

Mindfulness-based interventions for binge eating: a systematic review and meta-analysis

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Abstract Mindfulness-based interventions are increasingly used to treat binge eating. The effects of these interventions have not been reviewed comprehensively. This systematic review and meta-analysis sought to summarize the literature on mindfulness-based interventions and determine their impact on binge eating behavior. PubMed, Web of Science, and PsycINFO were searched using keywords binge eating, overeating, objective bulimic episodes, acceptance and commitment therapy, dialectical behavior therapy, mindfulness, meditation, mindful eating. Of 151 records screened, 19 studies met inclusion criteria. Most studies showed effects of large magnitude. Results of random effects meta-analyses supported large or medium-large effects of these interventions on binge eating (within-group random effects mean Hedge's $g = -1.12$, 95 % CI $-1.67, -0.80$, $k = 18$; between-group mean Hedge's $g = -0.70$, 95 % CI $-1.16, -0.24$, $k = 7$). However, there was high statistical heterogeneity among the studies (within-

group $I^2 = 93$ %; between-group $I^2 = 90$ %). Limitations and future research directions are discussed.

Keywords Mindfulness · Dialectical behavior therapy · Acceptance and commitment therapy · Binge eating

Background

Growing research on Cognitive Behavioral Therapy (CBT) has demonstrated its effectiveness in reducing binge eating (Brownley et al., 2007), and CBT protocols have been further developed into guided self-help (Wilson et al., 2010) and transdiagnostic versions (Murphy et al., 2010), which are considered first line or gold standard treatments for binge eating disorder (BED). CBT for binge eating is based on the restraint model where over-evaluation of shape and weight are believed to lead to a cycle of dietary restraint and binge eating in attempt to control weight (Iacovino et al., 2012; Telch et al., 2001). Therefore, CBT aims to decrease dietary restraint and establish healthy eating patterns. Despite moderate treatment outcomes, CBT remains ineffective for many patients with BED, and remission rates typically range between 40 and 60 % (Grilo et al., 2011). Further, these interventions have not been successful in promoting weight loss (Wilson et al., 2007), which is often a significant problem in this population. A need to further improve treatment outcomes and an interest in mindfulness has inspired a newly burgeoning literature on mindfulness-based interventions for binge eating.

Mindfulness is a process defined by two central components: attention to present-moment experiences and a stance of acceptance or openness towards these experiences (Bishop et al., 2004). Mindfulness-based interventions work on building a present-focused attentional state

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that emphasizes observing and experiencing rather than evaluating and changing experiences such as thoughts, sensations, feelings, or urges. Interventions including Dialectical Behavior Therapy (DBT), Acceptance and Commitment Therapy (ACT), and Mindfulness-Based Stress Reduction (MBSR) use mindfulness practice to build awareness, acceptance, and distress tolerance and reduce emotional and cognitive reactivity, automatic behavioral patterns, and avoidance of unwanted experiences (Baer, 2005). In addition, many of these therapies reorient the individual to his or her values, which guides new and more adaptive behavioral patterns. Mindfulness-based treatments can be conceptualized with the dual pathway model (Stice, 2001; Van Strien et al., 2005). This model proposes that dietary restraint is one pathway to binge eating while negative affect, interoceptive awareness, and emotional eating represent another pathway, consideration of which might improve our knowledge about the causes and potential treatment targets for binge eating. This second pathway conceptualizes binge eating as a way to regulate emotion, to avoid unwanted, negative experiences, or as a failure to recognize physical sensations (Van Strien et al., 2005). Thus, the dual pathway model provides a theoretical basis for the increasing interest in using mindfulness-based therapies for binge eating (Wonderlich et al., 2003).

Observational studies and experimental paradigms of emotion regulation or experiential avoidance and eating have provided some support for mindfulness-based therapies for binge eating in clinical and non-clinical samples (Barnes & Tantleff-Dunn, 2010; Epel et al., 2001; Forman et al., 2013; Laessle & Schulz, 2009; Wallis & Hetherington, 2009). Clinically, mindfulness-based interventions have been used to treat binge eating (Baer et al., 2005a; Safer et al., 2001, 2007). Mindful eating has also gained popularity in the self-help literature (Albers, 2012; Bays, 2009; Somov, 2008). Despite increased interest in applying mindfulness-based methods for binge eating, much of the support for these approaches is based in theory, experimental studies, or observational studies, although the literature from uncontrolled cohort studies (UCS) and randomized controlled trials (RCT) is growing. Two recent systematic reviews (Katterman et al., 2014b; O'Reilly et al., 2014) examined studies using mindfulness interventions to address binge eating and related outcomes such as weight, glycemic control, cravings, and emotional eating. However, there remains a gap in the literature regarding the systematic review and meta-analysis synthesizing the evidence from studies examining the effectiveness of all mindfulness-based interventions on binge eating specifically.

The aim of the current systematic review and meta-analysis was to summarize the literature and examine the impact of mindfulness-based psychological interventions

on binge eating. The review includes both UCSs that examine binge eating changes in single groups in response to mindfulness-based interventions and RCTs that compare relative changes in binge eating in response these interventions versus a waitlist, treatment as usual, or control group. This systematic review will describe the studies conducted and examine the overall evidence for the effectiveness of these interventions in reducing binge eating.

Methods

Search strategy

PubMed (from 1953 to December 1, 2013), PsycINFO (from 1806 to December 1, 2013), and Web of Science (from 1900 to December 1, 2013) were searched using the following terms: binge eating OR binge eating disorder OR overeating OR objective bulimic episodes AND acceptance and commitment therapy OR dialectical behavior therapy OR mindfulness OR meditation OR mindful eating. To minimize publication bias, listservs associated with the Society of Behavioral Medicine, the American Psychological Association's Division 38 (Health Psychology), and Academy for Eating Disorders were utilized to collect unpublished data. Additionally, the National Institutes of Health clinicaltrials.gov website was searched for any relevant studies. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were used to perform this systematic review (Liberati et al., 2009).

Inclusion and exclusion criteria

Studies that met the following criteria were included in the screening process for the review: written in English, published in peer-reviewed scholarly journals, RCTs or UCSs of group or individual psychological interventions using DBT, ACT, mindfulness-based therapies such as MBSR, mindfulness meditation, and mindful eating, or an adapted intervention related to these therapies, and assessed binge eating as an outcome variable, but not necessarily the primary target, of treatment. For example, a study that assessed weekly binge eating days before and after an ACT intervention targeting eating, body image, or self-stigma without a singular treatment emphasis on binge eating (Lillis et al., 2011) was included in the review because it still examined the impact of the ACT intervention on binge eating. Many mindfulness-based interventions are based on therapeutic philosophies or treatment approaches that do not emphasize reducing symptoms or changing disorders

but rather focus on cultivating awareness and improving quality of life. Therefore, including studies that did not specifically target changing binge eating during treatment was considered necessary in order to comprehensively represent the mindfulness-based treatment literature.

For the purpose of this review binge eating was defined as eating a large or excessive amount of food at one time and having a sense of loss of control; however, exceptions were made for studies assessing binge eating in individuals in whom eating excessive amounts was not possible. For example, a study of a mindfulness-based intervention with post-bariatric surgery patients assessed binge eating with only the loss of control and guilt after eating items from the Eating Disorder Examination self-report questionnaire (EDE-Q) as these individuals are not physically able to eat large quantities of food (Leahey et al., 2008). There were no inclusion or exclusion criteria regarding sample characteristics so study samples could demonstrate a range of binge eating severity, from clinical samples with a BED diagnosis to community samples without BED or significant binge eating pathology. Publications were excluded if they were book reviews, books, book chapters, published abstracts, conference proceedings, theses and dissertations, review articles, proof of concept papers, or treatment

guidelines or manuals. Observational studies, case studies, single case experiments, and RCTs studying the efficacy of pharmacotherapy for binge eating were also excluded. Studies that only examined binge eating in the context of bulimia nervosa (BN) and those using treatments that are related to ACT or DBT but did not include a mindfulness component (e.g., building emotion regulation skills only) were excluded. Finally, studies were excluded if they only measured constructs related to binge eating (e.g., emotional eating, emotional overeating, external eating, coping with cravings to eat), assessed a history of binge eating but not current binge episodes or symptoms, or only reported subscales of assessments that may be correlated with, but did not directly assess, binge eating (e.g., restraint subscale, external eating subscale).

Search results, effect size, and quality of evidence assessment

Figure 1 shows the flow of documents through the identification, screening, eligibility, and inclusion stages of the systematic review. Data were extracted from these studies by the first author (KG) into a data collection table that included study design, recruitment protocols, sample

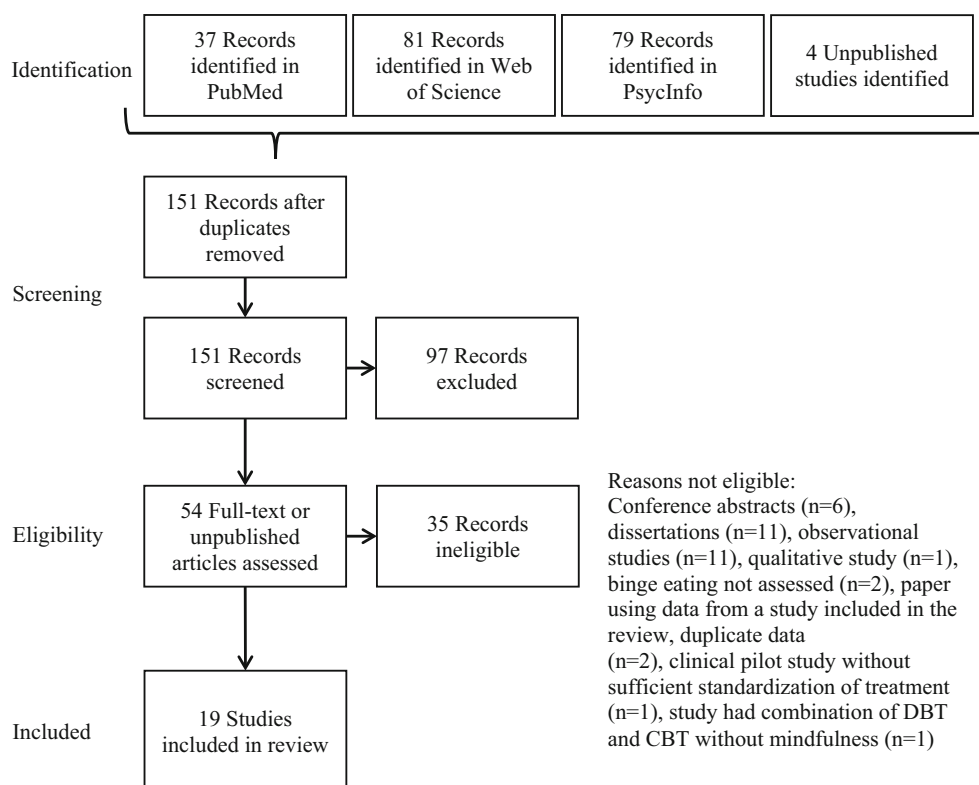


Fig. 1 Flow of documents through the systematic review. *BED* binge eating disorder. *BPD* borderline personality disorder. *DBT* dialectical behavior therapy. *CBT* cognitive behavior therapy

characteristics, intervention characteristics, binge eating outcome measures, follow up periods, means and standard deviations for outcomes of interest, and a statement of overall findings. An independent rater trained on the extraction protocol collected data from a random sample of 6 of the 19 included studies. There was 100 % agreement of the two raters for all data points for the dual-coded studies. Nine authors of the included studies were contacted to request additional study information. Due to the small sample sizes in many of the included studies, Hedges' *g* effect sizes were calculated using means and standard deviations, as appropriate and with the data provided or obtained. Within-group effect sizes used the difference from baseline to post-treatment or follow up period only. Between-group effect sizes compared study groups (e.g., ACT vs waitlist) at post-treatment or follow up. As our focus was on the effectiveness of mindfulness-based interventions per se rather than how they compare to other psychological interventions (e.g., CBT), between group effect sizes were only included in the calculation of mean study effect size if they compared a mindfulness-based intervention to waitlist, control, or treatment as usual. Separate meta-analyses were performed for within-group effect sizes and between-group effect sizes. To perform the meta-analyses using one effect per study, a mean effect size was calculated for each study by averaging effects across all time points. Variance of the mean effect sizes was calculated with an assumed correlation of $r = 0.70$, in line with previous meta-analyses on binge eating (Vocks et al., 2010). Variance of mean effect sizes was calculated using equations from Borenstein et al., (2009). Each study was assessed for quality of evidence using the Effective Public Health Practice Project Quality Assessment Tool (EPHPP; available online at <http://www.ephpp.ca/tools.html>), which has demonstrated lower risk of bias than the Cochrane Collaboration Risk of Bias Tool, another commonly used assessment of study quality for systematic reviews (Armijo-Olivo et al., 2012). Another consideration for analysis of bias was the number of studies arising from the same research group.

Statistical analysis

A meta-analysis was performed on the mean effect sizes calculated for each study to examine the effectiveness of the mindfulness-based interventions compared to baseline or control conditions. As studies in this review had clinical and methodological heterogeneity a random effects model was used to combine effect sizes in the meta-analysis. Overall I^2 statistics were calculated to examine the degree of heterogeneity (Higgins & Thompson, 2002) among included studies. Analyses were conducted using Microsoft

Excel according to standard procedures (Borenstein et al., 2009).

Results

Study characteristics

Table 1 provides the descriptions and details from the included studies. Of the 19 studies, 8 were RCTs, 10 were UCSs, and one was a two group, non-randomized cohort study. Studies were published from 1999 to 2014. Fourteen studies were conducted in the USA, and the remaining 5 were from Canada, Sweden, the UK, and Australia. Ten of the studies recruited participants who were binge eating and/or met criteria for BED. Four publications studied individuals from the community without specifically requiring binge eating as inclusion criteria. Three studies recruited individuals who were concerned about controlling their weight or had been attempting to lose weight. Two studies obtained their samples from a post-bariatric surgery population. The studies were typically comprised of samples that were mostly female (min percent female = 70; max percent female = 100), adult-aged (min mean age = 22; max mean age = 54), and overweight or obese (min mean BMI = 27; max mean BMI = 41).

Quality of evidence

Table 2 presents the component and global ratings of quality assessment for each study. Eight of the 19 studies received weak global quality ratings, mostly due to weak scores on the selection bias (e.g., low percent of eligible participants decide to enroll in the study) and rating of confounders (e.g., no mention of including covariates in the analyses to control for confounders) criteria. The remaining 11 studies received moderate ratings of global quality, with but one study receiving weak scores on the selection bias section. Taken together, the overall rating of quality for the studies reviewed was moderate (modal Global Rating = 2). Four (Masson et al., 2013; Safer et al., 2010; Telch et al., 2000, 2001) of the 6 DBT studies were conducted by or in collaboration with researchers at Stanford University Medical Center. Three (Dalen et al., 2010; Smith et al., 2008; Smith et al., 2006) of the 9 mindfulness-based studies were from a group out of the University of New Mexico, and 2 (Kristeller & Hallett, 1999; Kristeller et al., 2013) other mindfulness-based studies were conducted by researchers at the University of Indiana. Thus, the research using DBT and the other mindfulness-based interventions is limited by the small number of research groups publishing the studies.

Table 1 Information extracted from the studies on mindfulness- and acceptance-based interventions

Authors (Year)	Study type and setting	Sample	Treatment and group size	Comparison(s) and group size	Key findings
Katterman et al., (2014a)	RCT; Psychology department, Drexel University, Philadelphia, PA	$N = 58$; Interested in weight control; 100 % women; mean age 22.4 ($SD = 2.9$); mean BMI 26.6 ($SD = 2.2$)	ACT and behavioral weight control Focus: healthy eating and exercise behaviors promoting long-term weight control $n = 29$; 8 session (first 4–5 weekly, rest monthly), 75 min	Control: $n = 29$; no treatment	OBE days M (SD) Baseline: ACT 0 (0); Control 0.5 (1.7) Mid-tx: ACT 0.2 (1.0); Control 0 (0) Post-tx: ACT 0.1 (0.2); Control 0.1 (0.6) # OBEs M (SD) Baseline: ACT 0 (0); Control 0.52 (1.7) Mid-tx: ACT 0.2 (1.0); Control 0 (0) Post-tx: ACT 0.1 (0.2); Control 0.1 (0.6)
Kristeller et al., (2013)	RCT; Psychology department, University of Indiana, Terre Haute, IN and Duke University Medical Center, Durham, NC	$N = 140$; 111 met DSM-IV or DSM-5 BED criteria; 88 % women; mean age 46.6; mean BMI 40.3	MB-EAT Focus: awareness of inappropriate eating patterns, tools and support to make sustainable changes $n = 50$; group tx; 9 weekly sessions then 3 monthly booster sessions for 12 sessions total. Sessions 1 and 6 were 2 h, rest were 1.5 h	WL: $n = 42$; later offered access to active treatments	OBE days M (SD) Baseline: MB-EAT 14.8 (5.7); WL 14.0 (6.3) Post-tx: MB-EAT 4.8 (5.8); WL 12.8 (8.4) 4 or 6mfu: MB-EAT 3.8 (5.2); WL 11.4 (9.3) BES M (SD) Baseline: MB-EAT 29.0 (7.8); WL 28.1 (7.8) Post-tx: MB-EAT 15.2 (8.1); WL 25.9 (9.0) 4 or 6mfu: MB-EAT 13.5 (9.1); WL 25.1 (7.0)
Masson et al., (2013)	RCT; Department of psychology, University of Calgary, Calgary, Alberta, Canada	$N = 60$; all with DSM-5 BED; 88 % women; mean age 42.8 ($SD = 10.5$); mean BMI 38.0	DBT Focus: reduce binge eating by teaching emotion regulation $n = 30$; guided self-help tx; One 45 min in-person session, 6 biweekly 20 min support phone calls over 13 weeks of guided self-help tx	WL: $n = 30$; given DBT tx after 13 weeks on WL	# OBEs M (SD) Baseline: DBT 18.7 (13.2); WL 19.6 (11.9) Post-tx: DBT 6.0 (9.4); WL 14.4 (11.9) 6mfu: 9.5 (11.9)
Woolhouse et al., (2012)	UCS; University psychology clinic, Swinburne University, Victoria, Australia	$N = 30$; 50 % had symptoms of DSM-IV BED; 31 % had BN symptoms, 19 % had sub-clinical symptoms; 100 % women; mean age 32.2 ($SD = 7.9$)	Mindful MEG Focus: better understand and control eating behavior $n = 30$; group tx; 10 weekly sessions of 3 h duration		MAEDS binge eating M (SD) Baseline: 4.5 (0.9) Post-tx: 2.9 (1.2) 3mfu: 2.9 (1.3)
Klein et al., (2012)	UCS; University psychology clinic, United States	$N = 10$; all reported binge eating; 80 % met full or partial criteria for BED; 20 % BN; 100 % women; mean age 39.6 ($SD = 5.6$)	DBT Focus: group DBT for binge eating $n = 5$; treatment completers; group tx; 16 weekly sessions over 18 weeks (2 week break at midway point) each 2–2.5 h, coaching calls between sessions		Self-reported weekly binges M (SD) Baseline: 3.4 (1.8) Post-tx: 0.5 (0.6)

Table 1 continued

Authors (Year)	Study type and setting	Sample	Treatment and group size	Comparison(s) and group size	Key findings
Weineland et al., (2012b)	RCT; Medical center for minimally invasive surgery and psychology department at the University of Uppsala, Sweden	$N = 39$; all post-bariatric surgery patients; 90 % female; mean age 43.1; mean BMI preoperative 37.1, mean BMI at study baseline 27.2	ACT Focus: increase conscious valued life quality $n = 19$; 2 in-person sessions (1.5 h) at start and end of tx, 6 week self-help tx via internet modules, weekly 30 min support phone session	TAU: $n = 20$; dietary guidelines, follow up and in person telephone sessions as needed, conducted by bariatric team (surgeon, nurse, dietician)	DEBS M (SD) Baseline: ACT 4.1 (4.1); TAU 5.2 (5.2) Post-tx: ACT 1.6 (2.4); TAU 5.54 (5.9)
Courbasson et al., (2011)		$N = 38$; 79 % women; all met criteria for SUD; mean age 42 ($SD = 11.0$)	MACBT Focus: build skills in mindfulness including emotion regulation and mindful eating, psychoeducation, balanced physical activity, focusing on individual strengths $n = 38$; 16 weekly 2 h group sessions		# OBEs M (SD) Baseline: 19.1 (4.5) Post-tx: 8.1 (2.6)
Lillis et al., (2011)	RCT; University of Nevada, Reno	$N = 83$; all completed at least 6 months of structured weight loss programs; 90 % women; mean age 50.8 ($SD = 11.3$); mean BMI 33.0 ($SD = 7.1$)	ACT Focus: living a more fulfilling life consistent with chosen values $n = 40$; 1 workshop session of 6 h	WL: $n = 43$; completed the ACT workshop after the follow up	Weekly binge days M (SD) Baseline: ACT 1.8 (1.4); WL 1.8 (1.4) 3mfu: ACT 1.4 (1.5); WL 2.2 (1.9)
Dalen et al., (2010)	UCS; local YMCA Albuquerque, NM	$N = 10$; 70 % women; mean age 44 ($SD = 8.7$); mean BMI 36.9 ($SD = 6.3$)	MEAL Focus: cultivate awareness of behaviors and reduce automatic eating to reduce binge-type eating and improve psychological functioning $n = 10$; group tx; 6 weekly sessions lasting 2 h each		BES M (SD) Baseline: 16.2 (5.4) Post-tx: 9.2 (5.1) 3mfu: 7.2 (2.3)
Safer et al., (2010)	RCT; Stanford University Medical Center, Stanford, CA	$N = 101$ all with DSM-IV BED; 85 % women, mean age 52.2 ($SD = 10.6$); mean BMI 36.4 ($SD = 6.6$)	DBT Focus: eliminate binge eating by improving emotion regulation $n = 50$; group tx; 20 weekly in-person sessions of 2 h each over 21 weeks (2 weeks between sessions 19 and 20)		OBE days M (SD) Baseline: DBT 15.3 (6.1) Post-tx: DBT 1.4 (2.8) 12mfu: DBT 2.6 (5.0)
Tapper et al., (2009)	RCT; Cardiff University, Cardiff, Wales, United Kingdom	$N = 62$; all actively attempting to lose weight; 100 % women, mean age 41 ($SD = 13$), mean BMI 31.7 ($SD = 6.1$)	ACT Focus: enhance motivation, reduce associations between food- and exercise-related thoughts and behaviors, build tolerance of negative feelings $n = 31$; 4 2-h in-person workshop sessions total: 3 weeks consecutive then 1 follow up session 3 months later	TAU: $n = 31$; continue weight loss attempts, given a chance to attend a 1 day weight loss workshop at end of study	Shortened BES M (SD) Baseline: ACT 7.9 (3.9); TAU 9.1 (3.5) 4mfu: ACT 6.7 (3.6); TAU 9.4 (3.8) 6mfu: ACT 5.4 (3.5); TAU 10.1 (4.4)
Chen et al., (2008)	UCS; University of Washington	$N = 8$; all had BPD; $n = 5$ had BED; $n = 3$ had BN; all women; median age 31; mean BMI 35.8 ($SD = 6.4$)	DBT Focus: standard DBT modified to address binge eating $n = 8$; weekly DBT (skills group, individual therapy, 24 h telephone access) for 6 months		# OBEs M (SD) Baseline: 16.0 (10.4) Post-tx: 5.3 (10.1) 6mfu: 5.8 (9.9)

Table 1 continued

Authors (Year)	Study type and setting	Sample	Treatment and group size	Comparison(s) and group size	Key findings
Leahey et al., (2008)	UCS; Kent State University, Kent, Ohio	$N = 7$; all post-bariatric surgery patients; 85 % women; mean age 54; mean BMI 40.8 ($SD = 5.4$)	CB mindfulness-based intervention Focus: decrease binge eating and emotional eating; enhance well-being and postsurgical adjustment $n = 7$; group tx; 10 weekly sessions lasting 75 min each		Loss of control M (SD) Baseline: 9.1 (7.7) Post-tx: 0.4 (0.7) Guilt after eating Baseline: 2.3 (1.6) Post-tx: 0.6 (0.5)
Smith et al., (2008)	CA; University of New Mexico, Albuquerque, NM	$N = 50$; community sample choosing one of two fee-based stress reduction courses; 80 % women; mean age 44.9 ($SD = 13.7$)	MBSR Focus: increase mindfulness with a focus on eating $n = 36$; group course; 8 weekly sessions each lasting 3 h with a 1 day full retreat on week 6	CBSR: $n = 14$; group course; 8 weekly sessions each lasting 3 h	BES M (SD) Baseline: MBSR 1.8 (0.6); CBSR 1.5 (0.5) Post-tx: MBSR 1.6 (0.4); CBSR 1.4 (0.5)
Smith et al., (2006)	UCS; University of New Mexico, Albuquerque, NM	$N = 25$; community sample signing up for a fee-based stress reduction course; 80 % women; mean age 47.8 ($SD = 13.1$); mean BMI 27.9 ($SD = 7.4$)	MBSR Focus: increase mindfulness with a focus on eating $n = 25$; group course; 8 weekly sessions each lasting 3 h with a one day full retreat		BES M (SD) Baseline: 10.1 (9.6) Post-tx: 7.1 (7.1)
Baer et al., (2005b)	UCS; University of Kentucky, Lexington, KY	$N = 10$; 60 % met DSM-IV BED criteria 40 % met criteria except for frequency of binges (only 3–5 in past month); 20 % previous BN symptoms; 100 % women; age range 23–65; BMI range 22–40	MBCT Focus: mindfulness and cognitive-based skills to reduce binge eating $n = 6$ completers; group tx; 10 weekly sessions, 2 h in length		# OBEs M Baseline: 15.7 Post-tx: 4.0 BES M Baseline: 25.8 Post-tx: 18.4
Telch et al., (2001)	RCT; Stanford University Medical Center, Stanford, CA	$N = 44$; all with DSM-IV BED; 100 % women, mean age 50 ($SD = 9.1$); mean BMI 36.4 ($SD = 6.6$)	DBT Focus: eliminate binge eating by improving emotion regulation $n = 18$; group tx; 20 weekly in-person sessions of 2 h each	WL: $n = 16$; given a chance to complete DBT intervention at post-tx	OBE days M (SD) Baseline: DBT 10.5 (9.0); WL 14.0 (5.0) Post-tx: DBT 0 (0); WL 8.5 (10) # OBEs M (SD) Baseline: DBT 11.5 (10.8); WL 14.5 (7.5) Post-tx: DBT 0 (0); WL 10 (14) BES M (SD) Baseline: 28.8 (6.1); WL 31.8 (6.0) Post-tx: DBT 15.7 (9.4); WL 28.2 (8.3)
Telch et al., (2000)	UCS; Stanford University Medical Center, Stanford, CA	$N = 11$; all met DSM-IV criteria for BED; 100 % women; mean age 45 ($SD = 11.7$);	DBT Focus: eliminate binge eating by improving emotion regulation $n = 18$; group tx; 20 weekly in-person sessions of 2 h each		OBE days M (SD) Baseline: 11.8 (6.0) Post-tx: 1.8 (4.7) # OBEs M (SD) Baseline: 15.2 (12.3) Post-tx: 3.2 (7.6) BES M (SD) Baseline: 32.4 (8.5) Post-tx: 17.2 (9.6)

Table 1 continued

Authors (Year)	Study type and setting	Sample	Treatment and group size	Comparison(s) and group size	Key findings
Kristeller & Hallett (1999)	UCS; Psychology department, University of Indiana, Terre Haute, IN	$N = 18$; all met DSM-IV BED criteria; 100 % women; mean age 46.5 ($SD = 10.5$); mean BMI 40.3	MB-EAT Focus: use of general mindfulness meditation, eating meditation, and mini-meditation $n = 18$; group tx; 7 sessions over 6 weeks		Self-reported weekly binges M (SD) Baseline: 4.0 (1.4) Post-tx: 1.6 (1.5) BES M (SD) Baseline: 31.7 (7.7) Post-tx: 15.1 (8.1)

RCT randomized controlled trial, *UCS* uncontrolled cohort study, *CA* cohort analytic study (two non-randomized groups assessed pre- and post-tx), *ACT* Acceptance and Commitment Therapy, *MEAL* mindful eating and living, *CB* cognitive behavioral, *MBSR* mindfulness-based stress reduction, *CBSR* cognitive-based stress reduction, *MB-EAT* mindfulness-based eating awareness training, *MBCT* mindfulness-based cognitive therapy, *DBT* Dialectical Behavior Therapy, *BED* binge eating disorder, *BN* bulimia nervosa, *MEG* the moderate eating program, *PECB* psycho-educational cognitive behavioral, *WL* waitlist, *TAU* treatment as usual, *Tx* treatment, *Mfu* is month follow up, *TAU* treatment as usual, *OBE* objective bulimic episode, *BES* the binge eating scale, *EDI-3 SC* the eating disorders inventory-3 symptom checklist, *MAEDS* multifactorial assessment of eating disorders scale, *DEBS* disorder eating after bariatric surgery self-report questionnaire, *SUD* substance use disorder, *MACBT* Mindfulness-action based Cognitive Behavioral Therapy, *BPD* borderline personality disorder

Interventions

Mindfulness-based therapies

Nine of the 19 studies used mindfulness-based interventions. These studies typically used either Mindfulness-based Cognitive Therapies (MBCT) or MBSR in original format or adapted to address binge eating behaviors. Four of these studies examined the effects of MBCT on binge eating. Baer et al., (2005b) modified MBCT for binge eating (Segal et al., 2002). The protocol included mindfulness exercises, being accepting and non-judgmental, realizing that thoughts are not facts, increasing activities related to pleasure and mastery, reducing activities related to negative thoughts and moods, and observing and experiencing sensations, thoughts, and feelings while making a choice of behaviors to engage in. One group used an MBCT protocol adapted for the post-bariatric surgery population, emphasizing self-monitoring and modifying eating to be consistent with post-surgery recommendations, identifying and coping with external and internal triggers to overeating, practicing mindful eating, and emotion regulation techniques (Leahey et al., 2008). Woolhouse et al., (2012) employed a MBCT called Mindful Moderate Eating Group (MMEG), which added mindfulness exercises to CBT for binge eating (Crafti, 1994; Crafti & Peyton, 2005). The CBT component of the intervention involved regular and planned meals, self-monitoring, and identifying triggers for binge episodes. Courbasson et al., (2011) developed Mindfulness-Action based Cognitive Behavioral Therapy (MACBT) group treatment for individuals with concurrent BED and Substance Use Disorder (SUD). MACBT contained components of mindfulness, psycho-

education, and balanced physical activity taught in a group setting and practiced at-home through experiential exercises, behavior chain analysis, self-monitoring, goal setting, focusing on strengths (Courbasson et al., 2011). Although there were differences between these 4 MBCTs, they all contained CBT elements for binge eating that target dietary restraint such as self-monitoring and recognizing cognitive and emotional triggers for binge eating or overeating in addition to building mindfulness skills through exercises in group and as homework.

Five studies used an adaptation of MBSR (Kabat-Zinn, 1990) as a mindfulness-based intervention using meditation practice, breathing exercises, body scans, and gentle yoga to build mindfulness through group discussion, workbook activities, and at-home assignments. Two of the 5 studies used Mindfulness-based Eating Awareness Training (MB-EAT), a modified MBSR intervention for BED to improve responses to emotions, conscious food choices, hunger and satiety awareness, and self-acceptance (Kristeller & Wolever, 2011). MB-EAT employs general meditation practice, guided eating meditations, and mini-meditations to be used at meals and throughout the day. The other three studies (Dalen et al., 2010; Smith et al., 2006, 2008) modified MBSR for mindful eating, exploring relationships with common foods, taste awareness, and choices around food similar to the MB-EAT protocol. Five studies from 2 separate research groups, one based in Indiana and the other in New Mexico, adapted the MBSR intervention to integrate eating awareness and choices around food. These 5 studies were fairly similar and contained some overlapping content with the MBCT protocols without the focus on self-monitoring, problem solving to increase adherence to dietary rules, or identifying maladaptive cognitions.

Table 2 Component and global ratings of quality of evidence using EPHPP

Authors (Year)	Selection Bias	Study Design	Confounders	Blinding	Data Collection Method	Withdrawals and Dropouts	Global Rating
Katterman et al., (2014a)	3	1	1	2	1	2	2
Kristeller et al., (2013)	3	1	3	2	1	2	3
Masson et al., (2013)	3	1	3	1	1	2	3
Woolhouse et al., (2012)	3	2	N/A	2	1	2	2
Klein et al., (2012)	3	2	N/A	2	3	3	3
Weineland et al., (2012b)	2	1	3	2	1	2	2
Courbasson et al., (2011)	3	2	N/A	2	1	2	2
Lillis et al., (2011)	3	1	1	2	3	1	3
Dalen et al., (2010)	3	2	N/A	2	1	1	2
Safer et al., (2010)	3	1	3	2	1	2	3
Tapper et al., (2009)	3	1	3	1	1	1	3
Chen et al., (2008)	3	2	N/A	2	1	2	2
Leahey et al., (2008)	3	2	N/A	2	3	3	3
Smith et al., (2008)	3	2	N/A	2	1	2	2
Smith et al., (2006)	3	2	N/A	2	1	1	2
Baer et al., (2005b)	3	2	N/A	2	1	2	2
Telch et al., (2001)	3	1	3	2	1	2	3
Telch et al., (2000)	3	2	N/A	2	1	1	2
Kristeller & Hallett (1999)	3	2	N/A	2	1	1	2

EPHPP Effective Public Health Practice Project Quality Assessment. Ratings are as follows: 1-Strong; 2-Moderate; 3-Weak. N/A means not applicable and was given to uncontrolled cohort studies that only had one group indicating that identifying and controlling for confounders across groups does not apply

Dialectical behavior therapy

Six studies implemented DBT interventions. Five of these studies conducted in-person group therapy, and one used a guided self-help version of DBT. Telch et al., (2000, 2001) used a version of the DBT treatment manual (Linehan, 1993a, b) modified for women with BED. In this protocol, participants were told that binge eating often occurs to reduce negative emotions so noticing and regulating emotions would help them stop binge eating. The main modules included skill building in mindfulness (e.g., observing the present without judgment), emotion regulation (e.g., feeling identification and opposite action), and distress tolerance (e.g., enduring discomfort without binge eating). Participants performed behavior chain analysis and self-monitoring of mood and binge eating, comparable to CBT methods to reduce dietary restraint. This same DBT treatment protocol was later used by the authors of two other studies (Klein et al., 2012; Safer et al., 2010), with an adaptation by Masson et al., (2013) into a self-help manual. For the joint treatment of BED or BN and Borderline Personality Disorder (BPD), Chen et al., (2008) modified the standard DBT for BPD to add an emphasis treating eating-related problems with weekly skills groups, indi-

vidual psychotherapy, consultation teams, and 24-h telephone access to staff. Thus, 5 of the 6 studies using DBT applied versions of the same treatment protocol originally devised by Telch et al., (2000, 2001), and one study used the standard DBT modified to treat binge eating.

Acceptance and commitment therapy

Unlike the studies that used DBT, there was considerable variability in the delivery and content of the 4 ACT protocols. One study (Tapper et al., 2009) used ACT exercises and metaphors adapted to teach values, cognitive “defusion” (i.e., recognizing thoughts as internal events not facts), and acceptance relevant to weight-loss through workshops and at-home practice. Participants gained awareness that eating had been used as a way to avoid negative emotions, and acceptance and mindfulness were used to tolerate feelings and sensations related to diet like hunger and cravings. Lillis et al., (2011) also employed an ACT workshop intervention modified to address concerns around weight loss and maintenance with an emphasis on acceptance, mindfulness, and cognitive defusion. The information, exercises, and group processing activities targeted thoughts and feelings surrounding eating, body

image, and self-stigma, values regarding health and relationships, and barriers and commitments to valued living. Another ACT study (Weineland et al., 2012b) covered similar content (values, acceptance, mindfulness, defusion, and committed action) for a post-bariatric surgery population delivered through a combination of in-person, online, telephone, and recorded media information and exercises. This intervention targeted emotional eating, healthy behaviors, thoughts about shape and self-image, behavioral analysis, and barriers to valued change. The most recent ACT study (Katterman et al., 2014a) was unique in combining the core ACT exercises and topics with behavioral lifestyle changes (e.g., monitoring food, calories, and physical activity, and stress management) to control weight in group sessions with young adult women. Despite the varied methods of delivery, duration, and patient population, the 4 ACT intervention studies all included coverage of the core ACT processes as applied to specific targets of interest including weight loss, emotional eating, self-stigma, and quality of life.

Outcome measures

Eating disorder examination

Ten studies used the Eating Disorder Examination (EDE), the gold standard for assessing binge episodes, called objective bulimic episodes (OBEs), and for diagnosing BED (Cooper & Fairburn, 1987). The EDE assesses number of binge episodes and number of days in which binge episodes occur. Two items (loss of control and guilt after eating) from the EDE-Q were used by Leahey et al., (2008) to assess binge eating in a post-bariatric surgery sample. The other 9 studies using the EDE assessed for BED. Most used the DSM-IV research criteria for BED (American Psychiatric Association, 2000) included in the EDE version 12 (Fairburn & Cooper, 1993) and later in version 16 of the EDE (Fairburn et al., 2008). Two of the studies also assessed BED with DSM-5 diagnostic criteria, which reduces the frequency of binge days to only once per week over the past 3 months and retains all other DSM-IV BED criteria (American Psychiatric Association, 2013).

Binge eating scale

Eight studies used the Binge Eating Scale (BES), a 16 item self-report questionnaire assessing the severity of binge eating behavior in individuals with obesity (Gormally et al., 1982). The BES produces a severity score with ranges of 0–17 indicating no binge eating (none), 18–26 demonstrating moderate binge eating severity, and greater than 26 indicating severe binge eating. Tapper et al., (2009)

used a shortened, 6-item version of the scale assessing the central symptoms of binge eating, which they reported had good internal reliability at baseline in their sample ($\alpha = 0.74$).

Other measures of binge eating

Three studies assessed binge eating with self-reported number of weekly binges by diary card (Klein et al., 2012), phone, or in person (Kristeller & Hallett, 1999; Lillis et al., 2011). Less commonly used measures of binge eating included the Eating Disorders Inventory-3 symptom checklist (EDI-3 SC; Garner, 2004), the Multifactorial Assessment of Eating Disorders Scale (MAEDS; Anderson & Williamson, 1999), and the Disordered Eating after Bariatric Surgery (DEBS) questionnaire (Weineland et al., 2012a). One study assessed the percent of participants who binged using the EDI-3 SC and the binge eating subscale of the MAEDS (Woolhouse et al., 2012). Weineland et al., (2012a, b) used the DEBS, formerly called the Subjective Binge Eating Questionnaire for Bariatric Surgery Patients, which is a self-report measure they developed for assessing binge eating behavior in a post-bariatric surgery population that they report had reasonable psychometric properties (Weineland et al., 2012a).

Effect sizes and meta-analysis

The 19 studies yielded 52 effect sizes for the mindfulness-based interventions. One study (Baer et al., 2005b) did not provide sufficient information to calculate an effect size; the authors responded to a request for information but no longer had access to the data. Four studies only provided sufficient information to calculate a single effect size. Two effect sizes were calculated for 8 of the studies, and 3 effect sizes could be extracted from 2 studies. The remaining 4 studies yielded 4–8 separate effect size calculations. Within-group effect sizes comprised 36 of the 52 effect sizes, whereas only 16 were from between-group effects calculations. Using 0.3, 0.5, and 0.8 to interpret small, medium, and large effects (Cohen, 1992), 34 of the 52 calculated effect sizes were large, 5 were medium, and 4 were small. Eight effect sizes from the same study (Katterman et al., 2014a) were either of negligible magnitude (2 effect sizes: Hedge's $g = -0.15$) or positive in magnitude, suggesting an increase in binge eating in response to the intervention (6 effect sizes: Hedge's $g = 0.27$, Hedge's $g = 0.33$). Another study (Lillis et al., 2011) had nearly a small effect (Hedge's $g = -0.29$).

Figure 2 displays effect sizes and forest plot for the 18 studies comprising the within-group meta-analysis. Results from the within-group random effects meta-analysis

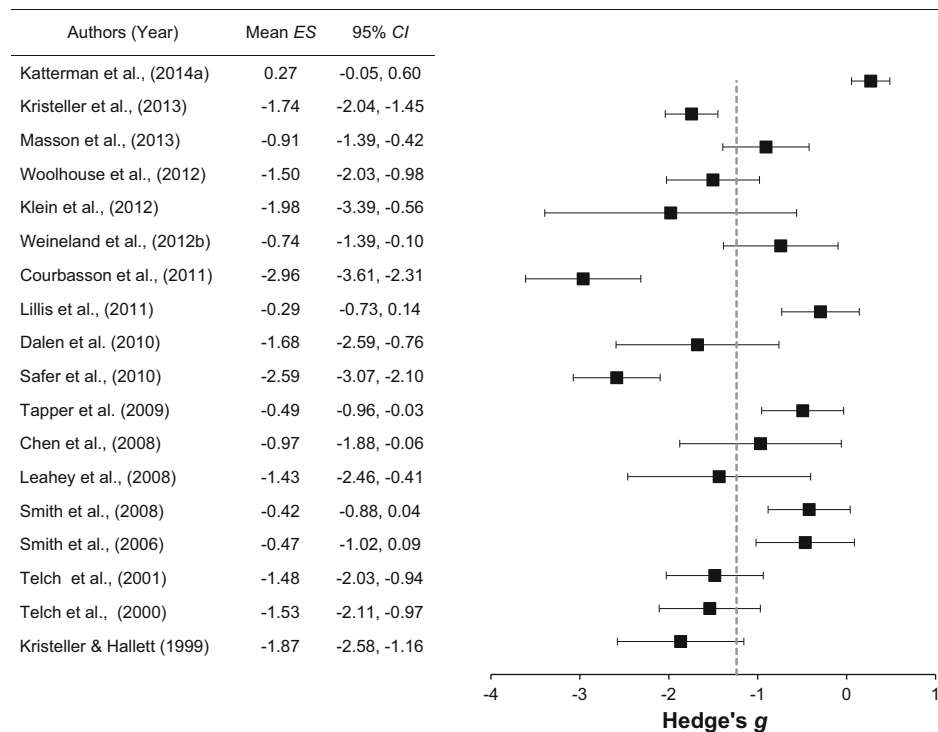


Fig. 2 Within-group effect sizes and forest plot. *Squares* are mean study effect size; *error bars* are 95 % confidence intervals; *dashed line* is mean effect size from the random effects meta-analysis (mean Hedge's $g = -1.12$, 95 % CI $-1.67, -0.80$, $k = 18$)

supported large effects of mindfulness-based interventions in reducing binge eating (mean Hedge's $g = -1.12$, 95 % CI $-1.67, -0.80$, $k = 18$). Figure 3 presents effect sizes and forest plot for the 7 studies involved in the between-group meta-analysis. Results from this between-group random effects meta-analysis supported medium-large effects of mindfulness-based treatments to reduce binge eating (mean Hedge's $g = -0.70$, 95 % CI $-1.16, -0.24$, $k = 7$). There was high statistical heterogeneity among these studies (within-group $I^2 = 93$ %; between-group $I^2 = 90$ %). The heterogeneity limits the overall conclusions that can be drawn from the current research, and therefore results of this meta-analysis should be interpreted with caution.

Discussion

Overall findings

To our knowledge, this is the first systematic review and meta-analysis to examine the effects of mindfulness-based psychological interventions for binge eating. Nineteen unique studies were identified, published between 1999 and 2014. Although many of the early studies were UCSs, some more recent studies were RCTs. MBSR or MBCT adapted for eating were the most common approaches, followed by DBT and ACT. Eleven of the 19 studies assessed BED in

their sample, and the majority of participants in these studies met criteria for BED. Two studies had inclusion criteria requiring participants have BED comorbid with another disorder such as BPD (Chen et al., 2008) or SUD (Courbasson et al., 2011). Three studies required that the participants be interested in or attempting to lose weight, and another 2 studies had a post-bariatric surgery sample. Binge eating measures from the EDE, BES, MAEDS, and weekly self-reports of binges were used to calculate effect sizes for the studies, with the majority of studies demonstrating large effect sizes and the results of the within-group and between-group random effects meta-analyses supporting large and medium-large mean effect sizes. Overall, mindfulness-based interventions were associated with effects on binge eating of large or medium-large magnitude and can be considered effective. The research and popular psychology literature on these interventions is relatively small but growing, which underscores the importance of conducting high quality studies to examine efficacy. Results from this systematic review and meta-analyses offer several considerations, limitations, and future directions for continued work in the field of mindfulness-based treatments for binge eating.

There are several issues to consider with respect to the effects included in these meta-analyses. Relatively larger effects were found in the within-group effect sizes and meta-analysis compared to effects from the between-group

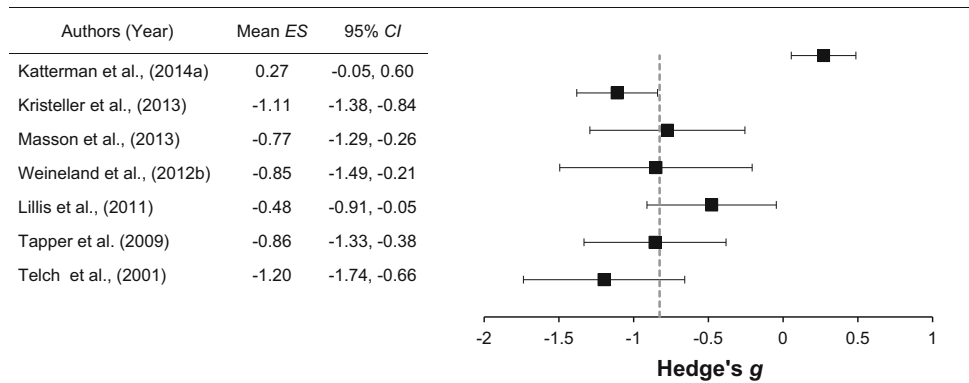


Fig. 3 Between-group effect sizes and forest plot. *Squares* are mean study effect size; *error bars* are 95 % confidence intervals; *dashed line* is mean effect size from the random effects meta-analysis (mean Hedge’s *g* = -0.70, 95 % CI -1.16, -0.24, *k* = 7)

effect sizes and meta-analysis, which is consistent with the differential within- and between-group effects found in CBT for binge eating (Vocks et al., 2010) and in meta-analyses on the efficacy of ACT and DBT for other conditions (Öst, 2008). The effects from a meta-analysis of CBT on binge eating were of similar magnitude with large effects for within-group effects and medium-large effects for between-group effect sizes (Vocks et al., 2010). The attenuated effect of between-group effect sizes may speak to the fluctuating nature of binge eating symptoms over time or unintentional effects of binge eating assessment on behavior, possibly resulting in symptom reduction in the control groups at follow up time points (Kristeller et al., 2013; Telch et al., 2001). The effect sizes in the present meta-analyses were relatively larger than effect sizes found for mindfulness-based interventions generally (Khoury et al., 2013; Öst, 2008), which may indicate that mindfulness-based interventions are particularly well-suited to treating binge eating.

Studies with small or medium effects

Effects of mindfulness-based interventions on reducing binge eating were generally large or medium-large, but there were several characteristics of studies with small effect sizes that deserve mention. Findings from the studies by Lillis et al., (2011), Tapper et al., (2009), Smith et al., (2006, 2008), and Katterman et al., (2014a, b) suggest that mindfulness-based interventions for binge eating may produce negligible, small, medium, or reverse effects in community-recruited samples without substantial binge eating behavior at baseline. Smith et al., (2006) showed that individuals with scores of 0–8 on the BES showed the smallest effect sizes, and participants in the mild, moderate, and severe groups demonstrated large effect sizes, supporting that smaller effects are expected in samples who do not have binge eating behavior at baseline. In Smith’s

et al., ((2006, 2008)) studies, the courses were made up of 26 and 45 participants, which is larger than traditional psychotherapy groups. It is possible that the treatment effectiveness was limited by the size of the groups. The same treatment protocol that yielded small effects for Smith et al., (2006, 2008) was used in a smaller group by Dalen et al., (2010) with large effects. Thus the same treatment protocol may have worked better at reducing binge eating in a small group treatment setting. However, more evidence is needed to compare the effectiveness of course-style intervention delivery compared to traditional psychotherapy groups. Finally, the specific focus of treatment in these studies was not binge eating but instead the interventions targeted weight-related stigma and distress (Lillis et al., 2011), eating (Smith et al., 2006, 2008), emotional eating (Tapper et al., 2009), or weight control (Katterman et al., 2014a). Although dietary restraint was not formally assessed, treatment emphasis on weight control, self-monitoring, and energy intake in Katterman et al., (2014a, b) study may have limited the effects on reducing binge eating, which is consistent with the CBT model of binge eating. These studies with smaller effects demonstrate the need to carefully consider the intervention sample, method of treatment delivery, and focus of treatment.

Limitations and future directions for research

There were several limitations in the literature. First, the quality of evidence was limited by selection bias, not including covariates in statistical analyses, and high drop-out rates from treatment. These weaknesses and others such as inconsistent use of intent-to-treat analyses and reporting only selective outcomes at various study time points should be addressed to strengthen the available evidence. Measuring effects of interventions is dependent upon the quality of the assessment metric so studies not using the EDE or assessing binge eating with novel or modified

measures could be limited by the reliability and validity of the assessment instruments used. Assessment becomes especially difficult when working with a post-bariatric surgery population as the standard definition of binge eating cannot apply due to limits in how much a participant can physically eat at one time. Thus, future research concerning in bariatric surgery populations will need to improve and standardize assessment of binge eating in this population. Another assessment issue arises with the arrival of the DSM-5 (American Psychiatric Association, 2013) and its modified BED criteria. The revised BED diagnostic criteria may impact future work in this area as individuals with less frequent binge episodes over a shorter time period may now receive a BED diagnosis.

The results from this systematic review and meta-analysis are also limited by the substantial methodological and statistical heterogeneity between studies. Studies included in this review were comprised of different samples with varying levels of binge eating symptom severity, varied types of treatment delivery and focus, and diverse assessment instruments. Similarly, two studies included had samples with comorbid BED and other diagnoses. These methodological differences, though they may contribute to statistical heterogeneity, are important to recognize as they likely represent the true variety of samples, methods, and measures employed with mindfulness-based treatments.

This systematic review and meta-analysis has important implications for future research as the literature on mindfulness-based interventions for binge eating grows. More RCTs are needed to examine the effectiveness of these treatments compared to no treatment in order to account for fluctuations in binge eating over follow up periods or the effects of assessment. Longer follow up periods are needed to examine the long-term effects of mindfulness-based interventions on binge eating, as most of the reviewed studies followed their samples for only 3–6 months. Ideally, these follow up periods will include waitlist or other inactive control conditions to examine if changes in binge eating seen over longer periods are part of the natural course or are due to interventions. Future work should also perform more detailed comparisons of treatment protocols and theoretical models supporting the use of various mindfulness-based treatments for binge eating. Another critical question that remains unanswered is how effective mindfulness-based interventions are compared to gold standard CBT treatments. As some of the studies included in this review incorporated CBT-type skills for dietary restraint in addition to mindfulness skills, studies including standard CBT may be able to parse out the effective components of these interventions (i.e., CBT for dietary restraint, mindfulness, or their combination). It may also be important to determine moderators of treatment, such as binge eating subtype (i.e., dietary vs dietary-affective), as

matching treatment type to binge eating subtype might provide clinical utility. Future studies should also begin to examine the mechanisms of change to determine the active ingredients (e.g., emotion regulation, slowed and lengthened periods of eating, awareness of hunger and satiety cues, tolerating distress of hunger, acting in line with values) of these interventions on binge eating. Finally, as the research literature on mindfulness-based interventions for binge eating grows future meta-analyses can be performed to quantitatively determine the relative performance of each mindfulness based intervention (e.g., DBT vs ACT) and the impact of certain treatment characteristics (e.g., online vs in-person; workshop vs multiple sessions; directly targeting binge eating vs focusing on building mindfulness skills) on the effectiveness of these treatments.

Conclusion

This systematic review and meta-analysis found that mindfulness-based psychological interventions for reducing binge eating have large or medium-large effects overall. Although based on a small number of studies, it also appears that the interventions appear to be less effective in individuals without significant reported binge eating at baseline and when delivered in larger workshop or course-style settings that do not target binge eating directly. Limitations of the literature include the quality of evidence and the assessment of binge eating. Future research should implement RCT designs, determine the long term effects, compare the effectiveness of mindfulness-based treatments to gold standard CBT interventions, explore moderators of treatment, and uncover mechanisms of these interventions.

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Conflicts of interest Kathryn Godfrey, Linda Gallo, and Niloofar Afari have no conflicts of interest to report.

Human and Animal Rights and Informed Consent All procedures followed were in accordance with ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000. Informed consent was obtained from all patients for being included in the study.

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