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Contingency management for smoking cessation for individuals with overweight or obesity: A randomized controlled trial

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ABSTRACT

Background: Interventions for quitting smoking and weight control among individuals with excess weight are scarce. Our study evaluated the effectiveness of cognitive behavioral therapy (CBT) plus contingency management (CM) in this population, and examined whether CM for smoking cessation improved CBT treatment outcomes at end of treatment (EOT) and at 1-, 3-, 6-, and 12-month follow-ups (FU).

Methods: In an 8-week randomized clinical trial, 120 adults who smoke with overweight or obesity (54.16% females; $M_{BMI} = 31.75 \pm 4.31$) were randomly assigned to CBT for both quitting smoking and weight control ($n = 60$) or the same treatment plus CM for smoking cessation ($n = 60$). Outcome variables were compared (i.e., treatment completion, smoking abstinence, weight change and secondary outcomes).

Results: At EOT, the CBT + CM group achieved 78.33% 7-day point-prevalence abstinence rates compared to 61.67% in the CBT group ($p = .073$), and rates declined over time (12-month FU: 18% vs 12%). Participants who attained abstinence weighed more compared to baseline at EOT ($M_{kg} = 1.07$; $SD = 1.88$) and over time (12-month FU: $M_{kg} = 4.19$; $SD = 4.31$). No differences were found between the two groups in outcome variables.

Conclusions: Both interventions were effective in promoting abstinence and reducing tobacco use over time. Combining CBT with CM for smoking cessation did not improve treatment outcomes in individuals with overweight or obesity compared to CBT only. Future studies should evaluate whether implementing CM for weight maintenance helps control post-cessation weight gain in this population.

1. Introduction

Smoking and obesity are significant public health problems priorities as they are among the main causes of preventable morbidity and mortality (He et al., 2022; Luijckx et al., 2019). The prevalence of chronic diseases related to smoking and obesity has increased and one of the objectives pursued by policymakers is to promote evidence-based interventions for quitting smoking, improving healthy eating, and increasing physical activity (Kris-Etherton et al., 2022).

Individuals with overweight or obesity who smoke are a vulnerable population. Tobacco use in this population is high and increases mortality and disability (Luijckx et al., 2019; Rupprecht et al., 2015; Townsend and Mehta, 2020). Excess weight is often a barrier to quitting, especially among women with obesity, since they exhibit more concerns about post-cessation weight gain, lower confidence in their ability to maintain their weight without smoking, and they are less willing to tolerate weight gain after quitting (Levine et al., 2013). Moreover, it is common to gain weight after quitting and this weakens the beneficial effect of tobacco cessation (Hasegawa et al., 2019; Kos, 2020).

Quitting smoking is associated with an average increase of 4–5 kg, although 13% gain more than 10 kg, increasing the risk of continuing smoking (Aubin et al., 2012; Tian et al., 2015). Post-cessation weight gain is related to nicotine's impact, which increases metabolic rate and decreases appetite, and to increased food intake and disordered eating triggered by quitting smoking (Anker et al., 2021; Cepeda-Benito, 2020; Killi et al., 2020). Problematic eating behaviours (e.g., grazing, binge eating) are prevalent in obesity (Catania et al., 2023; McCuen-Wurst et al., 2018; Nightingale and Cassin, 2019). Therefore, providing smoking cessation treatment to people with overweight or obesity is warranted, however interventions have to be adapted to the needs of this population.

Among the general population, there is evidence showing greater

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smoking cessation rates when smoking cessation treatments also provide weight management (García-Fernández et al., 2023; Hartmann-Boyce et al., 2021). However, few studies have evaluated the effectiveness of interventions for both quitting smoking and weight control for individuals with overweight or obesity (Heggen et al., 2016, 2017; Hurt et al., 2017; Love et al., 2011; Svendsen et al., 2021; White et al., 2019; Wilcox et al., 2010). Although cognitive behavioral therapy (CBT) is considered to be one of the most effective interventions for smoking cessation and obesity (Dalle Grave et al., 2020; Fonseca Pedrero et al., 2021; Hooper et al., 2023) and contingency management (CM) is effective for smoking cessation (Notley et al., 2019), no studies to date have explored the effect of CBT plus CM for smoking cessation for individuals with excess weight. The latest evidence is from a pilot study related to women who smoke with concerns about weight (Bloom et al., 2020), which looked at combined CM for weight loss and smoking cessation. Moreover, individuals with obesity who smoke may value brief, intense, immediate reinforcers more than individuals who smoke without obesity (Bickel et al., 2021). Therefore, CM may be a promising approach for this population.

The present study is an extension of a prior pilot study aimed at examining the feasibility, acceptability and preliminary efficacy of CBT and CBT-plus-CM in individuals who smoke with overweight or obesity (García-Fernández et al., 2022). Given the high recruitment success rate, completion rate, treatment attendance, and satisfaction rating for the treatment, its effectiveness needs to be evaluated with a large randomized controlled clinical trial (RCT). The present study assesses treatment effectiveness at end of the treatment (EOT) and follow-ups (FU) (i.e., 1-, 3-, 6-, and 12-month FU) by examining: 1) treatment outcomes (i.e., treatment completion, smoking abstinence, weight change and improvement in secondary outcomes) of CBT that simultaneously addresses smoking cessation and weight control in individuals with overweight or obesity, and 2) the contribution of CM to CBT.

2. Material and methods

2.1. Participants

Participants were adults wanting to quit smoking recruited in the Principality of Asturias (Spain) through television, radio, newspaper, social media, and poster advertisements between September 2020 and October 2021. Written informed consent was obtained and appropriate data protection and privacy legislation and guidelines were followed.

Inclusion criteria were (1) being ≥ 18 years old, (2) having smoked ≥ 10 cigarettes per day and not used electronic devices over the past year, (3) meeting the diagnostic criteria for tobacco use disorder (American Psychiatric Association, 2013) and (4) having a Body Mass Index (BMI) ≥ 25. Exclusion criteria were (1) being pregnant, breastfeeding or in the six-month postpartum period; (2) being currently (in the previous 30 days) in receipt of other treatment for smoking cessation or weight control (either behavioral or pharmacological); (3) being diagnosed with a current (during the previous year) severe psychiatric disorder (e.g., active psychotic disorder or suicidal ideation), eating disorder other than binge eating disorder (BED), or substance use disorder (SUD) other than tobacco use disorder; (4) having any health condition requiring a specialized diet or that affected eating (e.g., uncontrolled diabetes); (5) not being able to attend treatment; or (6) taking medication that affects weight.

The participants' baseline characteristics are shown in Table 1. There were no significant differences in any baseline characteristics between participants assigned to the CBT + CM or CBT conditions (all p-values ≥ .096), except in the case of the age variable. In the CBT + CM group, the mean age was 50.65 (SD = 8.24) years, versus 54.43 (SD = 11.85) years in the CBT group (U = 1.305, z = −2.601; p = .009; r = .23).

Table 1
Baseline characteristics.

	Overall (N = 120)	CBT + CM (n = 60)	CBT (n = 60)	p
Sex (female, n/%)	65 (54.16)	33 (55)	32 (53.33)	1
Age (years)[a]	52.54 (10.34)	50.65 (8.24)	54.43 (11.85)	.009
Marital status (married, n/%)	67 (55.8)	34 (56.7)	33 (55)	1
Educational level (≤ high school, n/%)	51 (42.5)	22 (36.67)	29 (48.33)	.268
Employed (n/%)	62 (51.67)	32 (53.33)	30 (50)	.855
Monthly income level (US$)[a]	2.119.35 (1.076.81)	2.011.74 (1.224.61)	2.226.96 (907.01)	.096
CPD[a]	21.34 (8.79)	22.75 (9.94)	19.93 (7.27)	.133
Age of smoking onset[a]	15.15 (4.17)	15.15 (3.56)	15.15 (4.75)	.580
Years of regular smoking[a]	30.85 (10.66)	29.29 (8.64)	32.41 (12.23)	.113
Previous quit attempts[a]	2.56 (2.12)	2.65 (2.35)	2.47 (1.87)	.805
Smoking state of change (n/%)				1
Preparation	84 (70)	42 (70)	42 (70)	
Contemplation	36 (30)	18 (30)	18 (30)	
FTCD[a]	5.43 (2.06)	5.53 (2.3)	5.32 (1.8)	.420
CO (ppm)[a]	22.96 (11.27)	23.93 (11.07)	21.98 (11.47)	.295
Cotinine (ng/ml)[a]	2318.25 (1215.54)	2461.75 (1242.91)	2174.76 (1180.43)	.156
Age of excess weight onset[a]	34.73 (14.36)	34.07 (13.04)	35.41 (15.68)	.796
Years of BMI ≥ 25[a]	20.9 (15.52)	22.11 (19.63)	19.81 (10.96)	.875
Previous diet attempts[a]	7.71 (17.37)	7.19 (15.71)	8.22 (18.98)	.85
Body weight dissatisfaction (n/%)	101 (84.17)	50 (83.33)	51 (85)	.803
Reported limitations to exercise (n/%)	27 (22.5)	14 (23.3)	13 (21.7)	1
Diet stage of change (n/%)				.60
Pre-contemplation	23 (19.17)	14 (23.33)	9 (15)	
Contemplation	35 (29.16)	14 (23.33)	21 (35)	
Preparation	26 (21.67)	14 (23.33)	12 (20)	
Action	21 (17.5)	11 (18.34)	10 (16.67)	
Maintenance	15 (12.5)	7 (11.67)	8 (13.33)	
Weight (kg)[a]	88.08 (14.01)	88.25 (14.19)	87.91 (13.94)	.894
BMI[a]	31.75 (4.31)	31.71 (4)	31.78 (4.63)	.709
BMI category (n/%)				.708
Overweight	47 (39.16)	22 (36.67)	25 (41.67)	
Obesity	73 (60.83)	38 (63.33)	35 (58.33)	
Presence of binge eating episodes (n/%)	26 (21.67)	12 (20)	14 (23.33)	.825

Note. [a]Mean (standard deviation). CBT = cognitive-behavioral therapy; CM = contingency management; CPD = cigarettes per day; FTCD = Fagerström Test for Cigarette Dependence; CO (ppm) = carbon monoxide in parts per million; ng/ml = nanograms/milliliter; BMI = body mass index; kg = kilograms.

2.2. Procedure

Interested individuals who met the preliminary eligibility criteria during a telephone screening were scheduled for an in-person baseline assessment in the Addictive Behaviors Clinical Unit at the University of Oviedo to confirm eligibility and to provide written informed consent. The participant flowchart gives a detailed description (see Fig. 1). From a total of 264 individuals screened, 123 met the inclusion criteria and were enrolled in the study. Participants were randomly assigned to one of the two treatment conditions in accordance with a computer-generated list of random numbers to allocate individuals to interventions in a 1:1 ratio. A total of 120 people were allocated to an intervention: CBT for smoking cessation and weight control (CBT, n = 60), or the same treatment alongside CM for smoking cessation (CBT + CM, n = 60). The trial was pre-registered on clinicaltrials.gov (ID = NCT04332029), and the study protocol was approved by the Research

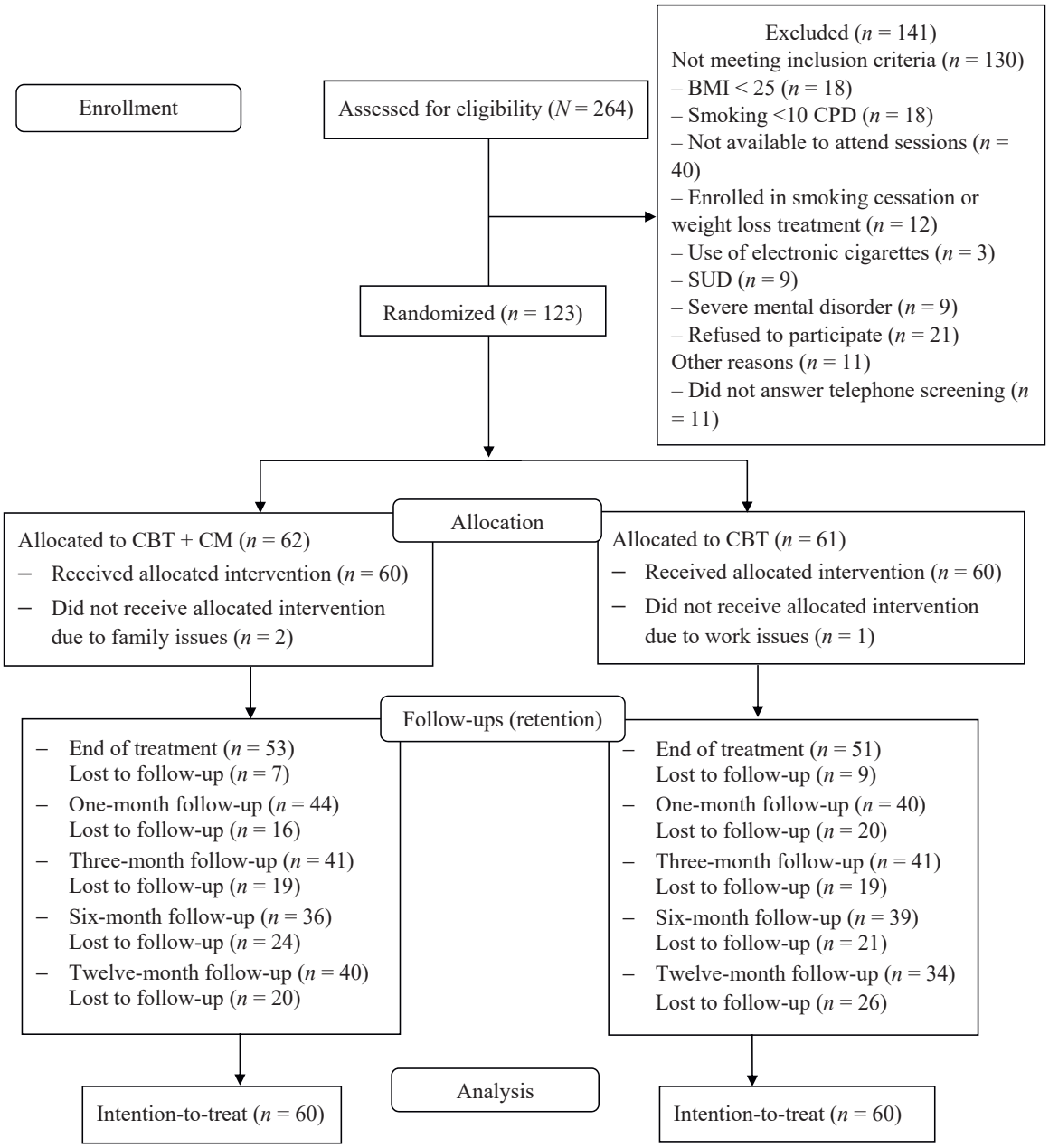

Fig. 1. Consort flow diagram of study participants. Note. BMI = body mass index; CPD = cigarettes per day; SUD = substance use disorder other than tobacco use disorder; CBT = cognitive-behavioral therapy; CM = contingency management; EOT = end of treatment.

Ethics Committee of the Principality of Asturias (nº 329/19).

Due to the COVID-19 pandemic, it is important to specify dates of this RCT to understand where in the pandemic data was collected. Recruitment began in October 2020 and between then and December 2020, 15 out of the 120 participants (12.50%) received interventions under the second stay-at-home order which included curfew and perimeter closures with exceptions for attending health services. Between January 2021 and May 2021 (the date on which the Spanish government decreed the end of the 'state of emergency'), a total of 31.67% (38/120) of the sample received intervention with notable restrictions (i.e., free movement between cities was allowed but leisure facilities such as bars remained closed). The remaining participants (55.83%; 67/120) received the intervention between June 2021 and December 2021 with restrictions such as time limitations for opening leisure venues, social distancing outdoors, use of masks indoors and prohibition of smoking on terraces.

2.3. Assessments and outcomes

2.3.1. Baseline characteristics

Participants were asked to complete a questionnaire including sociodemographic data, variables about tobacco use and variables about weight/eating. The Fagerström Test for Cigarette Dependence (FTCD) (Becoña and Vázquez, 1998) evaluated nicotine dependence establishing five levels: very low (0−2), low (3−4), medium (5), high (6−7) and very high (8−10). Current motivation for weight control was assessed using the S-Weight questionnaire (Andrés et al., 2011).

2.3.2. Primary outcomes and measures

The primary outcome variables were: (1) treatment completion (i.e., participants who started the treatment and completed the EOT assessment); (2) smoking abstinence outcomes at EOT and FU (i.e., 1-, 3-, 6-, and 12-month), in terms of 7-day point-prevalence abstinence rates (i.e.,

percentage of participants who attained abstinence, "not even a puff", for a minimum of seven days prior to assessment), prolonged abstinence rates (i.e., percentage of participants who attained abstinence, "not even a puff", after a grace period of 15 days after the target quit date), and duration of continuous abstinence (i.e., number of consecutive days without smoking, "not even a puff", since participants successfully quit) (Piper et al., 2020); (3) weight change in terms of body weight variation from baseline to EOT and 1-, 3-, 6-, and 12-month FU in those who achieved prolonged abstinence at these time points (Hartmann-Boyce et al., 2021).

Smoking was biochemically assessed through carbon monoxide (CO) and urine cotinine analysis, using 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) at baseline, at each session during the intervention, at EOT, and at FU. Abstinence was biochemically confirmed through CO readings ≤ 4 ppm and urine cotinine levels ≤ 80 ng/ml (Benowitz et al., 2020; Ramani et al., 2023).

Participants' height was measured at baseline using a medical stadiometer (SECA Mod.213, 20–205 cm). Body weight was measured, in light clothing and without shoes, using a calibrated medical scale (CL.III 200 kg. SECA Mod. 877) at baseline, weekly during the intervention, EOT and FU. BMI was calculated (BMI = weight [kg]/(height)^2[m]).

2.3.3. Secondary outcomes and measures

Other measures of efficacy were improvements in secondary outcomes (i.e., diet, eating behavior, physical activity, and psychological well-being) assessed with specific instruments completed by participants during the assessments. The scores at EOT and FU were only recorded for participants who completed the assessments.

The PREDIMED-Plus (Álvarez Álvarez et al., 2019) assessed adherence to the Mediterranean diet, and participants were classified as having low (< 7), medium (8−10), and high (≥ 11) adherence. The Spanish version of the Dutch Eating Behavior Questionnaire (DEBQ) (Cebolla et al., 2014) measured three eating styles (i.e., emotional, external, and restrained eating), with higher scores indicating greater agreement with each eating style. The Spanish Regicor Short Physical Activity Questionnaire (REGICOR) (Molina et al., 2017) assessed physical activity intensity (light, moderate, vigorous and total) in metabolic equivalents (METs) per week. The Spanish version of the Depression, Anxiety, and Stress Scales-21 (DASS-21) (Bados et al., 2005) evaluated emotional states (i.e., depression, anxiety, stress).

2.4. Treatment interventions

Participants visited the clinic 15 times over eight weeks. The first visit each week lasted 120 minutes and included a group CBT session (up to four participants) and taking samples for CO and cotinine. A second, midweek group session for each of the first seven weeks lasted 60 min and included sampling for CO and cotinine, a weigh-in, and a progress review. Masters- and doctoral- level psychologists with training in treatment protocols conducted the intervention.

2.4.1. Cognitive behavioral therapy for smoking cessation and weight control (CBT)

A CBT protocol for smoking cessation was used, with additional components for weight control. Participants received coping skills training to quit smoking and a nicotine fading procedure, which consisted of a weekly reduction in nicotine intake of 20% each week based on reductions of tobacco brands and number of daily cigarettes from the first session to 48 hours prior to the sixth session (target quit day). Additional components addressed restructuring post-cessation weight gain concerns, improving diet, increasing physical activity, and reducing problematic eating. Some treatment components were transdiagnostic, both for smoking cessation and weight control (e.g., distress tolerance and emotional regulation skills). A detailed description is provided in the pilot feasibility study (García-Fernández et al., 2022).

2.4.2. CBT plus contingency management for smoking abstinence (CBT + CM)

The CBT + CM condition included the CBT protocol described above plus CM for smoking abstinence. CM consisted of providing vouchers to reinforce abstinence contingent on biochemical breath and urine verification from the sixth session to EOT. Points were provided immediately upon biochemical verification of abstinence at each session and vouchers were exchangeable for a variety of goods, equipment and services, for exercising, cooking, leisure, and entertainment activities, among others. The maximum amount that participants could earn was 320 points (US$ 301.73), with one point equivalent to one euro (US$ 1.19). Vouchers began at 50 points (US$ 47.14) and increased by 5 points (US$ 4.71) for each consecutive negative sample. Participants could additionally receive a bonus of 10 points (US$ 9.43) for two consecutive negative smoking samples. A positive test or missed specimens reset the voucher value back to the initial 50 points, but if two consecutive negative tests were provided, the voucher value was reestablished. The value of the incentives was determined based on previous CM studies for substance use concluding that larger incentives were not associated with higher rates of abstinence (Breen et al., 2020), and that US$ 300 is the standard amount used to reinforce abstinence (Petry et al., 2015).

2.5. Statistical analyses

A power analysis was conducted using G*Power 3.1.9.2 (Faul et al., 2009) to determine sample size. Abstinence rates from a previous study conducted in the clinic comparing CBT + CM vs. CBT for smoking cessation among the general population (López-Núñez et al., 2016) were used to ensure a minimum power of 80% with a 0.05 alpha level. Bivariate analysis were conducted to assess participants' baseline characteristics. The distribution of the data was examined to determine whether to use parametric or nonparametric tests. Differences between groups were examined via *t*-tests or the Mann-Whitney *U* test for continuous variables, and chi-square for categorical variables at EOT and FU. Changes in continuous variables from baseline to EOT and FU were examined using *t*-tests and the Wilcoxon Signed-Rank Test. Effect sizes were calculated by Cohens' *d*, $r = Z / \sqrt{n}$, and the phi coefficient as appropriate. Data was analyzed according to intent-to-treat analysis, in which participants who did not attend assessments were considered as individuals who smoked. No imputation of missing weight data or secondary variables was performed.

Mixed between-within subjects analysis of variance (ANOVA) was conducted to analyze changes in secondary outcomes by treatment group (between-subjects variable) and over time (within-subjects variable). If the assumption of sphericity was violated, the Greenhouse-Geisser or Huynh-Feldt correction methods were used (Blanca et al., 2023). When there were significant group effects, post hoc analysis of covariance was performed to examine whether the significant difference in age between treatment conditions at baseline contributed to the observed differences in secondary outcomes. Simple comparisons were used to compare scores at EOT and FU with baseline scores. Effect size was calculated via partial eta squared (Tabachnick and Fidell, 2014). Confidence levels were set at 95%, and data were analyzed using SPSS package (V.20, Inc., Chicago, IL).

3. Results

3.1. Treatment completion

A total of 86.67% of the participants completed the treatment (104/120) and completion rates did not differ by treatment condition ($p = .788$). Specifically, 88.33% in the CBT + CM condition (53/60) and 85% in the CBT group (51/60) completed the intervention. Participants from

both conditions attended a mean of 13.56 sessions ($SD = 1.68$) with no differences between the groups ($M_{CBT + CM} = 13.87 \pm 1.62$ vs. $M_{CBT} = 13.24 \pm 1.69$; $p = .054$).

3.2. Smoking abstinence outcomes

3.2.1. End of treatment

At EOT, 70% of the total sample (84/120) achieved 7-day point-prevalence smoking abstinence and prolonged abstinence, with no statistically significant differences between the groups (CBT + CM = 78.33% [47/60] vs. CBT = 61.67% [37/60]; $p = .073$; $\varphi = 0.182$). The mean number of days of continuous abstinence for the total sample was 13.46 ($SD = 10.14$), with no statistically significant differences between the groups ($M_{CBT + CM} = 14.53 \pm 8.59$ vs. $M_{CBT} = 12.38 \pm 11.48$; $p = .216$; $r = 0.11$).

3.2.2. Follow-ups

In the full sample, 7-day point-prevalence abstinence rates at 1-, 3-, 6, and 12-month FU were 47.50% (57/120), 36.67% (44/120), 30.83% (37/120), and 25% (30/120). Prolonged abstinence rates at 1-, 3-, 6, and 12-month FU were 40.83% (49/120), 28.33% (34/120), 21.67% (26/120), and 16.67% (20/120) and the mean number of days of continuous abstinence at each FU were 21.57 ± 25.25, 35.41 ± 50.31, 50.67 ± 84.10, and 81.48 ± 150.54.

Table 2 shows smoking abstinence outcomes by group at each FU. There were no statistically significant differences between the groups for smoking abstinence outcomes at any FU (all p-values $\geq .268$)

3.3. Weight change outcomes

Fig. 2 shows weight change in participants who attained abstinence at EOT and FU.

3.3.1. End of treatment

Participants who achieved abstinence from both groups gained weight compared to their baseline ($\Delta_{kg} = 1.07 \pm 1.88$; $p < .001$; $r = .94$). Particularly, participants in the CBT + CM group had significantly increased weight over their baseline ($\Delta_{kg} = .90 \pm 1.90$; $p < .002$; $d = .47$), as did participants in the CBT group ($\Delta_{kg} = 1.29 \pm 1.85$; $p < .001$; $r = .60$). The amount of weight gained was similar in participants who attained abstinence from both groups ($p = .344$).

3.3.2. Follow-ups

Participants who achieved abstinence from both groups had significantly increased weight over their baseline at 1-, 3-, 6, and 12-month FU: 2.31 ± 3.61 ($p < .001$; $r = .61$), 3.03 ± 5.05 kg ($p = .001$; $r = .60$), 3.12 ± 3.48 kg ($p < .001$; $d = .90$), and 4.19 ± 4.31 kg ($p < .001$; $d = .97$).

Mean weight gain of participants who attained abstinence in the CBT + CM condition at 1-, 3-, 6, and 12-month FU was 2.23 ± 3.72 kg ($p = .004$; $r = .72$), 4.08 ± 5.64 kg ($p = .004$; $r = .47$), 3.69 ± 3.36 kg ($p = .003$; $r = .80$), and 4.62 ± 4.97 kg ($p = .016$; $r = .72$). Similarly, participants who attained abstinence in the CBT group significantly gained 2.40 ± 3.58 kg ($p = .004$; $d = .67$), 2.11 ± 4.42 kg ($p = .045$; $r = .47$), 2.48 ± 3.64 kg ($p = .034$; $r = .61$), and 3.67 ± 3.57 kg ($p = .038$; $r = .69$) at 1-, 3-, 6, and 12-month FU. Mean weight gain did not differ by treatment condition at any FU (all p-values $\geq .365$).

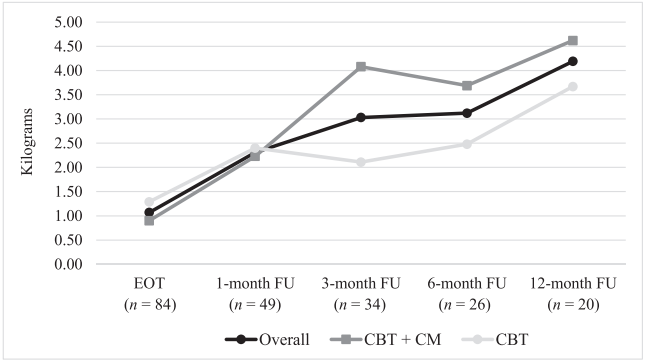

Fig. 2. Mean weight change in abstinent participants at end of treatment and follow-ups. Note. EOT = end of treatment; FU = follow-up; CBT = cognitive-behavioral therapy; CM = contingency management.

3.4. Secondary outcomes

Table 3 shows secondary outcomes at baseline, EOT, and all FU.

There was a significant effect for time in adherence to the Mediterranean diet ($p < .001$; $\eta p^2 = .103$) with improvements in the PREDIMED-Plus scores at EOT and at 1-, 3-, and 6-month FU (all p-values $\leq .008$). The effect for group ($F_{4.449,\ 240.231} = 2.980$; $p = .016$; $\eta p^2 = .052$) disappeared when the covariable age was added to the model ($F_{4.361,\ 231.14} = 1.572$, $p = .177$).

Significant effects for time were also found in emotional eating ($p < .001$; $\eta p^2 = .098$) and external eating ($p < .001$; $\eta p^2 = .258$). Emotional eating (all p-values $\leq .002$) and external eating scores decreased at EOT and all FU (all p-values $< .001$) while restrained eating remained stable ($p = .271$). No effect for treatment group was found in emotional eating ($F_{4.72,\ 254.89} = .895$; $p = .481$) or restrained eating ($F_{5,\ 270} = .352$; $p = .881$), but there was a significant effect for treatment groups in external eating ($F_{3.713,\ 200.496} = 18.758$; $p = .033$; $\eta p^2 = .048$). This effect remained significant ($F_{4.363,\ 231.215} = 3.503$; $p = .007$; $\eta p^2 = .062$) when baseline age was added to the model as a covariate. A larger fall in external eating scores in the CBT group was found at the 3-month FU ($p = .004$) and the 6-month FU ($p = .005$).

Light physical activity ($p = .212$) and moderate physical activity ($p = .242$) did not change, while vigorous physical activity ($p = .004$; $\eta p^2 = .088$) and total physical activity ($p = .005$; $\eta p^2 = .081$) increased at the 3-month FU ($p = .003$). However, in the final, 12-month, FU, participants had significantly lower scores for total physical activity ($p = .030$; $\eta p^2 = .086$). No differences between groups were found in light ($F_{2.177,\ 117.57} = 1.044$; $p = .360$), moderate ($F_{4.193,\ 222.232} = 2.298$; $p = .057$), vigorous ($F_{2.338,\ 126.237} = .840$; $p = .450$), or total physical activity ($F_{2.716,\ 143.950} = 2.045$; $p = .111$).

Finally, there was no effect for time in scores on depression ($p =$

Table 2
Smoking abstinence outcomes at follow-ups.

	PP (n/%)				PA (n/%)				CA (M/SD)			
	CBT + CM ($n = 60$)	CBT ($n = 60$)	p	Effect size[a]	CBT + CM ($n = 60$)	CBT ($n = 60$)	p	Effect size[a]	CBT + CM ($n = 60$)	CBT ($n = 60$)	p	Effect size[b]
1-month FU	30 (50)	27 (45)	.715	0.050	26 (43.33)	23 (38.33)	.710	0.051	22.52 (24.99)	20.62 (25.47)	.770	0.03
3-month FU	20 (33.33)	24 (40)	.570	-0.069	16 (26.67)	18 (30)	.839	0.037	33.45 (49.51)	37.37 (51.45)	.477	0.04
6-month FU	20 (33.33)	17 (28.33)	.693	0.054	14 (23.33)	12 (20)	.825	0.040	33.45 (49.51)	37.37 (51.45)	.610	0.05
12-month FU	18 (30)	12 (20)	.292	0.115	11 (18.33)	9 (15)	.806	0.045	92.27 (155.91)	70.68 (145.47)	.268	0.10

Note. [a] phi coefficient; [b] rank-biserial correlation coefficient. PP = 7-day point-prevalence abstinence rates; PA = prolonged abstinence rates; CA = days of continuous abstinence; M = mean; SD = standard deviation; CBT = cognitive-behavioral therapy; CM = contingency management; FU = follow-up.

Table 3
Secondary outcomes at baseline, end of treatment, and follow-ups ($n = 56$).

	Baseline ($M \pm SD$)	EOT ($M \pm SD$)	1-month FU ($M \pm SD$)	3-month FU ($M \pm SD$)	6-month FU ($M \pm SD$)	12-month FU ($M \pm SD$)	F^a	*df*	*p*	ηp^2
$PREDIMED_{Total}$							6.207	4.449, 240.231	<.001	.103
Overall	9.41 ± 2.90	10.55 ± 2.08	10.73 ± 2.41	11.09 ± 2.31	10.66 ± 2.44	10.05 ± 2.65				
CBT + CM	8.93 ± 2.49	10.77 ± 1.89	10.33 ±2.48	10.43 ± 1.87	10.93 ± 2.39	9.73 ± 2.46				
CBT	9.96 ± 2.74	10.31 ± 1.99	11.19 ± 2.46	11.85 ± 2.56	10.35 ± 2.50	10.42 ± 2.85				
$DEBQ_{Emotional}$							5.896	4.72, 254.89	<.001	.098
Overall	23.71 ± 11.05	21.32 ± 9.57	21.27 ± 9.32	20.21 ± 8.67	20.77 ± 8.82	20.43 ± 9.26				
CBT + CM	25.50 ± 11.59	22.33 ± 9.49	23.53 ± 9.13	22.37 ± 9.50	22.67 ± 9.32	22.60 ± 9.69				
CBT	21.65 ± 10.23	20.15 ± 9.71	18.65 ± 9.00	17.73 ± 6.97	18.58 ± 7.82	17.92 ± 8.21				
$DEBQ_{External}$							18.758	3.713, 200.496	<.001	.258
Overall	26.71 ± 7.44	24.32 ± 7.26	23.48 ± 7.46	22.82 ± 7.51	22.84 ± 7.60	22.52 ± 7.76				
CBT + CM	27.63 ± 6.44	25.37 ± 6.73	25.80 ± 6.49	24.17 ± 6.68	24.97 ± 6.95	24.03 ± 7.81				
CBT	25.65 ± 8.46	23.12 ± 7.77	20.81 ± 7.74	21.27 ± 8.23	20.38 ± 7.71	20.77 ± 7.46				
$DEBQ_{Restrained}$							1.284	5, 270	.271	-
Overall	22.46 ± 7.35	22.29 ±7.63	21.80 ± 8.24	21.57 ±7.49	21.73 ± 8.11	20.88 ± 8.59				
CBT + CM	23.40 ±7.57	23.57 ± 7.73	23.43 ±7.77	23.07±7.39	23.43 ± 7.22	22.20 ± 8.98				
CBT	21.38 ±7.08	20.81 ± 7.39	19.92 ±8.52	19.85±7.37	19.77 ± 8.77	19.35 ±8.01				
$REGICOR_{Light}$							1.565	2.177, 117.57	.212	-
Overall	664.46 ± 928.51	715.02 ± 794.58	507.64 ± 843.60	893.27 ± 1941.10	704.79 ± 947.29	411.45 ± 506.99				
CBT + CM	789.47 ± 1156.08	694.23 ± 761.20	288.33 ± 274.84	996.53 ± 2526.40	759.63 ± 1090.46	408.07 ± 499.65				
CBT	520.23 ± 553.09	739.00 ± 846.01	760.69 ± 1163.49	774.12 ± 926.17	641.50 ± 766.19	415.35 ± 525.23				
$REGICOR_{Moderate}$							1.376	4.193, 222.232	.242	-
Overall	492.60 ± 799.63	419.67 ± 599.33	360.13 ± 746.14	576.07 ± 923.03	439.98 ± 744.76	279.53 ± 384.61				
CBT + CM	534.31 ± 787.02	432.86 ± 526.69	246.28 ± 331.54	824.48 ± 1134.54	548.45 ± 819.49	302.90 ± 383.38				
CBT	446.08 ± 826.52	404.96 ± 681.72	487.12 ± 1023.53	299.00 ± 497.20	319.00 ± 645.81	253.46 ± 391.88				
$REGICOR_{Vigorous}$							5.208	2.338, 126.237	.004	.088
Overall	512.96 ± 1154.53	673.05 ± 1018.24	479.09 ± 808.68	1384.61 ± 2339.36	636.30 ± 1081.97	487.04 ± 713.77				
CBT + CM	564.63 ± 929.31	648.47 ± 691.38	400.43 ± 492.42	1652.90 ± 2711.61	804.30 ± 1384.92	584.47 ± 797.22				
CBT	453.35 ± 1386.99	701.42 ± 1313.37	569.85 ± 1068.39	1075.04 ± 1823.31	442.46 ± 526.89	374.62 ± 599.21				
$REGICOR_{Total}$							4.682	2.716, 143.950	.005	.081
Overall	1691.44 ± 1864.05	1830.22 ± 1669.30	1362.82 ± 1758.85	2894.64 ± 3879.05	1795.36 ± 2211.15	1191.44 ± 1218.89				
CBT + CM	1935.14 ± 1884.59	1816.62 ± 1376.37	955.10 ± 672.41	3564.03 ± 4781.28	2147.31 ± 2752.82	1324.07 ± 1293.67				
CBT	1419.62 ± 1838.93	1845.38 ± 1974.03	1817.58 ± 2401.62	2148.00 ± 2407.93	1402.81 ± 1330.15	1043.50 ± 1136.44				
DASS-21 $_{Depression}$							1.91	4.749, 251.685	.097	-
Overall	9.53 ± 8.87	6.98 ± 7.60	8.18 ± 8.79	8.04 ± 8.65	7.13 ± 6.84	7.27 ± 5.65				
CBT + CM	10.87 ± 8.33	7.93 ± 7.36	9.33 ± 8.36	9.33 ± 8.46	9.13 ± 5.50	8.07 ± 5.13				
CBT	7.92 ± 9.39	5.84 ± 7.87	6.80 ± 9.26	6.48 ± 8.78	4.72 ± 6.60	6.32 ± 6.18				
DASS-21 $_{Anxiety}$							2.199	5, 265	.055	-
Overall	7.24 ± 5.31	5.67 ± 5.61	5.02 ± 5.60	5.75 ± 6.18	4.87 ± 5.16	5.31 ± 5.25				
CBT + CM	7.93 ± 5.52	6.27 ± 6.14	4.60 ± 4.14	5.80 ± 5.52	5.87 ± 5.38	6.60 ± 5.69				
CBT	6.40 ± 5.03	4.96 ± 4.94	5.52 ± 7.03	5.68 ± 7.02	3.68 ± 4.72	3.76 ± 4.29				
DASS-21 $_{Stress}$							1.316	4.634, 245.583	.26	-
Overall	11.02 ± 7.15	9.38 ± 7.00	9.24 ± 8.12	9.20 ± 7.18	8.87 ± 6.72	9.64 ± 6.50				
CBT + CM	12.93 ± 6.78	10.33 ± 6.60	8.93 ± 6.36	10.07 ± 6.57	10.40 ± 5.95	10.33 ± 5.49				
CBT	8.72 ± 7.02	8.24 ± 7.42	9.60 ± 9.95	8.16 ± 7.85	7.04 ± 7.24	8.80 ± 7.57				

Note. [a] Based on mixed between-within subjects' analysis of variance. *F* statistic represents within-subjects effects on time. EOT = end of treatment; *M* = mean; *SD* = standard deviation; FU = follow-up; df = degrees of freedom; CBT = cognitive-behavioral therapy; CM = contingency management; DEBQ = Dutch Eating Behavior Questionnaire; REGICOR = Spanish Register Gironi del Cor (Short Physical Activity Questionnaire); DASS-21 = Depression, Anxiety, and Stress scale.

.097), anxiety ($p = .055$), or stress ($p = .26$), and no effect for group was found in depression ($F_{4.749,\ 251.685} = .451$; $p = .803$), anxiety ($F_{5,\ 265} = 1.432$; $p = .213$), or stress scores ($F_{4.634,\ 245.583}$; $p = .125$).

4. Discussion

This is the first RCT designed to examine the additive effect of CM for smoking cessation to CBT among individuals with overweight or obesity

who want to quit. The main results indicate that adding CM to CBT did not produce a better treatment response than CBT alone in this population. There was no specific benefit from CM for treatment completion, smoking abstinence outcomes, weight control, or improving health related secondary outcomes. Three major findings are highlighted: 1) both CBT + CM and CBT provided similar smoking abstinence outcomes at EOT and all FU; 2) both interventions, when participants successfully quit, similarly led to slight weight gain at EOT and to greater weight gain in the long term; 3) treatment effectiveness in improving secondary outcomes was similar for both interventions with improvements over time in adherence to the Mediterranean diet and reduced emotional and external eating.

The overall smoking abstinence rates at EOT were 78.33% in the CBT + CM group and 61.67% in the CBT group, which are high compared to those reported for smoking cessation interventions with weight management (García-Fernández et al., 2023; Hartmann-Boyce et al., 2021) and to those from studies for quitting smoking among individuals with overweight or obesity (Heggen et al., 2016; White et al., 2019; Wilcox et al., 2010; 71%, 25.9%, and 48.1%, respectively). There are at least three rationales that account for such high cessation rates. Firstly, both treatments for smoking cessation incorporated weight management, which improves smoking cessation rates (García-Fernández et al., 2023; Hartmann-Boyce et al., 2021). Secondly, all participants received CBT adapted to the needs of persons who smoke with overweight or obesity. Post-cessation weight concerns are known to be an important obstacle to quitting smoking in individuals with weight complications (Levine et al., 2013), and addressing diet, physical activity, problematic eating and psychological well-being are important components of interventions in obesity (Durrer Schutz et al., 2019; Pojednic et al., 2022; Spadaccini et al., 2022). Thirdly, treatment completion was high in both conditions (88.33% in CBT + CM vs 85% in CBT), which could have raised smoking cessation rates at EOT (Dorner et al., 2011; Garey et al., 2020).

Tobacco abstinence rates fell over time at 1-, 3-, 6-, and 12-month FU with overall 7-day point prevalence abstinence rates of 47.50%, 36.67%, 30.83%, and 25%. Similarly, prolonged abstinence rates were 40.83%, 28.33%, 21.67%, and 16.67% at 1-, 3-, 6-, and 12-month FU. Our abstinence rates were higher than those reported by Love et al. (2011) with 7-day point prevalence abstinence rates of 21.4% at 6 months, and White et al. (2019) with continuous abstinence rates of 25.9% at 6 months. They were lower than those reported by Heggen et al. (2016), with 7-day point prevalence abstinence rates of 46.3% at 3 months, and Wilcox et al. (2010) with continuous abstinence rates of 40.7% at 3 months. It is worth noting that those latter studies incorporated varenicline or bupropion (Guo et al., 2022).

Overall, both interventions were effective for prompting treatment completion and reducing smoking rates. Despite the CBT + CM group showing a trend towards higher smoking abstinence rates, there were no statistically significant differences between the two groups at EOT or at any FU. These results are not in line with previous research highlighting the effectiveness of CM for smoking cessation (Notley et al., 2019) and for specific populations (González-Roz and Secades-Villa, 2022; Yon et al., 2022). Given the robustness of CM across a range of circumstances and different populations, potential reasons for the lack of effect observed should be discussed. The COVID-19 pandemic, which has been identified as both an obstacle to and facilitator for smoking cessation (Johnston et al., 2023), might have impacted treatment effectiveness. On one hand, the pandemic might have positively affected the motivation to quit smoking and undergo treatment, as well as treatment attendance and completion (Barrington-Trimis et al., 2023), which could explain the high retention and smoking cessation rates at EOT in both groups. On the other hand, the stringent COVID-19 measures in Spain (e.g., movement restrictions, social distancing, bar and restaurant closures, commercial activity and leisure centers limits) might have hindered the effectiveness of CM because participants were unable to use the vouchers freely. Moreover, the post-pandemic normality, with its gradual relaxation of COVID-19 measures, might be a risk factor for smoking and might have affected smoking cessation rates at FU. Finally, another potential basis for the absence of effect could be related to the CM parameters. For example, providing vouchers after EOT may have improved abstinence outcomes in the CBT + CM group (see e.g., González-Roz et al., 2021).

In terms of weight outcomes, both interventions similarly led to a slight weight gain for those successfully quitting smoking at EOT (1.07 kg). This gain was lower than reports from some previous studies (Bize et al., 2010; Levine et al., 2010) but higher than others (Lycett et al., 2020). It is important to note that the treatment target was post-cessation weight control, not weight-loss. At 1-, 3-, 6-, and 12-month FU, post-cessation weight gain among participants who successfully achieved abstinence gradually increased (2.31 kg, 3.03 kg, 3.12 kg, and 4.19 kg), which are higher figures than Ussher et al. (2007) and Audrain-McGovern et al. (2023) but lower than Levine et al. (2010). Finally, there were no statistically significant differences between the two treatments in post-cessation weight gain. It is important to note that CM consisted of providing vouchers to reinforce smoking abstinence and weight control was not incentivized. CM has been used successfully to address several healthy behaviors (Ellis et al., 2021; Giles et al., 2014) and future research is needed to evaluate a dual CM schedule for simultaneously reinforcing smoking abstinence and weight control (Bloom et al., 2020; Van Der Pol et al., 2022). Finally, nicotine replacement therapy (NRT) may attenuate post-cessation weight gain (Farley et al., 2012; Hartmann-Boyce et al., 2021) but its effects on people with overweight or obesity remain unclear and future studies should explore the impact of NRT in this population. To the best of our knowledge, the only study that has used NRT in population with overweight or obesity included NRT in both the experimental and comparison conditions (White et al., 2019).

In secondary outcomes, participants from both groups improved adherence to the Mediterranean diet and reduced emotional and external eating at EOT and FU, as well as increased vigorous and overall physical activity at 3-month FU. There were no significant changes over time in the remaining secondary outcomes (i.e. restrained eating, light and moderate physical activity and emotional states). No statistically significant differences between the two groups were found except for a greater reduction in external eating in the CBT group at 3 and 6-month FU than the CBT + CM group, although the differences disappeared at the 12-month FU. CBT components addressing diet and emotional or external eating may be active factors for this multicomponent program, and this is consistent with previous research (Moraes et al., 2021; Saranapala et al., 2022).

These results must be considered within the limitations of the study. First, not being able to include the participants who did not complete the trial and assessments (e.g., only 61.67% of participants [74/120] attended the 12 month-FU) limits the inferences that can be drawn from the analysis of secondary outcomes, and the lack of data from these participants reduces the reliability of the conclusions. Second, adding a control condition providing the same incentives but not contingent on smoking abstinence would have been a strongest control condition. Third, the effect size observed for differences between groups in 7-day point prevalence rates at EOT is not excessively far from showing a weak association, which suggests that a larger sample might have uncovered significant effects in favor of the CM condition at EOT. Finally, the COVID-19 pandemic might have affected outcomes, and future research is needed to analyze how the pandemic affected smoking cessation, weight and secondary outcomes.

5. Conclusions

Addressing smoking cessation and weight control simultaneously was effective for quitting smoking among individuals with overweight or obesity but smoking abstinence rates declined over time. Participants who attained abstinence showed a slight weight gain at EOT and a greater weight gain over time. There was no benefit from combining

CBT and CM for treatment completion, tobacco abstinence outcomes, weight control, or secondary outcomes. Future research is needed to develop effective smoking abstinence maintenance strategies and post-cessation weight gain control, and to determine which CM parameters may be effective in this specific population group.

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CRediT authorship contribution statement

Sara Weidberg: Resources, Investigation. **Gema Aonso Diego:** Writing – review & editing, Resources, Investigation. **Gloria Garcia-Fernandez:** Writing – review & editing, Writing – original draft, Supervision, Resources, Project administration, Investigation, Funding acquisition, Conceptualization. **Andrea Krotter:** Writing – original draft, Investigation, Formal analysis, Data curation. **Ángel García-Pérez:** Writing – review & editing, Software, Resources, Investigation, Data curation.

Declaration of Competing Interest

The authors declare that they have no conflicting interests regarding this paper.

Data availability

The data underlying this article will be shared on reasonable request to the corresponding author.

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