cannabis frequency

Introduction

College student cannabis use is at a record high, with 44% of college students reporting past-year use in 2020.[1] Furthermore, evidence suggests that individuals aged 18–25 are at greatest risk for developing cannabis use disorder (CUD),[2] underscoring the need to investigate mechanisms associated with college student CUD symptomology.

Weekly cannabis use frequency is the most commonly used measure of cannabis consumption.

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However, this method of assessment lacks nuance (e.g., how much cannabis is used per session and per day, potency, route of administration, and so on), and researchers have recently identified the need to study additional consumption variables such as cannabis quantity, within-day frequency, product type (e.g., flower, concentrates), and potency (particularly in legal markets where cannabinoid content is required to be on packaging).[3]

While these variables may offer a more comprehensive overview of cannabis use behavior, current methods of assessing cannabis consumption are imperfect.[4] For example, evidence suggests that even regular-to-heavy cannabis users provide inaccurate self-reports of flower and concentrate quantities.[5] Likewise, while one recent study found that individuals in legal markets are capable of reporting on cannabis product delta-9 tetrahydrocannabinol (THC) content consistently,[6] labeling of cannabinoid content on legal-market products may lack precision (e.g., Colorado allows for 15% variance in potency labeling on cannabis products).[7]

Given the limitations described above, it is unclear whether these variables are associated with CUD symptoms over and above weekly frequency. For example, one recent study examined associations between weekly frequency, potency, and CUD symptom count among a community sample in Colorado, but no significant associations emerged between potency and total number of CUD symptoms when controlling for weekly frequency.[3] In another Colorado community sample, researchers found no association between potency and CUD symptom count, but this study was limited in that only the highest potency products reported by participants were included in analyses and no information was collected on frequency of use by mode of administration.[8]

We sought to build on this growing body of research[3,8–10] and extend existing findings in a college student sample. Specifically, using a two-part, model-building approach, we examined whether within-session cannabis quantity and within-day cannabis use frequency were associated with odds of experiencing any CUD symptoms and total number of CUD symptoms endorsed. We also investigated whether cannabis flower potency was associated with odds of experiencing any CUD symptoms and total number of CUD symptoms endorsed among a subset of the sample who reported knowledge of the cannabinoid content of their most frequently used products. Given the limited research in this area and prior findings highlighting the imperfect nature of self-report cannabis consumption measures, all study aims were exploratory and no directional hypotheses were generated.

Methods

Participants

Participants (Table 1 and Supplementary Data S2) were 2409 undergraduates (18–24 years old) recruited from the psychology department subject pool and were included in this analysis ($N = 617$) if they reported being a current cannabis user. Participants received course credit as compensation and the study was institutional review board approved.

Measures

Cannabis Consumption variables were adapted from previous studies examining legal-market cannabis use.[11–13] Questions pertained to weekly frequency of use, within-session quantity, within-day frequency of use, and flower THC content (Supplementary Data S1).
Cannabis Use Disorder Symptoms were assessed using an updated version of the Marijuana Dependence Scale (MDS),[14] as used in Drennan and colleagues.[15] The revised MDS is an 11-item scale based on CUD criteria outlined in the Diagnostic and Statistical Manual of Mental Disorders, fifth edition (DSM-5).[14,16] Participants responded yes/no to each item, and a sum score was calculated for total number of symptoms endorsed (mean = 2.55). Per DSM-5 criteria, 2–3 symptoms = mild CUD, 4–5 symptoms = moderate CUD, and 6 or more symptoms = severe CUD.

Analysis plan

Data cleaning procedures were performed using recommendations from Tabachnick and Fidell.[17] Specifically, univariate outliers (scores of ≥ 3.29 standard deviation, a likelihood of $p < 0.001$) were examined individually and adjusted by reducing outlying values to one score above the next highest value in the distribution. All "not applicable" responses were coded as zero to reflect instances in which the referenced cannabis consumption behavior was not endorsed. For example, if a participant responded "not applicable" when asked to report quantity of dabs used per sitting, they were assumed not to use dabs and were coded as "0" for that question. All "not sure" responses were coded as missing, given that the individual may participate in the cannabis use activity referenced in the question, but indicated that they were unsure how to answer it.

Table 1. Respondent Characteristics

Characteristics	*N*	%	*M*	SD	Sx^2	IQR	Min	Max	Skew
Age			19.22	1.42					
Age of first regular use			17.47	2.14					
Alcohol use									
Yes	518	84.0							
No	99	16.0							
Use of other drugs									
Yes	218	35.3							
No	399	64.7							
Gender									
Cis woman	400	64.8							
Cis man	193	31.3							
Trans woman	1	0.2							
Trans man	3	0.5							
Gender non-conforming	16	2.6							
Genderfluid	1	0.2							
Genderqueer	1	0.2							
Non-binary/woman	2	0.3							
Ethnicity									
Hispanic/Latino/a/e/x	96	15.6							
Non-Hispanic/Latino/a/e/x	520	84.4							
Race									
American Indian or Alaska Native	25	4.1							
Asian	27	4.4							
Black or African American	22	3.6							
Native Hawaiian or Pacific Islander	8	1.3							
White	569	92.2							
Total CUD symptoms			2.55	2.96	8.79	4	0	11	1.27
Weekly frequency									
Flower			3.55	2.76	7.63	6.25	0	7	0.16
Concentrates			1.88	2.53	6.43	3	0	7	1.18
Within-day frequency									
Flower			2.33	2.01	4.05	2	0	13	2.51
Dabs			0.97	1.75	3.05	1	0	10	2.91
Cartridge			1.47	2.56	6.54	2	0	22	3.97
Within-session quantity									
Flower (grams)			0.39	0.43	0.19	0.4	0	4	3.49
Dabs (number of dabs)			1.16	1.94	3.74	2	0	16	3.31
Cartridge (hits)			2.42	3.28	10.76	3	0	21	2.58
Flower THC content (%)			22.62	7.59	57.55	6	0	38	−0.43

CUD, cannabis use disorder; IQR, interquartile range; *M*, mean; SD, standard deviation; Sx^2, variance; THC, delta-9 tetrahydrocannabinol.

Analyses were conducted in Stata[18] using a two-part model-building approach (i.e., increasing model complexity in steps) to sequentially examine effects while maintaining a parsimonious model (Table 2). First, we conducted a series of logistic regressions to examine associations between cannabis consumption variables and odds of endorsing any CUD symptoms (likelihood model). We then estimated a series of left censored Poisson regressions (lower limit of 1) to examine associations between cannabis consumption variables and total number of CUD symptoms endorsed (count model).

For the likelihood model, we report odds ratios (ORs; interpreted as the estimated logs odd of the outcome per one unit increase in the independent variable, when all other independent variables in the model are held constant). For the count model, we report incident rate ratios (IRRs; interpreted as the percent increase in the outcome per one unit increase in the independent variable, when all other independent variables in the model are held constant). For both models, likelihood ratio tests examined the relative fit of nested models (i.e., the difference in −2 log-likelihood statistics between pairs of base and expanded models). Finally, we conducted a series of Spearman's Rho correlations to examine relationships between variables of interest (Table 3).

Likelihood model. In model 0 (base model), total CUD symptoms were regressed on weekly flower and

Table 2. Model Building Results

	Likelihood model			Count model		
	Criterion: presence of CUD symptoms			Criterion: total CUD symptoms		
Variable	OR	SE	$p > \|z\|$	IRR	SE	$p > \|z\|$
Model 0						
Weekly flower use frequency	**1.27**	**0.049**	**<0.001**	**1.06**	**0.011**	**<0.001**
Weekly concentrate use frequency	**1.10**	**0.051**	**0.044**	1.02	0.010	0.104
		$N = 617$			$N = 412$	
Model 1						
Weekly flower use frequency	**1.28**	**0.051**	**<0.001**	**1.06**	**0.011**	**<0.001**
Weekly concentrate use frequency	1.09	0.053	0.069	1.01	0.011	0.195
Within-session flower quantity	0.85	0.185	0.453	0.93	0.063	0.308
Within-session dab quantity	0.95	0.056	0.417	1.00	0.014	0.794
Within-session cartridge quantity	1.04	0.035	0.264	1.01	0.008	0.377
	$\Delta\chi^2$ (3, $N = 617$) 1.95, $p = 0.584$			$\Delta\chi^2$ (3, $N = 412$) 1.84, $p = 0.605$		
Model 2						
Weekly flower use frequency	**1.24**	**0.051**	**<0.001**	**1.05**	**0.012**	**<0.001**
Weekly concentrate use frequency	1.08	0.056	0.145	1.01	0.011	0.531
Within-day flower use frequency	1.11	0.076	0.112	1.03	0.013	0.050
Within-day dab use frequency	0.96	0.072	0.561	1.02	0.015	0.141
Within-day cartridge use frequency	1.06	0.059	0.328	1.00	0.009	0.841
	$\Delta\chi^2$ (3, $N = 617$) 4.46, $p = 0.216$			**$\Delta\chi^2$ (3, $N = 412$) 10.05, $p = 0.018$**		
Model 3[a]						
Weekly flower use frequency	**1.26**	**0.075**	**<0.001**	**1.07**	**0.018**	**<0.001**
Weekly concentrate use frequency	1.03	0.064	0.621	1.00	0.014	0.997
Within-day flower use frequency	—	—	—	1.01	0.016	0.632
Within-day dab use frequency	—	—	—	1.01	0.018	0.776
Within-day cartridge use frequency	—	—	—	1.00	0.011	0.771
Flower THC content	1.01	0.019	0.783	**1.01**	**0.005**	**0.008**
		$N = 288$			$N = 221$	

Boldface denotes significance. Count models were left centered with a lower limit of 1. In likelihood model 3, flower THC content was added to model 0 given that model 0 had the best fit. Thus, within-day frequency variables were not included in this model.

[a]Model 3 was exploratory and included a subsample of the larger sample who knew the THC content of their cannabis. Thus, it was not compared to the other models.

IRR, incident rate ratio; OR, odds ratio; SE, standard error.

Table 3. Spearman's Rho Correlation Results

	1	2	3	4	5	6	7	8	9
1. CUD total symptom count	—	0.37[a]	0.25[a]	0.12[b]	0.18[a]	0.13[b]	0.31[a]	0.22[a]	0.17[a]
2. Weekly flower frequency		—	0.41[a]	0.27[a]	0.28[a]	0.19[a]	0.54[a]	0.32[a]	0.27[a]
3. Weekly concentrate frequency			—	0.15[a]	0.48[a]	0.64[a]	0.33[a]	0.52[a]	0.68[a]
4. Within-session flower quantity				—	0.21[a]	0.15[a]	0.26[a]	0.21[a]	0.14[a]
5. Within-session dab quantity					—	0.37[a]	0.25[a]	0.86[a]	0.31[a]
6. Within-session cart quantity						—	0.18[a]	0.29[a]	0.80[a]
7. Within-day flower frequency							—	0.33[a]	0.28[a]
8. Within-day dab frequency								—	0.35[a]
9. Within-day cart frequency									—

[a]$p < 0.001$.
[b]$p < 0.05$.

concentrate use frequency variables. Model 1 was constructed by simultaneously adding within-session cannabis use quantity variables (i.e., grams of flower per session, number of dabs per session, and number of hits from a cartridge pen per session) to model 0. In model 2, nonsignificant quantity variables were dropped and the model was re-estimated with the inclusion of within-day cannabis use frequency variables (number of times using flower per day, number of times using dabs per day, and number of times using a concentrate cartridge per day) in addition to the weekly flower and concentrate use variables from the base model. Finally, a third model was estimated with a subset of the sample ($N = 288$) who indicated knowledge of the THC content of their most frequently used flower cannabis products. Model 3 included weekly frequency variables (i.e., the base model) and flower THC content.

Count model. For the count model, configuration of models 0–2 was identical to the likelihood model described above. However, in model 3 ($N = 221$), flower THC content was added to model 2 given that model 2 had the best fit in this series of regressions.

Results

Likelihood model

Model 0 results indicated that for every one unit increase in weekly flower use (OR = 1.27, $p < 0.001$) and weekly concentrate use (OR = 1.10, $p = 0.044$) frequency, odds of endorsing any CUD symptoms increased significantly. Model 1 results indicated that the addition of within-session cannabis use quantity variables did not significantly improve model fit $\Delta\chi^2$ (3, $N = 617$) 1.95, $p = 0.584$, with weekly flower use frequency (OR = 1.28, $p < 0.001$) remaining the only variable associated with increased odds of endorsing any CUD symptoms. Model 2 results indicated that the addition of within-day cannabis use frequency variables did not significantly improve model fit $\Delta\chi^2$ (3, $N = 617$) 4.46, $p = 0.216$, with weekly flower use frequency (OR = 1.24, $p < 0.001$) again remaining the only significant variable. Model 3 results indicated no association between flower THC content and odds of endorsing any CUD symptoms.

Count model

The outcome variable (total CUD symptoms) for the count model ($N = 412$ for Models 0, 1, and 2) was overdispersed (variance = 8.30, mean = 3.83, overdispersion = 2.16). Model 0 results indicated that weekly flower use frequency was positively associated with total CUD symptoms (IRR = 1.06, $p < 0.001$), but weekly concentrate use frequency was not. Model 1 results indicated that the addition of within-session cannabis use quantity variables did not significantly improve model fit, $\Delta\chi^2$ (3, $N = 412$) 1.84, $p = 0.605$, with weekly flower use frequency remaining the only significant variable in the model (IRR = 1.06, $p < 0.001$). Model 2 results indicated improved model fit with the addition of within-day cannabis use frequency variables, $\Delta\chi^2$ (3, $N = 412$) 10.05, $p = 0.018$, but with weekly flower use frequency again remaining the only significant variable (IRR = 1.05, $p < 0.001$).

Model 3 shows that weekly flower use frequency (IRR = 1.07, $p < 0.001$) and flower THC content (IRR = 1.01, $p = 0.008$) were positively associated with total number of CUD symptoms endorsed. Regression results are reported in Table 2. The outcome variable (CUD total) was overdispersed in the subsample ($N = 221$) included in the count model for Model 3 (variance = 8.79, mean = 4.14, overdispersion = 2.12).

Discussion

Most cannabis outcomes research to date has used some form of weekly or monthly frequency variable to reflect overall cannabis use.[9,19] However, more nuanced measures such as cannabis potency, within-session quantity, and within-day frequency may offer clinical utility over and above standard frequency variables. The results of this study raise the question of whether within-session cannabis quantity and within-day cannabis use frequency are relevant to consider when evaluating college student presentation of CUD symptoms.

While these variables have the potential to elucidate a more comprehensive understanding of cannabis use behavior,[4,20,21] current methods of assessing these variables do not appear to be associated with increased odds of endorsing any CUD symptoms or total CUD symptom count over and above weekly cannabis use frequency. These findings highlight the critical need to develop a gold standard[4] for measuring cannabis quantity (e.g., standard unit dose)[22,23] and frequency variables and to further investigate the utility of these measures in assessing relevant clinical outcomes.

Our finding that flower THC content was associated with total number of CUD symptoms suggests that this question may be useful for assessing CUD severity alongside weekly frequency of use. However, given that flower THC content was not associated with

odds of experiencing any CUD symptoms, this question may be less relevant for clinicians assessing whether or not symptoms are present. Our finding that flower THC content was associated with total CUD symptoms conflicts with prior research that found no association between potency and symptoms.[3,8]

Overall, potency findings should be considered in light of most study participants responding "not sure" when asked to report the cannabinoid content of the products they use most often. Given that most participants were under the age of 21 (the legal age to purchase cannabis in Colorado), it is possible that some participants were unsure of cannabis potency due to their inability to legally purchase products from a dispensary. In addition, due to discrepancies in potency labeling of legal-market products in Colorado,[7] self-report measures of THC content (even when based on packaging) may be inaccurate.

The relatively low mean number of CUD symptoms observed in our sample (mean = 2.55; indicating mild CUD) may have played a role in the nonsignificant within-session quantity and within-day frequency findings observed in this study. We acknowledge that these variables may hold greater clinical utility among individuals exhibiting more severe symptomology. We'd also like to recognize promising new consumption variables that were not included in the present study. For example, emerging evidence suggests that number of hours high may be a viable proxy for measuring cannabis quantity in survey research.[24] Likewise, associations between timing of cannabis use (e.g., morning vs. night) and consequences have recently been identified.[25]

Limitations and future directions

The current study is limited by its cross-sectional design, reliance on self-report, and homogeneity in terms of race, ethnicity, gender, and sexual orientation. In addition, we did not collect information on cannabis use sessions in which products may have been shared. First and foremost, we recommend replication of findings in a more diverse sample. Due to disparities in addiction treatment access and completion among racially and ethnically minoritized individuals,[26] and evidence suggesting that sexual and gender minority populations are at higher risk for the development of CUD,[27] we might expect to see differential patterns of cannabis consumption and CUD presentation in these populations. However, regardless of use patterns, individuals holding marginalized identities may be at greater risk of experiencing adverse outcomes due to a myriad of systemic factors at play (e.g., structural discrimination, racially biased policing, housing instability).[28]

Additional future directions include examining the utility of quantity, potency, and within-day frequency variables in assessing nonclinical outcomes related to college-student cannabis use (e.g., consequences) and employing intensive longitudinal designs (e.g., ecological momentary assessment) to examine variables over time. Finally, we recommend that future studies assess the utility of quantity, potency, and within-day frequency variables in clinical samples exhibiting more severe presentation of CUD symptoms.

Implications

Overall, our findings underscore the need for researchers to continue refining tools for cannabis measurement. Until a gold standard is developed, we recommend for clinicians to continue assessing consumption patterns beyond weekly frequency of use (e.g., within-day frequency, quantity, potency, mode of administration), but to exercise thoughtfulness around the weight they give to these measures in understanding a client's unique symptom presentation.

Data Availability Statement

Data available from corresponding author upon request.

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Authors' Contributions

C.J.P. is responsible for the conceptualization, writing—original draft, writing—review and editing, visualization, and project administration. V.T.S. is responsible for conceptualization, writing—original draft, and writing—review and editing. M.M. is responsible for conceptualization, writing—original draft, and writing—review and editing. N.N.E. is responsible for conceptualization, methodology, software, validation, investigation, formal analysis, data curation, writing—original draft and writing—review and editing, and supervision. H.C.K. is responsible for conceptualization, data curation, methodology, validation, investigation, writing—original draft and writing—review and editing, and supervision. All authors contributed to and approved the final article.

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Supplementary Material

Supplementary Data S1
Supplementary Data S2

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Abbreviations Used

CUD = cannabis use disorder
DSM-5 = Diagnostic and Statistical Manual of Mental Disorders, fifth edition
IRR = incident rate ratio
MDS = Marijuana Dependence Scale
OR = odds ratio
THC = delta-9 tetrahydrocannabinol