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Additive effectiveness of contingency management on cognitive behavioural treatment for smokers with depression: Six-month abstinence and depression outcomes

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ABSTRACT

Background: Depression and smoking co-occur at high rates and there is a lack of evidence on the efficacy of treatments specifically tailored to this population. This randomized controlled trial sought to compare the effectiveness of cognitive behavioural treatment (CBT) combined with behavioural activation (BA) and the same treatment protocol plus contingency management (CM).

Methods: A sample of 120 adult smokers (70.8%: females) with severe depressive symptoms were randomly allocated to: CBT + BA (n = 60) or CBT + BA + CM (n = 60). Smoking and depression outcomes were reported at end of treatment, 1-, 2-, 3-, and 6-month follow-ups. Self-reported smoking status was biochemically verified, and depression was assessed using the Beck Depression Inventory-II.

Results: At end of treatment, the overall quit rate was 69.2% (83/120). CM showed an additive effect on CBT + BA in enhancing abstinence rates. The significant effect of group [$F(1,155) = 9.55$, $p = .0024$], time [$F(4,96) = 7.93$, $p < .0001$], and group by time interaction [$F(4,96) = 6.12$, $p = .0002$], indicated that CM is more effective for generating longer durations of abstinence beyond those of CBT + BA. All treatment conditions equally promoted sustained reductions in depression across time [$F(1,111) = 0.53$, $p = .4665$]. A greater number of days of continuous abstinence and lower depressive symptoms mutually influenced each other.

Conclusions: Depressed smokers achieve high cessation rates without suffering negative mood changes. Quitting smoking is not detrimental and adding CM to CBT + BA enhances long-lasting abstinence rates while promoting large depression improvements.

1. Introduction

Smoking prevalence is particularly high among people with depression (Cook et al., 2014; Goodwin et al., 2017; Luger et al., 2014; Mathew et al., 2017; Weinberger et al., 2018), with women being highly vulnerable to this comorbidity at a ratio of 2:1 compared to men (Weinberger et al., 2013). Individuals with depression are more likely to smoke heavily, to meet criteria for high nicotine dependence, and to suffer from negative mood changes after nicotine withdrawal (Hall et al., 2015; Mathew et al., 2017). Furthermore, people with depression are less likely to quit smoking successfully compared to those without depression (Heffner et al., 2018; Leventhal et al., 2014; Reid and Ledgerwood, 2016; Weinberger et al., 2017).

These profound health-related concerns are compounded by both the limited evidence on the efficacy of smoking cessation treatments specifically tailored to this population, and the paucity of ongoing clinical research (Steinberg et al., 2019). Furthermore, most of the existing trials evaluated the effect of pharmacotherapy (especially, nicotine replacement therapy, varenicline or bupropion), showing both short- and long-term positive effects on smoking abstinence (e.g., Anthenelli et al., 2013; Doran et al., 2019; Evins et al., 2008; Kinnunen et al., 2008; Thorsteinsson et al., 2001). Cognitive behavioural therapy (CBT) has been included in a number of studies (Cinciripini et al., 2010; Hall et al., 2006; Japuntich et al., 2007), but the low cessation rates alongside the high relapse rates observed soon after quitting have prompted calls highlighting the necessity to provide this profile of smokers with mood management cessation interventions, such as behavioural activation (BA) (Bränström et al., 2010; Gierisch et al., 2012; Martínez-Vispo et al., 2018; Secades-Villa et al., 2017; van der Meer et al., 2013). Notwithstanding this, few studies have directly analysed

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the effect of BA treatments for depressed smokers, and results are inconsistent so far (MacPherson et al., 2010; Muñoz et al., 2006, 2009; van der Meer et al., 2010).

Contingency management (CM) is a well-established treatment for smoking cessation (Cahill et al., 2015; Sigmon and Patrick, 2012). However, limited research has been conducted on CM in smokers with depression and the existing evidence to date has focused on pregnant women (López et al., 2015) and patients with subclinical depression (Secades-Villa et al., 2015).

This study describes six-month outcomes and represents an extension of a prior pre-post work aimed at examining the combined effects of CM and CBT + BA on smoking abstinence and depression symptoms (see González-Roz et al., 2019). Though not significant, results from this study showed that CM added to a CBT + BA protocol led to 72.7% of abstinent patients at end of treatment, in comparison to 63.4% in those undergoing CBT + BA. Outcomes beyond the end of treatment have not been reported, leaving it unclear whether CM results in improved abstinence and depression outcomes and whether treatment gains are sustained after treatment termination. Given both the high efficacy of BA for depression (Ekers et al., 2014; Simmonds-Buckley et al., 2019), and CM additive effects when combined with standard treatments (Forster et al., 2019), it was hypothesized that this large-scale randomized controlled trial (RCT) will evince enhanced cessation rates and larger depression decreases in CBT + BA + CM as compared to CBT + BA.

2. Methods

2.1. Study design and participants

This RCT builds on a prior pilot study we conducted on 74 smokers with depressive symptoms (see González-Roz et al., 2019). New features of this study are: 1) the inclusion of a larger sample size (from 74 included in the pilot study to 120 in the present one), 2) the assessment of long-term smoking and depression outcomes (i.e., one, two, three, and six months after treatment termination), and 3) the stringent statistical control of relevant covariates (nicotine dependence and use of antidepressants).

The recruitment process took place between January 2015 and July 2018 and was conducted at the Clinical Unit of Addictive Behaviours in the Faculty of Psychology (Oviedo, Spain). Flyers, radio, television, web-based, and newspaper advertisements were posted in the community to announce the smoking cessation study (Clinical Trials-gov Identifier: NCT03163056). The study conformed to the Code of Ethics of the World Medical Association (Declaration of Helsinki) and written informed consent from participants was collected prior to the beginning of the study. Approval from the research ethics committee of the local community was obtained (nº124/15).

To qualify for participation, individuals were required to meet the following criteria: being aged ≥18, self-report using ≥10 cigarettes on a daily basis, meeting current criteria for nicotine dependence as per the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV-TR; American Psychiatric Association, 2000), and obtaining a score ≥ 14 on the Beck Depression Inventory, II edition (BDI-II; Beck et al., 1996). Not being available to attend the entire treatment or suffering from severe mental disorders (e.g., bipolar disorder) precluded participants from participating in this study. Other exclusion criteria were using pharmacotherapy and/or psychological treatment for smoking cessation or receiving psychotherapy for depression at the intake assessment. Those meeting the criteria for substance use disorders other than nicotine were also excluded and referred to other quitting services.

The participant flow chart displays a detailed description on the number of participants through each stage of the RCT (i.e., enrolment, allocation and follow-up visits) (see Fig. 1). A total of 147 potential participants were initially assessed. Of these, 120 met the inclusion criteria and were randomly assigned to: CBT + BA (n = 60), or CBT + BA + CM (n = 60). As per prior guidelines (Suresh, 2011), participants were randomized using a computerized-random number generator. No significant differences emerged in baseline variables across treatment groups (see Table 1).

2.2. Assessment

During a single assessment visit, participants were asked to fill out an ad-hoc questionnaire to collect data on sociodemographic characteristics (i.e., age, sex, monthly income level). The clinical history (e.g., cigarettes per day, years of regular smoking and current antidepressant use coded as yes or no) was obtained through self-reported questionnaires and a face-to-face interview. The Fagerström Test for Nicotine Dependence (FTND; Heatherton et al., 1991) was used as a measure of nicotine dependence severity. Sum scores range from 0 to 10 with those in the range between 7 and 10 suggesting severe nicotine dependence. Motivation to quit smoking was assessed by means of a two-item questionnaire consistent with the Prochaska and DiClemente (1983) Transtheoretical Model of Change. This two-item questionnaire allows us to identify five stages of change: pre-contemplation (no intention to change), contemplation (intention to change in the next six months), preparation (intention to change within the next month) action (having already quit) and maintenance (having been abstinent for at least six months).

The Spanish version of the Structured Clinical Interview for DSM-IV-TR Disorders (SCID-CV; First et al., 1999) was used to assess the presence of both current and lifetime depression episodes. The severity of depressive symptoms was assessed using the BDI-II (Beck et al., 1996) and interpreted according to the author's guidelines; sum-scores between 0 and 13 are indicative of minimal depression, those between 14 and 19 suggest mild depression, scores of 20–28 imply moderate depressive symptoms, and those above 29 are indicative of severe depression.

2.3. Treatment interventions

All treatment conditions were delivered in groups of maximum four patients, over eight continuous weeks. Considering that cotinine half-life in the body is approximately 12–20 h (Kim, 2016), all patients were asked to quit 48 h prior to the fifth session. This allowed patients to attain abstinence cut-offs and avoided early efforts at abstinence going unrewarded. Each session lasted 90 min and was delivered by master and doctoral level psychologists with prior clinical experience in smoking cessation treatments. Under the supervision of the principal investigator, a clinical psychologist, each therapist trained with at least three practice cases following the observation of one group. During the entire duration of the study, sessions were audio-recorded and reviewed each week by the principal investigator to discuss any difficulty and avoid deviations from the treatment protocols. This ensured high adherence and adequate competence in treatment delivery.

Following completion of the treatment, participants attended four follow-up visits that occurred at 1, 2, 3 and 6 months to assess long-term outcomes in smoking abstinence and depression. All the assessments occurred at the research clinic. Biochemical samples of carbon monoxide (CO) and cotinine samples were collected at the intake assessment and at each of the therapy and follow-up visits to confirm abstinence status. A piCO Smokerlyzer (Bedfont Scientific Ltd, Rochester, UK) and the BS-120 chemistry analyzer (Shenzhen Mindray Bio-medical Electronics Co. Ltd., Shenzhen, P. R. China) were used for this purpose. In all instances, CO readings ≤4 ppm (parts per million) and cotinine levels ≤80 ng/ml (nanograms per millilitre) indicated abstinence status. Throughout the treatment, patients were asked to attend the clinic twice for the purpose of collecting biochemical measures: one visit coincided with the therapy session and the other was scheduled mid-week. Results from the biochemical analyses were

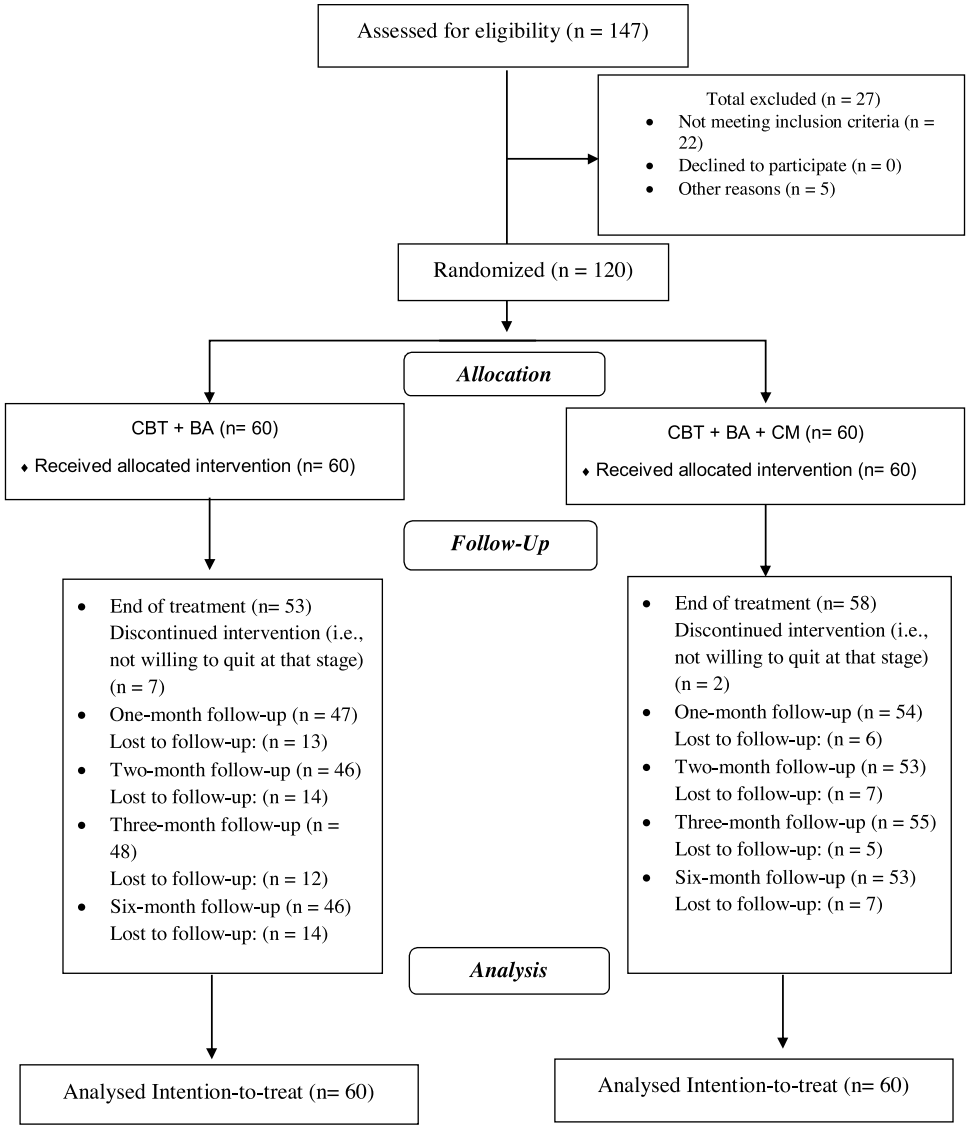

Fig. 1. Consort Flow Diagram of study participants.

provided immediately after the session ended.

2.3.1. Cognitive behavioural treatment plus behavioural activation (CBT + BA)

The CBT protocol used herein is an empirically-supported psychological intervention for quitting smoking that has been extensively described elsewhere (Secades-Villa et al., 2009, 2014). In this treatment condition, BA was delivered from the first treatment session. The primary CBT treatment components were: psychoeducation on cigarette use, nicotine fading (i.e., a 30% weekly reduction of nicotine consumption from the first to the fourth week and abstinence from 48 h prior to the fifth session onwards), self-monitoring and graphical representations of nicotine intake reductions, stimulus control, relaxation, role-playing in alternative behaviours, development of a preventive relapse plan through training in coping skills, and enhancement of social support.

The BA module was adapted from a previous BA for smoking cessation protocol (Lejuez et al., 2011). Its main goal is to increase the number of pleasant activities patients engage in. Activation assignment was based on patients' activity hierarchy of level of difficulty and interest. To facilitate this task, therapists worked with patients in a collaborative way to identify life-values and objectives. Through sessions 2–8, therapists and patients agreed on 2–3 activation goals aimed to enhance activation and decrease avoidance patterns of behaviour. Other treatment components included: discussion of the treatment rationale, psychoeducation on the relationship between smoking and depression (through functional analysis of behaviour and written materials developed by therapists), weekly activity and mood monitoring, and social support through social contracts that consisted of identifying which people in the patients' lives they would like to get support from when engaging in new positive activities.

2.3.2. Cognitive behavioural treatment plus behavioural activation and contingency management (CBT + BA + CM)

Participants allocated to this condition received the interventions previously described in combination with a CM protocol for reinforcing abstinence. Patients received a voucher-based abstinence reinforcement intervention in which they were given vouchers redeemable for a variety of goods and community services (e.g., mall gift cards, cinema tickets, free access to the gym, spa, hotels, restaurants, hairdressing and beauty salons). From the fifth session (i.e., the one in which biochemical verification of abstinence status occurred) onwards, participants earned vouchers contingent upon negative CO and cotinine samples. As per prior recommendations (Petry, 2012), the incentives followed an escalating schedule of reinforcement. The first abstinent sample started at a value of €10 [US$ 11] and increased by 5€ [US$ 6]. If participants

Table 1
Participants' baseline characteristics.

	CBT + BA (n = 60)	CBT + BA + CM (n = 60)	p	*Effect size*
Sex (% females)	65	76.7	.16	−.13
Age (years)[a]	50.62 (10.23)	52.72 (8.86)	.23	−.02
Motivation for change (%)			.64	.04
Pre-contemplation stage	54.2	50		
Preparation stage	45.8	50		
Monthly income (%)			.15	.22
Less than $686	18.9	34.5		
$688-$1,373	34	36.4		
$1,374-$2,288	39.6	21.8		
+$2,289	7.5	7.3		
Cigarettes per day[a]	22.95 (8.23)	20.67 (6.73)	.09	.30
Years of regular smoking[a]	31.70 (11.52)	32.20 (9.09)	.79	−.04
FTND[a]	6.85 (1.79)	6.18 (1.83)	.05	.37
CO (ppm)[a]	25.68 (15.16)	23.05 (13.59)	.32	.18
Cotinine (ng/ml)[a]	2,509 (1,252)	2,380 (1,078)	.55	.11
BDI-II[a]	27.10 (9.72)	29.50 (8.79)	.16	−.26
Current depression diagnosis (%)			.57	.11
Single episode	25	18		
Recurrent episode	50	48		
Chronic disorder	25	34		

Note. [a]Mean ± standard deviation; CBT + BA = Cognitive-Behavioural Treatment plus Behavioural Activation; CBT + BA + CM = Cognitive-Behavioural Treatment plus Behavioural Activation plus Contingency Management; FTND = Fagerström Test for Nicotine Dependence; CO (ppm) = carbon monoxide in parts per million; ng/ml = nanograms/milliliter; BDI: Beck Depression Inventory, II edition.

had CO or cotinine readings indicating smoking status (i.e., CO ≥5ppm and cotinine levels ≥81 ng/ml), they did not receive the voucher and the next abstinent sample was reset to the initial value of €10 [US$ 11]. After the reset occurred, if participants provided three consecutive abstinent samples, the voucher value that they received was the same as the one given before the reset. The total amount that patients could earn during the eight-week treatment phase was €175 [US$ 200]. During the follow-up phase (1- and 3-month follow-up visits), patients could earn vouchers upon submission of biochemically-verified 7-day point-prevalence abstinence. Patients could earn €45 [US$ 52] and €50 [US$ 57] worth of vouchers in those time frames. Instances in which patients did not submit urine and CO samples as scheduled rendered them positive.

2.4. Outcome measures

The primary outcomes were smoking and depression. Two measures of smoking were assessed: 1) point-prevalence (i.e., the percentage of participants being abstinent for a minimum of 24 h at the post-treatment and 7 days prior to the visit at 1-, 2-, 3- and 6-month follow-ups) and 2) continuous abstinence, defined as number of days without smoking, not even a puff, since quit day in each of the time frames.

Changes in depression-related variables were assessed using the BDI-II (i.e., depressive symptoms). None/minimal depression was defined as scoring below the clinical screening BDI cut-off for mild depression (< 14).

2.5. Statistical analyses

A set of t tests for continuous and χ^2 for binary variables were performed to compare baseline characteristics and abstinence outcomes across treatment conditions. Effect size estimates were calculated through ϕ, Cohen's D, and Cramer's V, as appropriate. The confidence level was set at 95% and SAS software v14.3 (SAS Institute, 2018) with the PROC FREQ statement was used.

Following an intent-to-treat approach, participants with missed study follow-up visits were considered as smokers. Likelihood based methods (e.g., covariance pattern regression model and linear mixed-effects model) are the most popular solution for dealing with incomplete longitudinal Gaussian data due to their validity when data are missing at random (MAR). Meanwhile, semiparametric methods, such as generalized linear mixed models (GLMM), provide an attractive alternative to the parametric methods when the data are MAR and the assumption of multivariate normality is deemed untenable (Vallejo et al., 2011). The mixed-effects model repeated measures (MMRM) analysis implemented herein included an unstructured modelling of frequencies at each visit and a within-subject error correlation structure. In this study, frequencies at each visit are considered as a classification rather than a continuous variable.

A generalized linear mixed model (GLMM) with a binomial error structure was conducted to assess the ability of treatment conditions to predict point-prevalence abstinence (i.e., smoking status) at end of treatment, and at 1–6 months, after randomization. This method is considered adequate in that it estimates and directly tests the effects of the interaction between treatment groups and time, and it accommodates time-invariant and time-varying covariates (Hall et al., 2001). In the absence of a theory providing contrasting data, a data-driven strategy was used to move toward a simpler structure by eliminating predictors or (co)variances (i.e., baseline depressive symptoms, group, time, and their interactions) that did not appear to be related to the outcome variable. A covariance pattern regression model was conducted to assess the ability of the treatment condition to predict continuous abstinence and depression at end of treatment and through 1–6-month follow-ups. Categorical abstinence variables (i.e., point prevalence) were analysed using MMRM with residual pseudo likelihood (REPL) estimation as implemented in SAS v14.3 Proc GLIMMIX. Continuous variables (i.e., continuous abstinence and depression) were analysed using MMRM with residual maximum likelihood (REML) estimation as implemented in SAS Proc MIXED. All analyses were controlled for nicotine dependence severity and antidepressant use.

3. Results

3.1. Effects of treatment conditions over smoking abstinence

3.1.1. Point-prevalence abstinence

Among participants, the overall point-prevalence abstinence rate at post-treatment (8 weeks) was 69.2% (83/120). Abstinence rates by treatment condition for each of the abstinence definitions and time frame assessments are provided in Table 2. Of the different tested MMRM models based on REPL estimation method, Model B was retained as the best-fitting one and showed a significant main effect of time [$F(4,395) = 12.04$, $p < .0001$], and group by time interaction [$F(4,394) = 2.47$, $p = .0442$] (see Table 3). This indicates that the effect of treatment conditions on point-prevalence abstinence differed over time. Specifically, the odds of a favourable response in terms of point-prevalence abstinence in the group receiving CBT + BA + CM were 2.42 times higher [$\beta = .88$, standard error (SE) = .42, $p = .036$, Yule's $Q = .42$] than that of CBT + BA at 1-month follow-up. Of the tested covariates, nicotine dependence severity measured in the intake [$F(1,130) = 5.99$, $p = .0158$] and the longitudinal covariate (i.e., depressive symptoms) [$F(1,487) = 9.06$, $p = .0027$] were inversely related to point-prevalence abstinence.

3.1.2. Continuous abstinence

The results obtained from REML-based MMRM analysis indicated that there was a significant main effect of group [$F(1,155) = 9.55$, $p = .0024$], time [$F(4,96) = 7.93$, $p < .0001$], and group by time interaction [$F(4,96) = 6.12$, $p = .0002$], which indicates that the effect of treatment conditions on continuous abstinence days differed by group and time-frame assessment. Simple effect comparisons of group by time

Table 2
Smoking abstinence by treatment condition at 8-week, 1, 2, 3 and 6-month follow-up.

	Overall (n = 120)	CBT + BA (n = 60)	CBT + BA + CM (n = 60)	χ^2/t	ϕ/Cohen's D
End of treatment					
PP (%)	69.2	63.3_a	75_a	1.91	−.13
†Continuously abstinent (%)	50	41.7_a	58.3_a	3.33	.17
Continuous abstinence[a]	16.50 (12.36)	15.11 (12.27)	17.76 (12.41)	−1.13	−.21
1-month follow-up					
PP (%)	50.8	36.7_a	65_b	9.64*	−.28
†Continuously abstinent (%)	40.8	30_a	51.7_b	5.83*	.22
Continuous abstinence[a]	31.39 (28.03)	23.57 (28.18)	38.19 (26.31)	−2.69*	−.54
2-months follow-up					
PP (%)	41.7	31.7_a	51.7_b	4.94*	−.20
†Continuously abstinent (%)	34.2	30_a	38.3_a	.93	.08
Continuous abstinence[a]	41.91 (42.59)	35.39 (43.28)	47.67 (41.55)	−1.43	−.29
3-months follow-up					
PP (%)	43.3	33.3_a	53.3_b	4.89*	−.20
†Continuously abstinent (%)	33.3	28.3_a	38.3_a	1.35	.11
Continuous abstinence[a]	51.72 (56.85)	43.60 (57.19)	58.80 (56.11)	−1.36	−.27
6-months follow-up					
PP (%)	36.7	31.7_a	41.7_a	1.29	−.10
†Continuously abstinent (%)	25	18.3_a	31.7_a	2.84	.15
Continuous abstinence[a]	76.11 (96.91)	60.93 (91.14)	89.28 (100.65)	−1.47	−.03

Note. Superscripts indicate between-group differences. †The percentage of abstinent patients since quit day is indicated at each of the follow-up assessments. [a]Mean ± Standard deviation. CBT + BA = Cognitive-Behavioural Treatment plus Behavioural Activation; CBT + BA + CM = Cognitive-Behavioural Treatment plus Behavioural Activation plus Contingency Management; PP = percentage of point-prevalence abstinence indicates no smoking for 24 h at the post-treatment and for seven consecutive days at the remaining follow-ups.
*p < .05.

least-squares means for smoking abstinence indicated that continuous abstinence at 1-, 2-, 3-, and 6-month follow-up was significantly higher in CBT + BA + CM compared to CBT + BA (See Table 4). Lastly, both the longitudinal covariate (i.e., depressive symptoms) [F(1,186) = 4.11, p = .0439] and nicotine dependence [F(1,110) = 4.98, p = .0277] were found to be main effects in predicting days of continuous abstinence, thus indicating a relationship between higher levels of depression and nicotine dependence severity and lower treatment effects on continuous abstinence.

3.2. Effects of treatment conditions on depression

There was a significant decrease in depressive symptoms across time [F(5,116) = 57.19, p < .0001] that did not differ by treatment

Table 3
Mixed-effects models of repeated measures predicting point-prevalence abstinence data.

	Model A				Model B[1]				Model C			
Fixed Effect	df_N	df_D	F	Pr > F	df_N	df_D	F	Pr > F	df_N	df_D	F	Pr > F
FTND	1	140	10.53	.0015	1	130	5.99	.0158	1	130	5.79	.0175
Antidepressant use	1	136	0.59	.4454	1	129	0.37	.5418	1	129	0.18	.6744
Group	1	139	3.02	.0843	1	129	1.60	.2078	1	225	2.39	.1235
Time	4	472	14.85	< .0001	4	395	12.04	< .0001	4	396	4.95	.0007
Group × Time	4	470	2.39	.0501	4	394	2.47	.0442	4	394	2.65	.0329
BL_DS									1	135	0.06	.8073
DS					1	487	9.06	.0027	1	492	10.31	.0014
Group × DS									1	485	1.12	.2903
Time × DS									4	396	0.75	.5577
Goodness-of-fit (Deviance/Parameters)												
		2132.62/30			1878.01/31				1871.22/36			

Note. FTND = Fagerström Test for Nicotine Dependence; BL_DS = Baseline depressive symptoms.
[1]The likelihood ratio test, which compares deviance statistics for two competing models, indicated that Models B and C had a significantly better fit to the data than Model A. As Models B and C did not significantly differ, Model B was chosen as the best fitting model because it was more parsimonious.

Table 4
Simple effect comparisons of group × time least-squares means for continuous abstinence (Model B).

Time	Group	Group	*Estimate*	SE	DF_{KR}	t Value	p > |t|	|*d*|
0	CBT + BA	CBT + BA + CM	−3.2824	2.2453	118	−1.46	.1464	0.27
1	CBT + BA	CBT + BA + CM	−21.0511	4.8785	123	−4.32	< .0001	0.78
2	CBT + BA	CBT + BA + CM	−22.2657	7.1590	146	−3.11	.0023	0.51
3	CBT + BA	CBT + BA + CM	−25.5261	9.1165	154	−2.80	.0058	0.45
6	CBT + BA	CBT + BA + CM	−32.8141	14.1952	195	−2.31	.0218	0.33

Note. Time-varying standardized effect sizes have been computed using a similar approach to that described by Vallejo et al. (2019). The *d* values for the significant contrasts ranged from .33 to .83, indicating a moderate-high effect according to Cohen's guidelines.

condition [F(1,111) = 0.53, p = .4665]. The non-significant group by time interaction indicated that treatment groups were similarly associated with a sustained reduction in depression at each of the follow-up visits [F(5,110) = 1.73, p = .1332] (see Fig. 2). Of the covariates, use of antidepressants at the intake assessment did relate to depressive symptoms across time [F(1,111) = 4.30, p = .0404], while nicotine dependence did not [F(1,113) = 0.72, p = .3990].

3.3. Effects of smoking abstinence on depression

The REML-based MMRM results for the depression data adjusted for days of continuous abstinence showed that the latter variable was negatively related to depressive symptoms scores [β = -.02, standard error (SE) = .007, t = -3.18, p = .0019], thus indicating that a greater number of days of continuous abstinence promotes lower depressive symptoms across time.

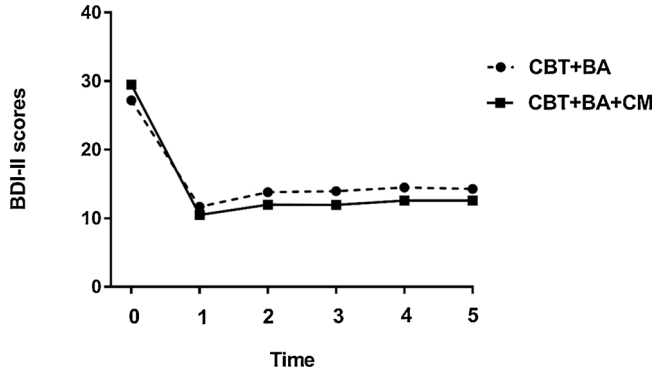

Fig. 2. Depression scores by time for each treatment group.
Note. Follow-up assessments are depicted on the horizontal axis whereas depression scores, as measured by the Beck Depression Inventory-II edition (BDI-II), are displayed on the vertical axis. Values on the horizontal axis represent the pre-treatment assessment (0), the post-treatment assessment (1), 1-month follow-up (2), 2-month follow-up (3), 3-month follow-up (4), 6-month follow-up (5).
CBT + BA = Cognitive-Behavioural Treatment plus Behavioural Activation; CBT + BA + CM = Cognitive-Behavioural Treatment + Behavioural Activation + Contingency Management.

4. Discussion

To the best of our knowledge, this is the first randomized trial designed to examine the additive effect of CM on CBT + BA for smoking cessation and ameliorating depression. Three major findings are highlighted: 1) both BA and CM provided enduring effects in smoking use reduction throughout the entire study period; however, the CBT + BA + CM condition had a more favourable effect for promoting abstinence outcomes than CBT + BA; 2) both interventions similarly led to sustained reductions in depressive symptoms; and 3) a greater number of days of continuous abstinence and lower depressive symptoms mutually influenced each other across time.

The overall post-treatment and 6-month abstinence rates were 69.2% and 36.7%, respectively, which are close to the upper limit of those observed for existing smoking cessation interventions, including pharmacotherapy (Anthenelli et al., 2013; Hall et al., 2006; Japuntich et al., 2007; Minami et al., 2015; Muñoz et al., 1997). There are at least two rationales that account for such high cessation rates. Firstly, all participants in this study received treatments specifically targeted to depression. Secondly, continuing drug use monitoring (twice during the 8-week treatment period and once at each of the follow-up visits) might have positively impacted the motivation to cease the behaviour, thereby increasing the treatments' effectiveness (Glynn et al., 1986; Schuler et al., 2014).

Adding CM to a CBT + BA treatment protocol consistently demonstrated a more favourable treatment response in terms of smoking abstinence than CBT + BA alone. Results are in line with accruing research showing that BA and CM facilitate abstinence in the substance use population (Daughters et al., 2008; Magidson et al., 2011), including smoking (Busch et al., 2017; Daughters et al., 2018; López et al., 2015; MacPherson et al., 2010). BA and CM share similar mechanisms to accomplish treatment objectives that might have accounted for such high abstinence rates (González-Roz et al., 2019). Both interventions enhance patients' contact with a positive environment while offering them the opportunity to engage in a range of substance-free sources of reinforcement (López et al., 2015; Martínez-Vispo et al., 2018).

Despite both interventions being shown to be effective in reducing smoking rates, CM significantly facilitated sustained continuous abstinence at each of the follow-up visits. The 6-month 10% difference in quit rates favouring CM (41.7% vs. 31.7%), represents a significant public health impact stemmed from the additive effect of the two approaches. It is possible that using CM not only reinforced abstinence, but also made other positive behaviours (e.g. exercise or healthy eating) more probable. Furthermore, the persistent reinforcement delivered through follow-ups (1–3 months) may work as an alternative to smoking, protecting patients from relapse, and ultimately extending the benefits of CM beyond those of BA alone (Dallery and Raiff, 2012). It is also possible that CM provided patients with mastery experiences to deal with high-risk smoking situations through engagement in non-drug related activities. This hypothesis, however, has not been tested herein and there is a necessity to examine the mechanisms of change in CM. Clinically, insights into both early predictors of treatment response and markers of smoking relapse will be necessary to optimize delivery of CM. Also, there exists a pressing need to elucidate which CM parameters (i.e., continuing provision of vouchers, reward magnitude) and target behaviours (e.g., activity engagement) need to be considered to enhance abstinence outcomes.

Both interventions similarly promoted sustained reductions in depressive symptoms that were associated with greater days of continuous abstinence across time. This result aligns with prior evidence gathered from mildly or moderated depressed smokers (Lembke et al., 2007; Rodríguez-Cano et al., 2016; Sonne et al., 2010; Stepankova et al., 2016) and further supports the beneficial effects of providing mood management and CM to smokers with a current diagnosis of depression or elevated depressive symptoms. Similar reductions in depression across conditions might be attributed to the inclusion of several shared cognitive behavioural-based strategies aimed at relieving depression (e.g., relaxation, involvement in goal-oriented pleasant activities, problem solving, stress management, enhancement of social support) (Butler et al., 2006). Also, the observed positive impact of abstinence on depression improvements might be accounted by the absence of mood fluctuations that occur in the context of withdrawal symptoms (Hughes, 2007; Lechner et al., 2019). Moreover, the increased rewarding effects stemmed from maintaining abstinence (i.e., enhanced self-esteem, quality of life and greater reward from non-smoking activities) (Piper et al., 2012; Snuggs and Hajek, 2013) might have arguably contributed to this effect. Additionally, the effect of depressive symptoms on smoking abstinence suggests a bidirectional relationship between smoking and depression (Audrain-McGovern et al., 2009; Tjora et al., 2014).

There are several limitations to this study. First, the relatively small sample size may have limited the power of the statistical analyses to detect long-term point-prevalence abstinence and depression differences between treatment conditions. A larger scale trial is needed to confirm whether adding a CM protocol enhances smoking abstinence and differentially impacts depression. Second, given that antidepressant use was only assessed at the intake session, results herein should be interpreted cautiously. Third, the lack of a BA only condition or a comparison arm (i.e., CBT only), urges further research aimed at disentangling the unique effects of BA on both long-term abstinence and

depression. Lastly, given that depression changes were assessed using BDI-II scores, treatment effectiveness on remission in major depression diagnosis could not be examined, highlighting the necessity for further research tracking changes in depression as assessed by clinical interviews.

4.1. Conclusions

Results underscore the feasibility of BA and CM for smokers with depression and provide initial support for their combined effectiveness in this particularly difficult-to-treat population. Importantly, these study findings are valuable not only for demonstrating that CM enhances abstinence outcomes, but also for supporting its feasibility in clinical settings. Both interventions promoted enduring effects on smoking use reduction and sustained improvements in depressive symptoms. However, adding a CM protocol enhanced smoking abstinence outcomes. These findings offer support for the necessity to systematically offer depressed smokers quitting aids. Future research needs to focus on developing methods to help sustain abstinence of those patients who relapse through the follow-up period.

5. Role of founding sources

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6. Contributors

RSV: participated in conceptualization, funding acquisition, project administration, writing of the first draft: AGR: participated in data collection, formal analyses, writing of the first draft: GVS: conducted formal analyses and wrote the results section: SW: participated in data collection, revised, and edited the final draft: AGP: participated in data collection, revised, and edited the final draft: FAP: participated in data collection, revised, and edited the final draft.

Declaration of Competing Interest

No conflict declared.

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