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Online Mental Contrasting with Implementation Intentions for changing snacking behavior and reducing body mass index in people with excess weight: a randomized controlled trial

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ABSTRACT

Mental Contrasting with Implementation Intentions (MCII) has proved useful for dietary changes, but not yet applied to people with excess weight. We aimed to determine the benefit of online MCII as an add-on to a standard Behavioral Weight Loss Intervention (Treatment as Usual-TAU) to change snacking behavior -one of the main contributors to excess weight- and reduce BMI. This online randomized controlled trial included 148 participants [MCII-group (50), Sham-group (50) and TAU-group (48)]. All participants received standard intervention: motivational interviewing, individualized diet and physical exercise. MCII and Sham groups received training for one week, while TAU-group had monitoring. Outcome measures were self-reported snacking behavior (frequency of snacking, total servings, ultra-processed food -UPF- servings) and BMI. Results of mixed ANOVAS showed interactions group x time (pre-vs post-treatment) for all variables: frequency of snacking [F (2,134) = 6.110, p = .003], total servings [F (2,126) = 4.291, p = .016], UPF servings [F (2,127) = 4.059, p = .020], and BMI [F (2,98) = 3.990, p = .022]. The MCII-group showed differences with Sham and TAU groups at post-treatment in all snacking behavior variables, with large effect sizes between the MCII-group and the other two groups, and null between Sham and TAU groups (except for UPF servings). Complimentary one-way ANOVA for standardized change showed greater BMI reductions for the MCII-group [F (2,103) = 3.990, p = .006], with moderate effect sizes. In conclusion, MCII improves the results of usual treatment for excess weight in snacking behavior and BMI. Trial registration: Clinical Trials NCT05158075.

1. Introduction

Excess weight (overweight and obesity) presents a substantial worldwide health concern (Shafiee et al., 2024). In 2022, 43 % of adults aged 18 years and older were overweight [Body Mass Index (BMI, kg/m2) ≥ 25], and 16 % were obese (BMI ≥30). The prevalence of obesity worldwide increased by more than 100 % between 1990 and 2022 (World Health Organization, 2024). Excess weight is a risk factor for a wide range of diseases and health problems (hypertension, hypercholesterolemia, type 2 diabetes mellitus, coronary heart disease, chronic kidney disease, musculoskeletal disorders, certain cancers, and other chronic diseases) (Humphreys & Verstappen, 2022; Khan et al., 2018; Ministerio de Sanidad, Consumo y Bienestar Social, 2020; Shantha & Cheskin, 2015). Moreover, high body weight is associated with poorer mental health, particularly clinical and subclinical depression (Steptoe & Frank, 2023). Thus, the so-called "epidemic of obesity" is a major global health problem (Cercato & Fonseca, 2019).

The traditional approach to weight reduction is behavior change aimed to induce a negative energy balance by initiating a calorie-restricted diet and increasing physical activity (Canuto et al., 2021). However, it has been reported that this approach results in small changes in weight in the short term and often in weight regain in the long term (only 25 % of patients maintain this loss) (Bellicha et al., 2021; MacLean et al., 2015; Paixão et al., 2020). Even when significant weight reduction is achieved, almost the total population returns to their

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Glossary:

Body Mass Index (BMI) The method of utilizing an adult's height and weight to broadly place them into underweight, normal weight, overweight and obese categories. BMI can be calculated using metric or imperial units. In this study, metric units were used: weight (kilograms) divided by height squared (meters) (kg/m2) (Zierle-Ghosh & Jan 2023)

Excess weight According to the WHO (World Health Organization), this term refers to BMI ≥25. Specifically, the present study included people with excess weight whose BMI was between 25 and 39.9, therefore, as explained in Zierle-Ghosh and Jan (2023), they have overweight or moderate obesity, and people with severe obesity (BMI ≥40) were not included

Mental Contrasting with Implementation Intention (MCII) Self-regulation strategy that enhances goal attainment combining Mental contrasting (a goal-setting strategy that can transform positive fantasy into binding goal commitment, followed by goal striving) and Implementation Intention (a goal implementation strategy that supplements goal intention and drives action) (Wang et al., 2021)

Snacking Eating occasions typically characterized by casual consumption of small quantities of food, in contrast to meals, which are usually defined as structured eating occasions corresponding to breakfast, lunch, and dinner. Thus, relative to meals, snacking can be irregular in terms of schedule and composition (Enriquez & Gollub, 2023)

Ultra-processed Food (UPFs) Formulations consisting mostly of food-derived substances and additives, with little or no amount of fresh food, as well as including multiple manufacturing processes in their creation, such as hydrogenation, extrusion, pre-processing, etc.) (Monteiro et al., 2018)

original weight within 5 years (Hall & Kahan, 2018). Adherence to diet and physical exercise has been found to be poor due to a lack of consistent motivation, which the evidence shows plays a pivotal role in behavior change or maintenance (Suire et al., 2021). Therefore, in recent years, Motivational Interviewing has been added to traditional behavioral modification. This approach is used to support preparation for behavior change and maintenance of progress within weight-loss settings through raising motivation, self-efficacy and improving adherence to the other/main parts of intervention (Moss et al., 2017). However, recent reviews conclude that efficacy of the behavior approach remains limited even with the addition of Motivational Interviewing (Makin et al., 2021; Michalopoulou et al., 2022). Hence the need to focus on other factors that are impacting the effectiveness of behavioral change beyond motivation.

Some authors propose that the lack of effectiveness of lifestyle-based treatments for excess weight is related to the limited effect that set new intentions have on behavioral change (Adriaanse et al., 2010; McDermott et al., 2016; Stroebe, 2023). Thus, many people may be genuinely motivated to eat healthier, but their intentions do not reliably translate into actual behaviors in their daily lives (Churchill et al., 2019; Mann et al., 2013). One technique that has demonstrated to close that intention-behavior gap is Implementation Intentions (ImpInt) (Rodger et al., 2023). ImpInt consists of forming highly specific action plans with an "if-then" format (e.g., if I want to eat a sweet, then I will eat an apple), which identifies when, where, and how an intended behavior will take place (Gollwitzer & Sheeran, 2006). Therefore, action control becomes highly automatized: as soon as the specified cue ('if' component) occurs, the goal-directed behavior ('then' component) is elicited (Achtziger et al., 2021). In the general population, ImpInt has shown effective in both acquiring healthy eating (Adriaanse et al., 2011; Bieleke et al., 2021; Carrero et al., 2019; Gollwitzer & Sheeran, 2006) and reducing unhealthy eating (Achtziger et al., 2008; Adriaanse et al., 2009, 2011). In the context of weight loss interventions, ImpInt facilitates behavioral change towards achieving healthy lifestyle goals (Gollwitzer & Sheeran, 2006; Hagger & Luszczynska, 2014). In addition, some studies showed that interventions including ImpInt increased weight loss compared to standard behavior change weight loss programs (Armitage et al., 2014). However, other studies have found no reductions in body weight when adding ImpInt (Benyamini et al., 2013; Hayes, 2019; Knäuper et al., 2018).

Given these mixed results, it has been proposed that including other elements in the "if-then" strategy could improve the efficacy of the technique. Thus, ImpInt with Mental Contrasting (MC) (Oettingen & Schwörer, 2013) aims to identify the motivational enablers as well as the barriers to achieving intended action plans and goals (Loy et al., 2016). As found in Wang et al. meta-analysis (2021), studies have shown that combining MC with Implementation Intentions (MCII) is more effective in goal achievement than either MC or ImpInt applied in isolation (Adriaanse et al., 2010; Kirk et al., 2013). In short, MCII qualifies as a cost- and time-effective self-regulation intervention to enhance health and to prevent unhealthy behaviors (Valshtein et al., 2020).

Nevertheless, as far as we know, only three studies have explored the usefulness of MCII applied to dietary changes. Results showed that MCII reduces meat consumption in participants with a moderate to strong intention (Loy et al., 2016), reduced the consumption of unhealthy snacks in females (Adriaanse et al., 2010), and increased the consumption of fruits and vegetables in females too, maintaining positive changes two years after the intervention (Stadler et al., 2010). However, this technique has not yet been applied in people with excess weight.

Furthermore, only two studies have so far applied the MCII in an online format, focusing on reducing alcohol (Wittleder et al., 2019) and tobacco (Mutter et al., 2020) use, showing the potential effectiveness of the MCII as a brief online intervention.

In the present study we applied an MCII online with a specific focus on the modification of snacking, since several studies have shown that its consumption is one of the main contributors to excess weight (review in Mattes, 2018; Kong et al., 2011; Verhoeven et al., 2014). There is strong evidence that snacking is associated with increased energy intake and BMI. As concluded in Mattes (2018), irregular meal and snack patterns were associated with an increased waist circumference, BMI, and prevalence of metabolic syndrome. As pointed out in Adriaanse et al. (2010), focusing the MCII on snacking is relevant because the identification of cues that typically lead to unhealthy eating might be difficult especially for snacking. In addition to snack consumption, previous literature also associates excess weight with increased consumption of ultra-processed foods (UPFs) in the adult population (Askari et al., 2020). Also, recent reviews and meta-analyses link UPFs to other major health outcomes, including all-cause and cause-specific mortality, cardiovascular disease, body composition and fat deposition, diabetes, cancer, and gastrointestinal and other diseases (Lane et al., 2024; Zhang & Giovannucci, 2023). Thus, decreasing consumption of these products seems an important target for interventions for excess weight individuals.

Based on all the above literature, the aim of this study was to **determine the efficacy of including a one-week online Mental Contrasting with Implementation Intentions technique (MCII) as an add-on to a standard online Behavioral Weight Loss Intervention (TAU) to make snacking healthier and reduce BMI, compared to a sham intervention within the TAU and the TAU applied in isolation, in individuals with excess weight.** We hypothesized that MCII (i) improves snacking behavior (reduces frequency of snacking,

number of total servings consumed during snacking and number of ultra-processed food servings) and (ii) leads to reductions of BMI.

2. Methods

2.1. Study design

The present randomized controlled trial had three parallel arms and adhered to the CONSORT guidelines (Schulz et al., 2010). The present study was part of the comprehensive cognitive intervention project for people with excess weight "TRAINEP", registered at clinicaltrials.gov (NCT05158075) and carried out between March 2021 and December 2022. This paper presents the results of one of the four cognitive trainings offered in the program (MCII). Participants were allocated by randomization to one of three groups: a MCII-group who received the MCII training in addition to the TAU (consisting of Motivational interviewing, personalized diet and physical exercise guidelines); a Sham-group who received a Sham Inactive Parallel MCII Training in addition to the TAU; and an TAU-group who only received the TAU. This random treatment assignment was conducted through the software Minimizer® (Stout et al., 1994) to avoid imbalances between the groups in age, sex, and BMI by a researcher who had no contact with the participants. This researcher assigned each participant a random alpha-numeric ID using a web-based code generator.

2.2. Participants

Recruitment was announced on social media platforms through Instagram, Facebook and the web site of the study (trainep.ugr.es). Those interested in participating contacted the research team by email and were asked to complete an online eligibility survey using the LimeSurvey platform, which was followed with an individual interview to determine compliance with inclusion and exclusion criteria. Participants had to be between 18 and 55 years old and fluent in Spanish, a BMI between 25 and 39.9 kg/m2 self-reported in the survey and subsequently checked in the pre-intervention assessment session (see section 2.5) and have at least one smartphone available to attend the online meetings and receive notifications. Exclusion criteria included: (i) traumatic, digestive, metabolic, or systemic disorders that affect the central nervous, autonomic or endocrine systems, (ii) cardiovascular or any other disorders that prevent physical exercise; (iii) psychopathological disorders or presence of severe symptoms in the Depression Anxiety and Stress Scale-21 (DASS-21; Daza et al., 2002); (iv) eating disorders or presence of DSM-5 criteria in the Questionnaire on Eating and Weight Patterns-5 (QEWP-5; Yanovski et al., 2015); (v) current pharmacological or any other kind of treatment for losing weight; (vi) bariatric surgery done or be a candidate for it; (vii) current pregnancy or breastfeeding (or expected pregnancy in the following six months); (viii) weight loss >5 % during the 3 months previous to the program; (ix) current use of psychiatric or any other drug that affects weight or food intake (fluoxetine, olanzapine, etc.); (x) frequent use of alcohol (>3 days a week).

The sample size was calculated based on a meta-analysis exploring changes in healthy snack consumption after the intervention with MCII (Carrero et al., 2019), that reported a Cohen's $d = 0.33$. With this effect size, considering the statistical method (mixed ANOVA tests), the number of groups ($g = 3$), and assuming an alpha level of 0.05 and a power of 0.80, the required sample size calculated with G-Power v3.1.9.7 (Faul et al., 2009) was 147 participants. Finally, 148 people were randomized and received the intervention. Section 3 presents the socio-demographic results of recruitment and Fig. 1 shows the flow chart.

2.3. Procedure

The present study was conducted in accordance with the Declaration of Helsinki and the protocol was approved by the Ethic Committee of the University of Granada (1754/CEIH/2020), fully previously published (Solier-López et al., 2022). It was based at the Mind, Brain, and Behavior Research Center (CIMCYC) at the University of Granada (Spain). The timeline (Fig. 2) following the SPIRIT guide (Chan et al., 2013) shows the schedule of recruitment, interventions and evaluations. All interactions with participants during the trial were online through the services contracted by the University on the GoogleMeet (videoconference during the evaluation and intervention sessions) and LimeSurvey (to administer the assessment instruments) platforms. As an online study, measures were taken to improve data quality. These strategies included restricting access to the evaluation questionnaires (the password, which was the participant's ID, had to be entered to gain access) and the date and time to complete the test were collected and checked for consistency. The researcher ensured that the participants reported the data as rigorously as possible through a detailed group explanation

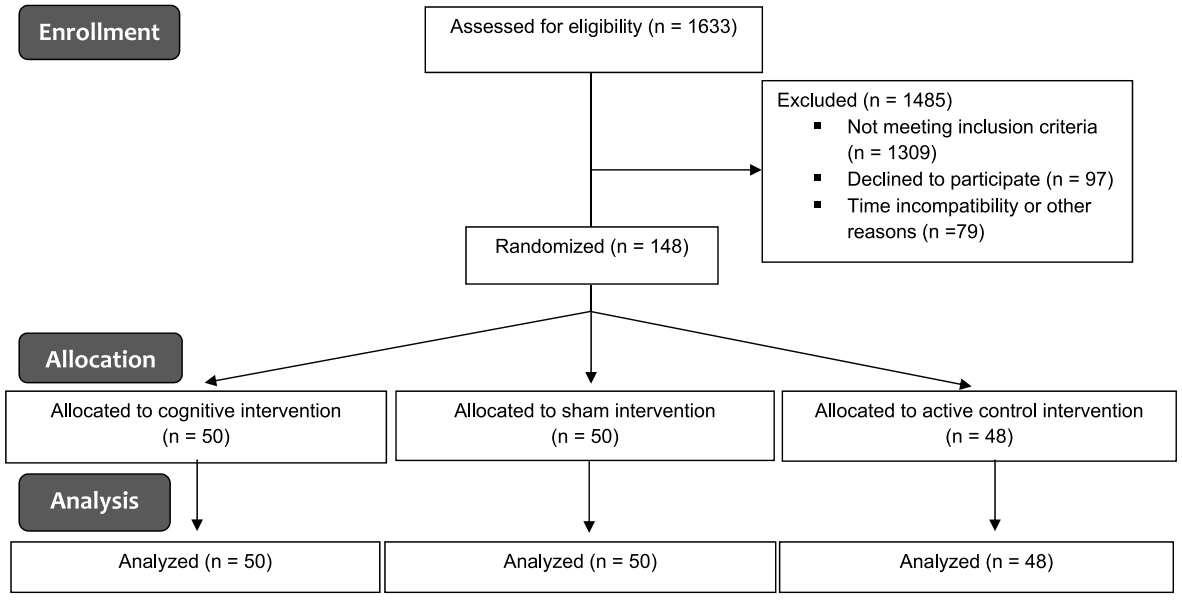

Fig. 1. CONSORT 2010 Flow diagram.

	STUDY PERIOD			
	Enrolment	Allocation	Post-allocation	
TIMEPOINT	$-t_1$	0	T_1	T_2
ENROLMENT:				
Eligibility screen	X			
Informed consent	X			
Allocation		X		
INTERVENTIONS:				
TAU sessions (Motivational Interview, nutrition and physical exercise)			X	
MCII session			X	
Sham session			X	
Diet and physical exercise personalized guidelines			◆—	—◆
MCII /Sham training			◆—	—◆
ASSESSMENTS:				
Sociodemographic measures			X	
BMI			X	X
Snack behavior			◆—	—◆

Fig. 2. Schedule of enrolment, interventions and assessments (SPIRIT). SPIRIT = Standard Protocol Items: Recommendations for Interventional Trials. T1 = 1-week before cognitive pre-intervention moment; T2 = post-intervention moment (one week after).

of the instructions to standardize the way self-reporting measures are taken and reported (see section 2.5). Subsequently, the researcher reviewed these self-records and confirmed the accuracy of the data, clearing up any possible doubts by asking the participant. In the same way, the worksheet of the intervention task (see Appendix A) was reviewed by the researcher, with the same subsequent verification of its proper completion.

Participants were told about the purpose of the study and provided with the participant information sheet in a first online group session, before signing the informed consent. Participants did not receive financial remuneration. Those in the Sham and TAU groups were offered the MCII after the study completion.

The study was double-blinded, and so neither the researcher conducting the assessments, nor the participants, were aware of the intervention group allocation. Only the researcher in charge of the interventions knew the participant's group. After being recruited and randomized, participants were organized into working groups of 5–7 people.

Blindness maintenance was assessed by asking participants, after the study completion: "Which experimental condition do you think you were in? How confident are you? Please, rate from 0 (not at all sure) to 10 (completely sure)". Further, *self-reported perceived usefulness of the interventions* was assessed asking participants to rate on a scale of 0–10 how useful they found: the MCII or Sham technique (whenever appropriate), the nutrition and exercise sessions and guidelines, the motivational interviewing, the group dynamics, as well as the professional attention and supervision.

2.4. Interventions

All participants received six online group sessions: one Motivational Interviewing, one with the nutritionist and another one with the physical trainer, two assessment sessions (pre- and post-treatment), and one experimental intervention session (participants in TAU-group, during the time of this intervention session, had monitoring). All participants received nutrition and physical exercise guidelines to carry out daily, so the only difference between groups was the MCII/Sham intervention focused on snacking. In both interventions, snacking has been defined as eating occasions typically characterized by casual consumption of small quantities of food, in contrast to meals, which are usually defined as structured eating occasions corresponding to breakfast, lunch, and dinner. Thus, relative to meals, snacking can be irregular in terms of schedule and composition (Enriquez & Gollub, 2023). Within snacking, unhealthy snacking is defined as the consumption of ultra-processed products (UPFs), understanding UPFs according to the NOVA classification ("formulations consisting mostly of food-derived substances and additives, with little or no amount of fresh food, as well as including multiple manufacturing processes in their creation, such as

hydrogenation, extrusion, pre-processing, etc.") (Monteiro et al., 2018).

Mental Contrasting with Implementation Intentions training (MCII): The MCII-group received a 90-min online group training session on MCII via GoogleMeet platform, given by a psychologist of the research group. The aim was improving snacking behaviors, replacing the unhealthy with healthy snacking. The MCII task was based on Adriaanse et al. (2010), Sniehotta et al. (2005) and Benyamini et al. (2013) (worksheet in appendix A). Instructions were read out loud to all participants. Each participant detailed a specific personal circumstance in which they would change their snacking, including the healthy alternative option they would consume. This resulted in an action plan that followed the structure "If-then" (e.g., "If I come home from work hungry in the evening, then I will eat an apple"). Furthermore, motivational cues ("why I eat?") were considered (e.g., emotions like sadness or pleasure, social motives, politeness/conformity with others, expectations, and so on). After that, potential barriers (obstacles) to fulfill the action plan were identified and solutions were identified in advance (Mental Contrasting) (e.g.: "What obstacles have prevented me in the past or could prevent me from eating an apple when I get home from work? Not having apples at home or having other more appetizing products. Anticipated solution: always write 'apples' on the shopping list and not buy products that tempt me"). Each participant wrote down their if-then plan in accessible places (e.g. on their mobile phones, on the fridge door, on a note in their wallet). During the 7 days following the training in MCII, to promote the implementation of the action plan, participants were asked to read their plan at least twice a day as homework. To facilitate this, participants received two daily reminders on their phones (at 7:00 a.m. and 5:00 p.m.). In addition, to maximize adherence, they were asked to answer two questions each evening on the implementation of the action plan, included in a self-report of snacking that was used as an assessment instrument (see section 2.5 and appendix B).

Sham Intervention: Participants in the Sham-group implemented a training without the active ingredients of MCII for one week. They attended a 90-min online group sham session via GoogleMeet platform, given by a psychologist of the research group. They attended a 90-min online group sham session via GoogleMeet platform, given by a psychologist of the research group. Following Adriaanse et al. (2010), participants were asked to think carefully about eating fewer unhealthy snacks and then to list their top ten healthy snacks (worksheet in appendix C). This condition was chosen to eliminate the possibility that any superior effects of the MCII active condition were caused merely by thinking about eating fewer unhealthy snacks by participants in this condition (Adriaanse et al., 2010). Parallel to the active group, participants received two daily reminders on their phones during the following week to read their healthy snack list as homework. In addition, they also had to answer two questions daily about their intention to snack healthy, included in a self-report of snacking that was used as an assessment instrument (see appendix D). Thus, the Sham Intervention was parallel to the MCII, with the difference that participants did not develop a personalized and concrete action plan, nor did they anticipate possible obstacles and solutions. Instead, they only set simple intentions related to healthier snacking making a list of ten healthy snack options.

Standard behavioral weight loss intervention (TAU): the three groups (MCII, Sham and TAU groups) attended a 1-h online meeting via Google Meet platform with a nutritionist and another one with a physical trainer. These two professionals sent participants a personalized diet and physical exercise guidelines with a weekly training plan (examples in appendix E and F). Furthermore, an explanatory video recorded by the nutritionist and another by the physical trainer (each lasting 20 min) about basic background knowledge were provided to participants before the meetings. In addition, all participants received a 90-min Motivational Interview group session aimed at reducing ambivalence about behavior change, via four core processes: engaging with the individual, focusing on specific behaviors to change, evoking change talk, and planning to enact change, based on Miller and Rollnick (2012). This Motivational Interview session was conducted in all three groups by the research psychologist in charge of applying the MCII and Sham interventions.

2.5. Outcome measures

Snacking behavior (frequency of snacking and number of total servings) were measured in a self-report (see appendix B). Participants completed the self-reporting of snacking seven days before and seven days after the MCII/Sham intervention session (taken from Verhoeven et al., 2014). The self-recording form was provided in Microsoft Word format, with one table for each day of recording. Participants could complete it electronically on their mobile devices or print it, fill it out by hand, and scan the completed form. In either case, the final file had to be uploaded to the Limesurvey platform at the end of each self-registration week for inclusion in the study database. To minimize recall bias, instructions delivered via Google Meet emphasized the importance of recording each snacking episode immediately to ensure accuracy. Participants were advised to keep the Word document readily accessible, such as on their smartphone. If immediate access to the form was not possible, they were instructed to temporarily record the details in their phone's notes app or a notebook and later transfer the information to the official document. To minimize measurement errors, examples of correctly completed self-records were presented during the Google Meet training session (see Appendix G), and participants' questions were addressed. Participants were instructed to report the quantity of food consumed in each snacking episode as precisely as possible, preferably in grams, or alternatively by specifying the number and size of units (e.g., "200 g of apple" or "one medium apple"). Rather than estimating the number of servings, they were asked to report the total amount consumed. The research team subsequently categorized these entries into servings to reduce variability arising from individual interpretations.

Participants had ongoing access to support from the psychologist who conducted the training, via WhatsApp and email, allowing them to resolve any questions throughout the self-registration period. The research team also reviewed submitted self-records to verify completeness and accuracy, contacting participants directly to clarify or correct missing or inconsistent data. Daily self-recording was further supported by two automated mobile reminders encouraging participants to make healthy snack choices. Self-reports submitted after the deadline were accepted, provided that the information had been accurately recorded during the appropriate week, either before or after the intervention session.

Frequency of snacking refers to the number of times per day that the snacking behavior was performed (number of times a snack was made during the week divided by seven). More than one serving can be consumed within the same snacking, and thus the total number of servings per day was also registered to obtain the average daily consumption. *To analyze the UPFs servings*, each self-reported serving was categorized according to a checklist for categorization of UPFs, following the NOVA classification (Monteiro et al., 2018).

BMI (kg/m2) was calculated by measuring weight and height from a pharmacy digital scale. The BMI was recorded before and after the intervention (that is, one week apart). Participants were instructed to take the measurements at both times using the same pharmacy digital scale at the same hour and under the same conditions to avoid measurement errors and control the influence of fluctuations in body weight due to external circumstances.

Participants had to upload their pharmacy scale measurements and snack records to the Limesurvey platform attaching photographs of the receipt of the digital pharmacy scale and the electronic documents or photographs of their self-reporting of snacking.

2.6. Statistical analysis

Baseline socio-demographic and health variables were compared using ANOVAs for the continuous variables and chi-squared tests for the

categorical variables ($\alpha = .05$).

To compare the groups on the different outcome measures, mixed-model repeated-measures ANOVA were performed (3 groups x 2 moments). In addition, *post-hocs* tests were carried out consisting of between-group analyses at pre-intervention and post-intervention (estimated marginal measures of the simple main effects group x time).

Since the model showed no differences between-groups in BMI, additional analyses were conducted to explore the clinical relevance of change. Thus, a one-way ANOVA of the individual-based standardized BMI pre-post change (adjusting for the standard deviation of each group) was performed. This approach has the advantage of revealing clinically relevant changes in scores on health-related measures to give meaning to the magnitude of change (Middel & Van Sonderen, 2002). It was calculated according to the following formula (Wyrwich et al., 2005): d individual = ($s2$ - $s1$)/s, where $s1$ = score of the individual at pre-intervention; $s2$ = the score of the individual at post-intervention; and s = the standard deviation of its group at pre-intervention.

Furthermore, Cohen's d effect sizes were derived using post-interventions means and standard deviations of each group at https://www.psychometrica.de/effect_size. Following the reference points suggested by Cohen (Cohen, 1988), the effect sizes were interpreted as small ($d = 0.2$–0.49), moderate ($d = 0.5$–0.79), and large ($d \geq 0.8$).

In addition, possible differences between participants in the three groups in the maintenance of the blind were analyzed using a chi-squared test. The self-reported perceived usefulness of the MCII and Sham interventions were compared by applying a t-test for independent means. The perceived usefulness of the other intervention tools (nutrition and exercise sessions and guidelines, motivational interviewing, group dynamics, professional attention and supervision) in all groups were analyzed using one-way ANOVA tests.

All statistical analyses were performed using the IBM® Statistical Package for the Social Sciences (IBM SPSS® Statistics 28).

The final database used, as well as the present results, are available in the repository osf.io/9j74d and that the lead author has full access to the data reported.

3. Results

3.1. Baseline data

Table 1 shows the socio-demographic and health characteristics of the sample at baseline by group. No significant differences were found between the groups. The percentage of women was high in all three groups (as frequently seen in the research of excess weight, between 83 and 88 % on average), mostly of Spanish nationality (95–98 %), average age between 43 and 45 years old, an average of 15 years of education, full-time work (between 72 and 79 % of participants), and half of the sample with a common income of over 2500€ per month.

3.2. Outcomes

All participants attended all evaluation sessions, without any drop-out in any group. If unforeseen events or time incompatibility prevented them from attending their group, they attended another group of their experimental condition (MCII, Sham or TAU) or individual sessions in case of time incompatibility.

Table 2 shows all the results of the mixed-model ANOVA comparing pre-post change between groups for each outcome variable, as well as pre and post intervention data. Table 3 shows the effect sizes between groups for all variables at post-treatment.

3.2.1. Snack consumption

Regarding *the frequency of snacking*, results showed a significant interaction group x time [F (2,134) = 6.110, $p = .003$], with the MCII-group obtaining greater reduction than the other two groups

Table 1
Baseline demographic and health characteristics of the groups.

		MCII (n = 50)	Sham (n = 50)	TAU (n = 48)	F/χ2	*p* value
Gender - % (Female)		88	88	83.3	χ2 = 0.604	.739
Age - yrs		44 (6.9)	43.6 (6.9)	45.2 (6.9)	F = 0.699	.699
Education - yrs		15.4 (5.5)	15.4 (5.1)	15.4 (5.3)	F = 0.000	1
Sleep - hs		7 (0.8)	6.9 (0.7)	6.8 (0.7)	F = 0.619	.540
Menopause/pre-menopause - % (yes)		38	30	43.8	χ2 = 2.005	.367
Higher weight in adulthood - kg		94.5 (13.8)	91.4 (17.6)	92 (14.8)	F = 0.584	.559
Motivation to participate in the program - %	A little	4	0	2.1	χ2 = 4.797	.570
	Quite	16	14	18.8		
	A lot	38	54	39.6		
	Very much	42	32	39.6		
Weight discrimination - % (yes)		38	42	45.8	χ2 = 0.618	.734
Country - % (Spain)		98	96	95.8	χ2 = 0.442	.802
Locality - %	Urban	70	48	68.8	χ2 = 8.006	.091
	Intermediate	22	36	27.1		
	Rural	8	16	4.2		
Marital status - %	Married/cohabiting	84	80	70.8	χ2 = 5.069	.535
	Single	12	8	12.5		
	Divorced	4	10	14.6		
	Widowed	0	2	2.1		
Cohabitation - %	Alone	8	6	8.3	χ2 = 3.951	.683
	With children	62	66	70.8		
	Adult family	30	28	18.8		
Net income - %	<600€	2	0	0	χ2 = 6.077	.809
	601€ - 1000€	0	4	4.2		
	1001€ - 1500€	8	4	8.3		
	1501€ - 2000€	10	6	10.4		
	2001€ - 2500€	24	30	27.1		
	>2500€	56	56	50		
Employment status - %	Full-time	72	74	79.2	χ2 = 5.271	.510
	Part-time	16	12	10.4		
	Unemployed	8	6	10.4		
	Student	4	8	0		

Note: Presented as mean (SD) or %.

Table 2
Descriptives and Mixed ANOVA results.

	Descriptives per group			Mixed ANOVA 3x2 (Group x Time)	Between group analyses *p* [b]		
Measures	MCII	SHAM	TAU	Interaction	MCII vs. SHAM	MCII vs. TAU	SHAM vs. TAU
	Mean (SD)	Mean (SD)	Mean (SD)	*F (p)*			
Frequency of snacking[a]				6.110 (.003)			
Pre	1.27 (0.96)	1.37 (0.87	1.33 (0.77)		.603	.767	.819
Post	0.54 (0.45)	1.10 (0.67)	1.12 (0.62)		<.001	<.001	.818
Total servings[a]				4.291 (.016)			
Pre	1.51 (1.09)	1.57 (1.05)	1.65 (0.92)		.789	.545	.731
Post	0.50 (0.51)	1.06 (0.73)	1.02 (0.70)		<.001	<.001	.811
UPFs servings[a]				4.059 (.020)			
Pre	1.39 (1.10)	1.21 (0.91)	1.41 (0.84)		.383	.901	.322
Post	0.42 (0.44)	0.65 (0.48)	0.91 (0.65)		.037	<.001	.028
BMI				3.990 (.022)			
Pre	31.83 (3.64)	31.13 (3.75)	30.28 (3.49)		.428	.078	.346
Post	31.55 (3.63)	30.98 (3.75)	30.16 (3.53)		.523	.117	.366

[a] Frequency of snacking, total servings and UPFs presented as daily average (frequency and servings per day during the week before the session vs. the week after).
[b] *post-hocs* tests consisting of between-group analyses at pre-intervention and post-intervention (estimated marginal measures of the simple main effects group x time).

Table 3
Effect sizes.

	Between group d_{Cohen} [a]		
	MCII vs SHAM	MCII vs TAU	SHAM vs TAU
Frequency of snacking	0.973	1.063	0.031
UPFs servings	0.500	0.885	0.455
Total servings	0.889	0.854	−0.056
BMI	−0.155	−0.388	−0.225
Standardized change in BMI	0.553	0.758	0.149

Note: positive values indicate that the mean of the first group is lower than that of the second.
[a] dCohen comparing the groups two by two at post-intervention moment.

[$M_{MCIIpre}$ = 1.27 (0.96), $M_{MCIIpost}$ = 0.54 (0.45)]. Between-group analyses showed no differences at pre-treatment, but differences between MCII and the Sham and TAU groups (the latter two equal) at post-treatment. Furthermore, effect sizes were large between the MCII and the other two groups (d_{sham} = 0.973, d_{TAU} = 1.063), and null between the Sham and TAU groups (d = 0.031).

In terms of *the total number of servings consumed during snacking* per *day,* the interaction group x time was also significant [F (2,126) = 4.291, p = .016], with the MCII-group obtaining greater reduction than the other two groups [$M_{MCIIpre}$ = 1.51 (1.09), $M_{MCIIpost}$ = 0.50 (0.51)]. No differences were found between the groups at pre-treatment, but the MCII-group showed differences with the Sham and TAU groups at post-treatment, with large effect sizes (d_{sham} = 0.889, d_{TAU} = 0.854), and null between the Sham and TAU groups (d = - 0.056).

For the number of UPFs servings, results also showed a significant group × time interaction [F (2,127) = 4.059, p = .020], with the MCII-group obtaining greater reduction than the other two groups [$M_{MCIIpre}$ = 1.39 (1.10), $M_{MCIIpost}$ = 0.42 (0.44)]. Between-group analyses showed no differences at pre-intervention, but differences between all groups at post-intervention. Effect sizes were moderate and large between MCII and the other two groups (d_{sham} = 0.500, d_{TAU} = 0.885) and small between Sham and TAU (d = 0.455).

3.2.2. BMI

Regarding *BMI*, despite a significant group × time interaction [F (2,98) = 3.990, p = .022; $M_{MCIIpre}$ = 31.83 (3.64), $M_{MCIIpost}$ = 31.55 (3.63)], no between-group differences were found. Thus, a planned one-way ANOVA of the individual-based standardized pre-post change was conducted, and differences between groups were found [F (2,103) = 3.990, p = .006]. The MCII-group obtained the largest standardized change in the BMI [M_{MCII} = − 0.8 (0.08), M_{Sham} = - 0.04 (0.07), M_{TAU} = - 0.03 (0.06)]. *Post-hocs* showed differences with moderate effect sizes between MCII and both the Sham (p = .014, d_{sham} = 0.553) and TAU (p = .002, d_{TAU} = 0.758) groups, with no differences between the latter two (p = .554, d = 0.149).

3.3. Manipulation checks

After the intervention, participants were tested for *maintenance of the blindness*. No differences between groups were found considering the participants who were more confident than chance (>5 on a scale of 0–10) in guessing their experimental condition (24 % of MCII-group, 10 % of the Sham-group and 22.9 % of the TAU-group participants) [$\chi 2$(2) = 5.105, p = .078]. Furthermore, blindness was maintained since no more than 50 % of the participants discovered their belonging in any group (Boutron et al., 2005).

The t-test of independent means about *the self-reported perceived usefulness of the MCII vs. Sham intervention* showed no difference between MCII-group and Sham-group [t (84) = 1.480, p = .143] [M_{MCII} = 8.9 (1.6), M_{sham} = 8.3 (1.6) on a 10-point Likert-type scale where 0 is "not at all useful" and 10 is "very useful"].

No differences were found between groups in the one-way ANOVAs carried out to study the *self-reported perceived usefulness of common intervention tools in all three groups* (table with results in appendix H). Both the nutrition and exercise material, the Motivational Interviewing, the group dynamics derived from the group sessions, and the weekly attention and supervision received from the psychologist of the research team were useful, all being scored above 7 on a ten-point Likert scale (0 = not at all useful; 10 = very useful).

No negative effects or harms were detected in any of the three experimental conditions.

4. Discussion

We showed that the Mental Contrasting with Implementation Intentions Training (MCII) as an add-on to a standard Behavioral Weight Loss Intervention (TAU consisting of Motivational interviewing, personalized diet and physical exercise guidelines) reduces snacking behavior and BMI in people with excess weight. One MCII intervention session added to the TAU, followed by the practice of the technique by the participants at home for one week, produced significantly greater changes compared to the TAU in isolation or joined to a sham version of the MCII. Specifically, MCII led to greater reduction in the frequency of snacking, in the total servings during snacking, as well as in consumption of ultra-processed foods (UPFs), and in BMI.

The changes found on snacking behavior in people with excess weight are consistent with the evidence of MCII benefits in modifying other eating-related behaviors in the general population. Specifically,

the usefulness of MCII in reducing the frequency of unhealthy snacking in a female population with normal weight after one week of intervention had already been demonstrated (Adriaanse et al., 2010). With our study we extend previous research, demonstrating the usefulness of the technique to modify snacking in the excess weight population. This finding is relevant given that snacking is a behavior highly associated with excess weight, and especially problematic when it is unplanned, uncompensated, and contributes to an irregular eating pattern (Mattes, 2018). Furthermore, our data show not only a decrease in the frequency of snacking in general (decreasing the number of times snacking and the total number of servings consumed during such snacks), but a specific reduction in servings of UPFs. That is, snacking behavior is modified both in quantity (less snacking occurs on fewer occasions) and in quality (when snacking occurs, there are fewer UPFs servings). Regarding the consumption of UPFs servings, it is worth mentioning the statistically significant difference found not only between the MCII-group and the other two, but also between the Sham and the TAU groups. This indicates that although the task performed in the Sham-group (the simple intention to snack healthily and the writing of a list of healthy snacking options) does not generate greater benefits in reducing the quantity of snacking (no differences were found in the Sham-group in the frequency of snacking nor in the total servings compared to the TAU), it does improve its quality, but only with a small effect size, below the moderate-large ones of the MCII. This decrease in the consumption of UPFs during snacking becomes valuable since higher consumption of UPFs have been associated with significantly higher 5-year body weight gain in a dose-response manner (Cordova et al., 2021). In addition to the association of UPFs with weight problems, the link between their consumption to other major health outcomes and diseases (Lane et al., 2024; Zhang & Giovannucci, 2023), as well as adverse mental health (Lane et al., 2022) highlights the importance of our finding.

Furthermore, our data also show the benefit of MCII in reducing BMI. Although no differences were found between groups in the mixed ANOVA, a higher standardized change in BMI was found in MCII compared to the other two groups, revealing the clinical relevance of the magnitude of change (Middel & Van Sonderen, 2002). This corroborates the greater benefit of the MCII intervention over the other two. This positive result on the BMI is relevant given that it is an index associated with health status. Recent robust systematic literature reviews such as that of Safaei et al. (2021) confirm the close relationship between BMI and various health conditions, increasing the risks of individuals for other primary lifestyle diseases, which include coronary heart disease, hypertension and stroke, type 2 diabetes (mellitus), sleep apnea, and osteoarthritis. Moreover, there is evidence that a modest weight loss achieved can prevent and/or reverse some of this obesity-associated comorbidities, having beneficial effects on conditions such as type 2 diabetes, nonalcoholic steatohepatitis, dyslipidemia, hypertension, obstructive sleep apnea, cardiovascular/cerebrovascular disease, hyperinsulinemia, inflammation, gastro-esophageal reflux, changes in sex hormones and fertility (Sarma et al., 2021). These multiple comorbidities explain why BMI is a marker directly related to quality of life: Even in healthy people with obesity, there is a clear and independent inverse relationship between BMI and Health Related Quality of Life (HRQoL) (Stephenson et al., 2021), patient activation (i.e., the patient's commitment to his or her own health care), work productivity, and weight loss behaviors (Rozjabek et al., 2020). In short, the reduction achieved in both UPFs consumption and BMI in our study would have a positive impact on overall health.

However, despite the positive findings from the ANOVA on standardized BMI change, it is important to consider possible explanations for the absence of significant differences in the mixed ANOVA. One likely factor is the short interval between the pre- and post-intervention assessments, as a substantial reduction in BMI would not typically be expected over a one-week period. In such a short timeframe, changes in behavior are more plausible than measurable anthropometric outcomes. Furthermore, the action plan generated and carried out by each participant within the MCII intervention primarily focused on replacing unhealthy snacks with healthier alternatives (e.g., "if I want to eat a sweet, then I will eat an apple"). Therefore, the goal was not to reduce caloric intake directly, but rather to improve the nutritional quality of snacking—specifically, by reducing the consumption of UPFs. While this may reflect a positive dietary change, many non-UPF foods, though considered healthy, can still be calorically dense. This may have limited the short-term impact of MCII on BMI. Future interventions targeting individuals with excess weight should therefore consider not only the healthiness of food choices but also their caloric content. Developing action plans that aim to reduce the frequency of snacking altogether—potentially by replacing it with non-food-related activities—may enhance the effectiveness of MCII-based strategies in promoting weight loss.

With respect to our trial, the subjective utility measure of both the MCII and the sham technique reveals that both are perceived as "very useful", confirming the validity of the sham procedure used in the parallel non-cognitive intervention. Similarly, all three groups of participants rated very positively the usefulness of all the intervention tools common to all three groups (nutrition and exercise sessions and guidelines, motivational interviewing, group dynamics and professional supervision). This, along with the maintenance of the blindness, allows us to conclude with a greater degree of certainty that the differences found between the groups in the outcome measures of the study are due to the active components of the MCII cognitive intervention. Thus, our findings support the theoretical basis of the present study, in which a self-regulation strategy (ImpInt) is combined with a goal-setting component (Mental Contrasting) to enhance goal attainment (Wang et al., 2021). Notably, these effects emerged after only one week of intervention, highlighting the potential of this approach for producing rapid behavioral change. The formation of a simple "If-then" plan linked to a specific trigger, enriched with the motivational-contextual elements of Mental Contrasting, appears to facilitate the translation of intentions into action. Both the Sham and MCII groups set intentions related to healthier snacking and participants in both groups reported being satisfied with the intervention they received. Therefore, the superior outcomes observed in the MCII group cannot be attributed to general therapeutic factors such as patient engagement or placebo effect. Instead, the underlying mechanism likely relates to the specific components of the MCII, particularly its capacity to reduce the intention-behavior gap. This is achieved by automating action control and helping individuals identify both the motivational drivers and the barriers to achieving their goals (Achtziger et al., 2021; Loy et al., 2016). A possible explanatory mechanism may involve impulsivity. De Pretto et al. (2017) found that ImpInt training improves inhibitory control in Go-NoGo tasks, with effects observable at both behavioral and electrophysiological levels. According to these authors, ImpInt may generate a stimulus-driven retrieval of verbally encoded stimulus-response rules which automatically activate inhibitory processes—a bottom-up form of control. However, those findings were derived from studies with healthy subjects using non-food stimuli, and without the context of a sustained habit-change intervention. Therefore, future research on cognitive interventions aimed at changing health-related behaviors should incorporate measures of impulsivity, as well as self-perceived control over the targeted behavior, to explore whether these neuropsychological mechanisms are similarly engaged in populations with excess weight.

In the present study, we have applied the intervention online and in group mode for the first time, proving to be as effective in people with excess weight as in the other populations tested above (Mutter et al., 2020; Wittleder et al., 2019). All this adds cost-effectiveness and efficiency to the application of the technique by saving time and money, eliminating physical barriers and allowing it to reach many more people. These aspects are relevant for the use of MCII in the clinical setting, thus favoring the reduction of the social costs associated with excess weight, including those related to the health sector (Hecker et al., 2022).

4.1. Limitations and strengths

The main limitation of the present study is that the effects of the technique have only been evaluated immediately after one week of intervention, so the medium-to long-term repercussions are unknown. Therefore, it should be recognized that this short period of time between evaluation moments requires a cautious interpretation of the results obtained. It would be interesting to include follow-up measures to be able to observe whether the changes are maintained over time, thus eliminating the problem related to the rebound effect that is currently present in many interventions in people with excess weight. Moreover, the online format required the use of self-reported measures. Nevertheless, different strategies were applied to reduce possible biases, such as the guidelines given to participants on how to measure weight, added to the randomization process (which would equalize possible individual errors between groups), favoring the reliability of the data collected.

In terms of strengths, this study has several points to highlight. Firstly, it is the first study to show the efficacy of MCII in people with excess weight, demonstrating improvements in both snacking behavior (frequency, number of servings and consumption of UPFs) and BMI in this population. Another strength of the study is its experimental design, comparing the intervention with both the TAU in isolation and with a sham procedure, which allows us to be more certain about the results of the MCII. Finally, at the clinical level, the results are especially relevant as the intervention was conducted online, in group, and in a single session.

4.2. Conclusion

This study is the first to demonstrate the efficacy of MCII as an add-on to a standard Behavioral Weight Loss Intervention (based on Motivational interviewing, diet and physical exercise guidelines) to decrease frequency of snacking behavior, total servings and UPF servings, as well as to reduce BMI in people with excess weight. In just one week of training in an online group format, immediate changes are achieved. These findings are important as they suggest that MCII may be a promising strategy not only for fighting unwanted habits, but also ultimately to achieve greater weight loss. It will be interesting to study in future research the medium-long term effect of this technique in this population, to analyze whether it also facilitates maintaining the reduction in BMI and changes in nutritional habits.

CRediT authorship contribution statement

Raquel González-González: Writing – original draft, Investigation, Data curation, Visualization, Formal analysis. **Lucía Solier-López:** Writing – review & editing, Formal analysis, Investigation, Data curation. **Raquel Vilar-López:** Writing – review & editing, Validation, Project administration, Funding acquisition, Visualization, Supervision, Methodology, Conceptualization. **Antonio Verdejo-García:** Visualization, Software, Methodology, Writing – review & editing, Validation, Resources, Conceptualization. **Carmen F. Navarro-Pérez:** Visualization, Investigation, Writing – review & editing, Resources. **Alfonso Caracuel:** Visualization, Supervision, Methodology, Conceptualization, Writing – review & editing, Validation, Project administration, Funding acquisition.

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Ethical statement

The research team of this study states that the privacy rights of human subjects have been observed and it was conducted in accordance with the Declaration of Helsinki. Participants were told about the purpose of the study and provided with the participant information sheet in a first online group session, before signing the informed consent. The protocol for this study was approved by the Ethic Committee of the University of Granada (1754/CEIH/2020) and fully previously published (Solier et al., 2022).

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.appet.2025.108209.

Data availability

Data will be made available on request.

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