Received: 27 November 2023 | Revised: 10 October 2024 | Accepted: 13 October 2024

DOI: 10.1111/obr.13860

REVIEW

Obesity Management / Intervention

OBESITY Reviews WILEY

Effects of mindfulness-based interventions on obesogenic eating behaviors: A systematic review and meta-analysis

Tsui-Sui Annie Kao[1] | Jiying Ling[1] | Mohammed Alanazi[2] | Ahmed Atwa[3,4] | Stephanie Liu[5]

[1]College of Nursing, Michigan State University, East Lansing, Michigan, USA

[2]University of Bisha, Bisha, Saudi Arabia

[3]Department of Translational Neuroscience, College of Human Medicine, Michigan State University, Grand Rapids, Michigan, USA

[4]Neuroscience Program, Michigan State University, East Lansing, Michigan, USA

[5]Department of Family Medicine, University of Michigan Medical School, Ann Arbor, Michigan, USA

Correspondence
Tsui-Sui Annie Kao, College of Nursing, Michigan State University, East Lansing, 1355 Bogue St. C342, East Lansing, MI48824, MI, USA.
Email: kaotsuis@msu.edu

Funding information
This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

[Correction added on 3 January 2025, after first online publication: An affiliation to Michigan State University has been removed for Mohammed Alanazi.]

Summary

This systematic review and meta-analysis examined the effects of mindful-based interventions (MBIs) on changes in obesogenic eating behaviors. Seven databases (CINAHL, PubMed, PsycINFO, Cochrane, Web of Science Core Collection, Embase, Sociological Abstracts) were searched. Random-effects models were performed to estimate the pooled effects, and mixed-effects models were used to explore potential moderators of MBIs on eating behavioral changes. The significant effects on mindless eating habits included controlled eating (Hedge's $g = 0.23$, $p = 0.005$), external eating ($g = -0.62$, $p = 0.001$), fullness awareness ($g = 0.64$, $p < 0.001$), hunger eating ($g = -0.69$, $p = 0.032$), energy intake ($g = -0.60$, $p = 0.003$), sweet intake ($g = -0.39$, $p < 0.001$), and impulsive food choice ($g = -0.43$, $p = 0.002$). However, small and insignificant effects were noted for stress-related eating habits like emotional eating ($g = -0.27$; $p = 0.070$) and binge eating ($g = -0.35$, $p = 0.136$). The long-term effects were significantly sustained on hunger eating ($g = -0.50$, $p = 0.007$) but insignificant on emotional eating ($g = -0.22$, $p = 0.809$). MBIs delivered in clinical settings were more effective for decreasing emotional eating compared with those in school settings. Our findings support the effectiveness of MBIs. The pooled effects on improving mindless eating habits were stronger than the modification of stress-related eating habits.

KEYWORDS
controlled eating, mindful eating, mindless eating, stress-related eating

1 | INTRODUCTION

Using mindfulness-based interventions (MBIs) to target obesity-related eating behaviors has demonstrated some promising results and been increasingly implemented to prevent or treat overweight or obesity.[1,2] The significant effects of MBIs on anthropometric outcomes (BMI: $g = -0.36$, waist circumference: $g = -1.20$) have been delineated in our previous meta-analysis,[3] but the effects of MBIs on eating behavioral outcomes remain relatively obscure. Mindless and autopilot eating habits/styles (↓control, ↓fullness awareness, ↑external eating, ↑hunger, ↑energy intake, ↑sweet intake, ↑unhealthy food choice)[4] and stress-related habits (emotional and binge eating) can position individuals at a greater risk for overweight and obesity.[1,5,6] Thus, this systematic review and meta-analysis examined the effects of MBIs on changes in various obesogenic eating behaviors including controlled, external, hunger, binge, and emotional

This is an open access article under the terms of the Creative Commons Attribution-NonCommercial License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited and is not used for commercial purposes.
© 2024 The Author(s). *Obesity Reviews* published by John Wiley & Sons Ltd on behalf of World Obesity Federation.

eating as well as fullness awareness, sweet and energy intake, and impulsive food choice.

1.1 | MBIs

Over the past few decades, MBIs for obesity prevention or treatment have been used with promising results.[1–3] MBIs typically are designed to improve individuals' psychological adaptation through enhanced awareness of their own emotions, acceptance, and cognitive processes. MBI techniques have been shown to support individuals' nonjudgmental self-motivation and self-awareness.[7] Mindful eating training, in particular, is designed to heighten individuals' awareness of the present moment, with a focus on their body's sensations when eating, as well as their thoughts and feelings about food. This approach has been frequently employed to overcome obesogenic eating behaviors such as mindless and stress-related eating styles/habits.[8,9] Existing relevant reviews and meta-analyses on the effects of MBIs mostly targeted populations suffering from overweight/obesity[10,11] or eating disorders[12] and assessed anthropometric outcomes.[3,11] Of the few systematic reviews that investigated the effects of MBIs on eating behaviors, many of them aggregated various eating behavioral outcomes to reflect the improvements in healthy eating ($r = 0.14$),[13] overall eating behavior ($g = 1.08$),[11] or eating attitude ($g = 0.57$).[11] Various aspects of mindful eating habits (↑eating control or disinhibition,[14] ↑fullness awareness,[2] ↓external eating [↓reactive to external cues],[15] ↓physical hunger,[9] ↓energy[16] and ↓sweet intake,[17,18] or ↓impulsive food choices[6]) were not explicitly examined. Understanding specific impact of MBIs on various obesogenic eating habits can shed lights on how to better tailor MBIs and more effectively prevent or treat overweight or obesity. Currently, stress-related eating habits (↑emotional or ↑binge eating) often were assessed when MBIs were implemented with populations diagnosed with eating disorders.[11,19] There is scarce understanding about how MBIs may have an impact on mindless[4] or stress-related eating habits[20] that can contribute to what is known about obesogenic eating behaviors, particularly among individuals who do not have an eating disorder. Bridging this knowledge gap in literature has potential to broaden the implementation of MBIs.

1.2 | Obesogenic behaviors: Mindless eating habits

Mindless (or autopilot) eating refers to the absence of conscious awareness when consuming snacks and meals and often leads to overeating behaviors because it can reduce individuals' ability to respond adequately to internal/external cues and/or physical hunger and to monitor the amount (or quality) of food intake.[4,15] In fact, individuals whose behavior includes mindless eating may not be able to discern the internal/external triggers to eat, the source of their hunger, and/or the level of fullness while eating. Subsequently, mindless eating can result in overweight and obesity, which puts them at higher risk for type 2 diabetes, cardiovascular diseases, and cancer.[21]

Because MBIs are designed to increase individuals' awareness of their actions by bringing their attention to the present moment, mindful eating training can help turn off individuals' autopilot eating mode by training them to really savor foods and establish a positive and healthy relationship with food. In addition, MBIs have provided strategies to improve physical movement and stress management and potentially can be used to mitigate stress-related eating behaviors (e.g., emotional and binge eating).

Currently, few systematic reviews or meta-analysis have comprehensively and explicitly examined the effects of MBIs on these mindless eating habits including enhancing awareness of fullness (the recognition of the unpleasant full sensation after eating),[2] physical hunger,[6] and minimizing external eating (in response to external cues rather than internal cues of fullness).[15] MBIs, particularly mindfulness training, can help decrease individuals' energy intake,[16] sweet intake (as a coping mechanism),[17,18] and impulsive food choices.[6]

1.3 | Obesogenic behavior: Stress-related eating habits

Many individuals eat as a reaction to stress. In fact, increased perceived stress is a known obesogenic risk factor for emotional or binge eating behaviors and indirectly impacts individuals' weight status.[22] Emotional eating is defined as a tendency to overeat in response to negative emotions, such as anxiety or irritability,[23] while binge eating refers to eating a large amount of food within a short amount of time and is associated with a sense of loss of control.[24] Emotional eating, for example, is highly prevalent among individuals who struggle with their weight; this may progress to binge eating without timely and effective interventions. MBIs are recognized as a promising approach to reduce stress-related eating behaviors,[2,5,25,26] and improve mental health outcomes.[27] Currently, the benefits of MBIs on emotional and binge eating are better understood among individuals who have suffered from mental health problems such as anxiety/depression[27] and eating disorders.[12] However, the results of these studies may not be applicable to emotional and binge eating behaviors manifested by people without mental health problems or eating disorders, and the benefits of MBIs on emotional and binge eating among the general population remain relatively unclear. Understanding the effects of MBIs on emotional and binge eating behaviors is essential because many individuals use eating to cope with excessive stress.[20,22]

The aim of this review and meta-analysis was to separate obesogenic eating behaviors into mindless or stress-related eating habits to better understand the effect of MBIs on each domain. The result of this review will help develop interventions tailored toward improving obesogenic eating habits. Furthermore, the present review seeks to provide insights about potential moderators (e.g., MBI type and focus, sessions, duration, setting, age, treatment fidelity) on the effects of MBIs on various eating habits. The moderation analysis will delineate the role of potential confounders on the pooled effects of MBI with various eating habits.

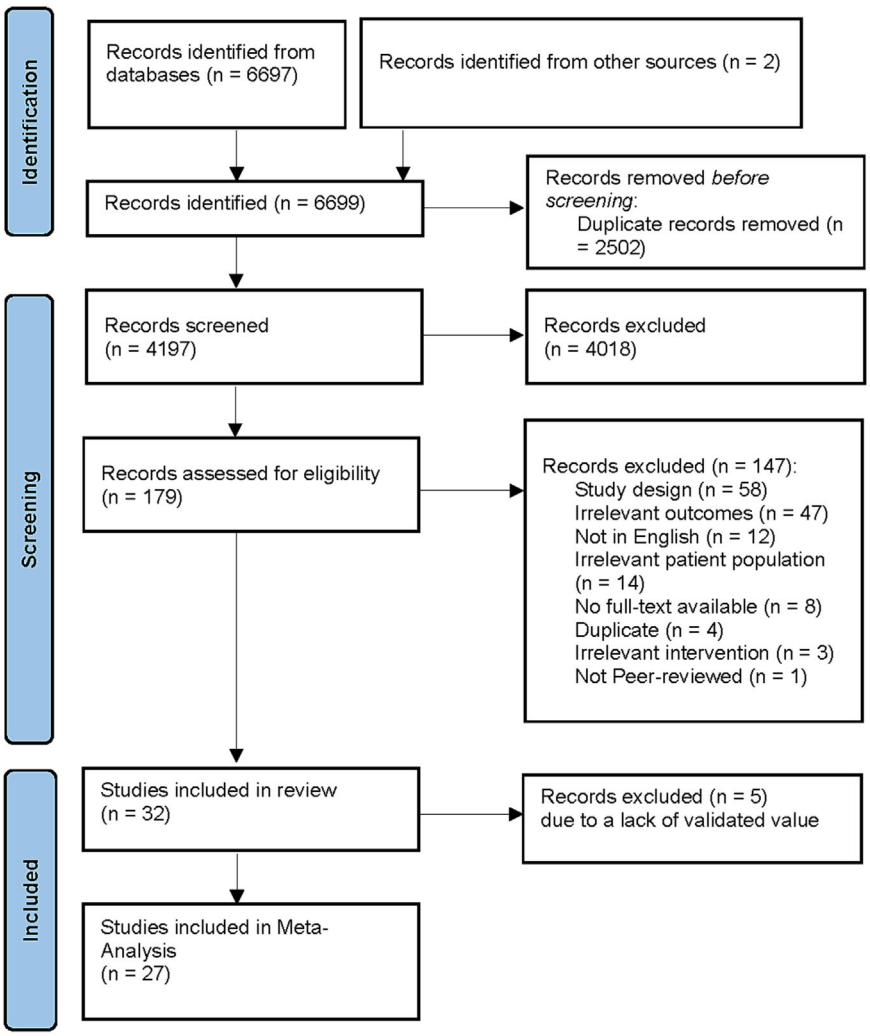
2 | METHODS

2.1 | Literature search

The current systematic review was undertaken to identify experimental studies that investigated the effects of MBIs on obesogenic eating behaviors. The study report was developed according to the Preferred Reporting Items for Systematic Reviews and Meta-analyses statement (PRISMA).[28] Figure 1 illustrates our search process. With the help of the university librarian, studies were identified from the following databases: CINAHL Plus with Full Text, PubMed, PsycINFO, Cochrane, Web of Science Core Collection, Embase, and Sociological Abstracts. The search also included gray literature, such as ClinicalTrials.gov, MedRxiv, and a manual search of reference lists. The following keywords and phrases were used in this search: (Mindful OR yoga OR meditate OR Mindfulness) AND (Eat OR eating OR eats OR food OR "eating behavior" OR "feeding behavior" OR "feeding behaviors" OR "food habit" OR "food habits" OR diet). To some extent, the search strings were modified for each database to enhance the search and meet some of the databases' formatting requirements.

2.2 | Eligibility criteria

The inclusion criteria were experimental studies with general participants, had a comparison group, included any of the eating behavioral measurements (i.e., hunger, fullness awareness, external eating, controlled [or disinhibited] eating, emotional eating, binge eating, energy and sweet intake, and impulsive food choice), and the intervention that included components of mindful eating, mindful movement, or mindful meditation. Exclusion criteria were studies that explicitly



Adopted From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

FIGURE 1 PRISMA flow diagram. *Source*: Adopted from: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021; 372:n71. doi: 10.1136/bmj.n71

targeted participants with acute or chronic medical conditions, who had eating disorders or mental health problems, or those were not published in English.

2.3 | Data screening and extraction

A two-step screening approach was used to code and extract data. In the initial step, the first author created the inclusion/exclusion criteria for data extraction and evaluation. Two of the authors (MA and AA) independently performed the eligibility assessment in a standardized manner using Covidence software. After removing duplicates, these authors reviewed the title and abstract for all studies to determine eligibility. Then, a full-text review was conducted on all potentially eligible studies. Finally, those studies that met the inclusion and exclusion criteria were included in the review and meta-analysis. Any disagreements between the authors were resolved by consensus. The search was completed in June 2023. The data extraction included the author's name, year of publication, country, design, sample size, participants' characteristics, type and focus of MBIs, duration, type of eating habits (outcomes), and key findings. The second step included multiple discussions among the two independent coders during the evaluation; consensus then was reached after resolving any discrepancies with the first author.

2.4 | Quality appraisal and risk of bias

The two independent raters (MA and AA) scored eligible articles using the Alberta Heritage Foundation of Medical Research tool.[29] This tool has 14 items that address five domains of quantitative study design, including study design (five items, sampling selection and data analysis), selection bias (two items), randomization procedure (one item), concealment procedure (two items), and reporting/overall synthesis (four items, internal/external validity). Each item was scored as one of the following: 0 (*Not met*), 1 (*Partially met*), and 2 (*Met*). A quality appraisal score (QA range = 0 to 1) for each article was calculated and averaged by using the total sum score of the 14 items divided by 28 (Table S2). Following the tool guideline, a quality score lower than 0.55 was considered low quality and consequently excluded from this review. Inter-rater consistency was evaluated using Cohen's kappa before averaging the quality score between these two raters.

2.5 | Statistical data analysis

The Comprehensive Meta-Analysis program (version 3.0) was used to perform all meta-analyses. To calculate the pooled effect size for each study outcome, we used the mean, standard deviation (SD), and the sample size in the experimental and control groups at each data assessment (baseline, post-intervention, and follow-up). If the mean or SD was not reported in the article, we contacted the corresponding author twice (2–3 weeks apart). If we did not receive a response within 6 weeks, we calculated the mean or SD from the reported median, sample size, interquartile range, and confidence intervals if applicable.[26,27] Influential outliers were defined as having residual >2.56 and I^2 being decreased by ≥10% after removing each potential outlier.[28] Hedge's g was calculated using random-effects models as the effect size in order to examine each study's sample size and was interpreted as small = 0.20, medium = 0.50, or large = 0.80.[30] A negative Hedge's g indicated that the intervention group had a greater decrease in the targeted eating habits than the control group. The pre- and post-intervention correlation was fixed at 0.50.[31] The effects of long-term sustainability from baseline to follow-up and post-intervention to follow-up assessment were also evaluated for the articles with follow-up data. Subgroup and meta regression analyses with mixed-effects models were applied to conduct exploratory moderation analyses. Heterogeneity among studies was evaluated using the Q test and I^2 statistics: low heterogeneity = 25%, moderate heterogeneity = 50%, and high heterogeneity = 75%. There was no strong evidence of publication bias when the results from the Begg and Mazumdar rank correlation test and the Egger's regression asymmetry test were nonsignificant, and the funnel plot[32] was symmetric. When publication bias existed, the Duval and Tweedie's trim and fill method were applied to adjust the effect size. Sensitivity analyses were performed to examine the robustness of the results according to each study's quality score.

3 | RESULTS

3.1 | Study characteristics

As illustrated in Table S1, of 32 included studies, 31 (97%)[15,16,30–58] were randomized controlled trials (RCT); 11 (34%)[16,33,35–37,39,41,45,55,57,58] were conducted in the United States, followed by the United Kingdom (k = 8, 25%),[38,40,43,46,52–54,56] the Netherlands (k = 4, 13%),[31,32,34,44] Spain (k = 3, 9%),[15,47,59] and Brazil (k = 2, 6%),[49,50] as well as one each from Austria,[51] Denmark,[42] Greece,[30] and Portugal.[48] A total of 2431 participants (78% female) were included, with ages ranging from 9[59] to 58[47] years (overall M_{age} = 36.72). Sample sizes ranged from 19[32] to 257,[34] with three studies (9%)[33,54,59] targeting children (M_{age} = 11.96).

3.2 | Intervention characteristics

Interventions were mostly delivered at a clinic (k = 27; 84%)[15,16,30–32,34–38,40–43,45–54,56–58] followed by school settings (k = 5; 16%).[33,39,44,55,59] Mean intervention length was 8.2 weeks (range: 1–24 weeks), with 20 studies (63%) having a minimal length of 7 weeks and nine (28%) having a maximum length of 3 weeks. About 47% (k = 15) of studies targeted participants with BMIs greater than 25.[30,32,35,36,42,45–50,55,56,58,60] Although mindful eating was introduced in all included studies to various degrees, the mindfulness components can be demarcated into mindful eating [k = 20], mindful

movement [$k = 4$], and mindfulness-based stress reduction [$k = 8$]. About 59% of studies ($k = 19$) used mindfulness strategies as the primary intervention component, while the remaining 41% ($k = 13$)[30,44–48,50,51,54–56,58,60] incorporated other health promotion programs to support healthy eating behaviors.

Of the 32 selected studies, nine (28%) utilized certified mindfulness practitioners as intervenors, while the rest trained their own intervenors. Most control conditions were waitlist or no-intervention control ($k = 11$, 34%), while others applied attention control including standardized weight-loss program ($k = 4$), existing care program ($k = 3$), reading ($k = 3$), PA ($k = 2$), PA/diet ($k = 1$), nutrition ($k = 2$), education ($k = 2$); and non-mindful eating ($k = 1$). Furthermore, 27 studies (84%) reported immediate post-intervention effects and six (19%) had follow-up assessments (T3)[15,45,47,51,54,55] to evaluate long-term effects. Treatment fidelity was described in two studies (6%).[41,54] While most studies ($k = 31$) delivered the intervention through in-person contacts, one study[35] delivered mindfulness training remotely (using phone calls).

3.3 | Risk of bias

Of the 32 included studies (see Table S2), no study was identified as having a high risk of bias (*QA* ≤0.55), while 15 studies (47%) had a moderate risk (*QA* = 0.56–0.74),[30–33,36,39,42,46,48,51,53–55,57] and 17 studies (52%) had a low risk of bias (*QA* ≥0.75). The moderate risks of bias were mostly due to selection bias (random sequence or allocation concealment), performance bias (blind outcome assessment), and attrition bias (incomplete data). No study was excluded as a result of high risk of bias. The inter-rater agreement between the two raters was acceptable (Cohen's Kappa = 0.83).

3.4 | Intervention pooled effects

3.4.1 | Mindless eating habits

Controlled eating

Among the 17 comparisons, one influential outlier[32] was identified ($z = 3.70$), and I^2 decreased from 58.70% ($p = 0.001$) to 29.23% ($p = 0.131$) after removing the outlier. Similarly, the pooled effects on increasing controlled eating decreased from 0.30 to 0.23 (see Figure 2A). Results from the Begg and Mazumdar rank correlation test (*Tau* = 0.12, $p = 0.528$), the Egger's regression intercept test ($p = 0.304$), and the funnel plot (see Figure 2B) showed no evidence of publication bias.

Moderators. As shown in Table S3, MM type was a significant moderator for the immediate intervention effects ($p = 0.010$). Programs that incorporated mindful movements and stress reduction interventions resulted in better effects than those that used mindful eating alone ($g = 0.50$, 0.28 vs. −0.01). Although not significant, interventions delivered by trained research assistants had greater effects than those delivered by a certified intervenor ($g = 0.32$ vs. 0.10). Moreover, MM as an add-on had smaller effects than MM-focused interventions ($g = 0.16$ vs. 0.34). Interventions delivered remotely that focused on older children or that were community-based tended to have better effects on improving controlled eating.

Impulsive food choices

One significant outlier was identified ($z = 3.32$).[55] After removing the outlier, the heterogeneity decreased from 83.40% ($p < 0.001$) to 71.05% ($p < 0.001$). The pooled effects on decreasing impulsive food choices increased from −0.28 to −0.43 (see Figure 3A). There was no strong evidence of publication bias based on the results from the Begg and Mazumdar rank correlation test ($p = 0.055$) and the Egger's regression intercept test ($p = 0.072$) as well as the funnel plot (see Figure 3B).

Moderators. As demonstrated in Table S4, no significant moderator was identified. When comparing the different effect sizes, the interventions had better effects when focusing on mindful eating ($g = -0.53$), with female participants ($g = -0.63$), not assessing treatment fidelity ($g = -0.53$), being an add-on component to another program ($g = -0.81$) or targeting OW/OB participants ($g = -0.81$).

External eating

After removing one influential outlier ($z = -5.32$),[60] the heterogeneity decreased from 93.13% ($p < 0.001$) to 61.66% ($p = 0.011$). The pooled effect size decreased from −1.29 to −0.62 (see Figure S1a). Results from the Begg and Mazumdar rank correlation test ($p = 0.138$), the Egger's regression intercept test ($p = 0.554$), and the funnel plot (see Figure S1b) showed no evidence of publication bias.

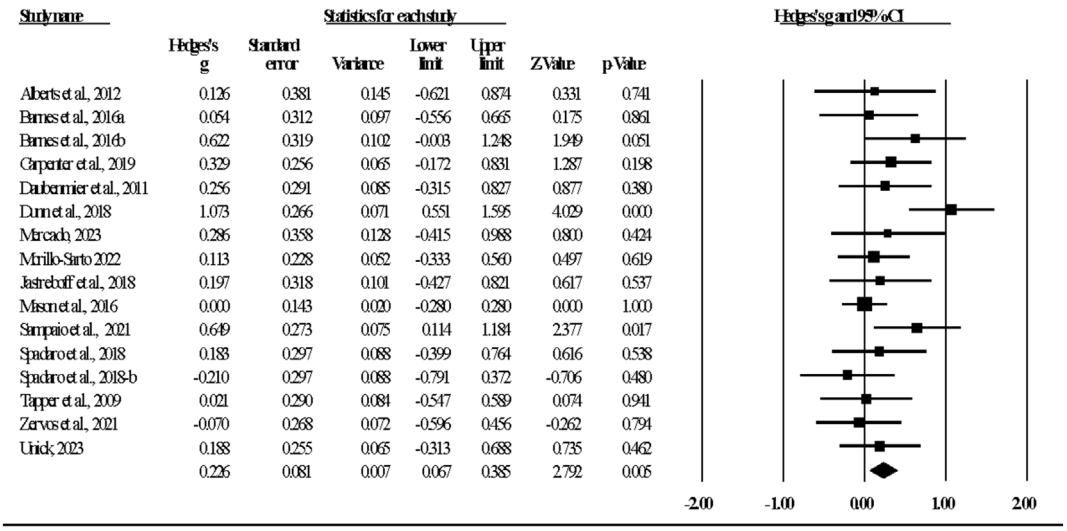
Fullness awareness and hunger

The heterogeneity was small for fullness awareness ($k = 4$, $I^2 = 5.52\%$; $Q = 3.18$, $p = 0.365$) and high for hunger ($k = 4$, $I^2 = 78.42\%$, $Q = 13.90$, $p = 0.003$). The pooled intervention effects were 0.64 on improving fullness awareness (see Figure S2a) and −0.69 on reducing hunger (see Figure S3a). Long-term sustained effects from post-intervention to follow-up were noted ($k = 2$; $g = -0.50$, *95%CI*: −0.87, −0.13; $p = 0.007$) on hunger. As shown in Figures S2b and S3b, there was no strong evidence of publication bias. This was supported by the results from the Begg and Mazumdar rank correlation test (*Tau* = 1.00, $p = 0.042$; *Tau* = 0, $p = 1.00$) and the Egger's regression intercept test ($\beta = 5.70$, $p = 0.295$; $\beta = 16.96$, $p = 0.342$).

Energy and sweet intake

The heterogeneity was moderate for energy intake ($I^2 = 55.56\%$; $Q = 13.50$, $p = 0.036$) and small for sweet intake ($I^2 = 0\%$; $Q = 1.94$, $p = 0.585$). The pooled intervention effects were −0.60 and −0.39 on reducing energy and sweet intake, respectively (see Figure S4a, S5a). Results from the Begg and Mazumdar rank correlation test (*Tau* = −0.05, $p = 0.881$; *Tau* = −0.33, $p = 0.497$), the Egger's regression intercept test ($\beta = 16.96$, $p = 0.342$; $\beta = 0.17$, $p = 0.970$),

(A) Forest plot for controlled eating



(B) Funnel plot for the controlled eating outcome

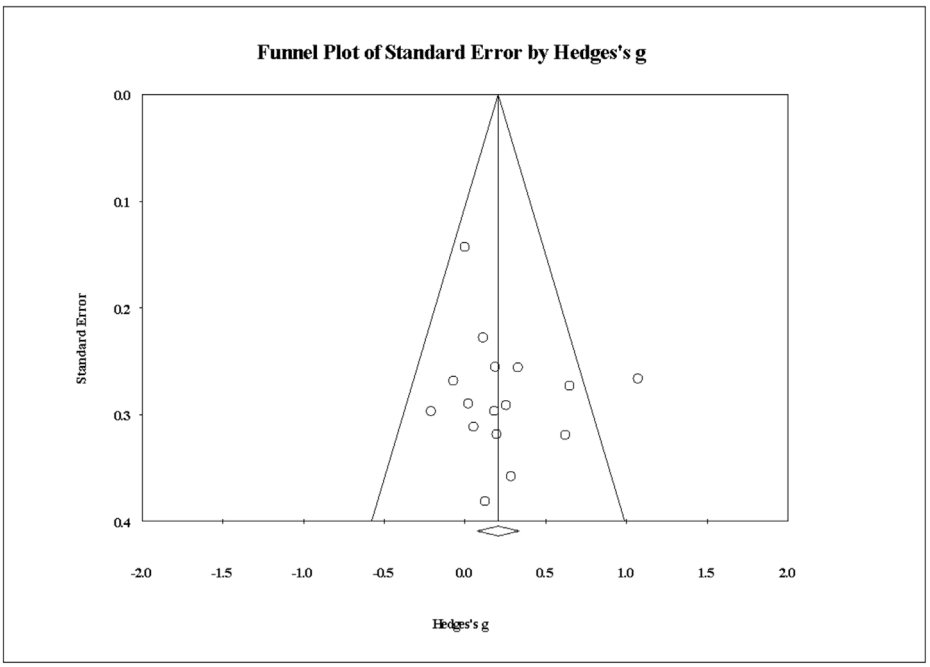


FIGURE 2 Mindless-related eating habits: controlled eating. (A) Forest plot for controlled eating. (B) Funnel plot for the controlled eating. *Note.* Begg and Mazumdar rank correlation test (*Tau* = 0.12, $p = 0.528$), the Egger's regression intercept test ($\beta = 1.26$, $p = 0.304$).

and the funnel plot (see Figure S4b, S5b) showed no evidence of publication bias.

3.4.2 | Stress-related eating habits

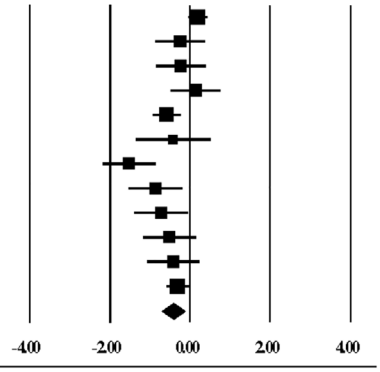
Emotional eating

The pooled immediate intervention effects on reducing emotional eating were −0.27 (see Figure S6a). The long-term sustained effects from post-intervention to follow-up were −0.22 (*95%CI*: −2.04, 1.59; $p = 0.809$). Results from both the Begg and Mazumdar rank correlation test (*Tau* = −0.28, $p = 0.053$) and the Egger's regression intercept test ($\beta = -3.68$, $p = 0.123$) as well as the funnel plot (see Figure S6b) indicated no evidence of publication bias.

Moderators. Community-based interventions had significantly better effects than school-based interventions ($g = -0.32$ vs. 0.96, $p = 0.038$; see Table S5). In addition, interventions that focused on stress reduction ($g = -0.61$), among females ($g = -0.41$), with young children ($g = -0.32$), and were delivered in-person ($g = -0.31$) or by

(A) Forest plot for impulsive food choices

Study name	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Berkel et al., 2014	0.190	0.125	0.016	-0.055	0.434	1.522	0.128
Jastreboff et al., 2018	-0.249	0.319	0.102	-0.874	0.376	-0.781	0.435
Jastreboff et al., 2018-2	-0.237	0.319	0.102	-0.862	0.388	-0.744	0.457
Jastreboff et al., 2018-3	0.133	0.318	0.101	-0.490	0.756	0.418	0.676
Mantzios et al., 2020	-0.595	0.180	0.032	-0.947	-0.243	-3.312	0.001
Simonsen et al., 2020	-0.430	0.479	0.229	-1.368	0.509	-0.897	0.369
Spadaro et al., 2018	-1.527	0.338	0.114	-2.190	-0.865	-4.520	0.000
Timmerman et al., 2012	-0.863	0.347	0.121	-1.544	-0.183	-2.486	0.013
Timmerman et al., 2012-2	-0.728	0.343	0.117	-1.400	-0.056	-2.124	0.034
Timmerman et al., 2012-3	-0.519	0.337	0.114	-1.181	0.142	-1.540	0.124
Timmerman et al., 2012-4	-0.417	0.335	0.112	-1.074	0.240	-1.244	0.214
Misra et al., 2016	-0.323	0.144	0.021	-0.605	-0.041	-2.242	0.025
	-0.429	0.139	0.019	-0.702	-0.156	-3.077	0.002



(B) Funnel plot for the impulsive food choices

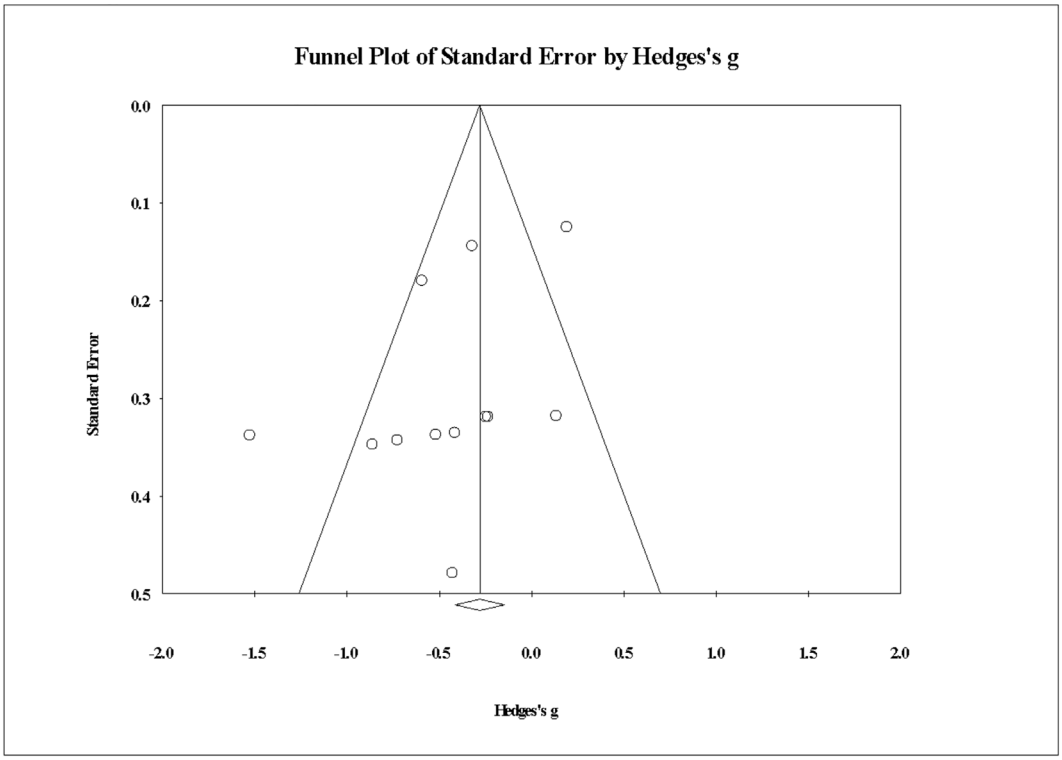


FIGURE 3 Mindless-related eating habits: impulsive food choices. (A) Forest plot for impulsive food choices. (B) Funnel plot for the impulsive food choices. *Note.* Begg and Mazumdar rank correlation test (*Tau* = −0.42, $p = 0.055$), the Egger's regression intercept test ($\beta = -2.28$, $p = 0.072$).

trained research assistants ($g = -0.37$) resulted in more positive effects, but the results were not significant.

Binge eating

The heterogeneity was moderate ($Q = 14.12$, $p = 0.007$, $I^2 = 71.68\%$). The pooled effects on reducing binge eating were −0.35 (Figure S7a). Results from both the Begg and Mazumdar rank correlation test (*Tau* = 0.60, $p = 0.142$) and the Egger's regression intercept test ($\beta = 11.72$, $p = 0.200$) indicated no evidence of publication bias. In addition, the funnel plot of standard error by Hedges' g was symmetric (Figure S7b).

3.5 | Sensitivity analysis results

Studies with a moderate quality had significantly greater effects on decreasing impulsive food choices than those with a high quality ($g = -0.81$ vs. −0.20, $p = 0.012$). Other outcomes were not

significantly related to study quality. However, high-quality studies were more likely to have larger effects on decreasing binge eating ($g = -0.51$ vs. -0.09, $p = 0.434$), energy intake ($g = -0.70$ vs. -0.51, $p = 0.663$), and increasing controlled eating ($g = 0.29$ vs. 0.13, $p = 0.348$) than moderate-quality studies. In contrast, studies with a moderate quality tended to have greater effects on decreasing emotional eating ($g = -0.35$ vs. -0.20, $p = 0.603$) than those that were of high quality.

4 | DISCUSSION

To the best of our knowledge, this is the first systematic review and meta-analysis that has explicitly evaluated the effects of MBIs for improving eating behaviors. Obesogenic eating habits can increase energy intake and contribute to elevated adiposity and obeisty.[61] This systematic review summarized the range of MBIs designed for preventing and treating obesogenic eating habits as well as the effectiveness of MBIs on various mindless and stress-related eating habits. Results from this meta-analysis revealed significant small-to-moderate pooled effects ($g = 0.23$ to -0.69) on improving mindless eating habits. These results are comparable to the effect sizes displayed conjointly in other studies, such as healthy eating ($r = 0.14$),[13] eating attitudes ($g = 0.57$), and overall eating behaviors ($g = 0.53$).[11] Subsequently, MBIs can be utilized to increase individuals' awareness with eating (↑awareness of fullness, physical hunger, and external/internal cues) and help them realize why, what, and how much they should eat. Additionally, mindful eating training can be used to successfully mitigate an autopilot eating style and help to re-establish a healthy and satisfactory relationship with food (↓impulsive food choices). Our results endorse the possibility of increasing participants' physical senses (satiety) to the eating experience and enable them to enjoy the food choices they have made (↑gratitude).

In addition, the significant increases in controlled eating and fullness awareness as well as the decreases in external eating and physical hunger are unique. It is possible that MBIs can be used to significantly connect individuals' sense of awareness with food and repurpose the meaning of eating. Mindful eating training might be a better approach for weight reduction than traditional dieting (dietary restriction for weight loss purpose) because MBIs help individuals purposefully pay attention to their food without judgment. As a result, MBI practitioners are more connected to their physical senses (hunger, fullness) and more appreciative of their food (satiety, gratitude, and enjoyment). Consequently, mindful eating practitioners are less likely to be concerned about restricting their food intake. Since mindfulness is a nonjudgmental approach, mindfulness practitioners are encouraged to choose what and how much they want to consume and are more likely to select foods that are beneficial to their health. For example, our findings in decreased energy/sweet intakes and impulsive food choices further authenticate the promise of using MBIs to tackle awareness-related mindless eating habits. Moreover, the significant long-term sustained effects on physical hunger further validate the benefits of using MBIs to improve mindless eating habits.

In terms of the effects on stress-related eating habits (binge and emotional eating), the effect sizes were small (-0.27 and -0.35, respectively) and insignificant. Our effect size on binge eating is much lower than outdated meta-analyses (>6 years) conducted with overweight/obese adults ($g = -0.90$)[10] or with adults who needed psychological interventions to reduce their problematic eating behaviors ($g = -0.70$).[12] For the more recent meta-analysis (conducted in 2023) targeting adults living with overweight or obesity, MBIs had a combined effect size (percentage change) of -2.37% on emotional eating.[62] In another recent systematic review focused on adults with problem eating behaviors, the positive effects of MBIs were concluded, but no pooled effect size was available for comparison.[63] Overall, the effects of MBIs on emotional or binge eating habits remain relatively obscure, particularly among the general population (those people with or without weight concerns). However, our present findings in improving emotional eating do provide some insights into how MBIs may be utilized to handle stress-related eating habits. Most importantly, the small effects on stress-related eating habits have some clinical significance, particularly when delivered in clinical settings, because our moderation analysis showed that the effects were significantly stronger in clinical settings than in school settings. This finding suggests that clinically tailored MBIs may be more useful for meeting participants' psychological needs and consequently have greater potential for improving participants' emotional and binge eating habits. Unfortunately. our study did not find a significant long-term sustained effect on reducing emotional eating ($g = -0.22$). Additional efforts are needed to understand how MBIs can be modified to improve stress-related eating habits over short- and long-term periods, particularly among those who do not yet have severe eating or mental health problems.

Only two studies (6.25%) in this review reported on treatment fidelity, which may affect studies' reproducibility. Assessing, monitoring, and reporting treatment fidelity (i.e., the degree to which an intervention has been implemented as intended) is essential because it is impossible to know the actual effects of the intervention if the intervention is not consistently delivered. This gap can seriously compromise the evolution of practical applications for MBIs (e.g., scaling up in the real world).[64] This concern is also reflected in the result of our sensitivity analysis in which study quality (moderate and high QA score) seemed to play a role on the effects of decreasing impulsive food choices. Future MBI studies should consistently and rigorously evaluate treatment fidelity to enhance intervention programs' replicability and scalability.

4.1 | Limitations

There were some limitations noted. First, there was high heterogeneity (78.42%) in hunger eating habits, which could impact the reliability of the result. Second, because different measurement tools were utilized to assess eating habits, not all tools were equally validated for people of all genders, ages, and BMIs. Moreover, only two studies (6.25%) in this review assessed treatment fidelity, which may have an

impact on interventions' reproducibility. Finally, while we reported on the risk of bias of all included studies and considered the impact of heterogeneity and publication bias during meta-analysis, a formal GRADE[65] evaluation was not performed for this review. Future research should consider a GRADE evaluation prior to making any practice related recommendations.

5 | CONCLUSION

This meta-analysis found that utilizing MBIs to address mindless eating habits resulted in significant improvements on controlled eating, fullness awareness, external eating, hunger, energy and sweet intake, and impulsive food choices. In terms of stress-related eating, MBIs showed some promise in reducing emotional and binge eating habits. Very few studies investigated the long-term, sustained effects of MBIs. Thus, long-term effectiveness on maintaining obesogenic eating behaviors warrants further investigation, particularly among the general population with or without weight-related issues. Such studies also should strive to better understand the active components and mechanisms of changes in effective MBIs on obesity prevention.

AUTHOR CONTRIBUTIONS

All authors contributed to the design of the study and writing of the manuscript. All authors have approved the final manuscript.

ACKNOWLEDGMENTS

We would like to acknowledge Jessica Sender, a master-prepared health sciences librarian at Michigan State University, for conducting the systematic literature review search for the study.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

ORCID

Jiying Ling https://orcid.org/0000-0003-1997-7914
Mohammed Alanazi https://orcid.org/0000-0002-1698-2892

REFERENCES

1. Daniela M, Robinson L, Gordon G, Werthmann J, Campbell IC, Schmidt U. The outcomes of mindfulness-based interventions for obesity and binge eating disorder: a meta-analysis of randomised controlled trials. *Appetite*. 2021;166:105464. doi:10.1016/j.appet.2021.105464
2. O'Reilly GA, Cook L, Spruijt-Metz D, Black DS. Mindfulness-based interventions for obesity-related eating behaviours: a literature review. *Obes Rev*. 2014;15(6):453-461. doi:10.1111/obr.12156
3. Kao T-SA, Ling J, Alanazi M, Atwa A, Suriyawong W. Effects of mindfulness-based interventions on anthropometric outcomes: a systematic review and meta-analysis. *Obes Res Clin Pract*. 2023;17(3):175-183. doi:10.1016/j.orcp.2023.05.006
4. Wansink B. From mindless eating to mindlessly eating better. *Physiol Behav*. 2010;100(5):454-463. doi:10.1016/j.physbeh.2010.05.003
5. Frayn M, Livshits S, Knäuper B. Emotional eating and weight regulation: a qualitative study of compensatory behaviors and concerns. *J Eat Disord*. 2018;6(1):23. doi:10.1186/s40337-018-0210-6
6. Hendrickson KL, Rasmussen EB. Mindful eating reduces impulsive food choice in adolescents and adults. *Health Psychol*. 2017;36(3):226-235. doi:10.1037/hea0000440
7. Shonin E, Van Gordon W, Griffiths M. Mindfulness-based interventions: towards mindful clinical integration. *Front Psychol*. 2013;4:194. doi:10.3389/fpsyg.2013.00194
8. Nelson JB. Mindful eating: the art of presence while you eat. *Diabetes Spectr*. 2017;30(3):171-174. doi:10.2337/ds17-0015
9. Warren JM, Smith N, Ashwell M. A structured literature review on the role of mindfulness, mindful eating and intuitive eating in changing eating behaviours: effectiveness and associated potential mechanisms. *Nutr Res Rev*. 2017;30(2):272-283. doi:10.1017/S0954422417000154
10. Ruffault A, Czernichow S, Hagger MS, et al. The effects of mindfulness training on weight-loss and health-related behaviours in adults with overweight and obesity: a systematic review and meta-analysis. *Obes Res Clin Pract*. 2017;11(5 Suppl 1):90-111. doi:10.1016/j.orcp.2016.09.002
11. Rogers JM, Ferrari M, Mosely K, Lang CP, Brennan L. Mindfulness-based interventions for adults who are overweight or obese: a meta-analysis of physical and psychological health outcomes. *Obes Rev*. 2017;18(1):51-67. doi:10.1111/obr.12461
12. Godfrey KM, Gallo LC, Afari N. Mindfulness-based interventions for binge eating: a systematic review and meta-analysis. *J Behav Med*. 2015;38(2):348-362. doi:10.1007/s10865-014-9610-5
13. Sala M, Rochefort C, Lui PP, Baldwin AS. Trait mindfulness and health behaviours: a meta-analysis. *Health Psychol Rev*. 2020;14(3):345-393. doi:10.1080/17437199.2019.1650290
14. Bennett BL, Latner JD. Mindful eating, intuitive eating, and the loss of control over eating. *Eat Behav*. 2022;47:101680. doi:10.1016/j.eatbeh.2022.101680
15. Allirot X, Miragall M, Perdices I, Baños RM, Urdaneta E, Cebolla A. Effects of a brief mindful eating induction on food choices and energy intake: external eating and mindfulness state as moderators. *Mind*. 2018;9(3):750-760.
16. Simonson AP, Davis KK, Barone Gibbs B, Venditti EM, Jakicic JM. Comparison of mindful and slow eating strategies on acute energy intake. *Obes Sci Pract*. 2020;6(6):668-676. doi:10.1002/osp4.441
17. Roe LS, Rolls BJ. Which strategies to manage problem foods were related to weight loss in a randomized clinical trial? *Appetite*. 2020;151:104687. doi:10.1016/j.appet.2020.104687
18. Christensen L. Craving for sweet carbohydrate and fat-rich foods–possible triggers and impact on nutritional intake. *Nutr Bull*. 2007;32(s1):43-51. doi:10.1111/j.1467-3010.2007.00615.x
19. Di Sante J, Akeson B, Gossack A, Knäuper B. Efficacy of ACT-based treatments for dysregulated eating behaviours: a systematic review and meta-analysis. *Appetite*. 2022;171:105929. doi:10.1016/j.appet.2022.105929
20. Frayn M, Knäuper B. Emotional eating and weight in adults: a review. *Curr Psychol J Diverse Persp Diverse Psychol Issues*. 2018;37(4):924-933. doi:10.1007/s12144-017-9577-9
21. Powell-Wiley TM, Poirier P, Burke LE, et al. Obesity and cardiovascular disease: a scientific statement from the American Heart Association. *Circulation*. 2021;143(21):e984-e1010. doi:10.1161/CIR.0000000000000973
22. Ling J, Zahry NR. Relationships among perceived stress, emotional eating, and dietary intake in college students: eating self-regulation as a mediator. *Appetite*. 2021;163:105215. doi:10.1016/j.appet.2021.105215
23. van Strien T, Peter Herman C, Engels RCME, Larsen JK, van Leeuwe JFJ. Construct validation of the restraint scale in normal-weight and overweight females. *Appetite*. 49(1):109-121. doi:10.1016/j.appet.2007.01.003

24. Higgins J, Hagman J, Pan Z, MacLean P. Increased physical activity not decreased energy intake is associated with inpatient medical treatment for anorexia nervosa in adolescent females. *PLoS ONE*. 2013;8(4):e61559. doi:10.1371/journal.pone.0061559
25. Lindsay EK. Mindfulness interventions for offsetting health risk following early life stress: promising directions. *Brain Behav Immun Health*. 2021;17:100338. doi:10.1016/j.bbih.2021.100338
26. Knol LL, Crowe-White KM, Appel SJ, Daquin JC. Direct yet opposite effects of stress-related and mindful eating on diet quality. *J Nutr Educ Behav*. 022;54(9):872-877. doi:10.1016/j.jneb.2022.04.006
27. Dunning DL, Griffiths K, Kuyken W, et al. Research review: the effects of mindfulness-based interventions on cognition and mental health in children and adolescents – a meta-analysis of randomized controlled trials. *J Child Psychol Psychiatry*. 2019;60(3):244-258. doi:10.1111/jcpp.12980
28. Liberati A, Altman DG, Tetzlaff J, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. *J Clin Epidemiol*. 2009;62(10):e1-e34. doi:10.1016/j.jclinepi.2009.06.006
29. Kmet LM, Cook LS, Lee RC. Standard quality assessment criteria for evaluating primary research papers from a variety of fields. 2004. https://era.library.ualberta.ca/items/48b9b989-c221-4df6-9e35-af782082280e
30. Zervos K, Koletsi M, Mantzios M, Skopeliti N, Tsitsas G, Naska A. An eight-week mindful eating program applied in a Mediterranean population with overweight or obesity: the EATT intervention study. *Psychol Rep*. 2022;125(2):1011-1040. doi:10.1177/0033294120988104
31. Alberts HJ, Thewissen R, Raes L. Dealing with problematic eating behaviour. The effects of a mindfulness-based intervention on eating behaviour, food cravings, dichotomous thinking and body image concern. *Appetite*. 2012;58(3):847-851. doi:10.1016/j.appet.2012.01.009
32. Alberts HJ, Mulkens S, Smeets M, Thewissen R. Coping with food cravings. Investigating the potential of a mindfulness-based intervention. *Appetite*. 2010;55(1):160-163. doi:10.1016/j.appet.2010.05.044
33. Barnes VA, Kristeller JL. Impact of mindfulness-based eating awareness on diet and exercise habits in adolescents. *Int J Complement Altern Med*. 2016;3(2). doi:10.15406/ijcam.2016.03.00070
34. van Berkel J, Boot CRL, Proper KI, Bongers PM, van der Beek AJ. Effectiveness of a worksite mindfulness-based multi-component intervention on lifestyle behaviors. *Int J Behav Nutr Phys act*. 2014;11(1):9. doi:10.1186/1479-5868-11-9
35. Carpenter KM, Vickerman KA, Salmon EE, Javitz HS, Epel ES, Lovejoy JC. A randomized pilot study of a phone-based mindfulness and weight loss program. *Behav Med*. 2019;45(4):271-281. doi:10.1080/08964289.2017.1384359
36. Daubenmier J, Kristeller J, Hecht FM, et al. Mindfulness intervention for stress eating to reduce cortisol and abdominal fat among overweight and obese women: an exploratory randomized controlled study. *J Obes*. 2011;2011:651936. doi:10.1155/2011/651936
37. Dunn C, Olabode-Dada O, Whetstone L, et al. Mindful eating and weight loss, results from a randomized trial. *J Fam Med Community Health*. 2018;5(3):1152-1159.
38. Fisher N, Lattimore P, Malinowski P. Attention with a mindful attitude attenuates subjective appetitive reactions and food intake following food-cue exposure. *Appetite*. 2016;99:10-16. doi:10.1016/j.appet.2015.12.009
39. Hsu T, Forestell CA. Mindfulness, mood, and food: the mediating role of positive affect. *Appetite*. 2020;158:105001. doi:10.1016/j.appet.2020.105001
40. Hussain M, Egan H, Keyte R, Mantzios M. Exploring the effects of mindfulness and self-distancing on chocolate intake after a negative state affect. *J Cogn Enhanc*. 2020;5(1):15-24. doi:10.1007/s41465-020-00181-5
41. Jastreboff AM, Chaplin TM, Finnie S, et al. Preventing childhood obesity through a mindfulness-based parent stress intervention: a randomized pilot study. *J Pediatr*. 2018;202:136-142.e1. doi:10.1016/j.jpeds.2018.07.011
42. Henninger SH, Fibieger AY, Magkos F, Ritz C. Effects of mindful eating and YogaDance among overweight and obese women: an exploratory randomized controlled trial. *Nutrients*. 2023;15(7). doi:10.3390/nu15071646
43. Mantzios M, Egan H, Asif T. A randomised experiment evaluating the mindful raisin practice as a method of reducing chocolate consumption during and after a mindless activity. *J Cogn Enhanc*. 2020;4(3):250-257. doi:10.1007/s41465-019-00159-y
44. Marchiori D, Papies EK. A brief mindfulness intervention reduces unhealthy eating when hungry, but not the portion size effect. *Appetite*. 2014;75:40-45. doi:10.1016/j.appet.2013.12.009
45. Mason AE, Epel ES, Kristeller J, et al. Effects of a mindfulness-based intervention on mindful eating, sweets consumption, and fasting glucose levels in obese adults: data from the SHINE randomized controlled trial. *J Behav Med*. 2016;39(2):201-213. doi:10.1007/s10865-015-9692-8
46. Mercado D, Werthmann J, Antunes-Duarte T, Campbell IC, Schmidt U. A randomised controlled feasibility study of food-related computerised attention training versus mindfulness training and waiting-list control for adults with overweight or obesity: the FOCUS study. *J Eat Disord*. 2023;11(1):61. doi:10.1186/s40337-023-00780-5
47. Morillo-Sarto H, López-Del-Hoyo Y, Pérez-Aranda A, et al. 'Mindful eating' for reducing emotional eating in patients with overweight or obesity in primary care settings: a randomized controlled trial. *Eur Eat Disord Rev*. 2023;31(2):303-319. doi:10.1002/erv.2958
48. Palmeira L, Pinto-Gouveia J, Cunha M. Exploring the efficacy of an acceptance, mindfulness & compassionate-based group intervention for women struggling with their weight (kg-free): a randomized controlled trial. *Appetite*. 2017;112:107-116. doi:10.1016/j.appet.2017.01.027
49. Sampaio CVS, Magnavita G, Ladeia AM. Effect of healing meditation on stress and eating behavior in overweight and obese women: a randomized clinical trial. *Complement Ther Clin Pract*. 2021;45:101468. doi:10.1016/j.ctcp.2021.101468
50. Sant'Anna EM, Paiva SPC, Santos RP, et al. Mindfulness-based program to support lifestyle modification and weight loss in infertile women: randomized controlled trial. *J Psychosom Obstet Gynaecol*. 2022;43(2):136-144. doi:10.1080/0167482x.2020.1823962
51. Schnepper R, Richard A, Wilhelm FH, Blechert J. A combined mindfulness-prolonged chewing intervention reduces body weight, food craving, and emotional eating. *J Consult Clin Psychol*. 2019;87(1):106-111. doi:10.1037/ccp0000361
52. Seguias L, Tapper K. A randomized controlled trial examining the effects of mindful eating and eating without distractions on food intake over a three-day period. *Nutrients*. 2022;14(5). doi:10.3390/nu14051043
53. Seguias L, Tapper K. The effect of mindful eating on subsequent intake of a high calorie snack. *Appetite*. 2018;121:93-100. doi:10.1016/j.appet.2017.10.041
54. Shomaker LB, Berman Z, Burke M, et al. Mindfulness-based group intervention in adolescents at-risk for excess weight gain: a randomized controlled pilot study. *Appetite*. 140:213-222. doi:10.1016/j.appet.2019.05.022
55. Spadaro KC, Davis KK, Sereika SM, Gibbs BB, Jakicic JM, Cohen SM. Effect of mindfulness meditation on short-term weight loss and eating behaviors in overweight and obese adults: a randomized controlled trial. *J Complement Integ Med*. 2018;15(2). doi:10.1515/jcim-2016-0048

56. Tapper K, Shaw C, Ilsley J, Hill AJ, Bond FW, Moore L. Exploratory randomised controlled trial of a mindfulness-based weight loss intervention for women. *Appetite*. 2009;52(2):396-404. doi:10.1016/j.appet.2008.11.012
57. Timmerman GM, Brown A. The effect of a mindful restaurant eating intervention on weight management in women. *J Nutr Educ Behav*. 2012;44(1):22-28. doi:10.1016/j.jneb.2011.03.143
58. Unick JL, Dunsiger SI, Bock BC, et al. A randomized trial examining the effect of yoga on dietary lapses and lapse triggers following behavioral weight loss treatment. *Obes Sci Pract*. 2023;9(5):484-492. doi:10.1002/osp4.678
59. Gayoso L, de Tomas I, Téllez R, Maiz E, Etxeberria U. Mindfulness-based eating intervention in children: effects on food intake and food-related behaviour during a mid-morning snack. *Mind*. 2021;12(5):1185-1194. doi:10.1007/s12671-020-01587-0
60. Dunn C, Haubenreiser M, Johnson M, et al. Mindfulness approaches and weight loss, weight maintenance, and weight regain. *Curr Obes Rep*. 2018;7(1):37-49. doi:10.1007/s13679-018-0299-6
61. Fogel A, Goh AT, Fries LR, et al. A description of an 'obesogenic' eating style that promotes higher energy intake and is associated with greater adiposity in 4.5year-old children: results from the GUSTO cohort. *Physiol Behav*. 2017;176:107-116. doi:10.1016/j.physbeh.2017.02.013
62. Smith J, Ang XQ, Giles EL, Traviss-Turner G. Emotional eating interventions for adults living with overweight or obesity: a systematic review and meta-analysis. *Int J Environ Res Public Health*. 2023;20(3). doi:10.3390/ijerph20032722
63. Yu J, Song P, Zhang Y, Wei Z. Effects of mindfulness-based intervention on the treatment of problematic eating behaviors: a systematic review. *J Altern Complement Med*. 2020;26(8):666-679. doi:10.1089/acm.2019.0163
64. Lambert JD, Greaves CJ, Farrand P, Cross R, Haase AM, Taylor AH. Assessment of fidelity in individual level behaviour change interventions promoting physical activity among adults: a systematic review. *BMC Public Health*. 2017;17(1):765. doi:10.1186/s12889-017-4778-6
65. Guyatt GH, Oxman AD, Vist GE, et al. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. *BMJ*. 2008;336(7650):924-926. doi:10.1136/bmj.39489.470347.AD

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Kao T-SA, Ling J, Alanazi M, Atwa A, Liu S. Effects of mindfulness-based interventions on obesogenic eating behaviors: A systematic review and meta-analysis. *Obesity Reviews*. 2025;26(3):e13860. doi:10.1111/obr.13860