Contingency management for smoking cessation among individuals with substance use disorders: in-treatment and post-treatment effects

Abstract

Introduction. Smokers with substance use disorders (SUDs) show elevated tobacco prevalence, and smoking abstinence rates are considerably low. This randomized controlled trial sought to compare the effect of a cognitive behavioral treatment (CBT) that includes an episodic future thinking (EFT) component with the same treatment protocol plus contingency management (CM). This study aims to examine the effect of CM on smoking outcomes and in-treatment behaviors (i.e., retention, session attendance and adherence to nicotine use reduction guidelines), and to analyze whether these in-treatment variables predicted days of continuous abstinence at end-of-treatment. **Method**. A total of 54 treatment-seeking participants (75.9% males, *M*=46.19 years old) were allocated to CBT+EFT (*n*=30) or CBT+EFT+CM (*n*=24). Intervention consisted of eight weeks of group-based sessions. Tobacco abstinence was verified biochemically by testing levels of carbon monoxide (≤4ppm) and urine cotinine (≤80ng/ml). **Results**. CM intervention increased 24-hour tobacco abstinence (50% vs. 20%, $\chi^2(1)=5.4$; $p=.021$) and days of continuous abstinence (M=5.92±7.67 vs. 5.53±12.42; $t(52)=-.132$; $p=0.89$) at end-of-treatment in comparison with CBT+EFT intervention. Although not statistically significant, CBT+EFT+CM enhanced in-treatment behaviors, in terms of retention (83.3% vs. 70%; $\chi^2(1)=.255$; $p=.208$), sessions attended (12.29±3.22 vs. 10.93±3.26; $t(52)=-1.527$; $p=.133$) and adherence to weekly nicotine use reduction targets (41.07% ± 31.96 vs. 35% ±2 6.28; $t(52)=-.766$; $p=.447$). A higher percentage of samples meeting reduction guidelines (β=.609; $p<.001$) predicted days of continuous abstinence at end-of-treatment. **Conclusion**. Combining CM with CBT+EFT improves short-term quitting rates. Findings suggest the need to incorporate strategies for improving adherence to nicotine reduction guidelines.

Keywords. Smoking cessation, contingency management, episodic future thinking, substance use disorders, in-treatment behaviors.

Highlights

- CM facilitates 24-hour tobacco abstinence more than CBT+EFT alone does.
- CM is related to improved, but not statistically significant, in-treatment outcomes.
- Higher adherence to nicotine fading produces higher continuous abstinence.

1. Introduction

Smokers with substance use disorders (SUD) are considered hard-to-treat smokers due to high smoking rates (59% - 86%) (Gass et al., 2018; Guydish et al., 2016; Ingram et al., 2017; Weinberger et al., 2018), elevated nicotine dependence (Goodwin et al., 2014; Parker et al., 2018) and severe withdrawal symptomatology (Heffner et al., 2011).

Despite the existing effective smoking cessation treatments, abstinence rates remain considerably low among this population. At end-of-treatment, 21% of participants achieve tobacco abstinence, whereas rates decline to 12% in long-term follow-up (Apollonio et al., 2016; Prochaska et al., 2004). To enhance quitting rates, smoking cessation treatments need to be adapted to this population, in terms of intensity (i.e., number of sessions, duration and frequency) and type of intervention (i.e., behavioral, pharmacotherapy or combined) (Hughes, 2013; Murphy and McKay, 2004).

Cognitive-behavioral therapies (CBT) have shown positive effects on smoking cessation, although abstinence rates remain moderate, ranging from 6% to 20% (Stead et al., 2017). Previous research has suggested that including components targeted at participants' characteristics, such as high impulsive choice, might enhance treatment outcomes (Verdejo-García et al., 2008). In this line, episodic future thinking (EFT), an intervention that consists of visualizing future situations with the aim of valuing the future consequences (i.e., health), has demonstrated promising results in tobacco and impulsive choice reductions (see e.g., Bulley and Gullo, 2017; Chiou and Wu, 2017; Patel and Amlung, 2020; Rung and Madden, 2018).

Contingency management (CM) is a behavioral intervention based on providing incentives contingent upon abstinence or therapeutic achievements (Notley et al., 2019). It stands as one of the most effective substance use treatments (Ainscough et al., 2017;

McPherson et al., 2018), and has shown additive effects on tobacco abstinence over standard smoking cessation treatments in difficult-to-treat populations (Hand et al., 2017; Secades-Villa et al., 2019a). A recent meta-analysis in smokers with SUD concluded that CM performs significantly better compared to control conditions, in terms of tobacco abstinence and reduction at end-of-treatment (Secades-Villa et al., 2020). Nevertheless, mean abstinence rates are considerably low (36%), so further research is needed to improve treatment effectiveness in this particular group.

Identifying factors associated with smoking cessation facilitates the improvement of treatments and thus, abstinence rates. In this regard, several in-treatment variables, such as a higher number of sessions attended (Dorner et al., 2011; Joo et al., 2020), greater treatment adherence (Marino et al., 2010) and early abstinence during the initial weeks of therapy (Ashare et al., 2013; Romanowich and Lamb, 2010) stand as consistent predictors of short- and long-term smoking abstinence among the general population. However, in-treatment behaviors in relation to smoking abstinence have been less studied in SUD populations. There are only two prior studies examining in-treatment behaviors among smokers with SUD. Rohsenow et al. (2017) showed that days of abstinence during treatment did not predict long-term smoking abstinence, although results at end-of-treatment were not analyzed. On the other hand, Okoli and Khara (2014) demonstrated that the number of sessions attended predicts smoking cessation at end-of-treatment, although the sample comprised both participants with SUD and with psychiatric disorders.

This randomized controlled trial was the first study to examine effects of adding CM to a CBT+EFT protocol in smokers with SUD. The study specifically sought to: 1) examine whether adding a CM component improves smoking outcomes and in-treatment behaviors (i.e., retention, session attendance and adherence to nicotine

reduction); and 2) to analyze whether in-treatment behaviors predict days of continuous abstinence at end-of-treatment.

2. Method

2.1. Participants and procedure

This study was conducted at the Clinical Unit of Addictive Behaviors of the University of Oviedo (ClinicalTrials-gov, ref: NCT03551704). Patients were recruited through their referral SUD facilities and by local advertisements (radio, TV, mass media, posters and flyers).

Inclusion criteria were being at least 18 years old, smoking at least 10 cigarettes per day within last year and receiving outpatient SUD treatment. Having severe a mental disorder (e.g., active psychotic or suicidal ideation/temptation), engaging in current cannabis use and receiving any other smoking cessation treatment were exclusion criteria.

Figure 1 shows the flow of participants from enrollment to end-of-treatment. Out of the 87 participants initially assessed, 54 participated in the study and were assigned to the CBT+EFT group (n = 30) or the CBT+EFT+CM group (n = 24). Treatment groups were randomized using a two-step random allocation approach: 1) generating a random assignment of participants implemented in excel, and 2) implementing the sequence in a way that conceals the treatments until patients have been formally assigned to their groups (Dettori, 2010). All participants provided informed consent and the study protocol was approved by the Research Ethics Committee of the Principality of Asturias (No. 114/16).

2.2. Measures

During the intake session, which lasted approximately an hour, participants were asked about sociodemographic data, substance use related characteristics, including tobacco use, and psychological variables. Sociodemographic characteristics included sex, age, marital status, educational level and monthly income. The following tobacco use variables were measured: cigarettes per day, years of regular use, previous 24-hour quit attempts and motivation to quit smoking. In addition, past year tobacco use disorder diagnosis was assessed using the Structured Clinical Interview for DSM-5 (SCID-5; First et al., 2016), and nicotine dependence was measured with the Fagerström Test for Nicotine Dependence (FTND; Heatherton et al., 1991). Drug-related characteristics considered were primary and secondary substance used, days of abstinence from substances other than nicotine and days enrolled in SUD treatment. Both tobacco and drug use were also measured by biochemical analysis, using urine cotinine analysis, carbon monoxide (CO) and alcohol in expired air, as well as substance consumption through drug cassettes.

Psychological variables included were depressive symptomatology evaluated with the Beck Depression Inventory (BDI-II; Beck et al., 1996) and impulsive choice assessed through a DD task. The discounting task consisted of a computerized task in which participants had to choose between an amount of money now or €1,000 ($1,197) after a fixed delay (1 day, 1 week, 1 month, 6 months, 1 year, 5 years and 25 years). With this task, the immediate value, which ranges from €5 ($5.99) to €1,000 ($1,197), is adjusted by a titration procedure based on the participant's response (Holt et al., 2012) in order to estimate the indifference point for each of the delays. The indifference point refers to the subjective value where delayed and immediate reward are equivalent.

Smoking outcomes were analyzed according to three measures considering all participants: 24-hour and 7-day point-prevalence prior to end-of-treatment assessment

and days of continuous abstinence at end-of-treatment. The following in-treatment variables were considered: a) retention (percentage of participants who completed the treatment), b) session attendance (mean total number of sessions attended) and c) treatment adherence (percentage of sessions in which patients met the cotinine criteria according to the weekly reduction of 20%).

2.3. Interventions

All therapists were master- and doctoral-level psychologists with previous training in specific protocols. All sessions were audio-recorded to ensure compliance with the study protocol.

2.3.1. Cognitive-behavioral treatment (CBT) + episodic future thinking (EFT)

The CBT protocol was based on Becoña (2007) but adapted to the SUD population (see Aonso-Diego et al., 2021). It consisted of eight weeks of group-based sessions with up to four patients. Participants had to attend the clinic twice a week: once for the therapy session ('session A') and once to provide CO and cotinine samples ('session B'). Therapy sessions took about 120 minutes, while mid-week sessions were of 30-minute duration. In total, patients had to visit the clinic 15 times.

Components included in CBT were psychoeducation about tobacco use, myths regarding the relationship between tobacco and drugs, monitoring of biochemical variables, stimulus control, problem-solving skills, relaxation for anxiety and relapse prevention strategies. The nicotine fading component consisted of reducing participants' nicotine intake by 20% each week (through weekly reductions in the number of daily cigarettes and changes in tobacco brands). Therefore, the quit day was set at 48-hours prior to the sixth session. The EFT component was added to promote the appraisal of the future reinforcers (i.e., personal future situations not related to tobacco use) against

the current behavior (i.e., smoking). Participants had to visualize a total of five events related to future non-smoking situations (one in a week, two in two weeks, one in a month and one in three months) throughout the treatment. As homework, they had to self-report visualization practices twice a day and rate their realism on a 10-point scale.

2.3.2. Cognitive-behavioral treatment (CBT) + episodic future thinking (EFT) + contingency management (CM)

Patients allocated to this treatment condition received the same components as the ones describes above but with the addition of CM. Participants received points (one point was equivalent to one euro (US$ 1.13) contingent upon biochemical confirmation of tobacco abstinence from the sixth session onwards. Smoking abstinence was defined as breath carbon monoxide (CO) equal to or less than 4 particles per million (ppm) and urine cotinine equal to or less than 80 nanograms per milliliter (ng/ml), according to prior recommendations (Benowitz et al., 2020). Vouchers began at 20 points (US$ 22.60) and escalated by 5 points (US$ 5.65) for each consecutive negative sample. Additionally, patients could earn a bonus of 10 points (US$ 11.30) for achieving two consecutive negative smoking samples. A positive test or missed specimens reset the voucher value back to the initial 20 points (US$ 22.60), but when patients provided two consecutive negative tests the vouchers value was re-established to the one given before the reset. The maximum amount that participants could earn at end-of-treatment was 170€ (US$ 203.63), and the average earned in vouchers was €68.33(US$ 81.85).

2.4. Data analysis

Baseline descriptive statistics and treatment outcomes (smoking status at end-of-treatment and in-treatment variables) by intervention groups were examined using *t*-test for continuous variables and chi-square for categorical ones. Effect sizes were

calculated using Cohen's *d* (Cohen, 1988), Cramer's *V* (Cramer, 1946) and phi coefficient (Fleiss, 1994), as appropriate.

A hierarchical linear regression was carried out to identify in-treatment predictors of days of continuous abstinence at end-of-treatment. The following variables were considered: mean total number of sessions attended (both therapy and control sessions) and percentage of samples meeting weekly nicotine reduction guidelines. Sex, AUC_{log}*d* as a measure of DD, number of cigarettes per day, nicotine dependence (FTND) and type of intervention (CBT+EFT vs. CBT+EFT+CM) were introduced as covariates.

An overall discounting rate was calculated using the AUC_{log}*d*.. This is a relatively novel indicator of discounting that addresses the limitations of the classic AUC calculation (Myerson et al., 2001). It is obtained by calculating the total AUC by dividing each logged delay by the longest logged delay (i.e., 25 years) (see Borges et al, 2016). The AUC_{log}*d* index varies between 0 and 1, with lower values indicating higher levels of impulsive choice (i.e., steeper discounting). The statistical package used was SPSS (version 24, Inc., Chicago, IL).

3. Results

3.1. Smoking outcomes

In the CBT+EFT+CM group, 58.33% (14/24) attained at least 24 hours of tobacco abstinence during the treatment, and this figure was 40% (12/30) in the CBT+EFT condition ($\chi^2(1) = 1.136$; $p = .287$; $\varphi = .182$). At end-of-treatment, 24-hour abstinence was 50% (12/24) in CBT+EFT+CM group and 20% (6/30) in CBT+EFT ($\chi^2(1) = 5.4$; $p = 0.021$; $\varphi = 0.316$). Seven-day point-prevalence was 33.33% (8/24) in CBT+EFT+CM condition and 20% (6/30) in CBT+EFT ($\chi^2(1) = 1.234$; $p = 0.212$; $\varphi = 0.151$).

Considering all participants, the number of days of continuous abstinence was higher, although not significantly, in CBT+EFT+CM versus CBT+EFT group (M = 5.92±7.67 vs 5.53±12.42; $t(52)$ = -.132; p = 0.895; d = 0.037). Of the participants who had achieved tobacco abstinence on quit day (i.e., the sixth session), all of those in the CBT+EFT condition (6/6) and 54.54% (6/11) in CBT+EFT+CM were continuously abstinent at end-of-treatment.

In the CBT+EFT+CM group, a higher percentage of participants completed the treatment compared to CBT+EFT (70% vs 83.33%; $\chi^2(1)$ = .255; p = 0.208; d = 0.155). Moreover, patients assigned to the CBT+EFT+CM group had a higher total number of sessions attended than CBT+EFT (M = 12.29±3.22 vs 10.93±3.26; $t(52)$ = -1.527; p = 0.133; d = 0.419). Adherence to weekly nicotine reductions, considered as the percentage of samples that met the recommended 20% reduction in nicotine use, was also higher in the CM group (CBT+EFT+CM: 41.07%; SD = 26.28; CBT+EFT: 35%; SD = 31.96; $t(52)$ = -.766; p = 0.447; d = 0.344). Adherence to nicotine reduction throughout treatment is displayed in Figure 2.

3.2. Relationship between in-treatment behaviors and smoking abstinence

Table 2 presents the regression model that tested the relationship between in-treatment behaviors and days of continuous abstinence ($F(7,46)$ = 8.349, p < .001). Adherence to nicotine fading and session attendance explained an additional 30.3%, so as a whole, this model accounted for 55.9% of the variance. Greater adherence to nicotine fading [β = .512; 95%CI .084, -.288; p = .001] predicted higher days of continuous abstinence at end-of-treatment over and above covariates.

4. Discussion

This randomized controlled trial aimed to examine the effects of CM on smoking cessation and in-treatment behaviors in smokers enrolled in SUD intervention. Two results are highlighted: First, although both treatments produced similar smoking abstinence and in-treatment outcomes, the data indicate a tendency towards lower tobacco use and better in-treatment behaviors in the CBT+EFT+CM group compared to CBT+EFT. Secondly, adherence to nicotine reduction guidelines predicted more days of continuous abstinence at end-of-treatment.

Our results show that adding CM to a CBT+ EFT treatment improves tobacco abstinence at end-of-treatment compared to the CBT+EFT group, which confirms and extends previous evidence showing that incentives can be successfully used for quitting tobacco use in smokers with SUD (Cooney et al., 2017, 2015; Hunt et al., 2010; Shoptaw et al., 2002; Sigmon et al., 2016; Tuten et al., 2012; Winhusen et al., 2014). Despite the fact that CM facilitates more individuals achieving 24 hours of tobacco abstinence at end-of-treatment, the number of days of continuous abstinence was not significantly higher in this group. This result, which seems contradictory, indicates that implementing another reinforcement procedure, such as shaping (see e.g., Secades-Villa et al., 2019b), could yield more continuous abstinence results.

Abstinence rates at end-of-treatment (18/33.33%) were superior compared to other smoking cessation treatments in this population (20.52%; Prochaska et al., 2004). This finding can be explained due to three reasons. Firstly, participants were trained in effective CBT strategies to deal with high-risk situations and withdrawal symptoms. Secondly, the continuous biochemical monitoring of tobacco use throughout the entire treatment might have arguably led to enhanced smoking cessation rates, particularly through an increase in motivation (McPherson et al., 2014; Schuler et al., 2014).

Thirdly, EFT has been proved to produce meaningful impacts on DD reductions (see e.g., Patel and Amlung, 2020; Snider et al., 2016; Stein et al., 2016), which is in turn a consistent predictor of smoking abstinence (see e.g., Coughlin et al., 2020; Miglin et al., 2017).

Concerning in-treatment behaviors (completion rates, number of sessions attended and percentage of adherence to nicotine reduction), incentive-based treatment yielded a clinically meaningful effect, although it was not significantly different from CBT+EFT. While the rates of session attendance were similar to those in other studies (see e.g., Cooney et al., 2017; Rohsenow et al., 2015; Shoptaw et al., 2002; Winhusen et al., 2014), the slightly superior average in the CBT+EFT+CM group over CBT+EFT may be related to increased motivation to attend sessions, as vouchers were only delivered upon participants' attendance.

A higher percentage of urine samples meeting nicotine use reduction targets was significantly related to days of continuous abstinence at end-of-treatment. This is in line with research in non-SUD populations (Ashare et al., 2013; Higgins et al., 2006; López-Núñez et al., 2016; Romanowich and Lamb, 2010). Gradual reduction of tobacco use could minimize withdrawal symptomatology and enhance motivation to quit, thus facilitating smoking cessation (Lindson et al., 2019). Moreover, in the addictions field, it has been shown that higher number of biochemical samples submitted is related to a greater likelihood of abstinence at end-of-treatment (Petry et al., 2006). The fact that participants provided biochemical samples (both CO and urine cotinine) twice a week may account for these results.

Several limitations should be considered. First, the relatively low sample size prevented us from obtaining sufficient representativeness, and it seems plausible that the failure to observe significant differences between treatment conditions was

attributable to low statistical power. Secondly, this study only reported data at the end of treatment, thus, results cannot draw conclusions regarding long-term effectiveness. Further research should seek to examine long-term effects in larger and more diverse samples. Thirdly, the high percentage of dropouts (24.07% may have important methodological and clinical implications for future research. Due to the small number of dropouts in the present study (n = 13), predictors of attrition could not be analyzed, however, future large-scale studies would benefit from identifying potential characteristics related to dropout in order to improve smoking cessation treatments for SUD populations. Finally, an isolated CBT group, without EFT, was not considered, so no conclusions can be drawn about the unique effects attributable to EFT.

In spite of these limitations, our findings suggested that adding CM into a CBT+EFT protocol facilitates tobacco abstinence and slightly superior completion rates, session attendance and treatment adherence. Moreover, participants who met the nicotine reduction criteria were more likely to achieve tobacco abstinence successfully. This underlines the importance of promoting adherence to weekly nicotine fading targets in this hard-to-treat population. The inclusion of biochemical feedback (Benowitz et al., 2020), offering a variety of incentives (cash, activities in the community), increasing their magnitude, or reinforcing behaviors other than abstinence (e.g., attendance or adherence to therapy activities for home practice) (Petry et al., 2018; Secades-Villa et al., 2019b) could be useful tools for this purpose.

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Table 1
Demographics, smoking and drug-related characteristics

	CBT+EFT *n* = 30	CBT+EFT+CM *n* = 24	*p*-value
Age(years)[a]	44.97 (10.83)	47.71 (6.56)	0.257
Sex (males) n(%)	23 (76.6%)	18 (75%)	0.568
Educational level n(%)			0.261
< High school	15 (50%)	9 (37.5%)	
≥ High school	15 (50%)	15 (62-5%)	
Monthly income (US$)[a]	1,517.86 (1,664.57)	1,666.36 (1,437.26)	0.731
Marital status (married) n(%)	8 (26.6%)	6 (25%)	0.571
Primary drug use n(%)			0.887
Cocaine	12 (40%)	8 (33.33%)	
Alcohol	12 (40%)	12 (50%)	
Opioids	5 (16.66%)	3 (12.5%)	
Others	1 (3.33%)	1 (4.16%)	
Stage of change n(%)			0.547
Pre-contemplation	1 (3.33%)	0 (0%)	
Contemplation	19 (63.33)	17 (70.83%)	
Preparation	10 (33.33%)	6 (25%)	
Dependence[a]			
CPD[a]	22.63 (10.5)	20 (8.19)	0.319
Years smoking	27.25 (10.85)	29.08 (9.39)	0.522
Days at SUD treatment[a]	506.1 (929.43)	252.54 (276.05)	0.203
CO (ppm)	22.13 (15.87)	24.96 (17.89)	0.542
Cotinine (ng/ml)	1,738.1 (679.65)	2,563.96 (2037.31)	0.068
24-h quit attempts	1.33 (1.69)	1.88 (1.33)	0.205
FTND[a]	6.57 (2.19)	5.65 (1.89)	0.117
BDI-II[a]	14.1 (1.65)	13.38 (12.41)	0.818

Note. [a]Mean (standard deviation); CBT = cognitive-behavioral therapy; EFT = episodic future thinking; CM = contingency management; CPD = cigarettes per day; SUD = substance use disorder; CO (ppm) = carbon monoxide in parts per million; ng/ml = nanograms/milliliter; FTND = Fagerström Test for Nicotine Dependence; BDI-II = Beck Depression Inventory, second edition.

Table 2

Predictors of continuous smoking abstinence

	ΔR^2	*F*	*B* [95% CI]	β	*p*
Step 1	.256	3.311			
Sex[a]			-.746 [-7.109, 5.618]	-.031	.815
AUC_{log}*d*			12.044 [-4.044, 28.132]	.195	.139
CPD			-.092 [-.476, .291]	-.084	.631
FTND			-2.221 [-4.023, -.418]	-.445	.017
Type of intervention[b]			-2.479 [-7.917, 2.959]	-.119	.364
Step 2	.303	8.349			
Sex[a]			-.998 [-6.014, 4.019]	-.041	.691
AUC_{log}*d*			3.882 [-9.118, 16.883]	.063	.551
CPD			-.101 [-.404, .201]	-.092	.503
FTND			-1.207 [-2.779, .364]	-.242	.129
Type of intervention[b]			-2.926 [-7.370, 1.517]	-.140	.192
Sessions attended			.420 [-.418, 1.259]	.132	.318
% of samples meeting weekly nicotine reduction targets			.186 [.084, .288]	.512	.001

Note. [a]Female sex was used as the reference category; [b]CBT was used as the reference category; ΔR^2 = increase in coefficient of determination; AUC_{log}*d* = base-10 logarithmic transformation of the area under the curve; FTND = Fagerström Test for Nicotine Dependence; CPD = cigarettes per day at baseline.

Figure 1.
CONSORT flow diagram of participants.

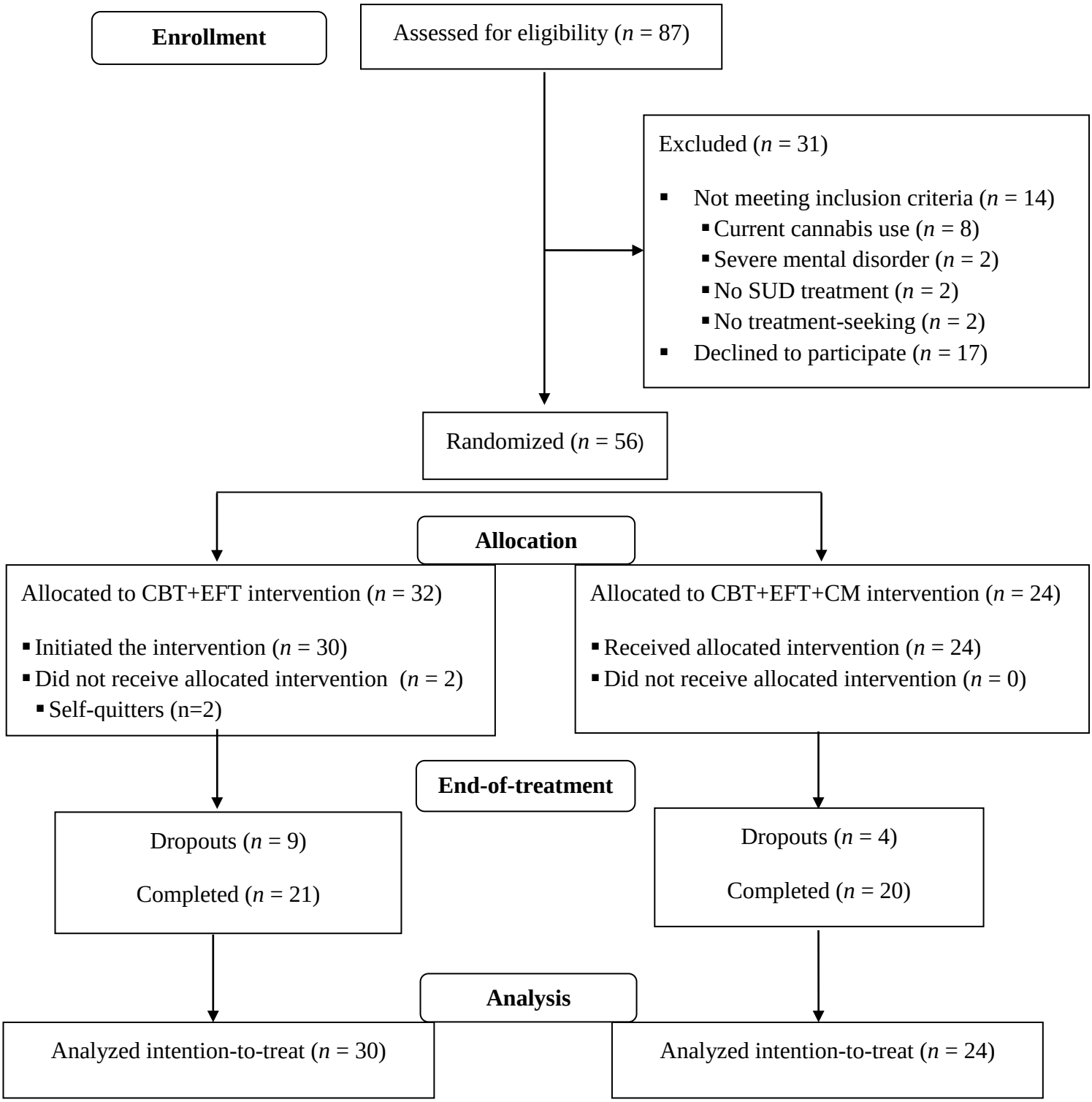
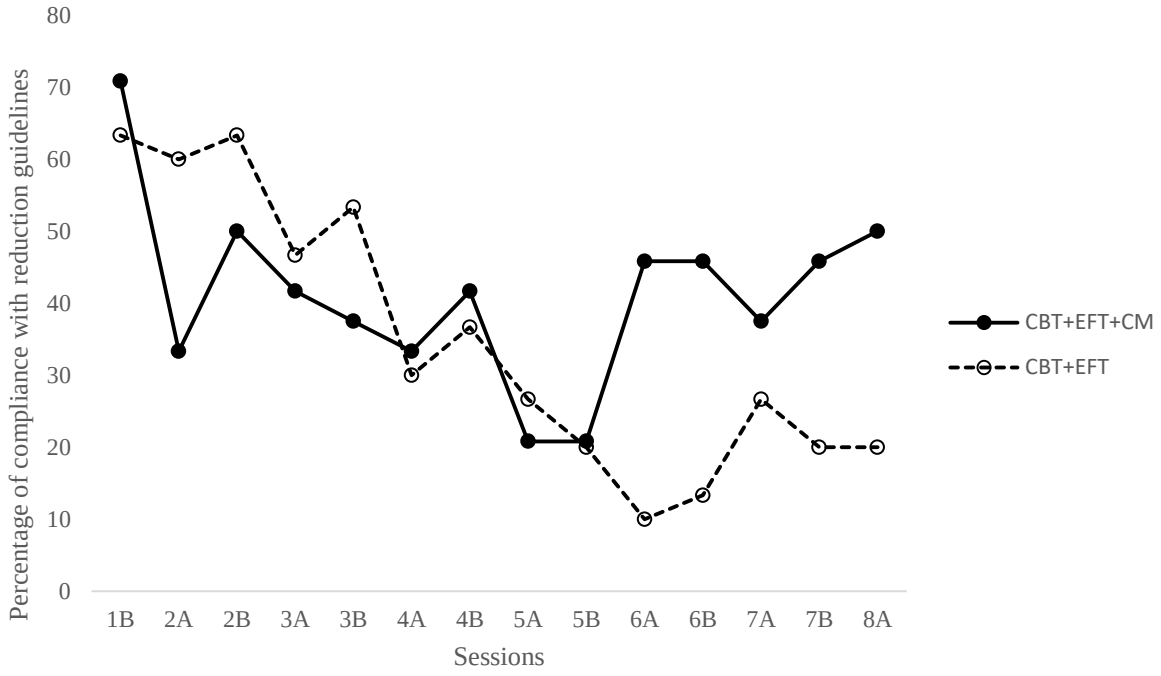


Figure 2.
Session-by-session progression of adherence to the nicotine reduction guidelines



Note. A = therapy session; B = mid-week session; CBT = cognitive-behavioral treatment; EFT = episodic future thinking; CM = contingency management.