HHS Public Access

Author manuscript

Exp Clin Psychopharmacol. Author manuscript; available in PMC 2021 April 01.

Published in final edited form as:

Exp Clin Psychopharmacol. 2020 April ; 28(2): 150–156. doi:10.1037/pha0000301.

A Preliminary Test of a Brief Intervention to Lessen Young-Adults' Cannabis Use: Episode-level Smartphone Data Highlights the Role of Protective Behavioral Strategies and Exercise

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Abstract

Brief interventions are increasingly being used to help young adults to moderate their cannabis use. We conducted a randomized clinical trial of a brief (4 weekly sessions), in-person intervention that included a smartphone application that reinforced the use of protective behavioral strategies (PBS) to lessen cannabis use. Young-adults (N = 37; 24 men, 13 women), who regularly used cannabis were randomized to two intervention conditions rooted in Cognitive Behavioral Therapy (CBT) and Motivational Enhancement Therapy (MET). Along with learning CBT+MET strategies, one of the conditions also was instructed to engage in exercise. All participants used smartphone-based ecological momentary assessment (EMA) to provide episode-level reports about use of cannabis and PBS. Two multilevel structural equation models were run to test the

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Dr. Collins conceived the study. Drs. Collins, Prince, and Vincent were involved in refining the procedures. Dr. Vincent and Ms. Wilson were involved in running the participants, and collecting the data. Dr. Prince conducted the statistical analyses. All authors reviewed and edited drafts of the manuscript and have approved the final version.

Disclosures

The authors have no real or potential conflicts of interest to report, including financial, personal, or other relationships with other organizations that may inappropriately impact or influence the research and interpretation of the findings.

Preliminary analyses of some of these data were presented at the 2016 annual convention of the American Psychological Association and at the 2017 annual meeting of the Research Society on Marijuana.

Ethical Standards Statement

This research has been approved by the Institutional Review Board at the University at Buffalo, State University of New York and therefore has been conducted in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

study hypotheses, that: 1) cannabis use would reduce over the course of the 6-month study; 2) reductions would be moderated by intervention condition; and, 3) episode-level PBS use would predict episode-level cannabis use. Participants reduced their cannabis use by approximately one-half of a standard joint per time-point. The MET+CBT+Exercise condition reduced cannabis use to a greater degree than the MET+CBT condition. With episode-level PBS use in the model, reductions in cannabis use were independent of intervention condition. Our findings suggest that young adults will engage with a smartphone app that serves as a component of an in-person intervention to moderate their cannabis use. Intervention content that promotes the use of PBS and exercise, facilitates reductions in cannabis use.

Keywords

cannabis use; protective behavioral strategies; smartphone app; brief intervention; ecological momentary assessment

In the USA, cannabis is the most commonly-used regulated drug. Young adults (aged, 18-to-30 years), tend to show the highest prevalence of cannabis use (e.g., annual = 30.4% and daily = 6.7%; Schulenberg et al., 2017) and are most at risk for experiencing cannabis-related problems. Multiple states are legalizing medicinal and recreational use of cannabis, thereby increasing access to the drug. Recent reviews have documented a range of adverse behavioral and health effects associated with frequent/heavy use of cannabis (Hasin, 2018; Hoch, Frimel, & Schneider, 2018; NAS, 2017). They include problems related to: 1) mental health; 2) cognitive impairments; 3) unsafe driving; 4) respiratory health problems; and, 5) development of cannabis use disorder (CUD; Compton, Han, Jones, Blanco, & Hughes, 2016).

Despite the negative consequences of frequent/heavy cannabis use, rates of formal treatment for cannabis-related problems are low, particularly for young-adults. Young adults, particularly those who do not meet diagnostic criteria for cannabis use disorder (CUD), but want to manage their cannabis use, may respond to interventions that are convenient and engaging. Various technologies are being used to increase engagement in treatment and provide convenient access to intervention strategies. Many of these technologies are beginning to show success in lessening a number of maladaptive health behaviors (Carroll & Kulik, 2017; Newman, Szkodny, Llera, & Przeworski, 2011; Shingleton & Palfai, 2016).

Among young adults, smartphones are a ubiquitous, convenient, and functional way to use technology to provide access to interventions (Shrier, Rhodes, Burke, Walls, & Blood, 2014; Smith, 2015). Smartphones applications/apps can perform tasks that include: 1) self-monitoring of behaviors/symptoms (e.g., EMA, daily reports); 2) providing therapeutic information/education in real-time (e.g., ecological momentary interventions/EMI); 3) monitoring compliance with/use of treatment protocols; 4) tracking changes in variables of interest; and 5) providing feedback over time (e.g., graphs of behaviors). The two-way functionality of smartphones allows for interaction between/among participants/clients and researchers/clinicians. For example, smartphones were successfully used in a brief (2 sessions) intervention in which young adults completed momentary and daily reports of

factors (e.g., specific triggers) related to cannabis use (Shrier et al., 2014). Results showed decreases in desire to use and cannabis use, in specific contexts.

To lessen young-adults' cannabis use, we developed and tested a brief, in-person, intervention that incorporated learning protective behavioral strategies (PBS) and interacting with a smartphone app. PBS content was informed by recent reviews, which demonstrated that cognitive-behavioral therapy (CBT; Davis et al., 2014), including elements of motivational enhancement therapy (MET; DiClemente, Corno, Graydon, Wiprovnik, & Knoblach, 2017), and problem solving were effective in reducing the frequency and severity of cannabis use (e.g., Gates, Sabioni, Copeland, LeFoll, & Gowing, 2016). PBS are behaviors one can use: 1) before; 2) during; and/or, 3) instead of substance use to avoid or reduce consumption and/or consequences (Martens et al., 2005; Prince, Carey, & Maisto, 2013). PBS use is associated with less frequent cannabis use and fewer consequences among college students (Bravo, Anthenien, Prince, & Pearson, 2017; Bravo, Prince, & Pearson, 2017; Pedersen et al., 2016; Pedersen et al., 2017). However, the research on PBS and substance use often is limited due to the use of cross-sectional designs (Prince, Carey, & Maisto, 2013; Pearson, 2013). One longitudinal study that examined daily use of PBS found significant within-person variation in the prediction of alcohol use (Pearson, D'Lima, & Kelley, 2013). The current longitudinal study included episode-level assessment of PBS and substance use.

Exercise/physical activity (PA) might serve both as prevention and intervention for reducing substance use (Bardo & Compton, 2015). Acute bouts of exercise reduce peoples' urge/cravings for alcohol (Ussher, Sampuran, Doshi, West, & Drummond, 2004), cigarettes (Daniel, Copley, Ussher, & West, 2004; Taylor & Katomeri, 2007), and cannabis (Wilson, Collins, Prince, & Vincent, 2018). Interventions using PA have enhanced smoking cessation (cf. Marcus et al., 2005; Ussher, Taylor & Falkner, 2014) and contributed to reductions in alcohol use (cf. Brown, Prince, Minami, & Abrantes, 2016). Moderate exercise (ten, 30-minute treadmill sessions) led to significant decreases in cannabis use and craving up to 2-weeks after exercise (Buchowski et al., 2011).

We developed and initially tested the efficacy of a brief, in-person, CBT+MET intervention to reduce cannabis use. Along with effective CBT+MET strategies, our intervention included the use of our study-specific, smartphone application/app. The app was used to collect real-time data (i.e., EMA) and to provide access to PBS in real-world contexts (i.e., EMI). The intervention study included the following components: 1) the Marijuana Check-up (MCU; Stephens et al., 2004; see Gonzalez & Dulin, 2015); 2) two conditions, in which participants attended four, weekly, structured and individualized, in-person sessions focused on teaching PBS for reducing cannabis use (see Shrier et al., 2014; Hoch et al., 2014); and 3) use of the smartphone app (see Shrier et al., 2014; Gonzalez & Dulin, 2015). Our hypotheses focused on outcomes post-intervention and at the 6-month follow-up. Specifically, H1: Cannabis use quantity will be reduced over time. H2: Intervention condition will moderate the change in cannabis use quantity over time. H3: Episode-level PBS use will predict episode-level cannabis use quantity.

Method

Participants

Participants were 37 young adult men (n = 24) and women (n = 13) who regularly used cannabis. The sample was 65% male, average age 20.36 years (SD = 1.71), predominantly (70%) European American, and 87% not Hispanic/Latino. Most (86.5%) were students (M = 14.37 years of education; SD = 1.65) and earned less than $10,000 per year (81%). Past-month baseline reports indicated participants had used cannabis an average of 23.86 days (SD = 6.38) and had consumed an average of 24.72 grams of cannabis (SD = 15.06); the equivalent of using 1.00 gram of cannabis per using day (SD = .47).

Participant characteristics reflected eligibility criteria: age (18–25 years), education (at least 5th grade), use of cannabis ≥ 3x/week, no history of treatment for substance misuse or psychiatric problems, no current drug abuse/dependence (screened using DAST-10; Skinner, 1982), no current criminal justice involvement. These criteria allowed us to recruit heavy/frequent cannabis users who were at risk for problems, but did not meet criteria for CUD. We used ads (flyers, newspapers, radio) to recruit young adults in the Buffalo, NY, area. The ads read, *Have you thought about cutting back on your marijuana use?,* mentioned the age range, and the contact number. We screened 154 individuals. The majority (n = 108, 70%) were ineligible (e.g., age, infrequent cannabis use). Forty-six (or 30%) individuals were invited to participate; nine withdrew or failed to comply with procedures. Given the study procedures (e.g., EMA), each participant could receive up to $500 USD. The study was approved by the University at Buffalo Social and Behavioral Sciences IRB (SBSIRB; protocol # = 463052–3), under the title “Smartphone Study”.

Design

We used urn randomization (gender, student status) to assign participants to one of two “active” intervention conditions: 1) learning and using PBS based on CBT and MET; and, 2) CBT+MET strategies + Exercise. There was no control condition (cf. Mohr et al., 2014). In the Exercise/PA condition, participants were provided with access to three, commercially-available exercise apps, and encouraged to engage in PA as a positive alternative to using cannabis (see Pate, Heath, Dowda, & Trost, 1996; Penedo & Dahn, 2005). During the 8-month study (including the 6-month follow-up), each participant visited the research site on a total of 12 occasions: 1) baseline questionnaires + app training; 2) four, in-person, individualized, intervention sessions with an MI-trained counselor; 3) post-intervention questionnaires + app feedback; and 4) follow-ups at 1-, 3-, and 6-months (total = 6 visits), during which participants provided 2 weeks of EMA data.

Procedures

In the initial appointment, participants read and signed the consent form and provided an on-site, unsupervised, urine sample for a drug screening, collected via the OnTrak TesTcup from Roche Diagnostics Corporation (Indianapolis, IN), which provided quick and simultaneous detection of drugs or drug metabolites. As required, all participants tested positive for THC (i.e., cannabis; 50 ng/m l). Women also completed a hormonal (urine) pregnancy test; none were pregnant or trying to get pregnant. Participants then completed

computerized baseline questionnaires. Other than demographics, the current manuscript includes only self-reported EMA data related to episodes of cannabis use, which are included in the analyses.

The Study-specific Marijuana Smartphone App - MApp—Throughout the study, participants used our study-specific, smartphone app, named MApp, which was developed using Apple's iOS software. Most participants (n = 31; 84%) received a loaner iPhone, restricted to data only. The MApp was used to collect EMA data and to review material (including PBS) learned during each intervention session. MApp included tracking graphs of weekly cannabis use and spending on cannabis, along with intervention Tips/PBS from each of the sessions (loaded cumulatively).

Collection of Real-time, Ecological Momentary Assessment (EMA) Data—Participants used MApp to provide prospective EMA data for a total of 11 weeks (1-week baseline, 4-week intervention, and at 2-week intervals at the 1-, 3-, and 6-month follow-ups). Each day, participants completed multiple, brief (2 to 4 minutes) EMA interviews to self-report variables such as their mood (e.g., angry, happy), location (e.g., at home, in car), social context (alone? with friends?), and cannabis use (number of joints). Of relevance to the current study, each participant initiated an interview *just before* (e.g., craving, motives) and *just after* (e.g., number of joints, "high") each episode of cannabis use. Response formats (Likert, binary) varied based on the nature of the question.

Brief Intervention Conditions—The two intervention conditions consisted of four, in-person, individualized sessions. The overall goal was to provide each participant with a range of PBS that they could use to manage/lessen their cannabis use. The content of each weekly, 60-minute session varied within a structured format, which was adapted from Walker et al.'s (2011) MCU-based intervention and the manual Brief Counseling for Marijuana Dependence (Steinberg et al., 2005).

The content for each of the sessions contained opportunities for individualization, based on each participant's needs. Participants began by completing the Marijuana eCheck Up (MCU; Pedersen et al., 2016), reviewing MCU feedback with their counselor and developing a change plan (Session 1). They explored ambivalence about change and learned coping skills (Session 2). Strategies for handling triggers for using cannabis were discussed in Session 3. Strategies for managing moods and plans for using PBS during follow-up were covered in Session 4. Participants in the Exercise/PA condition were instructed to continue to use PA as a positive alternative to cannabis use.

Measures

General Information Questionnaire—(GIQ; Collins et al., 1990). This 37-item self-report measure assessed background information including demographic characteristics (e.g., age, sex) and use of alcohol (the DDQ; Collins, Parks, & Marlatt, 1985) and other substances. Participants consumed M = 8.10 drinks/week (SD = 7.26).

Episodic Cannabis Use Quantity-EMA.—On EMA, we trained participants to identify an episode of cannabis use based of criteria such as a change in location. They reported the

quantity of cannabis used in terms of average-sized "standard" joint (i.e., about 0.50 gram; Prince, Conner, & Pearson, 2018), regardless of mode (e.g., bongs, blunts) of use.

Episodic Use of Protective Behavioral Strategies-EMA.—For each episode, participants were asked "Did you use any of the strategies you learned to help you cut down on smoking weed?" They could respond either Yes (= 1) or No (= 0).

Analysis Plan

Two multilevel structural equation models (MSEMs) were run to test the study hypotheses (see Figure 1). Analyses were conducted using Mplus 8 (Muthén & Muthén, 1998–2017). The first MSEM was used to test Hypotheses 1 and 2. To test Hypothesis 1, we created a random slope of time predicting cannabis use quantity on the episode-level. In order to test the moderation hypothesis (Hypothesis 2), we used a 2 X (1–1) moderation MSEM (Preacher, Zyphur, & Zhang, 2010; Preacher, Zhang, & Zyphur, 2016) because the predictor (time) and outcome (cannabis use quantity) variables are measured on the episode level, and the moderator (intervention condition) is measured once at baseline, this is called the Random Coefficient Prediction (RCP) Method. Intervention condition was coded "1" = MET+CBT and "2" = MET+CBT+Exercise. For Hypothesis 3, we ran a second MSEM testing the episode-level effect of PBS use predicting episode-level cannabis use quantity (see Figure 1). Running two separate models allowed us to examine the overall change in cannabis use over time, moderated by intervention condition, and then to examine the role of PBS as a potential episode-level mechanism of change.

The MSEM approach allows paths that include episode-level effects to have random intercepts and allows for the creation of Bayesian Credible Intervals for assessing significance of effects. Bayesian Credible Intervals provide a robust test of direct and moderation effects, are computationally efficient, and amenable to a variety of variable characteristics (e.g., hierarchical/nested data; Gelman et al., 2004; Muthén & Asparouhov, 2012).

Results

Reactions to Using MApp

Participants used a 10-point rating scale (1 = *Not at all*; 10 = *Very much*) to respond to eight questions about using the study-specific smartphone app (i.e., MApp). Their ratings generally were positive. For example, they rated MApp as being easy to use (M = 6.92, SD = 2.85) and helpful with reducing cannabis use (M = 6.73, SD = 2.27). Their ratings (1 = *Strongly disagree*; 4 = *Strongly agree*) on four questions about the physical features of MApp (layout, colors) were uniformly high (M = 3.11 to 3.86).

Compliance with EMA Protocol

In total, participants reported 1585 cannabis use episodes over the 11-week study period. They completed after cannabis use interviews for 1394 episodes (88%), suggesting very good compliance with the EMA protocol.

Examination of Specific Hypotheses

We predicted that cannabis use quantity would be reduced over the course of the study (Hypothesis 1). The results of the MSEM testing episode-level reductions in cannabis use quantity showed that the random slope of change in cannabis use overtime was negative and statistically significant (See Table 1). This finding indicates that participants reduced their cannabis use by approximately one-half of a standard joint, per timepoint.

We also expected intervention condition to moderate the change in cannabis use quantity over time (Hypothesis 2; See Table 1). Our MSEM analyses indicated that the between-subjects condition variable significantly predicted the random slope of change in cannabis use overtime, supporting our moderation hypothesis. Specifically, those in the MET+CBT +Exercise condition reduced their cannabis use quantity to a greater degree than the MET +CBT group over the course of the study (i.e., they had a steeper negative slope of reduction in cannabis use quantity overtime).

We also used MSEM to examine whether episode-level PBS use would predict episode-level cannabis use quantity (see Table 1). Results of the second MSEM, which added episode-level PBS use, showed that PBS use predicted cannabis use quantity, such that greater use of PBS, in the moment, predicted lower quantities of cannabis. Specifically, using PBSs in a given episode was associated with approximately one-half of a standard joint less (i.e., .25 grams) cannabis compared to episodes when no PBSs were used. When PBS use was added, the random slope of time predicting cannabis use quantity was negative, but no longer statistically significant. This suggests that episode-level PBS use may be a mechanism by which participants reduced cannabis use quantity, in both intervention conditions. Thus, with episode-level PBS use in the model, reductions in cannabis use quantity were independent of intervention condition.

Discussion

We examined intervention outcomes as a function of episode-level PBS use, time (intervention through 6-months), and cannabis use quantity, as well as the moderating effect of intervention condition. Results supported Hypothesis 1: regardless of the intervention condition, participants reduced cannabis use quantity, at the episode-level, across the course of the study. This provides preliminary evidence that a relatively brief, in-person intervention can be successful for young-adult cannabis users who seek to manage/reduce their cannabis use. Participants in both the MET+CBT condition and the MET+CBT +Exercise condition reported reductions in cannabis use quantity (cf. Gates et al., 2016). Our findings add to the limited evidence about the effect of exercise/PA in interventions to reduce cannabis use (cf. Bardo & Compton, 2015; Buchowski et al., 2011).

We found support for Hypothesis 2, that intervention condition would moderate the change in cannabis use quantity over time. Participants in the CBT+MET+Exercise condition reported greater reductions in cannabis quantity compared to those in the CBT+MET condition. The significant moderation effects show the benefits of promoting exercise/PA with young adults interested in reducing cannabis use. In addition, to reducing cannabis

craving (Wilson et al., 2018), exercise has a range of health benefits, and can be free and easy to utilize (Pate et al., 1996; Penedo & Dahn, 2005).

Hypothesis 3 stated that episode-level PBS use would predict episode-level cannabis use quantity. When episode-level PBS use was added to the MSEM model, it was negatively associated with episode-level cannabis use quantity. Further, the addition of episode-level PBS use washed out the overall effects of change in cannabis-use quantity and the moderation of intervention condition, suggesting that PBS use on the episode-level was a mechanism of change for participants in both conditions. Future research is needed to identify which strategies are most effective across cannabis use contexts.

Limitations of the study include a relatively small sample of young adults. Our results are relevant to young-adults' management of cannabis use and may not generalize to samples who meet criteria for dependence. We used a single-item to assess PBS use in each cannabis-use episode. Our study also shares the methodological challenges of measuring the cannabis quantity (cf. Prince et al., 2018). However, there is empirical support for our use of a 'standard joint' of .50 grams (Zeisser et al., 2012). Our intervention conditions contained multiple components. While results indicate that use of PBS *in situ* was associated with reductions in episodic cannabis quantity, we cannot discern the specific PBS that participants used and found most helpful. Importantly, participants reported on their use of cannabis and PBS *just after* each cannabis use episode, thereby enhancing the validity of the findings. Future research should be designed to disentangle the contributions of specific components to changing and maintaining reductions in cannabis use. Understanding that many young adults may not have access to, or interest in, in-person interventions, the next steps in the development of this program of research include refinement of the app and comparative studies, in *real world* contexts, using apps and other technologies.

Acknowledgements

This research was supported by National Institutes of Health grant R34-DA035358 (Collins) from the National Institute on Drug Abuse and grant T32-AA007583 (Leonard) from the National Institute on Alcohol Abuse and Alcoholism, which supported Dr. Prince. The funding sources had no role in the study design, analyses or interpretation of the data, manuscript preparation, or the decision to submit the manuscript for publication.

Special thanks to Molly Rath, LCSW, who served as the lead MI-trained counselor who implemented the intervention. Thanks also to Annaliese Campagna, Joshua Roozrokh, William Spoth, and Kristen Villalobos who served as undergraduate interns. We also thank all of the research participants.

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Public significance statement:

Young adults who regularly use cannabis reduced their use in response to a brief intervention that included a smartphone app that promoted the use of protective behavioral strategies. Exercise enhanced the reduction in cannabis use, over time.

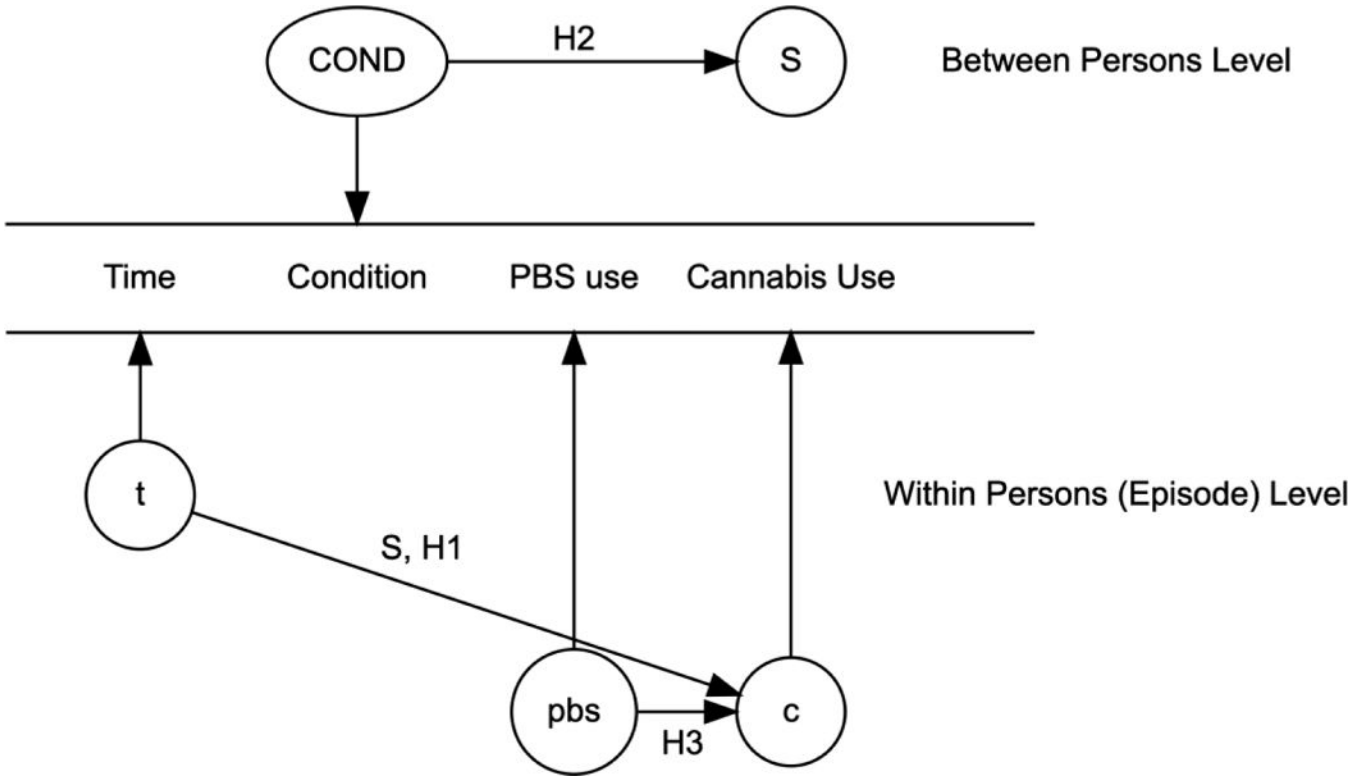

Figure 1.

Multilevel Structural Equation Model for testing relations among condition, protective behavioral strategy use, time, and cannabis use between and within persons. Note: Figure 1 is a combined figure of 2 nested MSEMs. Model 1 does not include PBS use, Model 2 does include PBS use. H1 = hypothesis 1; H2 = hypothesis 2; H3 = hypothesis 3; COND = between-person condition variable; S = random slope of time predicting cannabis use; t = within-person time variable; c = within-person (i.e., episode-level) cannabis use measured in standard joint units; standard joint = 0.5 grams; PBS = protective behavioral strategy; pbs = within-person protective behavioral strategy use.

Table 1.

Multilevel Structural Equation Models parameter estimates.

	Estimate	Posterior SD	Bayesian Credible Interval: Lower Bound	Bayesian Credible Interval: Upper Bound
Model 1				
Episode-Level				
H1: Time → Cannabis Use (S)	−.43*	.17	−.77	−.10
Person-Level				
H2: Condition→ S	.23*	.11	.03	.43
Model 2				
Episode-Level				
H3: PBS→ Cannabis Use	−.42*	.16	−.73	−.13
Time → Cannabis Use (S)	−.17	.27	−.69	.40
Person-Level				
Condition→ S	.14	.15	−.21	.40

Note: H1 = hypothesis 1; H2 = hypothesis 2; H3 = hypothesis 3; PBS = protective behavioral strategies; S = random slope of time predicting cannabis use; * = Bayesian Credible Intervals do not contain 0.