EFFECTS OF CANNABIS USE REDUCTION ON PTSD SYMPTOMS IN COMBAT VETERANS: AN ECOLOGICAL MOMENTARY ASSESSMENT STUDY

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ABSTRACT

Sara Ann Cratsenburg: Effects of Cannabis Use Reduction on PTSD Symptoms in Combat Veterans: An Ecological Momentary Assessment Study
(Under the Direction of Eileen J. Burker)

Posttraumatic stress disorder (PTSD) affects United States military veterans at a rate of approximately 20-30% and is associated with increased rates of cannabis use disorder (CUD). The current study utilized ecological momentary assessment (EMA) and contingency management (CM) to examine the effects of cannabis use reduction on daily functioning and PTSD symptoms in veterans with heavy cannabis use. It was hypothesized that decreased cannabis use would yield improved mental health outcomes. Results were mixed; decreased cannabis use was associated with worsening PTSD symptoms, reduced quality of life, and decreased satisfaction with concentration. Additionally, greater cannabis consumption was positively associated with better mental health outcomes during the ad lib period. These findings should be interpreted cautiously but contribute to ongoing discourse surrounding cannabis as a treatment modality. EMA methodology strengthened the study by minimizing recall bias and capturing symptoms in participants' natural ecological contexts

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Introduction

Posttraumatic stress disorder (PTSD) is a common psychiatric diagnosis given to veterans with combat exposure (Peterson et al, 2011). The department of Veterans Affairs (VA) has conducted research on measurements and methods of treatment of PTSD since the inception of the diagnosis after World War I, and the determination of a condition called shell shock (Friedman, n.d.). Today, the PTSD diagnosis has evolved and is strictly outlined in the Diagnostic Statistical Manual of Disorders (DSM-5-TR) as requiring exposure to an event of objective trauma as well as intrusive symptoms, avoidance symptoms, and changes in cognition, mood, and reactivity (American Psychiatric Association, 2022). The gold standard for treatment generally consists of prolonged exposure (PE) therapy, which has the highest success rate of any evidence-based practice (Sudie et al, 2022). Second to PE is cognitive processing therapy (CPT) followed by pharmacological intervention (Haagen et al., 2015). More recent studies indicate that PE is as efficacious as CPT in clinical trials, but the dropout rate for PE treatment is significantly higher (Schnurr et al., 2022). Unfortunately, treatment of PTSD becomes more complex when a comorbid diagnosis is introduced, such as a substance use disorder.

Veterans with a PTSD diagnosis are generally more likely to experience cannabis use disorder (CUD) than individuals who are diagnosed with PTSD and have no history of military service (Allan et al., 2019). There is a scarcity of research that currently exists inferring the correlative relationship between heavy, moderate, or light cannabis use on PTSD symptoms and

mental health outcomes. Very few studies address veterans with PTSD attempting to self-medicate with cannabis and other cannabinoids, and what little evidence does exist shows a propensity for cannabis use to develop into CUD (Bonn-Miller et al., 2021). Veterans with CUD have poorer mental health outcomes and an increased suicide risk (Hill et al., 2021), however no studies have measured PTSD prevalence and symptom severity in conjunction with a comorbid diagnosis of CUD while monitoring real time effects of decreased cannabis use and biosocial psychological symptoms such as suicidality, psychiatric distress, and general community engagement. This study aimed to bridge the gap between CUD and mental health outcomes for veterans who are also diagnosed with PTSD. Ultimately this research endeavors to execute the study leveraging first real time data regarding heavy cannabis use and the daily functioning of veterans with PTSD. It has the potential to provide recommendations that would lead to advances in VHA healthcare and inform political and academic discourse surrounding cannabis use and long-term functioning of veterans with PTSD.

Relationship Between Veterans and PTSD

Multiple studies estimate that the rate of veteran diagnosis of PTSD can be as high as 20-30% (Friedman, n.d.) depending on varying levels of risk factors that occurred prior to the traumatic event(s) such as adverse life circumstances, prior traumatic events, and prior psychological problems (Chen et al., 2015). Military veterans are at a higher likelihood of experiencing PTSD symptoms than the general public due to combat stressors experienced in war and exposure to gruesome and traumatic events (Richardson et al., 2010). The DSM-5-TR outlines the diagnostic criteria for PTSD and requires direct exposure to an objective trauma in which a person witnessed an instance that involved actual or threatened death or serious injury, or a threat to self or others' physical integrity. This experience is also characterized by intense

fear or horror that causes significant mental and emotional distress (American Psychiatric Association, 2022). In addition to experiencing objective trauma, the individual must also experience a required number of symptoms that comprise four additional symptom categories (Criterion B-E). Criterion B describes intrusion symptoms and consists of trauma related memories or recollections that are unwanted in nature such as recurrent nightmares, daydreams, thoughts, and memories (American Psychiatric Association, 2022). Criterion C describes avoidant symptoms and efforts made by an individual to prevent trauma associated thoughts, conversations, places, or people. Criterion D discusses cognition and moods that are associated with the traumatic event, beginning or worsening after the event occurred. Individuals may have an inability to recall certain or important aspects of the traumatic event as well as negative self-talk and feelings of detachment from themselves and others. Criterion E provides an overview of arousal symptoms that include hypervigilance, difficulty concentrating, and sleep disturbances (American Psychiatric Association, 2022). There are several evidence-based practices in use such as PE and CPT that treat these complex symptoms. However, there are also many conversations surrounding the practicality and use of other alternative treatments such as medical cannabis and cannabinoids for PTSD treatment (Hale et al., 2021). The current gold standard for PTSD treatment is prolonged exposure therapy (PE) closely followed by cognitive processing therapy (CPT) (Haagen et al., 2015).

Prolonged Exposure Therapy

Modern prolonged exposure therapies were born out of a convergence of Freudian and behavioral learning theory in the 1980s with the aim of "retraining" patients to no longer feel fear as a response to stimuli that reminds them of a traumatic event (Rubenstein et al., 2024). While early forms of exposure based treatment can be traced back to World War II, modern

conceptualizations were formed in the aftermath of the Vietnam war to support soldiers returning with PTSD (Rubenstein et al., 2024). Today PE is guided by principles of attempting to "expose" survivors of trauma to a stimulus that triggered a trauma response, while following core competencies of: psychoeducation, breathing retraining, in vivo-exposures, and imaginative exposures (Jeffreys et al., 2014). Exposure modalities vary by practitioner and can consist of techniques such as verbally recalling the traumatic event, exposure to traumatic cues such as sounds and smells, and virtual reality therapy (Rubenstein et al., 2024). While PE have shown to be effective, some clinicians give pause in adapting this methodology due some patients being unwilling to engage in the treatment out of fear of re-traumatization, and high patient drop out (Sloan et al., 2021). While further study is needed, increasing evidence shows that non-exposure techniques can be effective in treating PTSD with greater patient tolerance (Rubenstein et al., 2024).

Cognitive Processing Therapy

CPT was developed by Dr. Patricia Resnick in 1993 as a response to treating complex trauma in survivors of sexual assault and rape (Resnick et al., 2024). Dr. Resnick noticed that survivors of trauma frequently had comorbid disorders like anxiety/depression that made treatment of PTSD heterogeneous and a clinical art, and that revisiting trauma navigated other complex emotions (Resnick et al., 2024). Often clients had repeated negative thoughts or feelings that hindered treatment or caused PTSD to worsen. Dr. Resnick utilized CPT to help individuals process their trauma by identifying stuck points to identify negative thoughts and enable them to understand how their worldview has changed as a result of the trauma experience (Walter et al., 2014). Both PE and CPT place a deliberate emphasis on recalling and processing trauma, which can be emotionally distressing (Walter et al., 2014). In practice, CPT is designed as a 12-session

treatment utilizing techniques such as chosen exposure (in which the client dictates the amount of traumatic exposure and delivery), Socratic dialogue, asking clarifying questions, examining assumptions, and cognitive behavioral strategies (Resnick et al., 2024). While these evidence-based practices are effective, PE is associated with a higher patient drop out rate. Common reasons for treatment drop-out include re-exposure to intrusive thoughts and experiencing negative self-talk (Haagen et al. 2015). In addition to the concerns clinicians experience when considering these modalities, there is further concern with cannabis use broadly speaking; particularly in the wake of its increasing popularity.

Cannabis and Cannabinoids

Current literature remains mixed on the origins of cannabis use as a medicinal treatment. However, cannabis itself is considered one of the world's oldest cultivated plants, with recorded human consumption dating back to the 6th century (Committee on the Health Effects of Marijuana: An Evidence Review and Research Agenda et al., 2017). Modern interest in cannabis as a treatment for physical illnesses began around 1970, and the FDA currently has three cannabis-based drugs in circulation (Committee on the Health Effects of Marijuana: An Evidence Review and Research Agenda et al., 2017). More recently, clinical attention has shifted toward exploring cannabis as a potential treatment for mental health conditions such as anxiety, depression, and PTSD (Hasin, 2018). Some clinicians have proposed cannabis as an alternative to current standards of care for PTSD (PE or CPT), believing it may pose lower risk for drop out (Hasin, 2018). With increased legalization and availability, discourse and public interest surrounding cannabis as a psychiatric treatment for PTSD has grown substantially (Metrik et al., 2022). As a result, cannabis has entered academic conversations as a valid and meaningful modality that could provide symptom relief for psychiatric disorders such as PTSD with

seemingly less risk than PE or CPT (Metrik et al., 2022). However, researchers approach these discussions with caution, as several studies suggest there is potential for patient harm when cannabis use is introduced alongside a PTSD diagnosis (Allan et al., 2019; Bedard-Gilligan et al., 2022; Borodovsky & Budney, 2018; Metrik et al., 2016, 2020). As ongoing research continues to explore the relationship between cannabis and PTSD symptoms, its use has become increasingly prevalent; particularly among veteran populations and the general public (Hasin, 2018).

Cannabis is the most used psychoactive drug in the United States, with its use doubling in the past ten years post-legalization in over 30 states (Hasin, 2018). Veterans diagnosed with PTSD are increasingly likely to self-medicate with cannabis and other cannabinoids as a therapeutic treatment for difficulty sleeping and anxiety (Metrik et al., 2022). With its increased prevalence, some clinicians view the drug as a potential therapy worth studying in a controlled clinical environment (Metrik et al., 2022). However, there is a paucity of research that suggests a causal relationship between the relief of veteran PTSD symptoms and cannabis use, and what research does exist has shown that it can be linked to lower motivation to continue treatment as well as increases in lifetime suicidal ideation and depression (Allan et al., 2019) In addition, a recent review in the *Current Addiction Reports Journal* states that studies showing any correlation between improvement of PTSD symptoms and cannabis use provide temporary symptom relief (of some symptoms) and are mostly naturalistic retrospective studies (Bedard-Gilligan et al., 2022). Similarly, randomized clinical trials have shown that cannabis treatments performed the same as the placebo when evaluated for PTSD symptom relief and only resulted in temporary relief of symptoms (Bedard-Gilligan et al., 2022). Furthermore, a positive correlation has been noted between severity of cannabis use and severity of PTSD symptoms (Bedard-Gilligan et al., 2022). In fact, several studies have shown that cannabis use in conjunction with

another psychiatric disorder such as PTSD can lead to the development of a comorbid substance use disorder (SUD) or CUD even after adjusting for various sociodemographic factors (Borodovsky & Budney, 2018).

Cannabis Use Disorder

Much of the current research on cannabis use in veterans involve casual, recreational, or medicinal users, as opposed to the current proposed study which will highlight heavy users with a comorbid diagnosis of CUD. When a veteran has a diagnosis of both CUD and PTSD, they are significantly at higher risk for other psychiatric disorders such as depression or anxiety than those who do not have a comorbid SUD diagnosis (Allan et al., 2019). However, it should be noted that heavy cannabis users generally tend to have higher rates of psychiatric illness at baseline compared to veterans who have never had a CUD diagnosis, and it is unclear if cannabis use has a causal relationship to development of more severe psychiatric illness or if the underlying illness was the catalyst for initial cannabis self-medication (Hill et al., 2021).

A study conducted by Hassija et al. (2012) showed that veterans who had severe PTSD were more likely to engage in risk seeking behaviors such as heavy smoking and drinking than veterans with a mild to moderate severity with the aim of easing symptoms such as increased anxiety and difficulty sleeping. Drug use among individuals with PTSD is often conceptualized as an avoidance strategy (i.e., avoidance of traumatic reminders such as instrusive thougths). Some research also suggested self-medicating with cannabis can increase an individual's likelihood of developing a comorbid CUD (Borodovsky & Budney, 2018). In accordance with criterion outlined in the DSM-5-TR (2022), CUD is defined as a pattern of cannabis use that causes distress or impairment in daily functioning and is measured within a 12-month period (American Psychological Association, 2022). Many people, particularly veterans, have been

noted to attempt to decrease PTSD symptoms, such as nightmares and intrusive thoughts and memories, by self-medicating with cannabis and cannabis based products like CBD, THC, and delta 8 variants (Bonn-Miller et al., 2021). However, preliminary studies show a correlation between cannabis use and negative associated outcomes such as dropping out of PTSD treatment, an increased risk for accidents and self-injury, and an increased association of non-suicidal and suicidal self-injury (Allan et al., 2019). Research also shows that veterans are at risk for developing a CUD through their attempts at self-medication (Bonn-Miller et al., 2021). However, very few studies have been conducted to determine whether symptoms improve or worsen upon cannabis use reduction or cessation. The research that does exist regarding cannabis cessation and improvement of mental health outcomes has shown a notable psychiatric improvement with symptoms such as depression and anxiety with cannabis cessation (Borodovsky & Budney, 2018). However, this study did not include a veteran sample, nor did it specify if the sample contained people diagnosed with PTSD.

The Efficacy of Cannabis as a PTSD Treatment

Given the ongoing political discourse surrounding cannabis as a treatment for mental illness, there is a critical need to examine the relationship between PTSD symptom expression and cannabis use in veterans. This study sought to address this gap through evaluating PTSD symptoms in veterans with PTSD in real time and by qualitatively assessing symptom severity and improvement as cannabis use is reduced. The study's innovative and timely design has the potential to directly inform national discussions on the therapeutic use of cannabis and its impact on functional recovery in veterans with PTSD.

This study hypothesized that reducing cannabis use in veterans who are diagnosed with both PTSD and are heavy cannabis users would lead to a decrease in PTSD symptom expression

and severity and increase positive mental health outcomes. This hypothesis aligns with a literature review of 13 studies indicating that increased cannabis use or initiation of use can exacerbate PTSD symptoms such as anxiety and depression (Bedard-Gilligan et al., 2022). Data for this study is part of a grant to principal investigator, Dr. Jeannie Beckham, funded by the Department of Veterans Affairs and carried out at the VAMC in Durham, North Carolina.

Research Questions

This study was designed to address the following research questions:

1. What is the association between frequency and amount of cannabis use and daily functioning in veterans with PTSD? Building on the findings of Bonn-Miller et al. (2021) and Borodovsky and Budney (2018), it was hypothesized that higher cannabis use frequency and amount (measured by total days per month and total grams of cannabis/cannabinoid consumed), would be associated with poorer daily psychosocial functioning in veterans with PTSD as assessed through ecological momentary assessment (EMA) reports on mood, cognition, social interactions, and occupational functioning.

2. Does decreasing cannabis use in heavy users result in improved mental health outcomes for veterans with PTSD? Based on a meta-analysis conducted by Hill et al. (2021) and a study by Allan et al. (2019), it was hypothesized that veterans with PTSD (diagnosed by the CAPS-5) who are heavy cannabis users (defined as individuals who use cannabis more than 13 days out of the month), who decrease their cannabis use (no cannabis use for the duration of the study period) would experience lower scores on the PCL-5 PTSD assessment compared to veterans who did not decrease their cannabis use.

Method

The current study has been conducted, and data was collected by Dr. Beckham at the Durham Veterans Affairs Medical Center (VAMC). To conduct this secondary analysis, the dataset was provided in a de-identified format to ensure the protection of participant confidentiality. An abbreviated human subjects research application was submitted and approved by the UNC-Chapel Hill IRB. In addition the IRB and the VAMC ~~thesis advisory board~~ granted full approval for this secondary data analysis. Additionally, the current study and research team have separate IRB approval through the VAMC.

Participants

The study aimed to recruit 172 participants and enroll a final sample of 120 eligible veterans with PTSD in the following categories: 40 heavy cannabis users, 40 mild-moderate cannabis users, and 40 non-cannabis users, although this analysis only focused on heavy users. Recruitment methods primarily relied upon sending letters to veterans that had a pre-existing PTSD Diagnosis. Veterans were identified by using the Veterans Integrated Service Network (VISN), a regional organizational system in the VA. After letters had been sent, researchers on Dr. Beckham's team followed up by phone to gauge interest. Clinicians from partnered clinics were also asked to provide referrals for individuals who met the study inclusion criteria in addition to the use of social media and posting flyers.

Recruited non-cannabis users were defined as those with active veteran status, fluent and literate in English, possessing a current PTSD diagnosis, no cannabis use in the past year and minimal use throughout their lifetime. Criteria for the mild-moderate user category included active veteran status, fluent and literate in English, a current PTSD diagnosis, and cannabis use one to eleven days in the past month. Heavy users were defined as having: veteran status, fluent

and literate in English, current PTSD diagnosis, and used cannabis 13 or more days in the past month. It should be noted there is currently no universal definition to delineate between moderate and heavy cannabis use.

The CAPS-5 was utilized for PTSD diagnosis and study eligibility; this method has a historically high reliability rating with a Pearson coefficient that ranges from 0.78 to 0.82 according to meta-analysis (Chen et al., 2015). Interviewers were trained by staff at the Durham VAMC to conduct the CAPS-5 and other diagnostic interviews and maintained supervision throughout data collection via video recording. These procedures were consistent with high inter-rater reliability.

Exclusion criteria for the participant sample consisted of the following: (1) experienced a change in their psychiatric medication regimen the past month (a new medication had been prescribed or a dose of existing medication had changed); (2) was receiving non-study CUD treatment; (3) met criteria for a bipolar disorder or schizophrenia; (4) became imprisoned; (5) became hospitalized; (6) was at imminent risk for suicide or homicide; (7) met criteria for a SUD other than CUD or tobacco; and lastly (8) was pregnant or planned to become pregnant during the study. The individuals who agreed to participate in this study disclosed a desire to lessen cannabis use in conjunction with participation. Participants were compensated monetarily for participation in the study as well as for daily recording of symptoms in accordance with Contingency Management (CM) methodology. CM is considered an intense behavioral therapy that shows high efficacy in short-term reductions in cannabis use (Cooke et al., 2024) It is a powerful behavioral approach in which incentives (usually of monetary value) are provided on the basis of evidence of change in behavior. (Cooke et al., 2024).

Apparatus and Materials

Initial participant assessment for PTSD was conducted utilizing the CAPS-5 assessment. The CAPS-5 assessment is considered the gold standard in PTSD assessment according to the Department of Veteran's Affairs. The CAPS-5 is a 30-50 minute structured interview used to make a current diagnosis of PTSD, a lifetime diagnosis of PTSD, and to assess PTSD symptoms occurring over the past week. The test also structures questions to allow the clinician to understand the onset and duration of symptoms, subjective distress, impact of symptoms on day to day functioning, severity and specifications for dissociative subtype (Jackson et al., 2022). In addition to evaluating the 20 core DSM-5 PTSD symptoms across intrusion, avoidance, negative alterations in cognition and mood, and hyperarousal clusters, the CAPS-5 includes questions addressing symptom onset, duration, subjectivity distress, functional impairment, symptom change over time, overall PTSD severity, response validity, and dissociative features such as depersonalization and derealization. Administration requires the identification of a traumatic event that is supported by criterion A. The interview is administered by trained clinicians or supervised research staff and takes 45-60 minutes to complete. The CAPS-5 is scored by integrating both symptom frequency and intensity into a single severity rating for each of the 20 PTSD symptoms. Severity ratings range from 0 (absent) to 4 (most severe/incapacitating) with ratings of two or higher meeting the diagnostic threshold for any given symptom. Total PTSD severity is calculated by summing the severity scores across all 20 symptoms. Diagnostic determination requires the participant to endorse at least one intrusion symptom, one avoidance symptom, two negative alterations in cognition or mood, and two hyperarousal symptoms (Weathers et al., 2018). Most recent updates to the CAPS-5 psychometric properties occurred in 2022 and demonstrate strong test-retest reliability ($k=0.83$) and high internal consistency

(a=0.88) (Weathers et al., 2018). In addition to the CAPS-5 assessment, the PCL-5, a PTSD screening tool, was utilized throughout the duration of the study.

The PCL-5 is a widely used self-report questionnaire that screens for symptoms of PTSD in accordance with the DSM-5. Clinicians utilize this tool to make provisional diagnosis, monitor treatment, and to screen for PTSD. In the present study, it was used as a supplementary measure to monitor PTSD symptoms during the treatment phase, as the CAPS-5 was administered to determine participant eligibility. The PCL-5 consists of 20 items, covers the four main symptom clusters of PTSD and is summed for a total score (0-80), with higher scores indicating more severe symptoms. A cutoff score of 31-33 is often used for a provisional diagnosis (Forkus et al., 2023). According to the VA the PCL-5 demonstrates strong internal consistency (a=0.96), high test-retest reliability (r=0.84), and robust convergent and discriminant validity (Bovin et al., 2016). Consistent with prior research, these findings support the PCL-5 as a reliable and valid measure of PTSD symptom severity in veteran populations and indicate its utility for identifying probably PTSD when clinician administered assessments are not feasible. In this study, the PCL-5 was incorporated into diary entries as a means of collecting real time PTSD symptom data.

Throughout the study, the primary data collection tool was Ecological Momentary Assessment (EMA); a unique data collection methodology in which data is collected from participants in real time and in their natural environment. Recall bias and subconscious influences of behavior are minimized as this method ensures a more honest representation of data (Shiffman et al., 2008). In the current study, participants were monitored at home and in their natural environment while data was collected remotely. EMA entries were programmed to prompt a response from each participant at varying times during the day approximately four hours apart, totaling four entries per day. EMA data consisted of questions asking about

participant psychosocial functioning and health related quality of life (measured by the 3-item Sheehan Disability Scale), measurement of psychiatric distress and suicidal ideation (measured with the PC-PTSD-5, PANAS negative affect and PANAS positive affect), measurements of general life satisfaction, and lastly community integration and social contact (measured by the Kimbrel social contact/social support EMA protocol) (See Appendix A for a copy of the EMA measures.)

At the start of the study participants were prompted to download a smartphone app to facilitate data collection throughout the duration of the study. If participants did not have access to a smartphone, one was provided to them at the beginning of the study, and all participants were shown how to navigate the application's interface. CM was also implemented via mobile application in conjunction with mobile drug testing to evaluate treatment adherence and concentration of cannabis products in participant's systems.

The Durham VA has developed a state of the art approach that utilizes mobile phones for not only cessation methods and data collection, but also for daily drug testing to make CM techniques feasible. In line with these efforts, study participants were required to conduct routine saliva testing for THC levels and upload results via mobile application. The test was conducted on video that shows swabbing procedures from start to finish as well as testing strip results and upload. The saliva testing regimen was scheduled to occur twice a day, at least eight hours apart. In line with CM protocols, participants were rewarded by using an escalating reinforcement schedule, in which participants were rewarded for their first day of abstinence with $10.00 and every following day of abstinence resulted in compensation increasing by $1.00. Participants are also reinforced per upload of saliva test video in which they were compensated $2.50. Test kits were provided to study participants at the start of the study.

Procedure

The following methodology describes the data collection and analysis procedures conducted by Dr. Beckham and her team. The current study serves as a secondary analysis independent of the Durham VAMC with their permission and oversight. Data has already been run through its respective Multi Level Modeling (MLM) procedures by the Durham VAMC and were de-identified prior to a secondary analysis.

The current study evaluated data from heavy cannabis users who participated in cannabis use cessation methods gradually over a four-week period and completed measures of quality of life, psychiatric distress, suicidal ideation, working memory, executive functioning, and community integration. The study ran a total of six weeks with the first two weeks dedicated to EMA monitoring to establish a baseline of PTSD severity. The results of the first two weeks provided real time data reflecting participants' baseline PTSD symptoms and psycho-functioning prior to the intervention of cannabis use cessation. During this period, each participant received a questionnaire that provided data on type of symptoms, severity, time of occurrence, as well as monitoring symptoms such as suicidal ideation, working memory, executive functioning, and community integration. This also allowed for real time analysis of patterns in psychiatric symptoms in conjunction with cannabis use to determine if a causal relationship exists between reduction of cannabis use and positive mental health outcomes. Additional data such as number of grams consumed per day, total THC load, and days cannabis was used surrounding participant's cannabis use was also collected via oral swab. These entries were collected multiple times a day in addition to daily evening entries. Weekly cannabis consumption is aggregated by number of days used, number of grams consumed, and total THC load in order to examine the

weekly effects of reduced use. Percentage reduction of use from baseline was also used in association with quality of life improvements.

After the first two weeks of baseline data collection, the following four weeks consisted of contingency management (CM) in conjunction with EMA monitoring to leverage real time data collection of PTSD symptom severity and expression while cannabis use was reduced. It is worth noting only heavy cannabis users with a comorbid diagnosis of CUD participated in this portion of the study. Light users and light-moderate users only completed the first two weeks of the EMA procedures and were not enrolled in the reduction phase. All EMA procedures remained the same as the initial baseline data collection the first two weeks of the study. To provide an incentive for study participants to engage in CM, a baseline $10.00 payment was made to each participant every morning and increased in value by $1.00 each subsequent day of bioverified abstinence. Participants proved abstinence with twice daily saliva testing that was videotaped and uploaded onto the requisite mobile application. This data collection provided real time information on whether cannabis was in a participant's system at the time of PTSD symptom expression. At the end of the four weeks of CM and EMA, participants completed a follow up CAPS-5 assessment and out-brief where participants were asked thanked for their participation in the study and informed on data usage, results and expectations, and provided and opportunity for questions.

Statistical Analyses

All data analyses were conducted using the statistical program, R. The power analysis for this study was conducted by Dr. Beckham's statistical team at the Durham VAMC. The statistical power is set at 80% across all analyses. Initial data collection through the CAPS-5 allows detection of medium-sized effects (β = .25–.28), while the large volume of repeated EMA

data increases power to detect much smaller effects (β = .04–.05) using multi level modeling. Effective sample size calculations were based on prior intra-class correlation (ICC) estimates and adjusted for potential attrition.

The data collected was examined via multi level modeling (MLM), a statistical method used to analyze data of individuals nested in groups. Means, standard deviations, and frequencies were computed for all CAPS-5 scores after initial and final interviews as well as per aggregated category during EMA monitoring, while group differences in baseline characteristics were examined using independent t-tests and chi-square tests.

For hypothesis 1, the independent variable was the level of cannabis use (measured by days and amount of cannabis use), while the dependent variable was PTSD symptom severity (measured by PCL scores and qualtrics diary entries regarding psychosocial functioning). PCL scores were divided into symptom cluster groups as well as aggregated and were run through three separate models. This first hypothesis leveraged EMA protocols to determine the real time effects of cannabis consumption on PTSD severity and psychosocial functioning. For hypothesis 2, the independent variable was the frequency cannabis is ingested over the course of a month while the dependent variable was the EMA scores across all measured metrics. To assess the hypothesis, EMA data regarding psychosocial functioning were separated into three separate models via MLM and compared against the frequency and amount of cannabis use, and in comparison to the ad lib period.

Results

The following data has been collected and analyzed by the Durham VA statistician team led by Dr. Jeffrey Hertzberg and Dr. Paul Dennis.

Demographic information

A total of 51 participants met inclusion criteria for heavy users diagnosed with PTSD who were compliant with study instructions (Table 1). The median age for participants was 42.6 years with a standard deviation of 10.1 years while the sex demographic was 23.5% female and 76.5% male. Notably, their total PCL score during the two-week ad lib period was 36 out of 80 (range 8-72), with a standard deviation of 17.2. A score of 36 is above the clinical cutoff for probable PTSD (33) and indicates clinically significant PTSD symptoms. The individual symptom clusters were also measured with re-experiencing symptoms scoring an average of 9.2 (range 0-10, standard deviation of 4.9), avoidance symptoms scoring an average of 4.5 (range 0-8, standard deviation of 2.3), mood alterations scoring a 11.5 (range 0-12, standard deviation 6.9), and hypervigilance symptoms scoring 10.7 (range: 0-8, standard deviation of 5.7). Within the heavy user demographic, 40 participants (78.4% of the sample size) met official criteria for CUD and 38 participants (74.5%) met criteria for a psychiatric diagnosis that was not CUD or PTSD. Notably 34 out of the 40 participants who have CUD met criteria for other disorders. During the 2-week intervention period, seven participants (13.7%) met criteria for cannabis withdrawal syndrome.

To evaluate the two aims of the present study, three separate logistical regression analysis were conducted: beta (b) regression analysis, odds ratio (OR), and ratio of means (ROM). B coefficients were used to assess the strength of the independent variable as a predictor of the dependent variable in regression based analyses. Odds ratio was used in data with binary

outcomes and ratio of means was conducted to separate the changes in participants own momentary diary responses related to cannabis use urges and behaviors (within person effects) from how participants differed from each other overall (between person effects). Two types of scores were created. First, each participant's average affect level across the study was calculated and compared (z-scored) to the group's overall average to generate grand mean standardized scores (GMS). Next, affect calculations were completed to determine if scores were higher or lower than their own average, using their personal mean and standard deviation (individual mean standardized scores). By design, the GMS and individual means scores (IMS) are independent of each other. The confidence interval for all analysis was 95% suggesting high confidence in the results.

Aim 1.1: Association of days of cannabis use and diary outcomes

The results of Aim 1.1, the association of days of cannabis use and diary outcomes, can be seen in Table 2. Significance values were determined on a sliding scale to adjust for the false discovery rate. Thus, the cutoff score ranged for each individual metric, the most lenient being $p < 0.03$. B values were calculated in quality of participant concentration, daily activity satisfaction, and sleep satisfaction (recorded both in the morning and evening). To interpret B scores, note that a number less than 0 is indicative of a negative relationship with the dependent variable, while a number greater than zero is indicative of a positive relationship with the dependent variable. Scoring was recorded on a scale of 1-5 (five being the best quality). The mean scores for concentration quality was 2.91 with a standard deviation of .88 suggesting moderate satisfaction with concentration ability with a B coefficient of 0.05. These results suggest greater frequency of cannabis use was associated with reports of modestly higher concentration quality. Daily activity satisfaction was recorded with a mean of 3.35 (standard

deviation of .85) with a B coefficient of 0.04 suggesting greater frequency of cannabis use was associated with higher satisfaction with daily activities during the ad lib period. For sleep satisfaction in the morning and evening, mean scores were 2.75 and 2.76 with b values of 0.04 and 0.05 respectively, suggesting participants reported modestly higher sleep satisfaction on days cannabis was used during the ad lib period.

Odds Ratios (OR) were used to calculate whether or not participants perceived cannabis to be disruptive to their social functioning. To interpret OR scores, numbers greater than 1 indicate the event is more likely to occur. Scoring was based on nominal measure with a score of 0 or 1 (0 being not disruptive, and 1 being disruptive). The mean score for whether social functioning was disrupted by cannabis was 0.11 (standard deviation of 0.32) and an odds ratio of 1.05. Participants who reported more days of cannabis use during the ad lib period had increased odds of reporting cannabis related disruption to social functioning; a finding that was statistically significant ($p<.001$), though clinical significance remains uncertain.

Ratios of means (RoM) were collected for difficultly with concentration and amount of dream distress. RoM scores are interpreted by noting that a value less than 1 has a negative relationship with the dependent variable whereas a number greater than one has a positive relationship with the dependent variable. Difficulty with concentration was scored on a scale of 0-4 with 0 no difficulty, 1 meaning mild difficulty, 2 meaning moderate difficulty, 3 suggesting much difficulty, and 4 meaning highest difficulty. The mean score was a 1.06 (standard deviation of 1.03) and a RoM of 0.93. These results suggest more frequent cannabis use was associated with an increased difficulty in concentration, however the mean suggests only mild difficulty in concentration quality was reported. Although the observed relationships between cannabis use frequency and satisfaction of concentration quality reached statistical significance, these findings

are not necessarily indicative of clinically meaningful change. The mean scores for concentration quality satisfaction fell within the mild range, suggesting that while differences are detected at a statistical level, their practical impact on daily functioning may be limited. Statistical significance indicates the observed associations are unlikely to be due to chance within the sample, however clinical significance requires evidence that changes are large enough to meaningfully alter the participants functioning, symptoms, or need for intervention. Longitudinal assessment would aid in evaluating whether observed changes are sustained over time, as well as comparing mean scores to established clinical thresholds. Without these benchmarks, the present findings should cautiously be interpreted and understood as subtle shifts in symptom experiences rather than definitive indicators of clinically relevant improvement. Note that b values were also collected for concentration but for participant satisfaction with quality of concentration rather than ability to concentrate as shown here with the RoM. Dream distress was scored on a scale of 0-4 with 0 being no distress and 4 being highest distress. The average score among participants was 0.91 (standard deviation of 1.03) and a RoM of 0.95 suggesting more frequent cannabis use during the ad lib period was associated with less distress from dreams/nightmares.

Aim 1.2: Effects of Cannabis on PTSD using Grams as a Predictor

Aim 1.2 examined the relationship between amount of cannabis and severity of PTSD symptoms during a two-week ad lib period that monitored participants' cannabis intake by grams smoked or ingested. Thirty-four questions from the morning, afternoon, and evening qualtrics diary entries were selected to measure PTSD symptoms and social and occupational functioning. Of those 34, seven questions yielded significant results (see Table 3). Similar to Aim 1.1, statistical significance values were determined on a sliding scale to adjust for the false discovery rate.

In examining within person effects, eight values out of a total of 33 selected diary entries were statistically significant: PTSD upset reminders (loud noises, specific smells, places, dates, media reports, etc.), whether or not cannabis has been disruptive at work, overall PCL score, PANAS negative scores, PCL cluster scores for both intrusion and avoidance clusters, active avoidance of reminders of the traumatic event, and unpleasant memories of the trauma. Taken together, within-person increases of grams of cannabis used were associated with higher scores across each of these outcomes, meaning that on days when participants consumed more cannabis, they reported lower scores across each of these outcomes, meaning that on days when participants consumed more cannabis, they reported fewer PTSD upset reminders, lower overall PCL scores, fewer avoidance and intrusion symptoms, and less frequent memories of the trauma. Notably, increased use of cannabis was associated with increased work disruption. Odds ratios were calculated for whether cannabis was causing disruption to the participants' ability to work (0 being no, 1 being yes) and was calculated to have a mean score of 0.21 (standard deviation of 0.41) and an odds ratio of 1.26. These results indicate that participants who reported more days of cannabis use during the ad lib period had increased odds of reporting cannabis related disruption in their work environment. B values were calculated for total PCL score (0 being the least number of PTSD symptoms, 40 being the highest number). The average score during the ad lib period was a 9.54 (standard deviation 8.77) with a b value of -0.53, indicating that PCL scores decreased as the grams of cannabis used increased. In other words, participants who used greater quantities of cannabis tended to report lower overall PTSD symptom severity, suggesting a negative association between cannabis consumption and self-reported PTSD symptoms within the sample. RoM was calculated for amount of PTSD upset reminders, PCL scores for avoidance and intrusion clusters, and PANAS negative score for avoiding upsetting reminders of

the trauma, and intrusive memories of the trauma. Among outcomes with statistically significant RoM estimates (see table 3), all values were > 1 indicating higher cannabis use (in grams) was associated with lower mean levels of the measured PTSD symptoms. Specifically, increased cannabis use was associated with reductions in upset reminders (RoM 0.91), re-experiencing symptoms (RoM 0.91), negative affect measured by PANAS (RoM 0.97), multiple PTSD symptom clusters including avoidance (RoM 0.93), upset reminders (RoM 0.93), and intrusive memories (RoM 0.92). These findings suggest a consistent pattern in which greater cannabis consumption is associated with modest but statistically significant decreases in PTSD symptoms and quality of life. These findings are consistent with the results of the second study aim, in which participants decreased cannabis use and experienced symptom worsening.

Aim 2: The effects of decreasing cannabis on PTSD symptoms

Aim 2 results are depicted in Tables 4 and 5 and represent two sets of models. Similar to Aim 1.1 and Aim 1.2, significance values were determined on a sliding scale to adjust for the false discovery rate. Thus, the accepted significance level ranged for each individual metric, the most lenient being $p < 0.03$. For each outcome, the association of treatment was modeled/measured? vs. the ad lib phase (See Table 4) as well as the association of grams of cannabis used on a given day (See Table 5). Change in days of use in the treatment phase ranged from a decrease of 100% (i.e., total abstinence) to an increase of 23%, with a mean decrease of 47% (SD=33%). Change in grams used on a daily level ranged from a decrease of 100% to an increase of 240%, with a mean decrease of 43% (SD=74%). Results were generated to compare the treatment period to the ad lib period as well as calculation for grams of cannabis as a predictor for adverse mental health outcomes. Aim 2 was analyzed by examining eight different qualtrics diary entries, of which, two (strength of current high and health satisfaction) were

statistically significant when determining the change between the treatment and adlib period, while three (strength of current high, quality of life, and health satisfaction) were significant when examining grams as a predictor for adverse mental health outcomes. These findings produce mixed results. Higher cannabis consumption during the ad lib phase was positively associated with overall quality of life; in which participants who smoked more cannabis reported better quality of life. Health satisfaction followed a similar pattern in which greater cannabis use was associated with increased health satisfaction both during the ad lib period and when compared to the treatment phase. However, quality of life as a direct comparison between the treatment and ad lib phases did not reach statistical significance, suggesting that the positive association between cannabis use and quality of life was more apparent when examining within phase variability in grams consumed than when comparing across study phases.

The model comparing the treatment phase to the adlib phase reported participants had a mean high (on a scale of 0-5) of 0.27 (SD of 0.52) and a RoM value of 0.44, indicating that participants felt less high on average when compared to the ad lib period. Overall health satisfaction during the treatment period (on a scale of 1-5) scored a mean of 3.03 (SD: 0.88) and a b value of -0.06, indicating mildly less health satisfaction during the treatment period. Upon examining the treatment phase using grams as a predictor, scores for “overall high” had a RoM value of 1.16, indicating increased cannabis use was correlated with a greater self-perceived high. Unlike the modeling conducted comparing the treatment phase to the ad lib phase, overall quality of life was found to be significant when examining grams of cannabis consumed during CM protocols, indicating utilizing grams of cannabis as a predictor for quality of life provided more concrete outcomes when compared quality of life metrics from the A/B phases of the study. Overall quality of life had a mean score of 3.47 (SD 0.79) and a b value of

0.02. While these results indicated only mild improvements in reports of overall quality of life when more cannabis is used, they were statistically significant with a p value of < .001. Overall health satisfaction under this model had a RoM of 0.01 also indicated a modest increase in health satisfaction when participants consumed larger quantities of cannabis. These findings contribute to national debates regarding cannabis and cannabinoid use as a treatment modality for trauma disorders, particularly regarding their efficacy in supporting functional recovery for PTSD. The implications of this study have the potential to enhance understanding among mental health providers, inform policy decisions, and ultimately improve the quality of life for veterans with PTSD.

Discussion

The present study examined the effects of cannabis use reduction on PTSD severity and psychosocial functioning in veterans who are heavy cannabis users. It was hypothesized that decreased cannabis use would be associated with improvements in PTSD symptoms and general mental health outcomes, while higher frequency and quantity of cannabis use would correspond to worsening PTSD symptoms, poorer daily functioning, and adverse mental health outcomes. Contrary to the proposed hypothesis, the findings showed mixed results. While increased cannabis use was modestly associated with greater satisfaction in daily activities, concentration, and sleep quality, it was also associated with greater difficulty with concentration and disruptions to occupational and social functioning. When participants stopped using cannabis or reduced their cannabis intake, they reported being less satisfied with their sleep quality and quality of life when compared to the ad lib period. While this result is paradoxical, it is consistent with previous research that state cannabis is a well-tolerated treatment modality that participants enjoy. Additionally, PTSD symptom severity, as measured by the PCL during the EMA

collection protocols, showed a modest negative association with grams of cannabis used, meaning participants had slightly fewer PTSD symptoms when they consumed more grams of cannabis. It is also noteworthy that not all values for the PCL were statistically significant; yet, overall scores, questions regarding re-experiencing negative feelings, and questions regarding avoidance were all deemed to be significantly reduced during the two-week ad lib period. These improvements indicate a short-term relief of symptoms rather than an effective PTSD treatment, particularly since the CAPS at baseline and posttreatment failed to be significantly reduced. These results are consistent with a 2022 meta-analysis detailing existing research which states cannabis use can provide temporary relief (Bedard-Gilligan et al., 2022). Furthermore, this result is consistent with previous literature demonstrating that substance use among individuals with PTSD is an avoidance strategy and does not result in significant improvement in PTSD symptom severity or diagnosis (Kearns et al., 2021).

The first aim of the study focused on the association between frequency and amount of cannabis consumption with PTSD symptoms and other mental health outcomes. The results indicated modest positive associations between cannabis use and self-reported satisfaction with concentration, sleep, and daily activities. These findings partially support existing literature that suggest cannabis can provide short-term subjective relief from anxiety and hyperarousal symptoms in veterans with PTSD (Bonn-Miller et al., 2013; Johnson et al., 2016). However, participants also reported increased difficulty concentrating and a modestly greater likelihood of perceiving cannabis use as disruptive to work (i.e. being high during the day, at work, and while driving), which is consistent with prior research identifying cannabis related cognitive impairment in chronic users (Bedard-Gilligan et al., 2022). As a result, the findings suggest a somewhat contradictory relationship which has been noted in existing literature where cannabis

use may alleviate some symptoms of PTSD and improve self-reported social functioning in the short-term (Boden et al., 2013). However, collected diary entries also suggested cannabis may impair cognitive and occupational functioning in participants which could be indicative of long-term consequences in individuals who are heavy users.

The second aim compared the relationship between changes in cannabis use during the treatment phase via CM procedures and PTSD related outcomes. On average, participants reduced cannabis use by approximately 47% across the treatment phase. Participants reported slightly lower, overall health satisfaction and a reduced subjective "high" during this period compared to the ad lib phase and when examining grams of cannabis used as a predictor, more grams consumed was associated with modest increases in perceived quality of life and health satisfaction. It should be noted that, upon analysis of the second hypothesis, only three results were statistically significant when utilizing grams as a predictor and only two results were significant when comparing the treatment phase to the ad lib phase. This pattern suggests participants may have experienced discomfort or increased psychiatric distress during the reduction or abstinence phase, potentially reflecting both the psychological loss of a coping mechanism and the experience of physiological stress during withdrawal.

An important consideration in interpreting these results is the potential influence of Cannabis Withdrawal Syndrome (CWS) among heavy users during the treatment phase. Approximately 13.7% of participants in this study met criteria for CWS, while the remainder met criteria for heavy users in which they used cannabis more than half of the days of the month. The American Journal of Addiction published clinical instructions regarding symptom phenomenology in 2022 which states CWS typically emerges within 24 to 48 hours of cessation, peaks between days two and six, and may persist for up to three weeks in chronic users (Connor

et al., 2022). Common symptoms include irritability, insomnia, anxiety, depressed mood, and decreased appetite; all of which overlap with PTSD symptom domains, particularly hyperarousal and negative alterations in mood and cognition (Connor et al., 2022). Some of the increased distress and reduced health satisfaction observed during the cessation period could be attributed to withdrawal effects rather than true worsening of PTSD symptoms. It is also noteworthy that chronic and heavy users could experience CWS symptoms for up to three weeks, which accounts for 75% of the treatment phase. Because withdrawal symptoms and PTSD often share overlapping symptoms, separating the two would require more extensive analysis and a longer treatment period to disentangle CWS and PTSD. The suggestion of CWS as a factor in PTSD recovery is supported by a 2013 study in the American Journal of Addiction which states that temporarily discontinuing the use of cannabis among heavy users could lead to more severe PTSD as a function of withdrawal, and a heightened craving for cannabis and immediate relief (Boden et al., 2013). The present study was also contingent on self-reports from participants via EMA data. While EMA methodology promotes reductions of participant recall bias, the potential for unreliable reports of symptoms still exist (i.e. paradoxical findings on concentration quality vs. satisfaction). Future studies utilizing longitudinal methodology for a longer period along with monitoring standalone CWS symptoms disentangled from PTSD symptoms would allow for clearer differentiation of the source of distress and offer possible trajectories for recovery.

It is also notable that participants who used greater amounts of cannabis reported slightly lower PCL scores during the ad lib period, which suggests a short-term negative association between use and PTSD symptom severity. This finding might reflect sedative effects of THC, which could temporarily reduce hyperarousal and intrusion symptom reporting (Monti. & Pandi-Perumal, 2022). However, when the effects of cannabis use on PTSD symptoms and

social/occupational functioning are evaluated within the context of existing studies, this relationship does not always indicate a therapeutic benefit, particularly among heavy users or those diagnosed with CUD. These findings are consistent with previous longitudinal studies which have shown cannabis may help individuals cope with immediate distress, but it does not improve long-term mental health outcomes (Bedard-Gilligan et al., 2022). The current study's results are consistent with existing literature and the possibility that cannabis functions as a short-term coping mechanism rather than an effective treatment.

These mixed findings demonstrate the complexity of cannabis use, PTSD symptom expression, and withdrawal effects. The short-term improvements reported in concentration and sleep satisfaction during active use may represent temporary relief from mood disturbances, sleep disturbances, and hyperarousal, while the declines in perceived wellbeing during cessation could plausibly reflect both the emergence of withdrawal and the loss of a primary coping strategy as well as a greater awareness of life stressors, PTSD symptoms, and symptoms of other mental health disorders. The contradictory nature of these findings indicates the need for clinicians to approach cannabis reduction among veterans with PTSD through a lens that acknowledges the reinforcing properties of cannabis use and the challenges of withdrawal management, while still finding a treatment for PTSD that is both tolerable and effective. Supportive behavioral interventions such as contingency management and motivational interviewing for substance use may help mitigate withdrawal related distress and enhance treatment retention during the cessation process. CPT or PE would still be the recommended strategy for PTSD recovery while integrated into the abstinence or reduction period.

The findings of the present study should be interpreted within the context of the sample from which they are derived. Given the overwhelming majority of participants carried at least

one psychiatric diagnosis in addition to CUD and PTSD, the generalizability of these results is likely limited to veterans presenting with multiple comorbid conditions. Veterans with PTSD and CUD as their sole diagnoses could respond differently to cannabis use or its reduction differently, and the patterns observed here may not translate to that population. Clinicians and researchers should exercise caution in applying these findings broadly across veteran populations until studies with more homogenous samples can be conducted.

The present study contributes EMA methods demonstrating that the relationship between cannabis use and PTSD symptom severity in veterans yields mixed results. Participants reported cannabis provided relief from distress while contributing to modest reports of functional impairment in psychosocial functioning. The findings could suggest reductions in cannabis use are associated with initial declines in self-reported wellbeing potentially due to withdrawal, but results indicating improved long-term functioning once withdrawal symptoms improve are to be determined. These results support a cautious approach to interpreting the perceived benefits of cannabis among veterans with PTSD and reinforce the need for further longitudinal research assessing both immediate and long term outcomes of use reduction.

The current findings must also be interpreted with certain methodological considerations and limitations in mind, to include the potential competing effects of CWS, unreliable narration from participants, and the short duration of observation periods.

Strengths and Limitations

The present study had several strengths, but most notably was the use of EMA as the primary data collection method. There is a paucity of PTSD research that utilizes real time data collection, and the present study aims to add to the existing body of research. EMA data collection minimizes recall bias by ensuring symptoms are captured as participants are

experiencing them, ensuring researchers have the most accurate data possible. Many symptoms of PTSD such as intrusion, hypervigilance, and sleep disturbances are also context dependent and EMA collection provides an opportunity to examine expression of these symptoms in real world settings. This approach also enabled participants in the current study to remain in their own ecological setting, providing better insight into cognitive and behavioral changes across varying contexts. When compared to in patient settings, EMA collection methods can provide a more comprehensive understanding of how participants respond to treatment while living their daily lives. This methodology also provides promising outcomes in providing care to populations from varied social economic statuses. Instead of having to remain in an inpatient treatment program or find transportation to a VA facility, participants were able to record data where they reside regardless of housing and transportation status.

Despite these strengths, the present study also has limitations. The most notable limitation is the short duration of the study and the inability to capture the longitudinal effects of cannabis reduction/abstinence on PTSD symptoms with a pre- and post-measure. Because the study's treatment and observation period only lasted several weeks, it is difficult to determine whether changes in PTSD symptoms or psychosocial functioning were sustained over time. The design may reflect acute effects of reduction or withdrawal rather than legitimate clinical improvement. Another limitation is timing of the CAPS-5 reassessment which was conducted two weeks after the conclusion of the study. The CAPS-5 is considered to be the gold standard test of PTSD diagnosis and assessment. It was administered to participants at the beginning of the ad lib period to determine eligibility and was administered two weeks upon the conclusion of the abstinence period. Given the data analysis was primarily completed on the heavy user group with a relatively short cessation period, it can be presumed that participants resumed their

cannabis use prior to the follow up assessment. The reintroduction of cannabis into the participant's lives could have influenced CAPS-5 scores, limiting the ability to determine whether or not PTSD symptom severity could be attributed to cannabis reduction.

Another limitation includes CWS, which could plausibly compound PTSD symptom reporting during the treatment period. Withdrawal symptoms such as irritability, insomnia, anxiety, and dysphoria can overlap with PTSD symptom clusters. Symptom onset occurs 24-48 hours after cannabis cessation and most symptoms generally peak at days 2-6 with some symptoms lasting up to 3 weeks or more in heavy users (Connor et al., 2022). It is plausible that some of the reported increases in distress and decreases in sleep quality could be attributed to CWS and not a worsening of PTSD. The present study hinged upon the cannabis reduction/abstinence period occurring immediately following the ad lib period where some heavy users experienced a stark change in their typical behavioral patterns and likely increased psychological stress and physical withdrawal symptoms. The participant diary prompts included some questions about cannabis withdrawal; however, they were not disentangled from diary entries regarding PTSD symptoms or other psychosocial functioning metrics making the distinction between the two more challenging.

An additional consideration is the diagnostic complexity of the sample. Given 74.5% of participants met criteria for psychiatric diagnoses other than CUD and PTSD, it is difficult to attribute changes in PTSD symptom severity solely to cannabis use or its reduction. For participants carrying additional metal health diagnoses, worsening of symptoms during the treatment phase could plausibly reflect the exacerbation of a comorbid condition rather than a direct response to cannabis reduction. The presence of multiple comorbid diagnoses introduces compounding variables which limit the ability to draw clear causality between isolated

relationships between cannabis use and PTSD. Future research could aim to either control for comorbid diagnoses statistically or recruit samples with more uniform diagnostic profiles to further improve internal validity.

While the collected data set provides helpful insight into the relationship between cannabis use and PTSD symptom expression among veteran populations, these limitations underscore the need for future research employing longer study lengths, standardized withdrawal assessments, and formal post study assessments to determine clinical outcomes for PTSD.

Future Directions

The present study sought to add to the existing body of research which explores holistic applications for PTSD recovery and cannabis use. The current mixed findings raise further questions about the effectiveness of cannabis as a viable treatment for PTSD. Given the high volume of veterans with PTSD who manage their symptoms with cannabis, further study is required to determine long-term effects of symptom reduction and efficacy. Additionally, more studies that utilize multiple treatments in conjunction with one other behavioral treatment methodology could provide valuable insight on helpful uses of cannabis to treat short acting hyperarousal, sleep, and mood disturbances while participants are in behavioral treatment for PTSD. Ultimately further research needs to be conducted on the effects of cannabis reduction on PTSD symptoms in the long-term, as well as between group comparisons (heavy users vs. moderate users, vs. light users). Timely studies are required to better understand whether cannabis has true therapeutic benefits for veterans with PTSD in order to better inform practitioners on how to create well tolerated solutions that can promote improved quality of life.

Conclusion

The present study sought to examine the effects of cannabis use reduction on PTSD symptoms in veterans who were recruited by the Durham VA. It was hypothesized a decrease of cannabis use would be associated with improved PTSD and better psychosocial functioning, and that greater quantities of cannabis use would be associated with increased difficulties in psychosocial functioning and worsening mental health outcomes. While the findings yielded mixed results, the data indicated increased cannabis consumption was associated with improved PTSD symptoms and measures of quality of life satisfaction. It also showed a modest correlation between reduction of cannabis use and worsening quality of life and more severe PTSD symptoms. These results should be interpreted with prudence as the temporary discomfort participants felt during the reduction/abstinence phase could plausibly be attributed to cannabis withdrawal symptoms, or the adjustment in losing a central habit and coping mechanism. Despite the mixed nature of the present study's results, they ultimately seek to inform clinicians on the risks and benefits of recommending the integration of cannabis into treatment for PTSD. It is hoped that these findings build upon existing literature that encourage all providers to approach cannabis based treatment for PTSD with empathy, evidence based practices, and commitment to developing treatments that promote efficacious recovery.

Table 1: Demographic Information

	Heavy Users (N=51)
Age M(SD)	42.6 (10.1)
Gender N(%)	
Female	12 (23.5%)
Male	39 (76.5%)
Race N(%)	
Black	24 (47.1%)
White	25 (49.0%)
More than one	2 (3.9%)
Hispanic N(%)	
No	48 (94.1%)
Yes	3 (5.9%)
Smoke Tobacco N(%)	
Yes	24 (47.1%)
No	23 (45.1%)
Missing	4 (7.8%)
Education N(%)	
High School/GED	8 (15.7%)
Partial College	16 (31.4%)
Associate degree	8 (15.7%)
Bachelor's degree	11 (21.6%)
Graduate degree	4 (7.8%)
Missing	4 (7.8%)
PCL M(SD)	
Total score (0-80)	36.0 (17.2)
Re-experiencing (0-20)	9.2 (4.9)
Avoidance (0-8)	4.5 (2.3)
Mood Alterations (0-28)	11.5 (6.9)
Hyperarousal (0-24)	10.7 (5.7)
CUD N(%)	40 (78.4%)
Psychiatric Diagnosis N(%)	38 (74.5%)

Table 2: Aim 1.1 with days of cannabis use as a predictor

Outcome	Scale	Mean (SD)	B (95% CI)	OR (95% CI)	RoM (95% CI)	p-value	sign
cannabis_disrupt_social	0-1	0.11 (0.32)		1.05 (1.04, 1.05)		p<.001	Significant
concentration_quality	1-5	2.91 (0.88)	0.05 (0.03, 0.08)			p<.001	Significant
daily_activity_satisfaction	1-5	3.35 (0.85)	0.04 (0.02, 0.06)			p<.001	Significant
sleep_sat_AM	1-5	2.75 (1.02)	0.04 (0.02, 0.07)			p<.001	Significant
sleep_sat_PM	1-5	2.76 (0.96)	0.05 (0.02, 0.07)			p<.001	Significant
ptsd_concentration	0-4	1.06 (1.03)			0.93 (0.89, 0.98)	p=0.003	Significant
dream_distress	0-4	0.91 (1.03)			0.95 (0.91, 0.98)	p=0.007	Significant
PANAS_negative	9-45	14.95 (6.19)			0.99 (0.98, 1.00)	p=0.032	NS
pcl10_score	0-40	9.54 (8.77)	-0.26 (-0.54, 0.02)			p=0.07	NS
PANAS_positive	6-30	14.06 (5.10)	0.14 (-0.02, 0.30)			p=0.08	NS
ptsd_startle	0-4	0.95 (1.17)			0.95 (0.89, 1.01)	p=0.12	NS
ptsd_detachment	0-4	0.90 (1.04)			0.96 (0.90, 1.01)	p=0.12	NS
cannabis_dui_count	0-1	0.14 (0.35)		1.37 (0.90, 2.09)		p=0.14	NS
ptsd_hyperalert	0-4	1.28 (1.34)			0.97 (0.92, 1.02)	p=0.20	NS
ptsd_avoid_reminders	0-4	1.14 (1.22)			0.97 (0.92, 1.02)	p=0.20	NS
pcl10_Hypervigilance	0-8	2.23 (2.36)			0.96 (0.91, 1.02)	p=0.22	NS
health_satisfaction	1-5	3.10 (0.87)	0.02 (-0.01, 0.05)			p=0.22	NS
pain_interf_life	0-10	3.12 (2.87)			0.96 (0.90, 1.03)	p=0.23	NS
ptsd_nofeelings	0-4	0.88 (1.03)			0.97 (0.92, 1.02)	p=0.23	NS
pain_interf_activity	0-10	2.99 (2.81)			0.96 (0.90, 1.03)	p=0.29	NS
pcl10_AvoidanceScore	0-8	2.30 (2.36)			0.97 (0.92, 1.02)	p=0.29	NS
ptsd_avoid_memories	0-4	1.16 (1.21)			0.98 (0.93, 1.03)	p=0.36	NS
pain_avg	0-10	3.71 (2.76)			0.97 (0.91, 1.04)	p=0.40	NS
ptsd_memories	0-4	0.68 (0.89)			0.98 (0.93, 1.03)	p=0.45	NS
cannabis_disrupt_work	0-1	0.21 (0.41)		1.10 (0.83, 1.47)		p=0.51	NS
cannabis_disrupt_family	0-1	0.11 (0.31)		0.94 (0.74, 1.18)		p=0.58	NS
ptsd_upset_reminders	0-4	0.79 (0.97)			0.99 (0.94, 1.04)	p=0.60	NS
pcl10_Reexperiencing	0-12	2.17 (2.69)			0.99 (0.93, 1.04)	p=0.61	NS
cannabis_miss_work	0-1	0.00 (0.07)		0.90 (0.59, 1.38)		p=0.63	NS
quality_life	1-5	3.54 (0.71)	0.01 (-0.02, 0.03)			p=0.67	NS
cannabis_work_productivity	0-1	0.03 (0.16)		1.20 (0.50, 2.88)		p=0.69	NS
ptsd_physreact	0-4	0.70 (1.00)			0.99 (0.94, 1.05)	p=0.71	NS
aggressive_driving	0-1	0.02 (0.14)		1.03 (0.85, 1.25)		p=0.75	NS

Table 3: Aim 1.2: Grams of cannabis consumed as a predictor

Outcome	Scale	Mean (SD)	Within B (95% CI)	Within OR (95% CI)	Within RoM (95% CI)	Within p-value	sign
ptsd_upset_reminders	0-4	0.79 (0.97)			0.91 (0.91, 0.92)	p<.001	Significant
cannabis_disrupt_work	0-1	0.21 (0.41)		1.26 (1.25, 1.26)		p<.001	Significant
pcl10_score	0-40	9.54 (8.77)	-0.53 (-0.73, -0.33)			p<.001	Significant
pcl10_Reexperiencing	0-12	2.17 (2.69)			0.91 (0.88, 0.95)	p<.001	Significant
PANAS_negative	9-45	14.95 (6.19)			0.97 (0.96, 0.99)	p<.001	Significant
pcl10_AvoidanceScore	0-8	2.30 (2.36)			0.93 (0.90, 0.96)	p<.001	Significant
ptsd_avoid_reminders	0-4	1.14 (1.22)			0.93 (0.89, 0.97)	p=0.002	Significant
ptsd_memories	0-4	0.68 (0.89)			0.92 (0.87, 0.98)	p=0.005	Significant
pcl10_Hypervigilance	0-8	2.23 (2.36)			0.96 (0.93, 0.99)	p=0.007	NS
ptsd_detachment	0-4	0.90 (1.04)			0.93 (0.88, 0.98)	p=0.010	NS
ptsd_avoid_memories	0-4	1.16 (1.21)			0.94 (0.90, 0.99)	p=0.012	NS
ptsd_physreact	0-4	0.70 (1.00)			0.94 (0.89, 0.99)	p=0.031	NS
ptsd_nofeelings	0-4	0.88 (1.03)			0.94 (0.89, 1.00)	p=0.037	NS
ptsd_startle	0-4	0.95 (1.17)			0.95 (0.91, 1.00)	p=0.042	NS
ptsd_concentration	0-4	1.06 (1.03)			0.95 (0.90, 1.00)	p=0.046	NS
ptsd_hyperalert	0-4	1.28 (1.34)			0.97 (0.93, 1.01)	p=0.09	NS
PANAS_positive	6-30	14.06 (5.10)	0.10 (-0.03, 0.24)			p=0.13	NS
cannabis_dui_count	0-1	0.14 (0.35)		1.16 (0.90, 1.49)		p=0.26	NS
cannabis_disrupt_family	0-1	0.11 (0.31)		1.20 (0.86, 1.69)		p=0.29	NS
pain_interf_life	0-10	3.12 (2.87)			1.02 (0.98, 1.05)	p=0.30	NS
pain_avg	0-10	3.71 (2.76)			0.99 (0.98, 1.01)	p=0.34	NS
cannabis_work_productivity	0-1	0.03 (0.16)		0.82 (0.49, 1.35)		p=0.43	NS
sleep_sat_AM	1-5	2.75 (1.02)	-0.02 (-0.07, 0.03)			p=0.46	NS
concentration_quality	1-5	2.91 (0.88)	0.01 (-0.03, 0.05)			p=0.55	NS
quality_life	1-5	3.54 (0.71)	-0.00 (-0.02, 0.01)			p=0.56	NS
sleep_sat_PM	1-5	2.76 (0.96)	-0.01 (-0.05, 0.03)			p=0.56	NS
pain_interf_activity	0-10	2.99 (2.81)			1.01 (0.98, 1.04)	p=0.58	NS
cannabis_miss_work	0-1	0.00 (0.07)		1.33 (0.46, 3.85)		p=0.60	NS
daily_activity_satisfaction	1-5	3.35 (0.85)	0.01 (-0.03, 0.05)			p=0.62	NS
dream_distress	0-4	0.91 (1.03)			0.99 (0.92, 1.06)	p=0.70	NS
health_satisfaction	1-5	3.10 (0.87)	-0.00 (-0.02, 0.01)			p=0.79	NS
aggressive_driving	0-1	0.02 (0.14)		0.96 (0.53, 1.72)		p=0.89	NS
cannabis_disrupt_social	0-1	0.11 (0.32)		1.00 (0.76, 1.30)		p=0.99	NS

Table 4: Aim 2: Comparison of Ad lib to Treatment Phase

Outcome	Scale	Mean (SD)	Trx vs Ad lib B (95% CI)	Trx vs Ad lib B OR (95% CI)	Trx vs Ad lib B RoM (95% CI)	Trx vs Ad lib B p-value	sign1
current_high	0-4.5	0.27 (0.52)			0.44 (0.37, 0.52)	p<.001	Significant
quality_life	1-5	3.47 (0.79)	-0.04 (-0.08, -0.01)			p=0.021	NS
health_satisfaction	1-5	3.03 (0.88)	-0.06 (-0.09, -0.03)			p<.001	Significant
interpersonal_stress_level	0-2.3	0.09 (0.31)			1.02 (0.73, 1.43)	p=0.92	NS
interpersonal_stress	0-1	0.13 (0.34)		0.82 (0.53, 1.25)		p=0.35	NS
stress_level	0-4	1.02 (0.88)			1.13 (1.02, 1.25)	p=0.020	NS
selfinjury_urge	0-1	0.02 (0.14)		1.65 (0.66, 4.15)		p=0.28	NS
suicidal_thoughts	0-1	0.01 (0.08)		1.65 (0.35, 7.89)		p=0.53	NS

Table 5: Comparison of treatment to ad lib phase using grams as a predictor

Outcome	Scale	Mean (SD)	Grams B (95% CI)	Grams OR (95% CI)	Grams RoM (95% CI)	Grams p-value	sign2
current_high	0-4.5	0.27 (0.52)			1.16 (1.13, 1.20)	p<.001	Significant
quality_life	1-5	3.47 (0.79)	0.02 (0.01, 0.03)			p<.001	Significant
health_satisfaction	1-5	3.03 (0.88)	0.01 (0.00, 0.02)			p=0.006	Significant
interpersonal_stress_level	0-2.3	0.09 (0.31)			0.83 (0.71, 0.98)	p=0.025	NS
interpersonal_stress	0-1	0.13 (0.34)		0.82 (0.68, 0.98)		p=0.027	NS
stress_level	0-4	1.02 (0.88)			0.97 (0.94, 1.00)	p=0.06	NS
selfinjury_urge	0-1	0.02 (0.14)		0.73 (0.39, 1.37)		p=0.32	NS
suicidal_thoughts	0-1	0.01 (0.08)		0.40 (0.04, 4.17)		p=0.44	NS

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