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Obesity Treatment

Mindfulness-based interventions for weight loss: a systematic review and meta-analysis

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Summary

Background: An increasing number of studies are investigating the efficacy of mindfulness-based interventions (MBIs) for weight loss and obesity-related eating behaviours. However, the results of past reviews are inconsistent.

Objective: To clarify these inconsistencies, we conducted a comprehensive effect-size analysis to evaluate the efficacy of MBIs on weight loss and eating behaviours.

Data source: Data sources were identified through a systematic review of studies published in journals or as dissertations in PsychINFO, PubMed, CINAHL, Web of Science, Medline and Scopus, ProQuest or OATD from the first available date to March 10, 2017.

Review methods: A total of 18 publications (19 studies, n = 1,160) were included.

Results: Mean weight loss for MBIs at post-treatment was 6.8 and 7.5 lb at follow-up. In pre–post comparisons, effect-size estimates suggest that MBIs are moderately effective for weight loss (n = 16; Hedge's g = .42; 95% CI [.26, .59], $p < .000001$) and largely effective in reducing obesity-related eating behaviours (n = 10; Hedge's g = .70; CI 95% [.36, 1.04], $p < .00005$). Larger effects on weight loss were found in studies that used a combination of informal and formal meditation practice (n = 6; Hedge's g = .55; CI 95% [.32, .77], $p < .00001$) compared with formal meditation practice alone (n = 4; Hedge's g = .46; CI [.10, .83], $p < .05$).

Conclusion: Results suggest that MBIs are effective in reducing weight and improving obesity-related eating behaviours among individuals with overweight and obesity. Further research is needed to examine their efficacy for weight loss maintenance.

Keywords: Meta-analysis, mindfulness, weight loss.

Introduction

Obesity has become a major health concern over the past decade (1) and is associated with decreased life expectancy (2). It is a leading cause of preventable diseases, including type 2 diabetes, high blood pressure, heart disease and stroke (3). Annual healthcare costs attributed to obesity are upwards of $207 bn in the USA alone (4,5). Lifestyle change programs that focus on diet and exercise are considered a gold standard for obesity treatment and prevention (6,7). Despite their initial success, many of these interventions are less robust in the long-term (8). Although participants lose an average of 7% to 10% of initial body weight (9), they tend to regain one-third of this lost weight within a year after treatment, and by 5 years, approximately half of all participants will return to their original weight (10,11). Even the best examples of lifestyle change programs have only succeeded in maintaining clinically relevant weight losses (≥5% of initial body weight) in half of their participants at follow-up (12,13). Although lifestyle modification programs are effective in the short-term, long-term weight loss and its maintenance remain a challenge (14).

Overweight and obesity can be conceptualized as a dysregulation of various physiological and psychological

processes (15–17). It has been theorized that obesity-related eating behaviours are partially explained by a failure to recognize and respond to internal cues of hunger and satiety (18,19). This lack of internal awareness has been associated with more episodes of overeating (20) and a higher risk for weight gain (21,22). Weaker skills in emotion regulation have also been shown to be associated with certain obesity-related eating behaviours, namely, emotional eating and stress eating (23,24). More than half of all individuals with overweight and obesity compulsively overeat in response to negative emotions (25,26). Consequently, emotional eating is a strong predictor of body mass index (27–29) and is negatively associated with weight loss and its maintenance (30–32). Furthermore, the physiological discomforts associated with highly decreased caloric consumption and increased physical activity may also present an added barrier to long-term weight loss (33). Although many individuals with overweight and obesity consider these sensations as extremely unpleasant (34–36), most lifestyle change programs do not provide effective strategies to manage or overcome them. As a result, successful weight loss and its maintenance may be hindered.

Because effective weight management requires continued self-monitoring of weight and food intake (37), including an increased awareness of external triggers that drive overeating (38), mindfulness training has been proposed as a tool to help solve the growing obesity problem (39). It has been theorized that mindfulness training may facilitate long-term changes in diet and exercise (40,41). Behavioural modification is central to successful weight loss and its maintenance. Higher present-moment, non-judgemental awareness may assist an individual in recognizing and altering behavioural responses to internal cues (e.g. thoughts/emotional reactions) and external cues (e.g. environmental triggers) that would otherwise go unnoticed. Mindfulness may also improve the long-term compliance of lifestyle changes necessary for weight loss by facilitating the tolerance of adverse discomforts associated with calorie restrictions and increased physical activity.

Western contemporary psychology defines mindfulness as a state of awareness that arises from purposefully attending to ongoing experiences in a manner that is non-judgmental and accepting (42–44) (for a more comprehensive review of different definitions of mindfulness please refer to Khoury and colleagues (45)). This present-moment awareness is predominantly cultivated in two ways. The first way is through formal meditation practice, which requires an individual to designate specific times during the day to meditate, as seen in programs such as mindfulness-based stress reduction (MBSR) (46) or mindfulness-based cognitive therapy (MBCT) (47). The second, non-traditional approach is through informal exercises that are incorporated in daily life. During these exercises, individuals are asked to be completely aware of sensations experienced during everyday activities like walking or eating. Both approaches encourage a heightened awareness of body experiences, such as hunger and satiety, which may be fundamental in interrupting habitual responses to overeat when under emotional distress.

In the past 5 years, three systematic reviews and two meta-analyses have examined the effectiveness of mindfulness-based interventions (MBIs) on problematic eating behaviours and weight loss. In a review by Katterman and colleagues (48), improvements in binge-eating and emotional eating were reported for nine out of the eleven studies reviewed. Further support was provided by O'Reilly and colleagues (49) who documented improvements in binge-eating, emotional eating and external eating in 18 out of 21 studies reviewed. Significant weight reductions were also reported by Olsen and Emery (33) in 13 out of 19 studies reviewed. A meta-analysis of 12 studies conducted by Ruffault and colleagues (50) revealed negative effects for mindfulness training on impulsive eating behaviours and binge-eating as well as positive effects on physical activity levels. No significant effects were, however, found for weight loss. An additional meta-analysis by Rogers and colleagues (51) investigated the effects of MBIs on weight loss, eating behaviours and psychological outcomes in individuals with overweight and obesity. Findings showed large effects of MBIs on eating behaviours, medium effects on psychological variables and small effects on body mass index for the 15 included studies.

Although the aforementioned reviews and meta-analyses showed promising effects of mindfulness training on obesity-related eating behaviours and physical activity, including mixed effects on weight loss, they have several notable limitations. Except for Rogers et al. (2017), all authors included studies that combined formal meditation practice (e.g. Mantzios & Giannou (52)), informal mindfulness exercises (e.g. Kidd, Graor & Murrock (53)) or a mixture of both (e.g. Daubenmier and colleagues (54)) in their investigations. As stated earlier, formal meditation practice and informal mindfulness exercises differ significantly and should therefore be analysed separately. Separating both approaches will help to determine their independent effects on weight loss and other obesity-related outcomes, which, until now, remain unclear. Moreover, the reviews and meta-analyses included studies that incorporated complementary strategies such as acceptance commitment therapy (ACT) (33,49,50), cognitive behavioural therapy (33,48,50,51) and dialectical behaviour therapy (DBT) (50). Even though ACT and DBT fall under an umbrella of "third-wave cognitive behavioural treatments" (for a comprehensive review of third wave behavioural strategies see Öst (55)), they do not contain the same elements that form the basis of traditional mindfulness meditation approaches, while cognitive

behavioural therapy does not contain any mindfulness-related element. Combining such strategies may therefore result in misleading interpretations. Furthermore, both meta-analyses did not examine mindfulness as a potential moderator of the intervention effects, even though previous meta-analyses have found that mindfulness strongly moderates the effects of included interventions (56–58). Examining mindfulness as a potential moderator is important as it assists in distinguishing the effects of mindfulness practice from the effects of other complementary strategies. In addition, all previous reviews and meta-analyses did not include quality scores for the selected studies, which are important indicators of the strength of the findings. A final limitation is that the authors (48–51) combined clinical (e.g. binge-eaters) and non-clinical populations in their findings. This could be problematic as these two groups may differ significantly in terms of their responsiveness to MBIs. Examining these two populations separately will allow the investigation of potential differences in effectiveness between these two groups.

Objectives

To address the aforementioned weaknesses, we conducted a comprehensive effect-size analysis to examine the efficacy of MBIs on weight loss and other obesity-related outcomes among individuals with overweight and obesity. The objectives are as follows (i) quantify and compare the magnitude of the effects of MBIs on weight loss (ii), investigate mindfulness' role in the effectiveness of MBIs on weight loss, specifically comparing the effects of formal and informal practices on weight loss, and (iii) to quantify effects and moderators of MBIs on psychological outcomes.

Methods

Eligibility criteria

All studies examining the effects of MBIs on weight loss were eligible for inclusion in the meta-analysis. Studies were excluded if (i) weight loss was not a primary treatment objective (ii), mindfulness was not a primary treatment method or (iii) the study did not include sufficient data to compute effect size. MBIs included in the meta-analysis were MBSR (59), MBCT (47), Mindfulness-Based Eating Awareness Training program (MB-EAT) (60) and derivatives of the aforementioned programs. MBSR was first developed to facilitate stress reduction in medical patients, while MBCT was originally created to prevent recurrent relapse of major depressive episodes. Although MB-EAT was first developed as a treatment for binge-eating disorder (61,62), derivatives of the program are currently being implemented in non-clinical populations as an intervention for weight loss (e.g. Timmerman & Brown (63); Mason and colleagues (64); Daubenmier and colleagues (54)). Even though third-wave cognitive behavioural therapies such as ACT and DBT contain elements of mindfulness, they were excluded from our analyses as these programs include additional cognitive and behavioural components, which can lead to confounding interpretations regarding the effectiveness of mindfulness as a strategy for weight loss.

Information sources

Studies were identified by searching PsychINFO, PubMed, CINAHL, Web of Science, Medline and Scopus. Dissertations were identified by searching ProQuest and OATD. An additional manual search involved references from retrieved articles, and by using Google Scholar to access the searched papers.

Search

We used the search terms: mindfulness, mindful, mindfulness-based stress reduction, Mindfulness-Based Eating Awareness Training and mindfulness-based cognitive therapy in combination with weight, weight loss, weight management, obesity or overweight.

Study selection

Eligibility assessments were performed in a non-blinded, standardized manner by the first author and were reviewed by the third author. Disagreements between reviewers were resolved through discussions; when required, authors from the original studies were contacted for clarifications or to request missing data in order to compute effect sizes.

Data collection process

We developed an electronic data extraction sheet, pilot tested it on three randomly selected studies and refined it accordingly. Data collection was conducted in September 2016 and revised in March 2017. When duplicate reports were identified for the same data, only the most current ones were included.

Data items

Information was extracted from each trial based on (i) the characteristics of the trial (including the year of publication, design, randomization, blinding, therapist qualifications, number of participants, types of outcome measures and follow-up time in weeks) (ii); the characteristics of the intervention (including the target population, length of treatment, treatment type, i.e. informal or formal mindfulness, or a combination of both, and treatment setting). In order to provide a separation between our categorization

of informal and formal practices, interventions were only classified under the category of "formal" meditation practice when study participants were specifically asked and expected to meditate outside of their daily activities throughout the duration of the intervention (iii); the characteristics of the comparison group, in controlled studies (including the number of participants, type of control, type of treatment and length of treatment); and (iv) the characteristics of participants (including mean age, percentage of males/females and mean attrition rate for included studies).

Risk of bias in individual studies

To minimize the influence of data selection, we included data pertaining to all available psychological and weight-relevant outcomes, including among others, perceived stress, depression, emotional eating and cognitive restraint. Among potential mechanisms of action, we included measures of mindfulness and eating behaviours. When available, we included data from follow-ups.

We also included a study quality score, which was comprised of items based on Jadad's criteria (65) and others pertaining to mindfulness/meditation. The items include the program's adherence to traditional mindfulness-based interventions (MBSR, MBCT, MB-EAT): administration of measures at follow-up; use of validated mindfulness measures (44,66,67) (see Baer (68) for a more comprehensive review of mindfulness assessment measures); and training of therapists/facilitators (i.e. formal training in mindfulness meditation). For controlled studies, items included whether participants were randomized between the treatment and control groups, whether participants in both groups spent an equal amount of time in treatment and whether evaluators or experimenters were blind in regards to the treatment/control conditions and/or participants were blind in regards to the study's hypotheses. For all binary items (i.e. true or false), a value of 1 was assigned if the item was true, and a value of 0 was assigned if the item was false. For the study design, pre–post studies were assigned a value of 0; studies with a waitlist, no-treatment, or drop-out control group were assigned a value of 1; studies with an active treatment control were assigned a value of 2.

The inter-rater agreement was assessed by comparing the ratings of the first author (K. C.) with the ratings of the third author (M. G.), who received a written document including specific instructions on rating the studies and 1-h training about the rating procedure.

Results of individual studies

Hedge's *g* values for both clinical and mindfulness outcomes measures and both post treatment and last follow-up are presented in Table 1.

Summary measures

The meta-analysis was performed by computing standardized differences in means. We completed all analyses using Microsoft Excel 2010 and Comprehensive Meta-Analysis, Version 3.070 (69).

Synthesis of results

Effect sizes were computed using means and standard deviations when available. For remaining studies, effect sizes were computed using others such as F, p, t and χ^2. In with-group analyses, when correlations between pre-treatment and post-treatment measures were not available, we used conservative estimate (r = .70) according to the recommendation of Rosenthal (70). For all studies, Hedge's g, its 95% confidence interval (95% CI) and the associated z and p values were computed. To calculate the mean effect size for a group of studies, individual effect sizes were pooled using a random effect model rather than a fixed effect model, taking into account that the selected studies were not identical (i.e. their designs or target populations were not identical).

For all studies' groups, the mean Hedge's g, the 95% CI and the associated p values were computed. We systematically assessed the heterogeneity among studies in each group using I^2 and the chi-squared statistic (Q). I^2 measures the proportion of heterogeneity to the total observed dispersion and is not affected by low statistical power. Higgins, Thompson, Deeks and Altman (71) suggested that an I^2 of 25% might be considered low, 50% might be considered moderate and 75% might be considered high.

Risk of bias across studies

To assess publication bias, we computed the fail-safe N (70) and we constructed a funnel plot.

Additional analyses

According to the objectives of this meta-analysis, we conducted meta-regression analyses. The aim of a meta-regression is to explore one or more variables (called moderators) that account for the systematic differences in effect size, or outcome, that is being analysed. In this meta-analysis, we only included pre–post effect sizes, and we investigated two moderators (i) study quality score and (ii) treatment length. We also conducted a meta-regression analysis of the relationship between changes in mindfulness and eating behaviours on weight loss and psychological outcomes at post-treatment.

Table 1 Description and effect size analyses of the efficacy of included studies

Study	Type participants (*N*)	M. age	% Female	Tx group (*n*)	Comp. group (*n*)	Rnd ass	% Att	Tx h	Outcome measures (mind. measures)	Pre–post *g*(*gm*)	Fup wks	Pre-Fup *g*(*gm*)	Cntrl *g* post (gm)	Cntrl *g* fup (gm)	Sc
Alberts et al., 2010 (84) (both)	Overweight and obese adults (19)	Tx+ Cntrl 51.88	Tx+ Cntrl 89.5	DGT +MT (10)	DGT (9)	Yes	0	10.5	Weight; G-FCQ-T	1.64	–	–	1.90	–	4
Barnes et al., 2016 (80) (Informal)	Overweight and obese adolescents (40)	Tx+ Cntrl 16.2	Tx+ Cntrl 69.0	MB-EAT-A (18)	HE (22)	Yes	15.0	12.0	Weight; PSS; BES; TFEQ	−0.13	–	–	−0.58	–	6
Blevins, 2008 (76) (Formal)	College women (41)	Tx 21.0 Cntrl 21.0	Tx+ Cntrl 100.0	SBWL +MT (21)	SBWL (20)	Yes	43.9	6.0	Weight; BDI-II; STAI; QEWP-R (MAAS)	0.61	12	0.73	−0.61	−0.01	8
Chung et al., 2015 (79) (Informal)	Overweight and obese AA women BC patients (26)	50.1	100.0	MEI (26)	–	–	15.4	12.0	Weight; (MEQ)	0.15 (0.38)	–	–	–	–	1
Corsica et al., 2014 (74) (Formal)	Overweight adults (53)	Tx + Cntrl 45.4	Tx + Cntrl 98.0	MBSR-M (19)	SEI (20)	Yes	26.4	5.0	Weight; PSS; EADES-ESE	0.91	6	0.17	0.22	0.10	7
Study	Type participants (*N*)	M. age	% Female	Tx group (*n*)	Comp. group (*n*)	Rnd ass	% Att	Tx h	Outcome Measures (mind. measures)	Pre–post *g*(*gm*)	Fup wks	Pre-Fup *g*(*gm*)	Cntrl *g* post (gm)	Cntrl *g* fup (gm)	Sc
Dalen et al., 2010 (83) (both)	Obese YMCA individuals (10)	44.0	70.0	MEAL (10)	–	–	0	12.0	Weight (1); TFEQ; BES; BDI; BAI; PSS; (KIMS)	0.38 (0.42)	12	0.27	–	–	2
Daly et al., 2016 (78) (Informal)	Obese adolescent Latinas (37)	Tx 15.4 Cntrl 15.6	Tx+ Cntrl 100.0	MEI (14)	TAU (23)	Yes	37.8	9.0	Weight; (MAAS)	–	4	–	0.95	–	5
Daubenmeir et al., 2011 (54) (both)	Overweight and obese women (47)	Tx 40.4 Cntrl 41.4	Tx+ Cntrl 100.0	MPSE (24)	WLC (23)	Yes	25.5	29.5	Weight; BRS; WCSI; PSS; STAS; DEBQ (KIMS)	0.30 (0.64)	–	–	0.09 (0.86)	–	5
Davis, 2008 (75) (both)	Overweight and obese adults (71)	Tx 45.5 Cntrl143.4 Cntrl2 46.2	Tx 95.0 Cntrl1 81.3 Cntrl2 86.7	SBWL +MT (24)	SBWL (24) SBWL +RT (23)	Yes	28.2	21.0	Weight; EBI (MAAS)	2.25 (0.20)	–	–	0.85 (−0.24)	–	8

(*Continues*)

Table 1 (Continued)

Study	Type participants (*N*)	M. age	% Female	Tx group (*n*)	Comp. group (*n*)	Rnd ass	% Att	Tx h	Outcome measures (mind. measures)	Pre–post *g*(*g*m)	Fup wks	Pre-Fup *g*(*g*m)	Cntrl *g* post (gm)	Cntrl *g* fup (gm)	Sc
Hamel, 2010 (77) (Informal)	Overweight and obese adults (10)	53.8	90.0	MEI (10)	–	–	50.0	–	DEBQ; BDI-II (MAAS; MEQ)	0.15 (2.22)	–	–	–	–	1
Kidd et al., 2013 (53) (Informal)	Obese women (12)	51.8	100.0	MEI (12)	–	–	42.0	10.0	Weight; CES-D; (MEQ)	0.04 (0.16)	–	–	–	–	2
Mantzios & Giannou, 2014 (52) (Formal)	University students attempting weight loss (170)	Tx 22.4 Cntrl 23.4	Tx+ Cntrl 42.8	MM (83)	Act Cntrl (87)	Yes	10.6	14.0	Weight; (MAAS)	0.18 (0.10)	–	–	–	–	8
Mantzios & Wilson, 2014 (73) (Study 2/3) (Informal)	University/ College students (136/122)	Tx+ Cntrl 21.1/ 23.3	Tx+ Cntrl 71.4/ 41.8	CC (36/48)	AC/ MM (36/50)	Yes	47.1/ 12.5	N/A	Weight; NATQ; CBAS; (MAAS)	0.15 (0.15)	12	1.59	0.32 (0.36)	–	6
Mantzios & Wilson, 2015 (72) (Formal)	Military employees (88)	Tx1 22.4 Cntrl1 21.1 Cntrl2 22.2	Tx1+ Cntrl1+ Cntrl2 34.9	MM (29)	SC (29) Cntrl (30)	Yes	28.4	43.7	Weight	1.00	24	1.08	–	–	6
Mason et al., 2016 (64) (both)	Obese adults (194)	Tx 47.2 Cntrl 46.8	Tx 79.0 Cntrl 86.0	SBWL +MT (100)	SBWL (94)	Yes	18.5	42.5	Weight; RED; PSS	–	48	–	–	–	7
Miller et al., 2012 (both)	Overweight and obese adults with type II diabetes (68)	Tx 53.9 Cntrl 54.0	Tx 63.0 Cntrl 64.0	MB-EAT-D (32)	DSME (36)	Yes	23.5	25	Weight	–	12	–	–	–	6
Spadaro, 2008 (81) (both)	Obese and overweight adults (46)	Tx 45.8 Cntrl 44.8	Tx 83.3 Cntrl 90.9	SBWL+ MM (22)	SBWL (24)	Yes	23.9	23.9	Weight; EBI; (5FMQ; MAAS)	1.09	–	–	0.53	–	6

Timmerman & Brown, 2012 (63) (Informal)	Healthy premenopausal women (43)	Tx+ Cntrl 49.6	Tx+ Cntrl 100.0	MREI (19) (1)	WLC (16)	Yes	18.6	12.0	Weight; EES; SEEBS	0.58	–	–	0.67	–	4

Note. Treatment and control groups: Att, attrition; Cntrl, control; Comp, comparison; Fup, follow-up (Follow-up times were defined as the number of weeks following the active treatment); *g*, Hedge's *g* of clinical outcomes; *g*m, Hedges *g* of Mindfulness and/or Compassion outcomes; M, mean; Mind, mindfulness; Rnd ass, random assessment; Sc, quality score; Tx, treatment; Tx + Cntrl, treatment and control; wks, weeks; Interventions and conditions: Formal, formal meditation practice; Informal, informal mindful exercises; Both, a combination of formal mediation practice and informal mindfulness exercises; AA, African American; AC, abstract construals; Act Cntrl, active control; BC, breast cancer; CC, concrete construals; DGT, dietary group treatment; DGT + MT, dietary group treatment plus mindfulness training; DSME, diabetes self-management education; HE, health education; MB-EAT-A, Mindfulness-Based Eating Awareness Training for adolescents; MB-EAT-D, Mindful-Based Eating Awareness Training for diabetes; MBSR-M, mindfulness-based stress reduction – modified; MEAL, mindful eating and living; MEI, mindful eating intervention; MM, mindfulness meditation; MPSE, mindfulness program for stress eating; MREI, mindful restaurant eating intervention; N/A, not applicable; SBWL, standard behavioural weight loss program; SBWL + MM, standard behavioural weight loss program plus mindfulness meditation; SBWL + MT, standard behavioural weight loss program plus mindfulness training; SBWL + RT, standard behavioural weight loss program plus resistance exercise training; SC, self-compassion; SEI, stress eating intervention; TAU, treatment as usual; WLC, waitlist control; Outcome measures: BAI, Beck Anxiety Inventory; BDI, Beck Depression Inventory; BES, Binge Eating Scale; BRS, Body Responsiveness Scale; CES-D, Center Epidemiologic Studies-Depression Scale; CBAS, Cognitive Behavioural Avoidance Scale; DEBQ = Dutch Eating Behaviour Questionnaire; EADES-ESE, eating and appraisal due to emotions and stress; EBI, Eating Behaviour Inventory; EES, Emotional Eating Scale; G-FCQ-T, General Food Craving Questionnaire Trait; KIMS, Kentucky Inventory of Mindfulness Skills; MAAS, Mindful Attention and Awareness Scale; MEQ, Mindful Eating Questionnaire; NATQ, Negative Automatic Thoughts Questionnaire; PSS, Perceived Stress Scale; QEWP-R, Questionnaire of Eating and Weight Patterns; RED, Reward-based Eating Drive; SEEBS, Self-Efficacy for Eating Behaviours Scale; STAI, State-Trait Anxiety Inventory; STAS, State-Trait Anxiety Scale; TFEQ, Three-Factor Eating Questionnaire; WCSI, Wheaton Chronic Stress Inventory; 5FMQ, Five Factor Mindfulness Questionnaire; [1]authors were contacted and did not provide standard deviation scores of weight loss.

Results

Study selection

PsychINFO searches produced 2,024 publications, PubMed searches generated 373 publications, Web of Science yielded 369, CINAHL produced 94 publications, Cochrane Library generated 619 publications and Scopus yielded 559 publications. We manually added seven publications and then eliminated the publications that did not fit our inclusion criteria. This resulted in a final number of 18 publications (19 studies as one publication included two studies). Among these are 14 journal articles and four PhD dissertations. A detailed illustration of the study selection process is found in Fig. 1.

Study characteristics

The effect size (Hedge's *g*) and other characteristics for each study are shown in Table 1. The total number of participants included in our meta-analysis was 1,160. Among them, 529 were assigned to a mindfulness-based intervention treatment and 548 were controls.

Most studies (n = 15) were conducted in 2010 or later, and three were conducted in 2008. Overweight or obese individuals were the primary target of all studies. Eleven out of the 19 studies targeted adults from the general population, followed by students (n = 4), breast cancer survivors (n = 1), type II diabetics (n = 1), military employees (n = 1) and premenopausal women (n = 1). The majority of the participants (71.68%) were young adult females 37.53. The attrition rate was 24.96.

Risk of bias within studies

Table 1 presents the included studies and their quality scores. Four studies were (non-randomized) pre–post pilot studies; 14 were randomized controlled trials. Out of the 14 randomized controlled trials, two studies compared MBI with a waitlist control group (63,54), seven studies compared MBI with a standard weight loss program (of which five used a diet and exercise component similar to lifestyle change programs (77,76,64,84), one used a diabetes self-management program (78) and one used psychoeducation for nutrition and exercise (81)) and five studies compared MBI with an active control group (52,72–75).

Four of the 18 included papers used formal meditation practice as a primary intervention (52,72,74,76) while seven studies used informal mindfulness exercises (53,63,73,77–80), and the remaining seven studies used a combination of both (54,64,75,81–84). Because of a variation in protocols, treatment hours varied from 5 to 43.75, with a

mean of 15.39. Eleven studies used at least one validated mindfulness measure, eight included a follow-up measure (average follow-up time was 16.25 weeks). Follow-up times were defined as the number of weeks following the active treatment. All follow-up analyses used the same calculated average of 16.25 weeks. Thirteen studies assured equal time between treatment and control groups. The quality score varied from a minimum of one (i.e. the lowest quality) to a maximum of nine (i.e. the highest quality) with a mean of 5.22 (standard deviation = 2.46) and a median of 6. Inter-rater agreement was high (kappa = .95).

Results of individual studies

Hedge's *g* values for weight loss, eating behaviours, mindfulness and clinical outcome measures at post-treatment and last follow-up for both within-groups (i.e. pre–post)

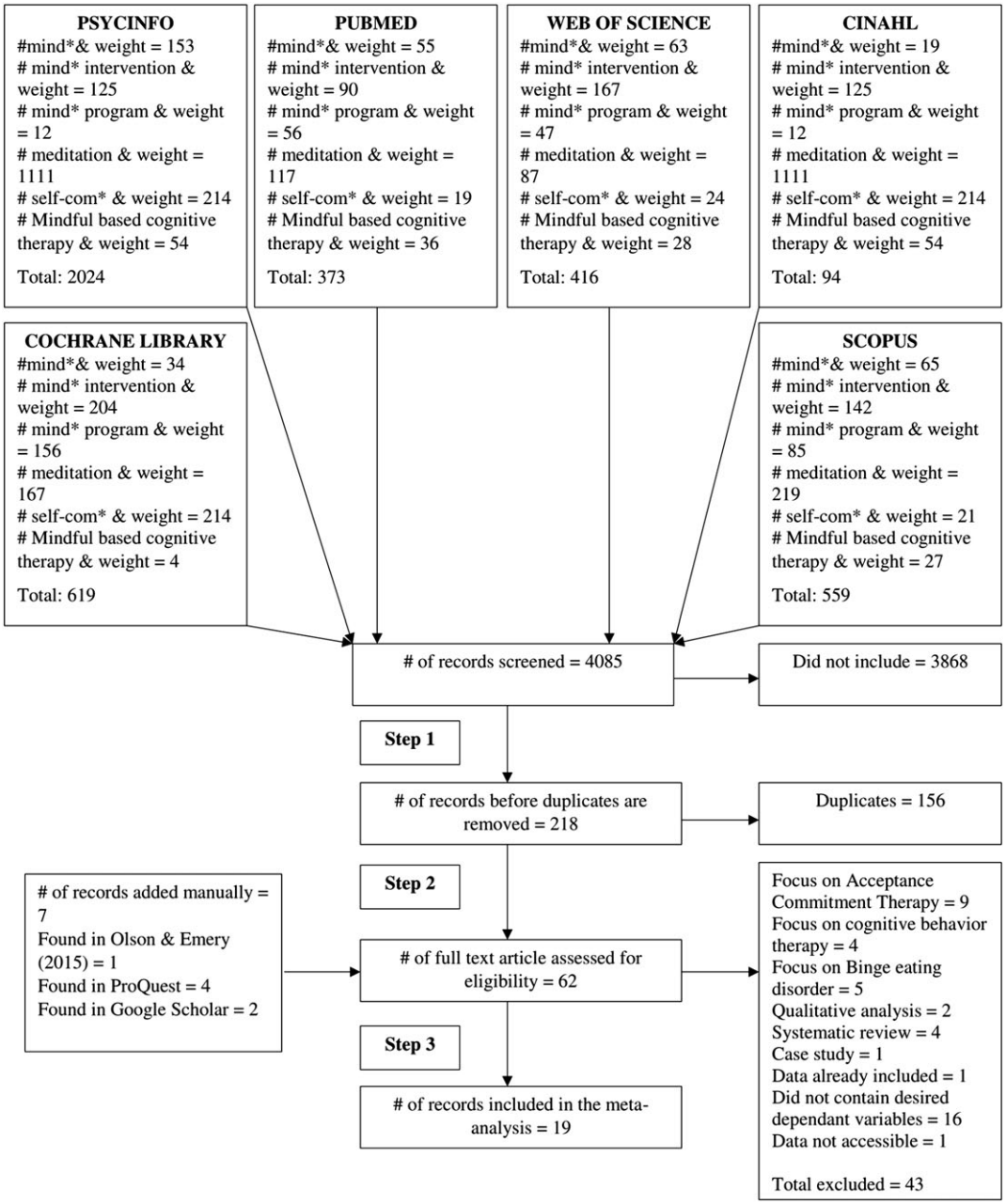

Figure 1 Flow diagram of the study selection process.

and between-groups (i.e. MBI versus a control group) are presented in Table 1.

Synthesis of results

Weight loss

Results suggest moderate effects of MBIs on weight loss in pre–post analyses (n = 16; Hedge's g = .42; 95% CI [.26, .59], $p < .000001$). Studies that used a combination of informal and formal meditation practice (54,64,75,81,82,84) showed higher effects (n = 6; Hedge's g = .55; CI 95% [.32, .77], $p < .00001$) than formal meditation practice (52,72,74,76) alone (n = 4; Hedge's g = .46; 95% CI [.10, .83], $p < .05$). The effects of informal mindfulness exercises (53,63,73,77–80) alone on weight loss were not significant (n = 6; p = .17). Effects of MBIs on weight loss were maintained at follow-up (n = 6; Hedge's g = .58; 95% CI [.12, 1.03], $p < .05$). Low to moderate effects of MBIs on weight loss were also found in controlled studies (n = 13, Hedge's g = .35; 95% CI [.02, .67], $p < .05$). Heterogeneity was high across all analyses (e.g., I^2 = 74.45, Q = 46.97 for controlled studies) suggesting caution in drawing definite conclusions. For studies comparing MBIs with lifestyle change programs, results were not significant (n = 5, p = .68). Studies that compared MBIs with an active control (e.g. resistance training and stress eating intervention) showed moderate effects on weight loss (n = 6; Hedge's g = .59; 95% CI [.04, 1.13], $p < .05$). Because of the limited number of studies, effects were however not significant at follow-up (n = 4, p = .21). At post-treatment, MBI participants lost an average of 6.8 lb (n = 16), representing a 3.3% mean loss of initial body weight. Participants continued to lose weight at follow-up (n = 6), losing an average of 7.5 lb, which constitutes 3.5% mean loss of initial body weight. At post-treatment, lifestyle change program participants lost an average of 9.6 lb (n = 4), which constitutes 4.7% mean loss of initial body weight. At follow-up, participants slightly gained weight, losing an average of 8.8 lb (n = 2), representing 4.3% mean loss of initial body weight.

Obesity-related eating behaviours

These behaviours include, among others, emotional eating, binge-eating and restrained eating. Results suggest large effects of MBIs on obesity-related eating behaviours in pre–post analyses (n = 10; Hedge's g = .70; CI 95% [.36, 1.04], $p < .00005$); however, heterogeneity was high (I^2 = 88.73, Q = 79.86), suggesting caution in drawing definite conclusions. These effects were maintained at follow-up (n = 4; Hedge's g = .62; CI 95% [.13, 1.1], $p < .05$). Studies that used a combination of informal and formal meditation practice showed high effects on eating behaviours (n = 5; Hedge's g = 1.15; CI 95% [.41, 1.89], $p < .005$). Results were not significant for studies that used formal meditation (p = .06) or informal meditation practice alone (p = .29). Moderate effects of MBIs on eating behaviours were found in controlled studies (n = 7; Hedge's g = .55; CI 95% [.26, .85], $p < .0005$), with low to moderate heterogeneity (I^2 = 42.79, Q = 10.49). Because of a limited amount of studies, effects were not significant at follow-up (n = 5, p = .21).

Psychological outcomes

Results from pre–post analyses suggest moderate effects of MBIs on anxiety (n = 3; Hedge's g = .44; CI 95% [.21, .69], $p < .0005$), with low heterogeneity (I^2 = 0, Q = .21) and small effects on depression (n = 3; Hedge's g = .34; CI 95% [.08, .61], $p < .05$), with low heterogeneity (I^2 = 12.19, Q = 2.28); results were however not significant for stress (n = 5, p = .07). Results were not significant at follow-up.

Mindfulness

Results from pre–post analyses suggest small effects of MBIs on mindfulness (n = 8; Hedge's g = .32, CI 95% [.12, .53], $p < .005$) with moderate heterogeneity (I^2 = 64.37, Q = 19.65). At follow-up, one study however yielded large effects (n = 1; Hedge's g = .76, CI 95% [.25, 1.27], $p < .005$). Results from controlled studies were not significant at follow-up (n = 3; p = .23).

Risk of bias across studies

The effect size for all pre–post analyses corresponded to a z value of 11.33 ($p < .00001$) indicating that 552 studies with a null effect size would be needed to nullify our results (i.e. for the two-tailed p value to exceed .05). Using the Trim and Fill method (85), three studies would need to fall on the right of the mean effect size to make the plot symmetric (Fig. 2). Assuming a random effects model, the new imputed mean effect for all outcomes combined was Hedge's g = .32 (95% CI [.13, .58]). Similar results were obtained for the controlled studies, with a z value of 4.35 ($p < .00005$) and a corresponding fail-safe N of 52. Using the Trim and Fill method (85), three studies would also need to fall on the right of the mean effect size to make the plot symmetric; the new imputed mean effect size for all outcomes combined was Hedge's g = .28 (95% CI [−.32, .59]). These analyses suggest that the effect size estimates were unbiased and robust.

Additional analyses

At the end of treatment, the average pre–post effect size of weight loss was positively moderated by changes in eating behaviours (n = 9; β = .31, standard error [SE] = .14, $p < .05$) (Fig. 3) and weakly moderated by treatment hours (n = 13; β = .02, SE = .005, $p < .005$) as well as by study quality score (n = 16; β = .07, SE = .005, $p < .00001$). The average pre–post effect size was not moderated by changes in mindfulness from pre-treatment to post-treatment (n = 7, p = .53, ns). Psychological outcomes (i.e. anxiety,

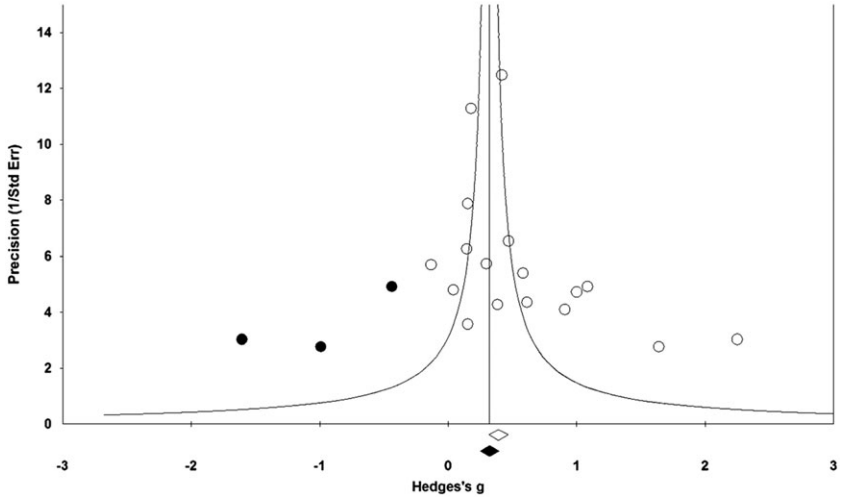

Figure 2 Funnel plot of precision by Hedge's *g* for pre–post data. In the absence of a publication bias, the studies should be distributed symmetrically with larger studies appearing towards the top of the graph and clustered around the mean effect size and smaller studies towards the bottom.

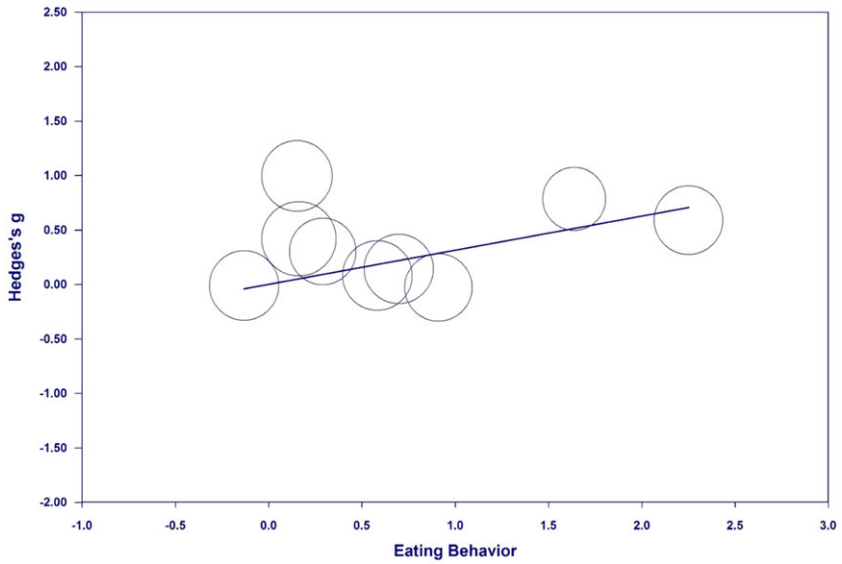

Figure 3 The relationship between changes in eating behaviour effect sizes and changes in weight loss at the end of treatment for pre–post data. The circles represent the studies and their diameter is proportional to the study weight. [Colour figure can be viewed at wileyonlinelibrary.com]

stress and depression) were neither moderated by length of treatment (n = 7, p = .58), quality score (n = 7, p = .96) or mindfulness (n = 3, p = .34).

Discussion

Summary of evidence

The meta-analysis examined 18 papers using mindfulness-based interventions for a combined total of 1,160 participants. The results showed that MBIs were moderately effective for weight loss in both within-group and between-group analyses. Results additionally showed that MBIs were largely effective on eating behaviours in within-group analyses and moderately effective in between-group analyses (i.e. in comparison with a waitlist or to an active treatment). Five studies compared MBIs with active treatments; the effects were moderate, but this result cannot be generalized because of the limited number of studies and the differences among control treatments (e.g., resistance training, stress eating intervention). In addition, the average attrition among participants in the selected studies (24.96%) was similar to the attrition rates (31%) obtained in weight loss clinical trials (86). These results suggest that MBIs are highly feasible and well received by individuals with overweight and obesity.

Our main objective was to determine if MBIs are effective in reducing weight and improving maladaptive eating behaviours among individuals with overweight and obesity. Our results showed that MBIs are moderately effective for weight loss and largely effective in reducing obesity-related eating behaviours. When compared with lifestyle change programs, even though effect size results were not significant, participants lost more weight in diet and exercise programs (4.7% of initial body weight) compared with MBIs (3.3% of initial body weight). However, at follow-up, participants in MBIs (52,64,73,74,76) showed continued weight loss (an additional 0.2% of initial body weight) while participants in diet and exercise programs (64,75,76,81) slightly gained weight (an increase of 0.4% of initial body weight). These reductions in weight were moderated by changes in eating behaviours. Although these results are still preliminary, they suggest that MBIs might be more effective in the long-term.

Our second objective was to determine the role of mindfulness in the effectiveness of MBIs on weight loss. Our results showed that participants increased in trait mindfulness at post-intervention even though effect sizes were small (Hedge's g = .32). This result is inconsistent with previous meta-analyses (56–58) that found moderate to large increases in mindfulness following treatment. This inconsistency may, however, be explained by the included studies, which used a combination of formal (i.e. meditation practice) and informal mindfulness practices (i.e. exercises to increase eating-related awareness), whereas previous meta-analyses included studies that predominantly used formal meditation practice. Additionally, our results showed that changes in measures of trait mindfulness did not moderate weight loss. This finding might be due to the limited number of selected studies that measured and reported mindfulness – only eight of 19 studies (42%) assessed and reported trait mindfulness. This lack of measuring or reporting mindfulness is a general criticism of mindfulness research that is highlighted by some authors (64,65). It is important that future research further investigate the role of trait mindfulness in weight regulation as it remains unclear how trait mindfulness affects weight-related behaviours.

Moreover, our results showed higher effects on weight loss for studies that used a combination of informal and formal strategies compared with formal meditation practice alone. The independent effects of informal mindfulness exercise were, however, not statistically significant. These results have important clinical implications as they suggest a benefit in combining both formal and informal mindfulness for weight loss. This advantage may result from a differentiating effect of informal and formal practices on various dimensions of mindfulness, namely effects on state versus trait mindfulness. Specifically, formal meditation practice may assist in strengthening dispositional or trait mindfulness (i.e. one's general tendency to be mindful) ((87)), whereas informal exercises may help strengthen state mindfulness (i.e. one's current expression of mindful attention and acceptance in everyday activities) ((44)), specifically in the context of weight-related behaviours like eating and exercise. Research should incorporate both trait and state mindfulness measures to better capture these two dimensions and to further explore their comparative effects on weight loss and weight relevant behaviours associated with eating and physical activity.

Informal mindfulness exercises, like mindful eating, may also be important in reducing certain maladaptive eating behaviours by increasing awareness of hunger and satiety cues as well as taste satisfaction (60,61) and decreasing impulsive tendencies to overeat when experiencing negative emotions. Meditation practice, on the other hand, may additionally facilitate weight loss by increasing one's general ability to self-regulate. In fact, when meditating, an individual constantly redirects attention to on-going experience in a non-judgmental and accepting way (88). This deliberate redirection of attention can be a mechanism through which general self-regulation capacity is increased, thus facilitating long-term behavioural change. For example, mindfulness meditation may assist an individual in increasing awareness of certain automatic patterns that drive their maladaptive eating behaviours. This, in turn, may facilitate their disengagement from these automatic patterns (19). If this is the case, mindfulness meditation may not only facilitate the tolerance of adverse discomforts associated with calorie-restrictions and increased physical activity, through non-judgmental awareness and acceptance, but it may also increase one's ability to initiate and maintain health-related behaviours in the long-term.

Our third and final objective was to examine the effects of MBIs on secondary outcomes (i.e. stress, anxiety and depression). Results showed small to moderate effects on clinical measures, namely, depression and anxiety. When calculating weighted means of studies measuring perceived stress, participants' levels of stress decreased from moderate levels at baseline (M = 15.07) to moderate–low levels at post-treatment (M = 13.64). This difference was, however, not statistically significant, probably because of the limited number (N = 5) of studies measuring stress and high heterogeneity among studies.

Limitations

When interpreting the findings of this meta-analysis, it is important to consider that even though all of the included studies used a mindfulness-based program, their implementations and program content varied. Some studies used a standard mindfulness-based protocol (e.g.

MBSR and MB-EAT) while others used a modified version or a novel program that varied in treatment length and practice time. Furthermore, included studies measured

different variables using different scales. This diversity in study design and outcomes may have largely contributed to the observed heterogeneity in effect size. However, despite this heterogeneity, results support significant reductions in weight and obesity-related eating behaviours in six within-group and twelve between-group trials. Although all studies assessed the effectiveness of an MBI on weight loss and other obesity-related outcomes, less than half of the studies (i.e. 44.4%) included a validated measure of mindfulness, and only one study assessed mindfulness at follow-up. This is particularly problematic given that these studies attributed the positive effects of these MBIs to increases in mindfulness. Without the use of validated measures of mindfulness, one cannot be certain whether these effects are the results of increases in mindfulness or due to other confounding variables. It is therefore important that future research include at least one validated measure of mindfulness. Further limitations of our meta-analysis include the small number of selected studies, the assessed outcomes that widely varied across studies and the high heterogeneity among study groups, which reduced, consequently, the specificity of obtained results. Because of the small number of included studies in the meta-analysis, we were inevitably required to use studies of varying quality, which we quantified via the study quality score.

Conclusions

Despite the aforementioned limitations, our results showed that MBIs are moderately to largely effective in reducing weight loss and improving obesity-related eating behaviours. Although average weight loss was modest at post-treatment (3.3% of initial body weight), continued decreases in weight at follow-up (3.5%) is encouraging and highlights the potential of using mindfulness training to support weight loss and its maintenance. More research is, however, needed to examine the long-term effectiveness of MBIs on eating behaviours and weight loss maintenance. We recommend that further research investigate how integrating mindfulness training into lifestyle change programs can improve weight loss and produce better long-term results.

Conflict of interest statement

No conflict of interest was declared.

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