Research Article

Effects of Cannabis Use on Physical Pain and the Moderating Role of Depressive Symptoms

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Samantha G. Cassidy[1], Jackson T. Jin[1], Angela J. Zaur[1], & William V. Lechner[1]
[1]Department of Psychological Sciences, Kent State University

ABSTRACT

Objective: While cannabis has several empirically supported medical benefits, the literature is mixed regarding the effectiveness of cannabis in reducing symptoms of physical pain. Depressive symptoms are a potentially important moderator of the relationship between cannabis and pain that could help explain the mixed literature. The current study aimed to assess whether the magnitude of pain relief from cannabis use was higher in individuals with elevated depressive symptoms. **Method:** Seventy-six participants (64.5% female; 80.3% White; M_{age} = 22.19 years [*SD* = 5.69]) who self-reported using cannabis at least once per week were recruited in northeastern Ohio. Multi-level modeling was utilized to examine the effect of daily cannabis use and depressive symptoms on pain ratings over one week. Additional analyses examined a sub-sample of participants with more than minor pain ($N = 36$). **Results:** It was found that using cannabis on any given day was associated with lower average pain ratings ($B = -0.60$, 95%CI[-1.10 - -0.09]) within the sub-sample. Within the entire sample, depressive symptoms were associated with higher average pain ratings ($B = 0.21$, 95%CI [0.09-0.32]). Depressive symptoms did not moderate the relationship between cannabis use and pain. **Conclusions:** We found that cannabis use was associated with lower reported pain in the sub-sample. Further research is needed to explore the impact of the type of pain on the efficacy of cannabis. Experimental studies exploring the ideal therapeutic dose for cannabis and controlling for route of administration are needed to further inform this research concerning the subjective effects of cannabis.

Key words: = cannabis; pain; depressive symptoms; mental health; moderation

Cannabis use has increased significantly in recent years, with daily use rising from 16.2% pre-pandemic to 20.7% during COVID-19 (Lake et al., 2023), alongside an increase in cannabis use disorder (CUD) from 5.8% to 7.0% (Substance Abuse and Mental Health Services Administration, 2020; Substance Abuse and Mental Health Services Administration, 2024). Risks for cannabis use include impaired driving (Asbridge et al., 2012) and an increased risk of psychosis, particularly when sub-clinical threshold psychotic symptoms were already present before cannabis use (Bechtold et al., 2016; Carney et al., 2017; Kraan et al., 2016). However, there are also benefits of cannabis use, such as reduced nausea associated with chemotherapy in cancer patients (Abrams et al., 2020) and reduced inflammation (Ellis et al., 2020; Okafor et al., 2020). Cannabis has also been reported to reduce depressive symptoms and pain (Stockings et al.,

Corresponding Author: Samantha Cassidy, M.A., Kent State University, 600 Hilltop Drive, Kent, Ohio, 44240. Email: scassid6@kent.edu.

2018; Wang et al., 2021a; Whiting et al., 2015). These reports are reflected in the reported motives for cannabis use, which frequently include depression and pain (Kosiba et al., 2019; Leung et al., 2022).

Due to motivations for cannabis use frequently including pain, it is important to examine the relationship between cannabis and pain, given that chronic pain affects approximately 20% of U.S. adults (Zelaya et al., 2020). While chronic pain is commonly treated with opioids, there are numerous consequences of opioid use. These consequences include respiratory depression (Lee et al., 2015; Taylor et al., 2005), addiction (Cragg et al., 2019; Degenhardt et al., 2019), and overdose deaths, which have risen from 1.8% in 2011 to 4.5% in 2021 (Gomes et al., 2023). Given these risks, cannabis has emerged as a potential alternative treatment.

However, while pain is a predominant motive for cannabis use (Kosiba et al., 2019; Leung et al., 2022), the research on cannabis' analgesic effects remains mixed (Eisenberg et al., 2022). While some meta-analyses have shown significant pain reduction (Stockings et al., 2018; Whiting et al., 2015), others have reported no substantial impact (Giossi et al., 2022). Results remain mixed when focusing on the efficacy of cannabis use in reducing pain associated with specific conditions, such as osteoarthritis (Dubois et al., 2024; Xiao et al., 2024) and rheumatoid arthritis (Guillouard et al., 2021; Hauser et al., 2018). Studies utilizing ecological momentary assessment (EMA) further illustrate these discrepancies. While one EMA study found an inverse relationship between cannabis use and pain severity over time (Wang et al., 2021b), another reported no significant pain relief following use (Sznitman et al., 2021). Factors contributing to these mixed findings include the lack of standardized dosing (Kraft et al., 2008), varying THC-to-CBD ratios in different strains (Baron et al., 2018; Bidwell et al., 2018), and differences in administration routes (Hart & Ksir, 2022a).

Reflecting the numerous factors that impact the subjective effects of cannabis, the extant literature regarding the relationship between cannabis use and depressive symptoms is also inconsistent. Cross-sectional studies present conflicting results, with some suggesting cannabis use decreases depressive symptoms (Cuttler et al., 2018; Stith et al., 2018), while others indicate it exacerbates them (Degenhardt et al., 2003; Lev-Ran et al., 2014). Meta-analyses of longitudinal studies also show inconsistent findings, with some linking cannabis use to a higher likelihood of developing depression (Gobbi et al., 2019) and others finding no association (Stockings et al., 2018). Possible explanations for the mixed literature include lack of established therapeutic dose (Kraft et al., 2008; Wallace et al., 2007), the different effects due to modes of administration (Bidwell et al., 2022; Grotenhermen, 2003; Spindle et al., 2020), and the dysregulation of the dopaminergic pathways. Cannabis temporarily increases dopamine levels by binding to cannabinoid receptors, but chronic use can lead to dopamine depletion, which is linked to depression (Sami et al., 2015; Volkow et al., 2017). Additionally, many studies fail to account for frequency of use, despite evidence suggesting heavy cannabis use correlates with greater depressive symptoms (Degenhardt et al., 2003; Gorfinkel et al., 2020).

Due to the inconclusive results regarding the subjective effects of cannabis, recent research has focused on the interaction between pain and mental health to explain the varying results. Meta-analyses confirm a significant association between pain and depression across conditions, including lower-back pain and osteoarthritis (Dickens et al., 2002; Wong et al., 2022). The relationship is likely bidirectional, as pain and depression share neurobiological mechanisms, such as alterations in dopamine, serotonin, and norepinephrine levels (Bair et al., 2003; Han & Pae, 2015). Moreover, pain is associated with reduced physical activity, social isolation, and increased stress—all of which are risk factors for depression (Erzen & Cikrikci, 2018; LeMoult et al., 2020). Given the overlap between pain and depression, their interaction may explain the inconsistencies in cannabis research.

Despite conflicting findings, pain and depression remain common reasons for medical cannabis use (Kosiba et al., 2019). Studies assessing cannabis use, pain, and depressive symptoms together yield mixed results. While some studies suggest individuals with depression are more likely to use cannabis (Feingold et al., 2020), others indicate no relationship between cannabis use and same-day pain or depression (Tervo-Clemmens et al., 2023). However, longitudinal studies report reductions in both pain and depression over time following cannabis use (Poli et al., 2018; Sotoodeh et al., 2023).

Mediation and moderation analyses provide additional insight. One study found that pain mediated the relationship between depressive symptoms and cannabis use (Tsao et al., 2011), while another showed that improvements in negative affect partially explained pain reductions from cannabis (Sotoodeh et al., 2023). Furthermore, Goesling and colleagues (2015) found that depressive symptoms moderate the relationship between pain and opioid use, where the probability of taking opioids increased with higher levels of pain severity in non-depressed participants; nonetheless, this probability did not change based on pain severity in participants with depressive symptoms. Given these findings, we conducted a moderation analysis to examine the role of cannabis in managing pain and depressive symptoms. Our hypotheses were as follows: 1) not using cannabis will be associated with higher levels of reported pain; 2) elevated levels of depressive symptoms will be associated with higher levels of reported pain; and 3) depressive symptoms will moderate the relationship between cannabis use and pain severity. We theorized that the inconsistent literature regarding the association between cannabis and pain severity is because 1) the relationship between cannabis and pain severity differs significantly between individuals, and 2) the association between depressive symptoms and pain severity is stronger. Thus, we hypothesized that individuals with lower levels of depressive symptoms would show a significant effect of cannabis use on pain reduction, whereas individuals with higher levels of depressive symptoms will not experience a significant effect. Finally, we predicted that these hypotheses would be observed within our total sample and the sub-sample including only participants who endorsed experiencing pain.

METHODS

Participants and Procedure

To determine the recommended sample size for this study, we conducted a power analysis utilizing G*Power Analysis Software, Version 3.1 (Faul et al., 2007). We chose a moderate effect size of Cohen's f2 (0.20), reflecting the effect size in the literature ranging from small to large (Cuttler et al., 2018; Dickens et al., 2002; Guillouard et al., 2021; Stith et al., 2018; Stockings et al., 2018; Wang et al., 2021b; Whiting et al., 2015; Wong et al., 2022; Xiao et al., 2024), and the alpha was set as 0.05. It was estimated that a sample size of 60 would be necessary for adequate power. To account for attrition, the target sample size was adjusted to 100.

Participants ($N = 97$) were recruited from the research subject pool at a large University, as well as through advertisements in the community within northeastern Ohio, United States (i.e., cannabis stores, local retailers, food establishments). Thirty-eight participants were recruited from the community, and 59 participants were recruited from the research subject pool. Primary inclusion criteria required participants to: 1) be 18 years of age or older, 2) use cannabis at least weekly, and 3) live in the United States. After confirming eligibility, participants completed a baseline assessment and a brief assessment over the course of one observation week. Participants were directed to complete brief assessments within an 8-hour window starting at the time that they self-selected (repeated each day). Due to a suggested minimum of three observations needed per participant to conduct mixed linear modeling analyses (Bolger & Laurenceau, 2013; Singer & Willett, 2003), 21 participants were excluded from analyses (final $N = 76$). Additional analyses were conducted examining the hypotheses within a sub-sample of participants with more than minor pain (n = 36). Participants were included in the sub-sample if they endorsed having more than minor aches and pains that day during the Brief Pain Inventory, Short Form (Cleeland, 1991) within the baseline assessment. This study is covered through University IRB approval #909 and was pre-registered utilizing the Open Science Framework through the Center for Open Science (https://osf.io/7th34).

Measures

Baseline pain and daily pain. The Brief Pain Inventory, Short Form (BPI-SF; Cleeland, 1991), a 15-item self-report scale, assessed pain-related symptoms within the baseline assessment. The item that inquired about participants' average pain (in general, no time frame indicated) was included in analyses. During each brief assessment, participants provided information regarding their average pain level that day. Participants ranked their pain on a scale of 0 to 10, 0 representing "No pain" and 10 representing "Pain as bad as [they] can imagine."

Baseline depressive symptoms and daily depressive symptoms. The Patient Health Questionnaire-8 (PHQ-8; Kroenke et al., 2009) assessed depressive symptoms during the baseline assessment. The items were summed to create a total score (ranging from 0 to 24). The Cronbach's alpha for the PHQ-8 was 0.87 within the sample, which demonstrates good internal reliability (Cronbach, 1951). During each brief assessment, the Patient Health Questionnaire-2 (PHQ-2) (Kroenke et al., 2003) assessed depressive symptoms. Language of the PHQ-2 was altered to ask participants about their symptoms within that day instead of over the last two weeks (0 = Not at all, 1 = Some of the time; 2 = Most of the time; 3 = All the time). For each measure, the items were summed to create a total score. Total scores ranged from 0 to 24 for the PHQ-8; the range was 0 to 6 for PHQ-2. The Cronbach's alpha for the PHQ-2 was 0.75 within this sample, which demonstrates acceptable internal consistency (Cronbach, 1951).

Daily cannabis use and cannabis use frequency. During each brief assessment, participants were asked if they had used cannabis since the last assessment (0 = yes; 1 = no). Cannabis frequency was assessed by asking participants how often they use cannabis during the baseline assessment (0 = Once or more per day; 1 = 1-2 days per week; 2 = 3-4 days per week; 3 = 5-6 days per week; 4 = Less than once per week; 5 = Less than once per two weeks).

Past month opioid use, over-the-counter medicine use, and demographics. Participants provided information about past-month opioid use and over-the-counter medication use during the baseline assessment, as well as demographic information. Participants were provided a list of possible treatments within the BPI-SF when asked what they have used to treat their pain (Cleeland, 1991), and the following were identified as over-the-counter medications: acetaminophen (Tylenol), aspirin, NSAIDs, and local treatment of pain (i.e., lidocaine patch). Participants were identified as having used over-the-counter medication if they endorsed using any of these treatments. The following demographic information was assessed: race, ethnicity, highest level of education completed, gender, and age.

Analytic Strategy

Multi-level modeling (MLM; Singer & Willett, 2003) was utilized to examine the association of changes in cannabis use and depressive symptoms at repeated brief assessments. Analyses were conducted with a variance components structure of compound symmetry and with full maximum likelihood estimation to handle missing data. We examined other covariance component structures (i.e., scaled identity, unstructured, and first-order heterogeneous) but found that the results remained the same. We assessed model fit with -2 Log Likelihood. Analyses were conducted utilizing the linear mixed-effects models (MIXED) procedure in IBM SPSS Statistics (Version 29). In level 1, we modeled within-participant change in daily pain ratings using mean level (intercept) and time (brief daily assessment, coded 1, 2, 3, 4, 5, 6, and 7). We examined whether parameters significantly differed from zero across participants in the level 2 model. In level 2, we covaried the effects of baseline pain, cannabis use frequency, baseline depressive symptoms, past-month opioid use, and over-the-counter medication use on mean levels of daily pain ratings. Cannabis use frequency was included due to the association between heavy use and depressive symptoms (Degenhardt et al., 2003; Gorfinkel et al., 2020). These effects of these variables were covaried due to the necessity of controlling for baseline levels of pain, cannabis, and depressive symptoms. Random intercepts and slopes were specified within the MLM analyses. Opioid and over-the-counter medication use was included, considering they are prominent treatments for pain. We examined main effects models first (daily cannabis use and daily depressive symptoms) prior to adding the interaction term for these variables in the final model. Correlation analyses between the demographic variables and daily pain were conducted prior to the MLM analyses to determine whether any effects of the demographic variables should be covaried. None of the correlations between the demographic variables and daily pain were significant. Finally, we conducted an exploratory analysis to further examine the main effect of cannabis on daily pain ratings within the sub-sample by comparing the mean pain severity of cannabis use (using cannabis on a given day vs. not using cannabis on a given day) and depressive symptoms (low levels vs. high levels; operationalized according to Kroenke and colleagues, 2003).

RESULTS

Descriptive Statistics

Demographic characteristics for participants are presented in Table 1. The majority of the sample identified as female (64.50%), white (80.30%), and non-Hispanic (88.20%). Mean age was 22.19 (*SD* = 5.69) years, and 59.2% of the sample had attended some college. The majority of the sample reported no opioid use within the past 30 days (98.7%) and did not use over-the-counter medications to treat pain (67.1%). Mean baseline depressive symptom level was 9.12 (*SD* = 5.62), and mean baseline pain ratings were 3.92 (*SD* = 1.81). The highest cannabis use frequency was using cannabis once or more per day (36.8%).

Table 1. *Baseline Participant Characteristics (N = 76)*

Baseline characteristic	Mean/%	*SD/n*
Age (years)	22.19	5.69
Gender		
Male	21.1%	16
Female	64.5%	49
Non-binary	7.9%	6
Transgender	6.6%	5
Race		
White	80.3%	61
Black/African American	10.5%	8
Asian	1.3%	1
Multiracial	7.9%	6
Ethnicity		
Hispanic/Latino	7.9%	6
Not Hispanic/Latino	88.2%	67
Education		
High school diploma or GED	26.3%	20
Some college, but no degree	59.2%	45
Associate's or technical degree	7.9%	6
Bachelor's degree	6.6%	5
Cannabis Use Frequency		
Once or more per day	36.8%	28
1-2 days per week	19.7%	15
3-4 days per week	15.8%	12
5-6 days per week	23.7%	18
Less than once per week	2.6%	2
Less than once every two weeks	1.3%	1

Past-Month Opioid Use		
Yes	1.3%	1
No	98.7%	75
Over-the-Counter Medication Use		
Yes	32.9%	25
No	67.1%	51
Depressive Symptoms (PHQ-8)	9.12	5.62
Pain Rating	1.85	2.32

Note. *SD* = standard deviation; *n* = number of participants who selected this item; PHQ-8 = Patient Health Questionnaire-8

The mean number of daily assessments completed per participant within the entire sample was 5.91 (*SD* = 1.37) out of a total possible 7, and 471 total observations were included in analyses. Of those 471 observations, participants reported having used cannabis since the last assessment on 68.2% of observations. Mean daily pain rating was 1.87 (*SD* = 1.83), and the range of pain ratings in the sample was 0 to 8. Mean daily depressive symptom level was 1.43 (*SD* = 1.42) (minimal depressive symptoms).

Within the sub-sample, the mean number of daily assessments completed per participant was 6.22 (*SD* = 1.22), and 133 total observations were included in analyses. Participants within the sub-sample reported having used cannabis since the last assessment in 85% of observations. Mean daily pain rating was 2.42 (*SD* = 1.69), and the range of pain ratings within the sub-sample was 0 to 7. Mean daily depressive symptom level was 1.86 (*SD* = 1.39) (minimal depressive symptoms). Mean daily pain ratings by cannabis use (yes/no) and depressive symptom category (minimal/significant) are presented in Table 2.

Table 2. *Results of Comparing Mean Pain Severity (SD) of Cannabis Use (Using Cannabis On A Given Day vs. Not Using Cannabis On A Given Day) and Depressive Symptoms (Minimal Low Levels of Depressive Symptoms vs. Significant Levels of Depressive Symptoms) Within the Sub-Sample of Participants Who Reported Experiencing More Than Minor Pain*

	Participants who had minimal levels of depressive symptoms	Participants who had significant levels of depressive symptoms
Participants who used cannabis on any given day	1.55 (1.62)	2.97 (2.23)
Participants who did not use cannabis on any given day	1.84 (1.72)	2.50 (1.82)

Note. *SD* = standard deviation

Main Results

Main effects of daily depressive symptoms and daily canabis use on daily pain ratings. Results of the MLM analysis examining the main effects of daily depressive symptom level and daily cannabis use on daily pain ratings are presented in Table 3. The main effect of daily depressive symptom level was associated with 0.21-point increase in daily pain rating (95% C.I. = 0.09-0.32). The main effect of daily cannabis use was not associated with daily pain ratings.

Moderation analysis. The interaction term between daily depressive symptom level and daily cannabis use was not associated with daily pain ratings.

Table 3. *Estimates of Fixed Effects From Multi-Level Modeling Analysis Exploring The Main Effects on Daily Pain Rating Within the Entire Sample*

Variable	*B* (95% C.I.)	*SE*	*p*
Level 1			
Within-person residuals	1.49 (1.30 – 1.72)	0.11	<.001
Level 2			
Daily Cannabis Use	-0.23 (-0.55 – 0.09)	0.16	.153
Daily Depressive Symptoms (PHQ-2)	0.21 (0.09 – 0.32)	0.06	<.001
Baseline Pain Rating	0.23 (0.11 – 0.36)	0.06	<.001
Baseline Depressive Symptoms (PHQ-8)	0.02 (-0.02 – 0.06)	0.02	.378
Baseline Cannabis Use Frequency	-0.05 (-0.22 – 0.12)	0.09	.542
Baseline Past-Month Opioid Use	0.30 (-1.61 – 2.20)	0.97	.761
Baseline OTC Medication Use	0.48 (-0.13 – 1.09)	0.31	.126
Time	-0.02 (-0.09 – 0.05)	0.03	.558
Intercept	0.91 (0.42 – 1.40)	0.25	<.001

Note. B = estimate of the effect size; C.I.= confidence interval; Daily Cannabis Use = using cannabis on a given day; PHQ-2 = Patient Health Questionnaire-2; PHQ-8 = Patient Health Questionnaire-8; OTC = over-the-counter.

Analyses including only participants who endorsed experiencing more than minor pain. Results of the MLM analyses examining the main effects of daily depressive symptom level and daily cannabis use on daily pain rating within a sub-sample of participants with more than minor pain are presented in Table 4. The main effect of cannabis use (time varying use day vs. no use day) was associated with 0.60-point decrease in daily pain rating (95% C.I. = -1.10 - -0.09). The main effect of daily depressive symptom level was not associated with daily pain ratings. The interaction term remained non-significant when analyses were conducted within the sub-sample.

Table 4. *Estimates of Fixed Effects From Multi-Level Modeling Analysis Exploring The Main Effects on Daily Pain Rating Within the Sub-Sample of Participants Who Reported Experiencing More Than Minor Pain*

Variable	B (95% C.I.)	*SE*	*p*
Level 1			
Within-person residuals	1.49 (1.21 – 1.83)	0.16	<.001
Level 2			
Daily Cannabis Use	-0.60 (-1.10 – -0.09)	0.26	.020
Daily Depressive Symptoms (PHQ-2)	0.11 (-0.05 – 0.28)	0.08	.180
Baseline Pain Rating	0.30 (0.13 – 0.48)	0.09	<.001
Baseline Depressive Symptoms (PHQ-8)	0.02 (-0.04 – 0.08)	0.03	.474
Baseline Cannabis Use Frequency	-0.13 (-0.39 – 0.14)	0.13	.335
Baseline Past-Month Opioid Use	0.23 (-1.64 – 2.10)	0.95	.809
Baseline OTC Medication Use	0.30 (-0.39 – 0.98)	0.35	.399
Time	-0.07 (-0.17 – 0.03)	0.05	.197
Intercept	1.00 (0.05 – 1.96)	0.49	.040

Note. B = estimate of the effect size; C.I.= confidence interval; Daily Cannabis Use = using cannabis on a given day; PHQ-2 = Patient Health Questionnaire-2; PHQ-8 = Patient Health Questionnaire-8; OTC = over-the-counter.

DISCUSSION

To our knowledge, the current study was the first to model pain ratings as a function of changes in cannabis use and depressive symptoms and to examine depressive symptoms as a moderator of the relationship between cannabis use and pain ratings, utilizing a daily diary methodology. Our findings reflect the mixed extant literature regarding the efficacy of cannabis in improving physical and psychological conditions, such as pain and depressive symptoms. When only participants with more than minor pain were included in analyses, we found that the main effect of using cannabis on any given day was associated with decreased daily pain ratings. This finding suggests that using cannabis decreases pain ratings by 0.60 points, which may be interpreted as a small effect clinically. Given that the effect was significant, it is possible that cannabis indeed has an analgesic effect, but it is limited in reducing overall pain severity. This interpretation is in line with the meta-analysis conducted by Stockings and colleagues (2018), in which they found that cannabis was more significant than placebos at reducing pain when pain ratings decreased by at least 0.3 points. Similarly, an EMA study found that pain severity decreased by 0.84 points following cannabis use (Wang et al., 2021b). However, we did not find that the main effect of cannabis was associated with daily pain ratings in the full sample. This finding suggests that cannabis is more efficacious at reducing pain in participants with more than minor pain. Further research is needed in larger samples to assess how to maximize the analgesic effects of cannabis, such as examining the impact of characteristics the individual possesses (e.g., the type of medical condition(s)) and the type of pain the individual has.

While the main effect finding regarding the association between cannabis use and pain when the sub-sample was examined is in accordance with numerous meta-analyses (Stockings et al., 2018; Strand et al., 2023; Wallace et al., 2015; Wang et al., 2021a; Whiting et al., 2015), it also contradicts the results presented in other meta-analyses (Boland et al., 2020; Giossi et al., 2022; Goldenberg et al., 2017). There are several possible interpretations of the inconsistent results due to the inconsistencies regarding cannabis use behaviors. For example, the potency of cannabis varies significantly between strains, and the various strains have different ratios of the cannabis plants (i.e., cannabis sativa and cannabis indica), which in turn, already have different ratios of THC to CBD (Hart & Ksir et al., 2022b) and contribute to varying subjective effects of cannabis (van de Donk et al., 2019; Wilsey et al., 2008). Furthermore, the effects of cannabis are also dose dependent (Wilsey et al., 2016). As expected, larger doses are associated with increased subjective effects (Hart & Ksir et al., 2022b; Wilsey et al., 2016). Given the short-term impact cannabis dose has on subjective effects, it is also possible that dose has long-term effects as well, which possibly further contribute to the extant mixed literature. Mode of administration similarly impacts the subjective effects of cannabis. Following oral ingestion of cannabis, the duration and onset of effects are longer compared, for instance, compared to inhaling cannabis (Bidwell et al., 2022; Grotenhermen et al., 2003; Spindle et al., 2020).

It is possible that these factors influenced the results, given that participants did not provide information regarding these factors within the study. For example, participants within this study might have used cannabis strains with a higher THC content and/or consumed larger doses. Some participants might have orally ingested cannabis, whereas other participants inhaled cannabis, also possibly contributing to our results. We did not collect this information due to the difficulty of obtaining it outside of experimental manipulation (National Academies of Sciences, Engineering, and Medicine, 2017; Li et al., 2025). Observational studies have found that the majority of their participants are unaware of the dose (Coelho et al., 2024; Goulette et al., 2024; Kruger et al., 2020) and amount of cannabis they used (Leone et al., 2025; Prince et al., 2019). Research has documented inconsistencies as well in the labelling of strains and CBD/THC ratios compared to the actual components within the cannabis products (Bonn-Miller et al., 2017; Gidal et al., 2024; Oldfield et al., 2021; Spindle et al., 2022). There were also concerns regarding measurement reactivity (i.e., Hawthorne effect) due to the repeated brief assessments, which could have further confounded the information collected regarding dose/strains (Berkhout et al., 2022; McCambridge et al., 2014). Additionally, studies have reported that several participants are unable to accurately report the mode of administration they utilized (Boehnke et al., 2022; Health Canada, 2024).

Future research should examine these variables using experimental manipulation, which allows for control over dose/strain, quantity, and the mode of administration. For example, Bidwell and colleagues (2024) provided participants with a cannabis product that was either THC-dominant, CBD-dominant, or an equal mixture of THC and CBD in a quasi-experimental study. Nonetheless, the experimental study design exhibits reduced external validity. Thus, future research should also aim to address these methodological obstacles in observational research to further examine the subjective effects of cannabis over time outside of experimental manipulation.

Moreover, we found that the main effect of depressive of symptom level was associated with an increase in daily pain ratings. Nonetheless, when only the sub-sample of participants with more than minor pain was examined, we did not find that the main effect of depressive symptom level was associated with pain ratings. This finding is inconsistent with the extant literature, given the documented positive association between pain and depressive symptoms with increased levels of pain associated with increased levels of depressive symptoms (Dickens et al., 2002; Dudeney et al., 2024; Fonseca-Rodrigues et al., 2021; Stubbs et al., 2017; Wong et al., 2022). This incongruency within our results is likely due to the lack of power to detect a significant effect when analyses focused on the sub-sample. Given that our sample had relatively low levels of pain and daily depressive symptoms, it is likely that a larger sample is needed to detect a significant association between pain and depressive symptoms. This interpretation is supported by our finding that the main effect of depressive symptoms on daily pain ratings was observed within the entire sample, but not within the sub-sample.

It is also possible that the association between depressive symptoms and pain severity is non-linear. For example, transitioning from minimal to moderate pain might be associated with an increase in depressive symptoms, whereas transitioning from moderate to severe pain might be associated with no increase in depressive symptoms. While the mean daily pain severity ratings were still relatively low within the sub-sample, it is possible that participants considered their pain moderate to severe. The explanation that the association between depressive symptoms and pain severity is non-linear is plausible, given that the sub-sample was comprised of participants who endorsed experiencing more than minor aches and pains.

While we did not observe a significant effect for the cannabis use by depressive symptom interaction term, to further examine the main effect of cannabis on daily pain ratings within the sub-sample, we compared the mean pain severity of cannabis use and depressive symptoms. We hypothesized that individuals with lower levels of depressive symptoms would show a significant effect of cannabis use on pain reduction, whereas individuals with higher levels of depressive symptoms would not experience a significant effect. Our hypothesis was not supported, given that we did not find a significant moderation effect; however, the group means were in the hypothesized direction. Specifically, we observed that individuals with lower levels of depressive symptoms reported a mean level reduction in pain on cannabis use days, whereas those with higher levels of depressive symptoms reported a mean level increase in pain. This finding may be due to the relatively low levels of daily pain, even within the sub-sample, which comprised participants who endorsed experiencing more than minor aches and pains during the baseline assessment. The sample also reported minimal levels of daily depressive symptoms. Thus, it is possible that the low levels of daily pain and daily depressive symptoms contributed to not finding a significant moderation effect within this study. This emphasizes the need for further research of the subjective effects of cannabis within samples who report elevated levels of pain severity and depressive symptoms (McClelland & Judd, 1993).

It is also possible that the non-significance of the moderation effect can be attributed to the mode of administration, dose, and/or quantity consumed. As previously discussed, these factors influence the subjective effects of cannabis, including the analgesic effect and the impact on depressive symptoms. Experimental research, which can control for these confounding factors, should aim to explore whether these variables impact the moderation effect of depressive symptoms on the association between cannabis use and pain severity. Additionally, although the sub-sample size did not meet the recommended sample size to achieve adequate power, the entire sample did. Nonetheless, the moderation effect was not significant for both samples. Power analyses are imperfect because they are based on an estimated recommended sample size. Thus, further research should include a larger sample size to assess if the moderation effect was not significant within this study due to a lack of power.

The results of this study must be interpreted considering numerous limitations. Due to the observational nature of the study, causality between cannabis use on any given day and pain ratings cannot be extrapolated. This study was limited to participants who use cannabis at least weekly, and results may differ in occasional cannabis users or in people with cannabis use disorder. The majority of the sample was also non-Hispanic and white, limiting the generalizability of the findings to other ethnic and racial groups. Moreover, analyses examined parallel relationships between pain ratings and cannabis use; therefore, it is possible that decreased pain ratings preceded cannabis use and did not occur as a function of cannabis use on any given day. This study also did not include information regarding the mode of administration and dose consumed, which may impact the subjective effects of cannabis.

In summary, depressive symptom level was associated with daily pain ratings when analyses were sufficiently powered. Using cannabis on any given day was associated with real-time pain reductions in participants with more than minor pain. Depressive symptoms did not moderate the relationship between cannabis use and pain ratings. Given the prevalence of chronic pain within adults and the predominance of cannabis as a pain management method, it is important to explore the analgesic effect of cannabis and identify factors that impact its effectiveness. Future research should explore the effect of cannabis use behaviors, such as the mode of administration and dose of cannabis consumed, on subjective effects through experimental manipulation.

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