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Marijuana eCHECKUPTO GO: Effects of a personalized feedback plus protective behavioral strategies intervention for heavy marijuana-using college students

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ABSTRACT

Background: Marijuana use is common among U.S. college students. Liberalization of marijuana use policies is hypothesized to decrease social norms discouraging use, which protects against marijuana use. This may increase the importance of protective behavioral strategies (PBS) to reduce marijuana use harm.
Methods: This study tested direct and moderated (by sex) program effects of an adapted version of the Marijuana eCHECKUPTO GO, a web-based marijuana use intervention providing university-specific personalized feedback (PF) with normative information and PBS to students attending a university in a state with legalized adult recreational marijuana. Participants were 298 heavy-using college students randomly assigned to receive Marijuana eCHECKUPTO GO or strategies for healthy stress management (HSM). General linear models (GLMs) tested direct program effects on proximal intervention targets, marijuana use, and use consequences. Multigroup GLMs then tested the moderating effect of sex on direct intervention effects.
Results: Marijuana eCHECKUPTO GO participants reported decreases in estimated use prevalence (i.e., descriptive norms), self-reported hours high per week, days high per week, periods high per week, and weeks high per month. Sex moderated intervention effects on the use of PBS such that females in the PF condition increased their use of PBS more than males.
Conclusion: Results demonstrate preliminary support for the adapted Marijuana eCHECKUPTO GO in reducing marijuana use for "heavy college-aged users". Future research should test adapted Marijuana eCHECKUPTO GO sustained effects over time, and examine whether program effects on harm reduction manifest after sustained (e.g., booster) program implementation.

1. Introduction

Marijuana use is common among U.S. college students with 22% percent reporting past-month use and daily use at its highest level in three decades (Schulenberg et al., 2017). Marijuana use is associated with several psychosocial and academic problems during college. College student marijuana users report more emotional problems including anxiety and depression, greater health service utilization for physical and mental health problems, and lower subjective well-being than non-users (Arria et al., 2016; Keith et al., 2015). Marijuana use during college has also been shown to be significantly associated with lower GPA, discontinuous enrollment, delay of graduation, and drop-out (Arria et al., 2013; Suerken et al., 2016). Thus, college student marijuana use represents a challenge to stakeholders from public health, mental health, and higher education sectors.

1.1. Perceived social norms and marijuana use prevention

Perceptions of social norms encouraging use have been identified as risk factors for one's personal marijuana use and misuse (Kilmer et al., 2007; Neighbors et al., 2008). Studies demonstrate positive associations between injunctive norms (i.e., perceptions of approval of use) and college student marijuana use. Specifically, perceptions of typical-students' and close friends' approval are positively associated with personal use, and that perceptions of parents' approval are indirectly associated with personal use through personal approval of use (Labrie

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et al., 2011, 2010). Other studies have found that injunctive and descriptive norms (i.e., perceptions of marijuana use prevalence) are positively associated with college student marijuana use and marijuana-related problems and that descriptive norms account for the greatest amount of unique variance in use frequency (Buckner, 2013; Neighbors et al., 2008). Concerns from public health, mental health, and higher education perspectives are that college students consistently overestimate peer use and approval of use, misperceptions that are, in turn, associated with increased risk for personal use (American College Health Association, 2011). Thus, normative reeducation (i.e., correcting misperceptions of social norms) related to marijuana use and acceptability represents a sensible target for addressing marijuana misuse among college students.

Personalized feedback (PF) interventions with normative feedback are designed to correct misperceptions of substance use norms. While few studies exist studying the efficacy and effectiveness of PF interventions for marijuana use, several efficacious PF interventions exist for college student alcohol misuse that may indicate that these types of interventions would be effective at reducing the harm associated with marijuana use (Larimer and Cronce, 2007; Neighbors et al., 2004). A meta-analysis of 22 social-norms interventions targeting student alcohol misuse demonstrated that these programs could effectively reduce alcohol-related problems, binge drinking, peak blood alcohol content, drink quantity, and drinking norms (Moreira et al., 2009). Notably, a web-based implementation may be particularly effective and cost-efficient with greater intervention diffusion potential as this implementation strategy has been shown to affect a broad array of alcohol misuse problems (Moreira et al., 2009).

Due to overlapping risk and protective factors for alcohol and marijuana use, including the influence of peers who use alcohol and marijuana and poor school involvement as risk factors and moral, religious, and social influences as protective factors (Wongtongkam et al., 2014), and evidence supporting online approaches to college student alcohol misuse prevention (Moreira et al., 2009), adapting an online alcohol misuse prevention programs to the prevention of college student marijuana use is a potential strategy for reducing marijuana use among college students. However, the efficacy of a PF approach to the prevention of marijuana use among college students has yet to be systematically tested. One study successfully adapted a brief, intensive, one-on-one motivational interviewing approach for reducing alcohol misuse to marijuana use intervention among frequently using (i.e., at least five times in the last month) college students in a state without legalized adult recreational use (Lee et al., 2013). Participants randomly assigned to the motivational interview condition reported significantly fewer past 30- and 60-day weekly joints smoked, and marijuana-related consequences at three-month follow-up. However, as noted above, one-on-one program implementation may limit large-scale program diffusion.

A second study tested the efficacy of a PF approach to decreasing marijuana use among past three-month college marijuana users (n = 341). This study found no significant overall program effects at either three- or six-month follow-ups. However, marginally significant interaction effects suggested that those who were more likely to have contemplated reducing marijuana use and those with a family history of substance misuse problems were more likely to benefit, suggesting that those at higher risk for marijuana use may be more receptive to PF (Lee et al., 2010).

1.2. Protective behavioral strategies and marijuana use prevention

Protective Behavioral Strategies (PBS), strategies an individual can use to prevent or reduce substance use, by definition protect against substance use (Prince et al., 2013). PBS are behavioral strategies used (a) before a substance use episode begins (e.g., setting a limit), (b) during the substance use episode (e.g., refusing drinks or hits), or (c) doing something else instead of using (e.g., not going to a party) to avoid or reduce consumption and/or consequences (Prince et al., 2013). Although support exists for PBS as a protective factor for alcohol use and problems, support for its capacity to protect against marijuana use and consequences is limited, but growing (Bravo et al., 2018a, b; Pedersen et al., 2017, 2016). Similarly, although it is known that PBS can mediate program effects on reduced alcohol use and associated problems (Martens et al., 2005, 2007, Martens et al., 2009, 2011; Pearson et al., 2012, 2013), no intervention studies targeting PBS for marijuana have been conducted. However, three randomized controlled trials (RCTs) with college students found that PBS mediated the effects of the intervention on alcohol outcomes (Barnett et al., 2007; Larimer et al., 2007; Murphy et al., 2012). It follows that interventions explicitly targeting PBS for marijuana use may potentially result in stronger effects on marijuana use outcomes. In short, although theoretically sound, PBS approaches to marijuana use prevention or reduction have yet to be systematically tested.

1.3. Marijuana eCHECKUPTO GO college student marijuana misuse

In 2012, Colorado, which now ranks first in the nation in youth marijuana use (Hughes et al., 2015), was one of two states first to legalize recreational use for adults aged 21 and over. Liberalization of marijuana use policies is hypothesized to increase personal misperceptions of marijuana use prevalence, potentially increasing the salience of PBS as a protective factor against misuse. Consequently, social norms and PBS may represent particularly important targets for marijuana use interventions, implemented during the college years, within the context of legalized adult recreational marijuana. However, a combined PF + PBS approach aimed at correcting social norms misperceptions and use of PBS to reduce heavy college student marijuana use has yet to be tested in the context of legalized adult recreational marijuana use.

There is one such intervention, the Marijuana eCHECKUP TO GO program, an online intervention designed to reduce the harms associated with heavy marijuana use by correcting normative perceptions of marijuana use (San Diego State University Research Foundation, 2009). Despite being widely implemented (more than 300 universities in the U.S. use the intervention), few studies have tested the efficacy of Marijuana eCHECKUP TO GO. One study of 245 college student abstainers failed to demonstrate significant intervention effects on marijuana use. However, intervention participants reported lower descriptive norms and friend disapproval (i.e., injunctive norms) at one-month posttest than did an assessment-only control group (Elliott and Carey, 2012). A second study with relatively heavy (i.e., 2+ times per week) users demonstrated Marijuana eCHECKUPTO GO intervention effects on decreasing “extreme” descriptive norms of college student marijuana users, but not on student use or consequences (Elliot et al., 2014). These findings demonstrate promise in Marijuana eCHECKUP TO GO’s ability to alter normative attitudes, however, research is needed to test whether, and for which populations, the intervention can change personal marijuana use rates and consequences of use.

The purpose of this study was to pilot-test the efficacy of an adapted PF + PBS version of Marijuana eCHECKUP TO GO in reducing heavy marijuana use among college students. The current study targeted heavy marijuana users in a state with legalized recreational adult marijuana use because they may especially misperceive actual marijuana use rates and approval of use, and thus be more influenced by an intervention correcting these misperceptions. It was hypothesized that participants randomly assigned to the adapted Marijuana eCHECKUP TO GO would self-report significantly lower descriptive and injunctive marijuana use norms, greater use of PBS, less marijuana use, and fewer consequences for marijuana use at six-week posttest than participants assigned to healthy stress management (HSM) comparison condition. Due to the early stages of this research, we were also interested in testing whether males or females benefited differently from Marijuana eCHECKUP TO GO participation. Although no *a priori* hypotheses were

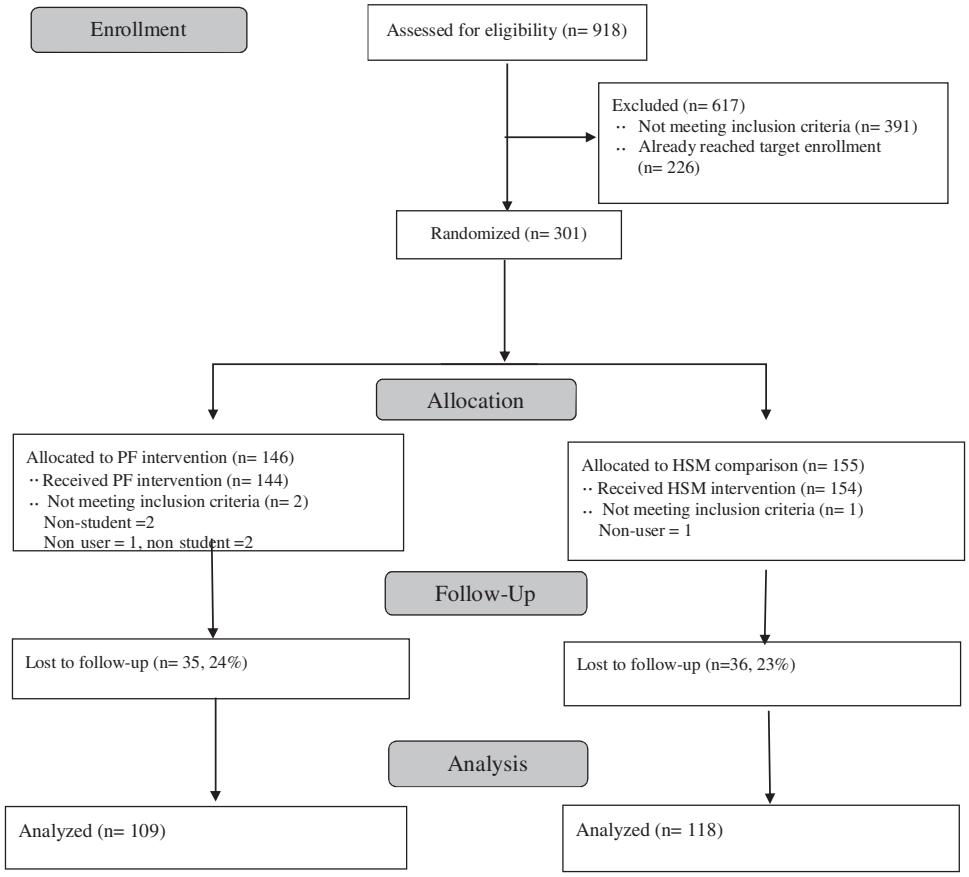

Fig. 1. Consort Flow Diagram.

proposed, sex differences in program effects could inform future intervention recruitment and/or content.

2. Method

2.1. Participants & procedures

All aspects of the study were conducted online. Undergraduate college students were recruited in the Fall of 2016 via emails to on-campus and residence and fraternity/sorority life, on-campus fliers, Facebook advertisements, and word-of-mouth. Students expressing interest in the study were e-mailed a screener to determine eligibility (See Consort Flow Diagram). The consort flow diagram is Fig. 1. Eligibility criteria were that participants were 18 years of age or older, a university student, a recreational marijuana user (i.e., non-medicinal), and reported typical marijuana use of at least twice per week. Of the 918 completed screeners, 527 (57%) met eligibility requirements. Participants were invited to participate on a rolling basis until the target number of 300 participants was achieved. One additional student was added to the study sample in between the time the target number of participants was achieved and when study staff was able to discontinue enrollment. Thus, the sample at baseline was 301 participants. Participants received $20 for completing the baseline survey and $10 for completing the 6-week posttest survey. The research described was conducted in accordance with The Code of Ethics of the World Medical Association.

Participants were randomly assigned in the Fall of 2016 to either the adapted Marijuana eCHECKUP TO GO (n = 146) or HSM (n = 155) condition. Marijuana eCHECKUP TO GO is a commercially available, online, PF intervention designed to motivate college students to reduce marijuana use by correcting misperceived social norms, as well as providing education on marijuana use (San Diego State University Research Foundation, 2009). Marijuana eCHECKUP TO GO was originally adapted from the eCHECKUP TO GO alcohol misuse intervention and is currently being implemented in universities worldwide. In its original form, participants complete a survey asking them about their personal use and perceived social norms. Upon completion of this survey, participants are provided immediate feedback regarding how their personal use and perceived norms related to the United States and university-specific marijuana use rates.

The Marijuana eCHECKUP TO GO was further adapted in the current study to address our research questions better. One of the primary adaptations of the Marijuana eCHECKUP TO GO was to collect data on empirically supported Protective Behavioral Strategies for Marijuana (PBSM, Pedersen et al., 2017) and injunctive norms items (e.g., “To what extent do you feel the following individuals approve of using marijuana?” and “To what extent do you feel the following individuals approve of using marijuana daily?” asked of “Your best friends,” “Typical college students,” and “Your parents,”). Injunctive norms data were included as part of data collection but were not used in the feedback portion. However, PF encouraged participants to use PBS from the PBSM measure, and there is some empirical support demonstrating that simply providing a list of potential alcohol-related PBS as part of PF can mediate reductions in alcohol use (Murphey et al., 2012). The current study will be the first to test this approach for the prevention of marijuana misuse.

Suggestions for healthy stress management served as the attention placebo control (APC) group. Attention placebo control groups are commonly used to control for expectancy effects and other aspects of the treatment condition that are thought to potentially contribute to intervention effects beyond the intervention content including attention to participants, contact with research team members, perceived social support, and other nonspecific intervention effects. Although APCs control for these effects, and are often used in psychosocial and

Table 1
Demographic variables by intervention condition.

		PF	HSM
Sex			
	Female	45.1%	52.6%
Race			
	American Indian	0.0%	1.3%
	Asian/Asian American	2.1%	2.6%
	African American	3.5%	5.2%
	Native Hawaiian/Pac Islander	0.0%	2.6%
	Caucasian	88.9%	82.5%
	Multiracial	2.1%	1.4%
	DNR	3.5%	4.5%
Ethnicity			
	Hispanic/Latino	8.4%	8.4%
	Non-Hispanic/Latino	87.1%	90.3%
	DNR	3.5%	1.3%

PF (n = 144), HSM (n = 154).
DNR = Did Not Report.
Between group differences not statistically significant.

behavioral intervention efficacy studies, there is no gold standard for APCs in psychosocial intervention research (Popp and Schneider, 2015). The HSM condition was developed to control for expectancy effects, attention, and electronic contact with the research team that was also present for the PF + PBS condition.

Baseline survey responses from three participants indicated that they did not meet study eligibility (n = 1 non-user, n = 2 non-students), despite indicating as such on the screener. These participants were removed from further analyses. Therefore, the final baseline sample included 298 participants (PF = 144, 48%; HSM = 154, 52%). The sample was 51% male and had a mean age of 19.97 years (SD = 2.0). Table 1 illustrates full participant demographics by intervention and control condition. No significant differences existed between the two conditions on sex, racial/ethnic background, or age.

After completing baseline surveys, PF + PBS experimental condition participants received the standard PF regarding personal marijuana use, perceptions of marijuana use norms versus actual use prevalence at their university and nationally, and a list of change strategies related to marijuana use (i.e., PBS), and asked to consider using them as a means to moderate use as implemented in the Marijuana eCHECKUP TO Go intervention. The goal of the PF feedback was to illuminate discrepancies between student perceptions and the actual prevalence of use among peers to increase cognitive dissonance related to participants' use. They also received suggestions on what they could have purchased (i.e., a cell phone bills, mp3 purchases) had they saved all of the money they spent on marijuana. Comparison condition participants were provided with strategies for HSM (e.g., deep breathing, mindfulness, exercise). A manipulation check was performed and confirmed that all participants received the intended information.

Participants were then sent up to three e-mails at four-day intervals inviting them to complete the same survey at 6-week posttest. Two hundred and twenty-seven (76%) participants (PF = 109, 76%; HSM = 118, 77%) completed this survey. Retained participants reported significantly fewer hours high per week (t = -3.71, p < .001), hours high per use day (t = -3.60, p < .001), days high per week (t = -2.46, p < .05), and time periods per week (t = -4.25, p < .001) than those who did not complete 6-week posttest surveys. Retained participants were also significantly less likely to be male than female (OR 0.52, 95% CI 0.30–.89, p < .05). However, there were no statistically significant differences in the number of retained vs. non-retained participants across condition (OR 1.05, 95% CI 0.62–1.79, p > .05). There were also no statistically significant differences by the condition in the attrition of heavy or male users.

2.2. Measures

Prior to, and six weeks following the intervention, all participants completed a 203-item survey asking about participants personal substance use, use consequences, perceived marijuana use norms, and PBS. The independent variable of primary interest was intervention condition (PF = 1, HSM = 0). Sex (male = 0, female = 1) served as a covariate. Three categories of dependent variables were measured; program targets, marijuana use, and marijuana use consequences. The three program targets were descriptive and injunctive norms, as well as PBS. Descriptive norms were measured by asking what percent of students at their university the participant believes used marijuana in the past month. Injunctive Norms were measured by asking participants how approving they believe their friends, other students, and their parents are of marijuana use, measured on a 7-point scale from "strongly disapproving" to "strongly approving." An overall Injunctive Norms score was created by averaging responses to the three reference groups. PBS was measured using the PBSM (Pedersen et al., 2017), which assesses 17 various PBS by asking the frequency of use (6-point scale, "never" to "always"). A total score was created by summing the number of items endorsed above the "never" level (i.e., used "rarely" to "always"). The five indicators of marijuana use were Hours High per Week (Range = 0–168), Hours High per Using Day (Range = 0–24), Days High per Week (Range = 0–7), Weeks High per Month (Range = 0–4), and Periods High per Week (Range 0–28). Periods High per Week was computed by dividing each day of the week into four 6-hour time blocks (e.g., 12am-6am, 6am-12pm) and asking participants to identify time blocks for each day of the week they are typically under the influence of marijuana. A number of endorsed time periods were summed across days of the week. Marijuana use consequences were assessed by summing the total number of consequences experienced in the last month and the average severity of the endorsed consequences, measured on a 5-point scale from "never" to "always" experienced.

Univariate descriptive statistics for each dependent variable at baseline, by intervention condition, are provided in Table 2. There were no significant baseline differences between the two conditions in any variable. All dependent variables were normally distributed with the exception of the number of PBS used being somewhat leptokurtic.

2.3. Analyses

Hypotheses were tested with general linear (GLM) models in SAS 9.2 statistical package. The standard inverse probability of follow-up weights adjusted for the disproportionate loss of males and heavier users to attrition. The first step in this process was to develop a logistic model regressing dropout on sex and the dependent variable at baseline. We then calculated the log odds of participants' dropout, separately for each model, and upweighting participants similar to those who dropped out. These estimated probabilities of drop out were then entered as covariates into GLM models.

Direct effects models regressed dependent variables at 6-week posttest on these same variables at baseline, sex, estimated probabilities of drop out, and intervention condition. Moderation models then introduced sex by intervention interaction term. Type III sums of squares were utilized with p < .05 to determine significance.

3. Results

Bivariate associations among dependent variables at baseline are presented in Table 3. Table 3 also provides results from models testing for baseline group differences in study dependent variables by biological sex and intervention condition. Intervention condition was not associated with any of the dependent variables at baseline. Sex was associated with Descriptive and Injunctive Norms and Hours High per Use Day such that females reported higher perceived use prevalence and approval while reporting getting high for fewer hours on days in

Table 2
Variable univariate statistics at baseline by treatment condition.

	PF (n = 144)				HSM (n = 154)			
	Mean	SD	Skewness	Kurtosis	Mean	SD	Skewness	Kurtosis
Intervention Targets								
Descriptive Norms	56.61	20.28	−0.11	−0.58	60.73	20.86	−0.40	−0.59
Injunctive Norms	4.91	0.96	−0.23	−0.45	4.89	0.88	−0.33	−0.22
Number PBS Used	14.96	2.75	−1.76	2.64	15.34	2.16	−1.93	5.45
Marijuana Use								
Hours High/Week	20.80	15.71	1.00	0.08	20.19	15.10	0.87	−0.13
Hours High/Use Day	3.90	1.99	0.82	−0.24	3.98	0.18	0.71	−0.32
Days High/Week	5.01	2.19	−0.50	−1.31	4.77	2.30	−0.36	−1.48
Weeks/Month	3.70	1.01	−1.78	2.60	3.53	1.10	−1.63	1.51
Number of Periods	9.24	6.89	0.95	0.25	8.90	6.60	0.90	0.36
Use Consequences								
Number of Consequences	14.06	6.57	−0.18	−0.88	14.51	5.62	−0.02	−0.55
Average Consequence Severity	1.77	0.54	0.38	0.54	1.79	0.54	0.89	1.52

which they used than males.

Table 4 illustrates results from GLMs used for hypothesis testing. Intervention Condition was significantly associated with variation in 6-week posttest perceived Descriptive Norms, Hours High per Week, Days High per Week, Weeks High per Month, and Periods High per Week such that Marijuana eCHECKUP TO GO participants reported significantly reduced perceived use prevalence, and less marijuana use at 6-week posttest compared with HSM comparison participants after covarying for baseline marijuana use and sex. Partial η^2 effect sizes for significant differences were in the small to medium range. Biological sex did not moderate intervention effects with the exception that females in the intervention condition used significantly more PBS at posttest than males in the intervention condition ($b = 1.06$, $SE = 0.47$, $t = 2.23$, $p < .05$).

Table 4
Direct eCHECKUP TO GO Intervention Effects.

	B	*SE*	*t*	*η2*
Intervention Targets				
Descriptive Norms	-11.83	2.50	-4.73**	0.09
Injunctive Norms	-0.12	0.08	-1.37	0.01
Number PBS Used	0.28	0.24	1.15	0.01
Marijuana Use				
Hours High Per Week	-3.26	1.29	-2.53*	0.03
Hours High Per Using Day	-0.10	0.31	-0.34	0.00
Days High Per Week	-0.75	0.19	-4.02**	0.07
Weeks High Per Month	-0.37	0.11	-3.53**	0.05
Periods High Per Week	-1.11	0.54	-2.06*	0.02
Use Consequences				
Number of Consequences	-0.01	0.06	-0.10	0.00
Consequence Severity	-0.67	0.80	-0.82	0.00

* = $p < 0.05$, ** = $p < 0.01$.

4. Discussion

Study results demonstrate preliminary support for the adapted Marijuana eCHECKUP TO GO to reduce heavy marijuana use frequency among university students attending school in a state with legalized adult recreational marijuana. Specifically, participants in the Marijuana eCHECKUP TO GO condition reported lower perceived use prevalence and being high fewer hours per week, days and periods per week, and weeks per month than HSM comparison participants. Interpreting unstandardized estimates, Marijuana eCHECKUP TO GO participants reported being high approximately 2.5 h per week, ¾ of a day per week, ½ weeks per month, and 1 "period" per week less than HSM participants. The fact that marijuana use did not significantly change from pre- to posttest among HSM participants suggests that between-group differences were due to reductions in use among PF participants, and not between-group differences in use escalation.

Results add to the limited research on a PF + PBS approach to marijuana use prevention among college students. Existing literature suggests little support for program effectiveness among non- to occasional users (Elliott and Carey, 2012). However, short-term program effects have occurred for somewhat regular users and potentially for

Table 3
Baseline associations among study variables.

	Descriptive Norms	Injunctive Norms	PBS Used	Hrs. High/ Week	Hrs. High/ Use Day	Days High/ Week	Weeks High/ Month	Periods High	Use Consequences	Average Consequences
Descriptive Norms										
Injunctive Norms	0.30**									
Number PBS Used	-0.06	-0.14*								
Hrs. High/Week	0.14*	0.23**	-0.48**							
Hrs. High/Use Day	0.09	0.13*	-0.37**	0.82**						
Days High/Week	0.19**	0.36**	-0.31**	0.72**	0.29**					
Weeks High/Month	0.18**	0.37**	-0.21**	0.45**	0.19**	0.63**				
Periods High	0.12*	0.20**	-0.50**	0.84**	0.55**	0.79**	0.53**			
Use Consequences	-0.13*	-0.20**	0.21**	0.01	0.00	-0.05	-0.09	0.02		
Consequence Severity	0.06	0.07	-0.32**	0.33**	0.30**	0.26**	0.19**	0.30**	0.05	
Sex	$t = 2.37$*	$t = 2.60$**	$t = 0.19$	$t = -1.23$	$t = -2.48$*	$t = 0.73$	$t = 0.70$	$t = 0.00$	$t = -0.95$	$t = 0.66$
Condition	$t = -1.77$	$t = 0.06$	$t = -1.35$	$t = -0.08$	$t = 0.24$	$t = 0.09$	$t = 1.06$	$t = 0.35$	$t = -0.64$	$t = -0.40$

Sex: Male = 0, Female = 1. * = $p < .05$, ** = $p < .01$.

those at greater risk for problem use (i.e., family history of substance misuse) (Lee et al., 2010). The current study fits with this research in demonstrating reductions in marijuana use frequency for regular, or heavy, marijuana users (i.e., two or more times per week).

Notably, the lone non-significant effect among use variables was for hours high per using day. This may be due to the possibility that although intervention effects were present for various measures related to marijuana use episodes, most PF participants continued to use marijuana, albeit at reduced levels. That participants reported being high for a comparable amount of time during a given use episode may be due to participants using comparably potent marijuana during both assessment periods.

Biological sex did not moderate Marijuana eCHECKUP TO GO intervention effects on marijuana use. Therefore, it appears that PF was an effective approach to reducing heavy marijuana use for both males and females. In contrast, a recent meta-analysis on brief alcohol interventions demonstrated that the efficacy of computer-delivered interventions was reduced when more women were included in trials (Carey et al., 2012). Specifically, Carey et al. (2012) reported that the moderation of gender on treatment effects was for comparisons of a computer-delivered intervention to a control condition, in contrast to other active intervention conditions, which they suggest represents a reduced reaction to the computerized intervention itself. One explanation for these findings, noted in Carey et al. (2012), is that because women typically respond more positively to low-intensity interventions (Sanchez-Craig et al., 1991) they may be responding positively to the assessment only or no treatment conditions. Regarding the lack of moderation in the current study, it is possible that females respond differently to marijuana interventions compared to alcohol interventions, or that the HSM control condition was well designed and did not result in the same differential assessment reactivity by sex as was seen in the alcohol studies included in the meta-analysis.

Marijuana eCHECKUP TO GO successfully reduced perceived prevalence of marijuana use (i.e., descriptive norms) and increased use of PBS, although program effects on the latter were specific to females. The adapted Marijuana eCHECKUP TO GO did not significantly reduce perceived social approval of marijuana use (i.e., injunctive norms). Among the potential reasons for this lack of program effect may be that the sample was composed of heavy marijuana users who were not specifically looking to reduce their marijuana use. It is unclear how effective these types of interventions are for those not seeking to reduce their use. Additionally, it is important to note the Marijuana eCHECKUP TO GO was originally designed to be administered before recreational marijuana use was legalized. It may be the case that the intervention needs to be updated to address the issue that in certain states in the U.S., recreational marijuana use is not illegal for individuals over the age of 21. In addition, previous research has shown that females are more likely to use alcohol PBS compared to males (Prince et al., 2013). The finding that females were more likely to increase PBS use for reducing marijuana use may be an indication that females are more protective or more open to trying more strategies to protect themselves compared to males.

Participation in Marijuana eCHECKUP TO GO was not associated with self-reported decreases in marijuana use consequences. One potential explanation is that modest decreases in marijuana use from heavy to somewhat less heavy use was not sufficient to significantly decrease use consequences, particularly in the short-term. However, it could be that if program effects are sustained over longer periods of time, perhaps accompanied by supplemental or booster intervention content, program effects on use consequences may have enough time to manifest. However, future research with long-term program follow-up is necessary to test this research question.

Results should be considered in light of study limitations, the first of which is that 24% of participants were lost to attrition with no information provided with respect to reasons for discontinuing participation. Participants not completing posttest surveys used marijuana at significantly higher rates and were more likely to be male. This attrition is similar to that of other studies with heavy substance users (Hansen et al., 1990; Radtke et al., 2017). However, it is unclear whether Marijuana eCHECKUP TO GO was an effective intervention approach for those using at the highest rates. Thus, future studies should develop more effective participant retention strategies for the heaviest of heavy using males. The present study was characterized by a limited budget for participant incentives (i.e., $40 may not have adequately incentivized the heaviest of male users). However, future studies should consider retention strategies beyond simply increasing monetary incentives, including consideration of how the Marijuana eCHECKUP TO GO is presented or framed to very heavy users and males. It may have been the case that the way the Marijuana eCHECKUP TO GO was presented discouraged a disproportionate number of heavy using males from further study participation by either appearing overly punitive or lacking credibility. However, worth noting is that we adjusted for participants' propensity for attrition and there were no between-condition differences in attrition of heavy users and males. Regardless, future studies will need to increase participant retention to increase the generalizability of intervention results in exceptionally heavy and male users.

A second study limitation is the self-report nature of the data. Self-reports are limited by several threats to the internal validity including recall and social desirability, the prior which may be of particular concern due to established effects of heavy marijuana use on certain aspects of memory (Podsakoff et al., 2003). However, participants in both conditions self-reported heavy use and there were no significant condition by baseline differences in self-reported marijuana use. Social desirability may have been an issue if it somehow becomes less socially desirable for Marijuana eCHECKUP TO GO than HSM participants to report heavy use. Future research, including the use of post-intervention focus groups, may be able to obtain qualitative reports detailing whether Marijuana eCHECKUP TO GO disproportionately influences social desirability and/or other threats to internal validity of self-reported marijuana use data.

As stated above, a third limitation is the relatively short, 6-week interval between baseline and follow-up surveys. The fact that group differences in reported marijuana use emerged within a 6-week period is encouraging. However, longer-term follow-ups are needed to determine whether group differences are sustained, or whether group differences in use consequences emerge, over time. Also of related interest for future research would be to test whether the sustained intervention (i.e., boosters) are necessary to sustain or increase the size of intervention effects.

Finally, although Marijuana eCHECKUP TO GO participants reported reducing use, most participants continued using marijuana at relatively high rates. For example, Marijuana eCHECKUP TO GO participants on average decreased their number of days high per week from 5.01 to 4.27. Although still using at high rates, these decreases may be of practical importance if reductions are sustained over time. For example, if a significant difference in days high per week are sustained, participants would report being high 38.48 fewer days per year. By reducing college student marijuana use –as opposed to complete cessation— there may be an enhanced possibility of academic success (e.g., improved retention rates) and decreased mental health problems (e.g., anxiety, depression) associated with highest use rates. Future research is needed to examine if students who reduce their marijuana use from heavy use to moderate or low use attain better outcomes related to family, legal, and social consequences.

In sum, this study demonstrated early support for a low-cost, easily diffused, PF + PBS approach to reducing heavy marijuana use among college students. Although effect sizes were generally small, prevention effects may be practically significant if sustained. Future research is needed to establish whether intervention effects are sustained over time or whether they vary based on subgroups other than sex.

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Contributors

Dr. Riggs is the primary author, drafted all sections of the text, and conducted study analyses.

Dr. Conner adapted the e-CHECKUP TO GO on-line intervention for the current study and contributed to drafting and editing the manuscript. Mr. Parnes assisted in data analysis and edited the manuscript. Dr. Shillington contributed to the measurement creation, methodology decision making, identified university partners for data collection, contributed to the background and discussion sections. Dr. Prince contributed to the drafting of the introduction and discussion sections, reviewed and provided comments on the complete manuscript, and approved the final version of the manuscript. Dr. George contributed to the conceptualization and execution of the study and reviewed and edited the manuscript. All authors have approved of the final manuscript.

Conflict of interests

No conflict declared.

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