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Empirical research

Trusting homeostatic cues versus accepting hedonic cues: A randomized controlled trial comparing two distinct mindfulness-based intervention components

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ABSTRACT

Objective: Mindfulness-informed cognitive behavioral interventions for obesity are promising. However, results on the efficacy of such treatments are inconsistent which in part may be due to their substantially different methods of practice. This study is the first direct comparison of two theoretically distinct mindfulness-based weight loss approaches: increasing awareness of homeostatic/innate physiological cues versus hedonic/externally-driven cues for eating.

Methods: Overweight adults were randomized to one of three group-based workshops: Mindful Eating (ME; n = 21), Mindful Decision-Making (MD; n = 17), or active standard behavioral control (SC; n = 19). Outcome measures included percent weight change and reduction in caloric intake from baseline to 6 weeks.

Results: Differences in weight loss and calorie reduction did not differ significantly among groups. However, the difference in weight loss between the MD and ME groups trended towards significance, with medium-large effect sizes.

Conclusions: Results provide modest preliminary evidence for the utility of mindful decision-making strategies over mindful eating for short-term weight loss and calorie reduction.

1. Introduction

Obesity is an alarming public health issue (Finkelstein, Trogdon, Cohen, & Dietz, 2009), and gold standard behavioral treatment yields equivocal long-term outcomes (Garner & Wooley, 1991; Wing & Jeffery, 1999). Behavioral interventions incorporating mindfulness have shown recent promise for improving weight loss outcomes and promoting successful long-term maintenance (Forman, Butryn, Hoffman, & Herbert, 2009; Lillis, Hayes, Bunting, & Masuda, 2009; Niemeier, Leahey, Palm Reed, Brown, & Wing, 2012; O'Reilly, Cook, Spruijt-Metz, & Black, 2014). However, reports on the efficacy of the various treatments are inconsistent. One factor clouding the support for these approaches is that mindfulness-based interventions differ substantially in practice (Olson & Emery, 2015; O'Reilly et al., 2014; Tapper, 2017). Mindful Eating (ME) and Mindful Decision-Making (MD) are two such components with promising evidence, but with theoretically distinct conceptualizations of how to apply mindfulness.

2. Mindful Eating in behavioral weight loss interventions

Mindful Eating (ME) is a component of Mindfulness-Based Eating Awareness Training (MB-EAT; Kristeller & Wolever, 2011; Kristeller, Wolever, & Sheets, 2014) that includes training in multiple skills aimed to better engage the body's homeostatic mechanisms and decrease mindless overconsumption. It is based on the theory that increasing awareness and discernment of hunger and satiety cues improves the body's natural ability to self-regulate food consumption (Kristeller & Wolever, 2011). Research has shown that attending to bodily sensations immediately before eating improves awareness of hunger and satiety cues and adjusts further consumption (Van de Veer, Van Herpen, & Van Trijp, 2016). Similarly, tuning in to sensory experiences (e.g., taste, texture, flavor), specifically of tasty, high-calorie foods, enhances enjoyment and awareness of satiety resulting in fewer calories consumed (Arch et al., 2016). Overweight individuals have difficulty recognizing and responding to physical hunger and satiety

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cues (Craighead & Allen, 1995; Lowe, 2003); thus, increasing awareness of bodily cues should reduce consumption by allowing individuals to recognize when they are hungry and/or satisfied by a food (Kristeller & Wolever, 2011; Mathieu, 2009).

ME-based interventions have been shown to reduce overconsumption and promote weight loss in overweight individuals (Miller, Kristeller, Headings, Nagaraja, & Miser, 2012; Sloan, Colleran, & Shelley, 2007; Timmerman & Brown, 2012) and to regulate eating patterns in overweight/obese individuals with binge eating disorder (Kristeller et al., 2014). Components of ME treatment appear to help reduce caloric intake in normal weight individuals (Jordan, Wang, Donatoni, & Meier, 2014; Marchiori & Papies, 2014), decrease specific intake of sweet foods (Mason et al., 2015), and yield reduced drives to consume highly palatable food (Mason et al., 2016) in obese individuals.

Despite the promise suggested by the previously described results, studies evaluating ME-based approaches specifically for weight loss have yielded conflicting findings. The largest, most well-controlled weight loss trial to date (n = 194) comparing an ME-based intervention with an active control produced no significant weight loss differences between groups (Daubenmier et al., 2016). Another smaller study comparing an intensive four-month ME-focused intervention for overweight/obese individuals also reported no significant advantage for weight loss over waitlist control (Daubenmier et al., 2011). One potential explanation for conflicting findings among ME-based interventions is that the positive and null results are driven by different mechanisms, and reflect distinct components of treatment that have been bundled differently. Indeed, as ME is usually packaged with other techniques (e.g., cognitive and behavioral techniques, psychoeducation, other acceptance-based strategies), different results may derive from intervention components other than ME. It is thus unclear which intervention component(s) drive behavioral changes (e.g., Katterman, Goldstein, Butryn, Forman, & Lowe, 2014; Timmerman & Brown, 2012).

It is possible that training awareness of internal processes may not, in fact, improve the ability to distinguish homeostatic cues from hedonic cues (Lowe & Butryn, 2007). People may be unable to discern these signals, and in fact may respond to greater internal awareness with an enhanced hedonic drive to eat that *increases* food consumption. This notion is consistent with the biobehavioral model of obesity, which theorizes that humans possess a biologically-based, evolutionarily-driven tendency to eat energy-dense foods and to default toward behavioral consumption of caloric surplus (Lowe, 2003; Stroebe, Papies, & Aarts, 2008). This promotes exceptional difficulty resisting the highly palatable foods that are persistently available in modern society, and promoting a positive rather than homeostatic energy balance (Blundell & Gillett, 2001; Hill & Melanson, 1999; Lowe, 2003; Stroebe et al., 2008). Drawing attention to these evolutionary drives may serve only to exacerbate the problem of overconsumption. Empirical research also provides support for this theory. While many factors are thought to contribute to development of obesity, responsiveness to hedonic cues for eating (Lowe & Butryn, 2007) rather than physiological hunger/satiety cues (Hall, Hammond, & Rahmandad, 2014) has been implicated as one major contributing factor. Indeed, self-reported hunger is only minimally associated with subsequent consumption (Herman, Fitzgerald, & Polivy, 2003; Mattes, 1990). Moreover, hedonically pleasing foods (e.g., high fat, high sugar) can actually increase physical hunger signals to a degree that suppresses satiety signaling, thus disrupting appetite regulation (Erlanson-Albertsson, 2005). In fact, evidence supporting the biobehavioral model raises the possibility that *discouraging* reliance on homeostatic cues to guide eating decisions may more effectively change consumption than would training to discern and follow the "wisdom" of homeostatic signals.

3. Mindful Decision-Making in behavioral weight loss

Mindful Decision-Making (MD) is a mindfulness-based approach theoretically in line with Acceptance and Commitment Therapy (Hayes, Strosahl, & Wilson, 2011) and other acceptance-based behavioral treatments (ABTs) specifically targeting weight loss (Forman, Butryn et al., 2013; Niemeier et al., 2012). The approach aligns with the biobehavioral model of obesity and suggests that consumption is primarily cued by hedonic hunger (appetitive drive to consume highly palatable foods; Lowe et al., 2009). Thus, training an awareness of cues that trigger urges to eat highly palatable foods and increasing one's willingness to experience (versus avoid) these food-related internal experiences will facilitate the behavioral control necessary to *override* hedonic drives.

Converging evidence has demonstrated that ABT interventions (that include MD) may be equally or more effective than traditional or standard cognitive-behavioral interventions for the modification of eating and weight-control behavior (Forman et al., 2009). One RCT of 128 overweight individuals comparing ABT to standard behavioral treatment (SBT) found that ABT achieved superior weight loss and maintenance at 6 months follow-up when delivered by clinicians with weight-control experience (Forman, Butryn et al., 2013). A similar, larger comparison of ABT and SBT (n = 190) found greater weight losses at 6-months mid- and 12-months post- treatment in the ABT condition, as well as a greater likelihood of maintaining 10% weight losses at 12-months (Forman, Butryn et al., 2016). Lillis et al. (2016) evaluated ABT and SBT across 24-months and showed that ABT participants had a greater mean weight loss and a higher proportion of participants maintaining 5% weight loss at 24-months. Notably, MD-based interventions have effectively reduced chocolate consumption in normal weight (Forman et al., 2007; Jenkins & Tapper, 2014) and overweight samples (Forman, Hoffman, Juarascio, Butryn, & Herbert, 2013) and compared to a psycho-educational control, reduced salty snack food consumption (Forman, Martin, et al., 2013).

The mechanism by which ABT interventions provide an advantage over traditional cognitive-behavioral approaches is still unclear. Some have proposed that these interventions may be more effective at targeting problematic eating patterns that are associated with poorer treatment response (Forman & Butryn, 2015; Lillis & Kendra, 2014), including hedonic hunger (appetitive drive to consume highly palatable foods; Lowe et al., 2009) and emotional eating (tendency to eat in response to negative affective states; Oliver, Wardle, & Gibson, 2000). Forman, Butryn et al. (2013) found that individuals high in hedonic hunger lost more weight in ABT relative to SBT only, a benefit that was further mediated by changes in acceptance. Relative to receipt of SBTs, individuals high in both hedonic hunger and emotional eating (either alone or in combination) have also been shown to better minimize their chocolate intake after learning awareness and acceptance-based (versus control-based) strategies for managing strong cravings (Forman et al., 2007; Hooper, Sandoz, Ashton, Clarke, & McHugh, 2012). Additional evidence suggests that individuals high in hedonic hunger who are assigned to ABTs versus SBTs also lose more weight and maintain their losses better (Niemeier et al., 2012).

Similar to ME, most studies examining the efficacy of MD-based interventions to date have utilized multi-component interventions that include additional acceptance-based strategies (e.g., defusion, values clarification; Forman et al., 2007; Forman & Hoffman, et al., 2013; Forman, Martin, et al., 2013) or a combination of acceptance-based and standard-behavioral strategies (Forman et al., 2009; Forman, Butryn et al., 2013; Niemeier et al., 2012). Thus, no conclusions can be drawn as to which specific strategies account for the changes observed.

Proponents of the ME component might argue that MD's emphasis on intentionally abstaining from eating in response to urges to eat can be counterproductive in that attention to external cues and not acting on innate drives would disconnect individuals from their interoceptive awareness, leading to further overeating in the long-term. ME is meant to cultivate awareness and discernment of internal processes (e.g., physical hunger and satiety, emotions) as a *natural* mechanism for strengthening self-control and interrupting conditioned behavioral patterns (e.g., automatic overeating behavior). Thus, based on the premise of these ME components, re-regulating the body's innate homeostatic processes is sufficient for guiding food-related decisions (e.g., food choices, initiating and stopping the eating process) that lead to a negative energy balance. Given that programs using ME utilize multiple components which confounds the literature, this theory has yet to be tested (Tapper, 2017).

4. Theoretical similarities and differences in components

Whereas MD draws on evidence that overconsumption is motivated automatically through external stimuli (e.g., presence of food, container size, plate size; Wansink & Kim, 2005; Wansink, Painter, & Lee, 2006; Wansink & Park, 2001; Wansink & Sobal, 2007), both MD and ME rest on the science showing that overconsumption is also driven by internal cues (e.g., emotions, cognitions; Garaulet et al., 2012; Ozier et al., 2008). Developers of both components also agree that inability to recognize the automatic effect of cues on eating decisions produces "mindless eating," which is associated with overeating and weight gain (Barkeling, King, Naslund, & Blundell, 2007; Wansink, 2010; Wansink, Payne, & Chandon, 2007), and both concur that individuals need to increase *awareness* of internal experience to shift behavior patterns. The focus of awareness, however, is distinct in these two components. Though both ME and MD components acknowledge the importance of interrupting automaticity to allow more deliberate rather than impulsive processes to occur, these two components attempt to interrupt automaticity with highly distinct tactics.

Bidirectional interactions between higher cognitive processes and other bodily mechanisms can be described via the heuristic of "bottom-up" or "top-down" mechanisms (Gard, Noggle, Park, Vago, & Wilson, 2014; Taylor, 2010), and this heuristic is useful in describing the distinction of the two studied treatment components. Bottom-up mechanisms influence cognitive processes through peripheral stimulation of somatosensory, viscerosensory and chemo-sensory receptors that communicate to the brainstem and cortex through afferent/ascending pathways. In contrast, top-down mechanisms are initiated at the level of the cerebral cortex and are thought to involve mostly conscious and intentional processes. ME relies primarily on "bottom-up" processes that emphasize discernment of the physical cues for starting and stopping eating; these mindful practices create a pause in automatic behavior patterns allowing space for different decision-making to emerge. MD trains individuals to consciously inhibit consumption by intentionally choosing behavior that is aligned with longer-term goals, using "top-down" processes (Forman & Shaw, et al., 2016). In MD, individuals are taught to observe their higher-order decision making processes, and in particular their automatic reactivity to hedonic consumption cues. MD aims to increase awareness and acceptance of drives and cues to consume highly palatable foods to control one's eating behavior. MD teaches nonjudgmental acceptance of these urges to eat as understandable and expected, yet momentary, internal experiences. Rather than trying to change, control, or relieve the urges (e.g., by attempting to suppress thoughts or eating a craved food), individuals are taught to build tolerance to the potential discomfort associated with not giving in to urges.

4.1. Current study

In summary, ME and MD represent two theoretically distinct components of mindfulness-based approaches with unique implications for weight loss and reduced caloric consumption. ME trains awareness and discernment of physical hunger and satiety cues to be trusted as guides for eating decisions, whereas MD trains awareness and acceptance of consumption cues to promote deliberately *overriding* such cues. These two apparently efficacious and highly unique mindfulness-based approaches have not previously been evaluated independently of one another, and their comparative effects are yet unknown. To our awareness, the current study is the first to directly compare these two distinct intervention components. We aimed to 1) examine the independent and relative efficacy of ME and MD for weight loss and reduction in caloric consumption among overweight and obese individuals and 2) evaluate the moderating effects of hedonic hunger, emotional eating, and food-related psychological acceptance on the relationship between intervention type and weight loss/caloric reduction.

5. Methods

5.1. Participants and procedures

Participants were recruited through mass email announcements to staff and faculty at an urban university. Eligibility was examined via a semi-structured phone screen interview and confirmed in a brief in-person clinical assessment. Participants were eligible to participate if they were: interested in losing weight; aged 18–70 years; had a BMI 25–50 kg/m^2 (inclusive); fluent in English; had access to a high-speed Internet connection for completing the self-administered dietary assessment (listed below). Participants were excluded if they were currently engaged in a lifestyle modification or weight loss program; had type I or type II diabetes or polycystic ovarian syndrome (PCOS); were pregnant or planning to become pregnant in the next two months; had started, stopped, or changed a routine dose of medication affecting weight or appetite within the last two months; had a current or historical eating disorder diagnosis; or had severe psychiatric symptoms that would limit ability to benefit from the program. Participants completed a baseline assessment and follow-up measurements of caloric intake, weight, and treatment acceptability/satisfaction for which they received $40. The follow-up assessment occurred approximately six weeks after baseline, approximately two weeks after the final intervention session.

5.2. Measures

5.2.1. Percent change in body weight

Body weight was measured at baseline and six weeks later using a digital, self-calibrating scale accurate to .1 kg; participants were instructed to remove their shoes and all jewelry. Percent weight loss was then calculated by subtracting an individual's baseline weight from post-treatment weight, and dividing by baseline weight. Larger positive values correspond to greater weight loss.

5.2.2. Total caloric intake

Caloric intake was assessed using the Automated Self-Administered 24-h Dietary Recall (ASA24; National Cancer Institute, 2014), a web-based tool that enables participants to report their food and beverage intake over a 24-h period. Studies have shown that the *ASA24* is superior to traditional food diaries and questionnaires (Buzzard, 1998; Moshfegh et al., 2008). Participants completed the ASA24 at baseline and 6 weeks on three randomly selected, non-consecutive days across a 7-day period, including one weekend day. Three days were chosen, as that is the number of days considered to be a representative of an individual's intake (Ma et al., 2009). Residualized change, rather than raw change, was assessed to account for baseline differences in pre-treatment caloric intake.

5.2.3. Treatment acceptability and participant satisfaction

At the 6-week visit, participants rated treatment acceptability (e.g., perceived helpfulness for losing weight and for minimizing consumption: "How helpful do you believe that the treatment strategies were for losing weight / minimizing your consumption?") and overall treatment satisfaction (e.g., "How satisfied were you with your treatment experience?") on a Likert-type scale ranging from 1 (not at all) to 5 (very).

5.2.4. Hedonic hunger

The *Power of Food Scale* (PFS; Lowe et al., 2009) is a 15-item self-report scale which assesses individual differences in hedonic drives for consumption of highly palatable foods (including general drives, and those when such foods are present or tasted). The scale has good internal consistency (α = .91) and strong test-retest reliability (4-month test-retest reliability r = .77).

5.2.5. Emotional eating

The Emotional Eating subscale of the *Three-Factor Eating Questionnaire-Revised* (TFEQ-R; Stunkard & Messick, 1988) is a 6-item subscale to assess tendency to eat in response to negative emotional states. The TFEQ is widely used in obesity research and has strong psychometric qualities (α = .78–.94; Stunkard & Messick, 1988).

5.2.6. Food-related acceptance

The *Food-Related Acceptance and Action Questionnaire* (Juarascio, Forman, Timko, Butryn, & Goodwin, 2011) assesses one's ability to experience uncomfortable internal experiences (e.g., thoughts, feelings, urges and cravings) versus attempting to change or control them; the scale has adequate internal consistency (α = .66) and convergent and divergent validity (Juarascio et al., 2011).

5.3. Intervention

Each intervention was delivered in a small-group, 6- to 12-participant format. All interventions lasted 4 h. Participants in all groups attended two additional 60-min booster sessions, occurring two and four weeks post-workshop. These sessions were designed to facilitate reinforcement of concepts learned during the workshop, and to provide accountability for self-monitoring.

To ensure that treatment effects were attributable only to the difference in psychological/behavioral strategies introduced, participants in all conditions were instructed that the strategies learned in group would help them to achieve a negative energy balance of at least 500 kcal/day. This guideline was used as a general means by which to convey to all participants that the interventions were designed to facilitate reductions in caloric intake. All participants were specifically prohibited from counting calories and instead, encouraged to intentionally rely on the psychological and/or behavioral strategies taught in their treatment groups. Differences in the strategies by which participants were instructed to reduce food intake in each treatment condition are detailed below. Groups were led by doctoral level students with behavioral weight loss experience. Level of experience of group leaders was balanced across conditions.

5.3.1. Mindful Decision-Making (MD)

The MD intervention was adapted from previously studied MD-based protocols for weight loss (Forman, Butryn et al., 2013; Niemeier et al., 2012). The MD treatment rationale was as follows: gaining awareness and acceptance of urges and cravings to consume, and the cues that trigger them, is important to override the body's desire to consume and reduce caloric intake. Participants were first instructed to draw their attention to internal and external cues that typically drive their consumption at each phase of the eating process. The intervention also included exercises to help participants practice experiencing (rather than avoiding) urges to consume highly palatable foods (e.g., to eat potato chips that were placed in front of them), without consuming as much as was desired. Daily self-monitoring was conducted via a tracking worksheet between intervention sessions. Participants were asked to note at least one situation per day in which they intentionally used MD strategies (increased awareness and acceptance of internal/external drives to eat) to help override an urge to consume. Optimally, participants were asked to attend to the cues that prompt urges to eat all meals and snacks and to willingly experience any discomfort associated with inhibiting their eating behaviors.

5.3.2. Mindful Eating (ME)

The ME workshop was adapted from 5 of the 8 ME components of the MB-EAT protocol (Kristeller & Wolever, 2011) in consultation with one of its authors (Ruth Wolever, Ph.D.). The ME workshop specifically focused on cultivating awareness of physical hunger and satiety cues. Interventionists began by providing the rationale that tuning in to the body's homeostatic cues can serve as a guide to the decisions individuals make about when to start and stop eating, which can lead to decreased caloric consumption. Group leaders guided experiential exercises including general mindfulness meditations and mindful eating exercises designed to help individuals register homeostatic cues. Participants engaged in exercises designed to help them tune in to physical hunger, gastric or "stomach satiety" (i.e., sensation of fullness in the stomach) and "taste-specific satiety" (i.e., bite-to-bite change in pleasure experienced by flavors on the tongue), three primary homeostatic cues thought to guide eating behavior. Participants practiced tuning in to their homeostatic drives throughout the workshop and rating momentary hunger and fullness on a scale from 1 (very hungry) to 10 (very full). Daily self-monitoring between intervention sessions included recording at least one daily snack or meal that was consumed using ME strategies, along with hunger and fullness ratings before and after consumption. Optimally, participants were encouraged to eat all meals and snacks mindfully, and no limit was set as to the maximum frequency with which hunger and fullness ratings could be monitored; moreover, participants were encouraged to engage in a food or non-food-related "mini-meditation" daily.

5.3.3. Standard behavioral control (SC)

The SC group received extensive dietary guidance based on the U.S. Dietary Guidelines for Americans developed by the USDA and USDHHS. Setting specific, personalized, and realistic behavioral goals for reduction of food intake was promoted as an essential tool for weight loss. The intervention's approach was didactic, with exercises aiding participants in interpreting food labels that varied in nutritional content, identifying portion sizes, and calculating the calories in sample meals. Participants were instructed to self-monitor daily, by selecting specific goals for reduced consumption of a target high-calorie food, or other nutrition strategies taught in group, and to note whether they met their goals each day. Though participants frequently focused on reducing intake of one or more specific high-calorie foods, they were explicitly instructed not to count overall daily caloric intake.

5.4. Statistical analyses

All statistical analyses were completed using SPSS v. 23.0 (IBM Corp.). Assumptions for Analysis of Variance (ANOVA) were checked prior to conducting inferential analyses.

5.4.1. Primary outcomes analyses

The effect of group assignment (ME, MD, or SC) on each of the primary outcome variables (% weight change and residualized change in caloric intake) was evaluated using one-way ANOVA. Post-hoc pairwise comparisons were assessed using Tukey's Honestly Significant Difference. Due to small group sizes and limited power to detect significant effects, we elected to focus primarily on effect size for all primary outcome and secondary moderation analyses.

5.4.2. Moderation analyses

The moderating effects of food-related acceptance, hedonic hunger, and emotional eating on treatment outcome were assessed with three separate between-subjects analysis of covariance tests (ANCOVAs). For each outcome variable, the model included main effects of group and the continuous moderator variable, as well as the group by moderator interaction term.

6. Results

6.1. Baseline participant characteristics & overall outcome

A total of 88 individuals consented to take part in the study and 79 were randomized to one of the three treatment conditions. Following completion of data collection, cases meeting the *a priori* criterion for gross outliers (per guidelines outlined in Bollen and Jackman, 1985) were removed from analyses ($n = 2$ for weight loss and $n = 4$ for calorie reduction) to avoid undue influence of single data points on the overall pattern of results. Primary analyses were conducted with and without outliers. See Fig. 1 for diagram of participant flow. The sample was primarily female (71.9%) and White (54.3%), although considerable racial and ethnic diversity was observed (Black/African American: 24.6%; Asian: 17.5%; Latino/Hispanic: 7%). Mean age was 38.9 ± 10.31 years and mean baseline BMI was 32.6 ± 5.96 kg/m^2. See Table 1 for a summary of baseline sociodemographic and clinical

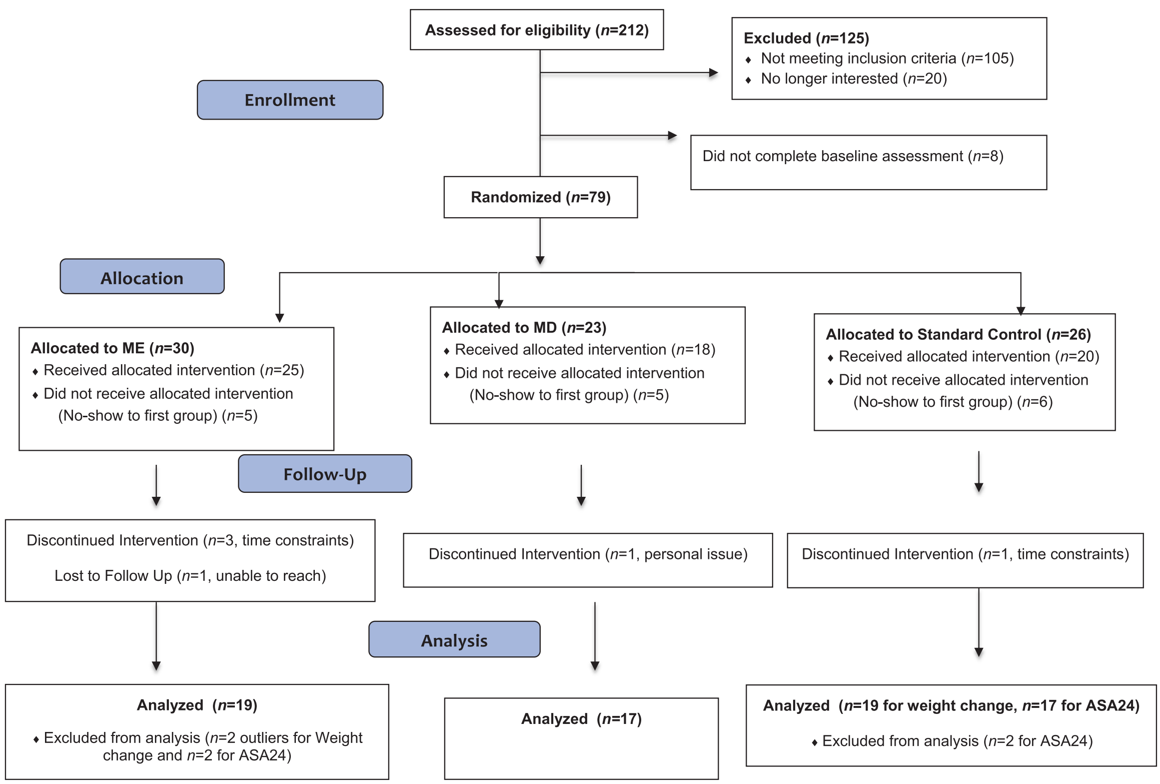

Fig. 1. CONSORT diagram.

Table 1
Baseline group characteristics.

Baseline variable	SC ($n = 20$)	MD ($n = 18$)	ME ($n = 24$)	Test statistic & *p*-value
n Female Participants (%)	14 (70.0%)	14 (77.8%)	18 (75.0%)	$\chi^2(2) = .31; p = .86$
Race—*n* of group:				$\chi^2(8) = 6.43; p = .60$
Caucasian	9	10	15	
African-American	5	5	5	
Asian	5	2	4	
Pacific Islander	1	0	0	
Other	0	1	0	
Age	41.6 (15.5)	39.8 (15.7)	38.0 (18.0)	$F(2,59) = .26; p = .77$
BMI	33.0 (5.8)	32.0 (5.4)	32.7 (6.4)	$F(2,59) = .13; p = .88$
Daily Caloric Intake[a]	2422 (1015)	2324 (833)	2179 (596)	$F(2,47.2) = .47; p = .63$
FAAQ	28.6 (6.9)	28.4 (9.0)	33.8 (8.6)	$F(2,59) = 2.96; p = .06$
PFS	2.5 (.7)	2.8 (.7)	2.6 (.9)	$F(2,59) = .41; p = .54$

BMI = Body Mass Index; FAAQ = Food Acceptance and Action Questionnaire; PFS = Power of Food Scale. Baseline characteristics comparisons shown here account for all individuals who attended the first workshop session, including dropped out of treatment or were lost to follow-up ($n = 8$).

[a] Brown-Forsythe test of equality of means applied in place of one-way ANOVA due to inequality of variances among groups.

Table 2
Primary outcomes: weight change and calorie reduction.

Outcome variable	SC *M (SD)*	MD *M (SD)*	ME *M (SD)*	*F* (df)	*p*	η_p^2	Post-hoc comparisons
% Weight loss	1.3 (1.47)	1.8 (1.87)	.6 (1.58)	2.66 (2,52)	.08	.09	MD vs. ME: p = .07 d = .72 MD vs. SC: p = .55 d = .34 SC vs. ME: p = .41, d = .45
Calorie reduction	444.3 (653.35)	624.1 (660.10)	264.7 (634.65)	1.78 (2,50)	.18	.07	–

SC = Standard Behavioral Control; MD = Mindful Decision Making; ME = Mindful Eating. For the Calorie Reduction model, analyses were conducted on residual gain scores; raw change scores are listed here for ease of interpretation.

characteristics among the three treatment groups. No significant baseline group differences were detected.

Across six weeks, participants lost an average of 2.5 lbs (SD = 3.40), or 1.2% of starting weight, and reduced their daily intake by approximately 437 cal (SD = 653.4). No significant differences between groups were detected on ratings of perceived helpfulness for weight loss (F(2,54) = .77, p = .47, $\eta_p{}^2$ = .03), perceived helpfulness in minimizing consumption (F(2,54) = .02, p = .98, $\eta_p{}^2$ < ; .01), and overall treatment satisfaction ratings (F(2,54) = .27, p = .77, $\eta_p{}^2$ = .01).

6.2. Effect of treatment assignment on weight loss

Results from a one-way ANOVA revealed an effect of group on percent weight loss that trended towards significance, with a medium-large effect size (p = .08, $\eta_p{}^2$ = .09). Post-hoc comparisons indicated that the effect was primarily driven by greater weight loss observed in MD (M = 1.8%, SD = 1.87) versus ME (M = .6%, SD = 1.58), and that the size of this difference was medium-large (p_{diff} = .07, Cohen's d = .72). The percent weight loss for neither the MD nor the ME group was significantly different from the control group. Full summary statistics for both weight loss and caloric intake are given in Table 2.

6.3. Effect of treatment on reduction in caloric intake

The mean caloric reduction in the MD group was 624 kcal (SD = 660.1), relative to 264 kcal (SD = 634.7) in the ME group. The one-way ANOVA for residualized change in caloric intake did not reach significance (p = .18, $\eta_p{}^2$ = .07).

6.4. Moderators of weight loss outcome

One-way ANCOVAs yielded no significant treatment group by moderator interaction effects. A trend toward a main effect of hedonic hunger (p = .10, $\eta_p{}^2$ = .06) indicated the likelihood that, collapsed across groups, participants with greater hedonic hunger tended to lose less weight during treatment. Food-related acceptance was found to be a significant moderator of weight loss outcome across treatment groups (p = .05, $\eta_p{}^2$ = .08); specifically, greater acceptance of food-related thoughts and cravings was associated with greater overall weight loss. No significant effect of emotional eating on total percent weight loss was detected across groups. A summary of these results and corresponding statistics can be found in Table 3.

Table 3
Hedonic hunger, food-related acceptance, and emotional eating as moderators of weight loss outcomes.

Moderation model Factor/Covariate	*F*	df	*p*	η_p^2 & 95% CI
Hedonic Hunger	2.85	1,49	.10	.06 [.00, .22]
PFS Score	1.34	2,49	.27	.05 [.00, .21]
Group	.62	2,49	.54	.03 [.00, .16]
Group * PFS				
Food-Related Acceptance	4.22	1,49	.05	.08 [.00, .25]
FAAQ Score	.98	2,49	.38	.04 [.00, .19]
Group	.51	2,49	.60	.02 [.00, .15]
Group * FAAQ				
Emotional Eating				
TFEQ-EE	.40	1,49	.53	< .01 [.00, .12]
Group	1.14	2,49	.33	.04 [.00, .20]
Group * TFEQ-EE	.92	2,49	.40	.04 [.00, .18]

PFS = Power of Food Scale; TFEQ-EE = Three-Factor Eating Questionnaire-Emotional Eating Subscale; FAAQ = Food Acceptance and Action Questionnaire.

Table 4
Hedonic hunger, food-related acceptance, and emotional eating as moderators of calorie reduction.

Moderation Model Factor/Covariate	*F*	df	*p*	η_p^2 & 95% CI
Hedonic Hunger	.86	1,47	.36	.02 [.00, .15]
PFS Score	2.09	2,47	.14	.08 [.00, .26]
Group	2.66	2,47	.08	.10 [.003, .29]
Group * PFS				
Food-Related Acceptance				
FAAQ Score	2.55	1,47	.12	.05 [.00, .21]
Group	1.72	2,47	.19	.07 [.00, .24]
Group * FAAQ	1.63	2,47	.21	.07 [.00, .23]
Emotional Eating	.05	1,47	.82	< .01 [.00, .72]
TFEQ-EE	1.52	2,47	.23	.06 [.00, .23]
Group	1.82	2,47	.17	.07 [.00, .24]
Group * TFEQ-EE				

PFS = Power of Food Scale; TFEQ-EE = Three-Factor Eating Questionnaire-Emotional Eating Subscale; FAAQ = Food Acceptance and Action Questionnaire.

6.5. Moderators of reduction in caloric intake

A group by hedonic hunger interaction trended towards significance (p = .08, $\eta_p{}^2$ = .10), suggesting that for individuals high in hedonic hunger, the MD treatment appeared to provide particular benefit over ME and SC for reductions in calorie intake. No significant group-by-moderator interaction effects were observed for emotional eating or acceptance. See Table 4 for full summary statistics.

7. Discussion

This study is the first to isolate two theoretically distinct mindfulness-based intervention components for obesity, i.e., Mindful Eating (ME) and Mindful Decision-Making (MD) and examine their specific efficacy relative to each other and to a control intervention that provided basic knowledge and behavioral skills for reducing caloric intake (SC). Across all conditions, participants reported similarly high levels of treatment satisfaction, and indicated that they believed the skills taught would help them lose weight. Despite the high acceptability of all three treatment approaches, findings provide modest empirical support only for an advantage of MD over ME in producing short-term weight loss that trended towards significance. The SC intervention demonstrated intermediate performance, with no trend or statistically significant differences between this intervention and either of the two mindfulness-based interventions.

Though preliminary and limited in scope, these results have implications for behavioral weight loss intervention strategies. When considering only mindfulness-based interventions, individuals seeking to lose weight may benefit more from mindfulness skills emphasizing increased awareness, acceptance and *overriding* of hedonic drives to eat, rather than those promoting reliance on homeostatic cues to reduce consumption. These findings reflect previously reported evidence supporting MD (Forman, Butryn, et al., 2013; Forman, Butryn, et al., 2016; Forman, Hoffman, et al., 2013; Niemeier et al., 2012), and parallel findings showing that ME did not promote weight loss (Daubenmier et al., 2016; Kristeller et al., 2014). However, the short-term advantage of either of these mindfulness-based approaches relative to standard behavioral weight loss treatment was not supported by the present results. The preliminary nature of these results must be emphasized. Rather than supporting firm conclusions about the advantage of one treatment over another, these results instead emphasize the need for larger, longer-term trials.

It is interesting to consider why the ME intervention demonstrated a modest disadvantage relative to MD in terms of short-term weight loss. The limited timeframe in which this study was conducted is an important factor to consider when interpreting these results. It is possible that MD skills may be easier to acquire, and that participants were able to enact these strategies competently within the six-week timeframe, whereas ME participants may have had difficulty obtaining the perceptual skills trained in ME. In ME, learning to tune into and discern one's hunger and satiety cues may be a process that requires substantially more time and practice (in or out of treatment) than other strategies, and effects on weight loss may only be observable after several weeks or months. Indeed, anecdotal evidence from our participants revealed challenges both noticing and trusting their hunger and satiety cues early on in treatment. For example, participants in the ME group endorsed difficulty achieving a “mindful” state during meal times, particularly during the first two to three weeks following the workshop.

The present study may have provided insufficient time for participants to master the skill of mindful eating and incorporate it into their daily eating routines. Indeed, in their review, Katterman, Kleinman, Hood, Nackers, and Corsica (2014) described a need for longer-term treatment studies, with more extensive follow-up periods, to determine whether ME skills may provide overall advantages for weight management once mastered and incorporated into daily life. Notably, results from the ME treatment study with longest follow-up to date (18 months) found no significant weight loss effects at end of treatment (Daubenmier et al., 2016). However, participants in the ME-like condition exhibited very little weight regain at one-year follow-up (.3 kg), compared to the consistent and significant weight regain typical of most behavioral weight loss trials.

The fact that SC yielded outcomes similar to MD was contrary to our initial hypothesis about the relative added benefit of mindfulness-based approaches for weight loss. However, the finding is perhaps not surprising given the active nature of the control intervention and its similarity to standard behavioral weight loss treatment approaches (Standard Behavioral Therapy, SBT; Butryn, Webb, & Wadden, 2011). In fact, given that SBT has been shown to be equally as effective over the short-term as multicomponent acceptance-based SBTs that include MD (Forman, Butryn et al., 2013), this finding may be considered a mere replication of past work. What is notable here is that MD was delivered without standard behavioral strategies or other acceptance-based components (i.e., cognitive defusion, values-guided behavioral control) and still performed similarly to SC across 6 weeks. Notwithstanding these results, it is still important to acknowledge that MD and SC both have room for improvement given that participants in each condition lost on average one pound.

Results from moderation analyses also have implications for behavioral weight loss intervention strategies. Across conditions, greater baseline acceptance was associated with modestly greater overall weight loss. This suggests that a willingness to accept chronic drives to eat, and willingness to experience uncomfortable internal experiences associated with these drives, may be associated with better response to weight-loss interventions, regardless of the treatment type offered. Importantly, this study only assessed acceptance at baseline. In the future, it will be important to continue targeting psychological acceptance and evaluate the effect of change in psychological acceptance as a predictor of weight loss (Niemeier et al., 2012) and mediator of treatment outcome (Forman, Butryn et al., 2013). Results also suggested that higher levels of hedonic hunger predicted smaller weight losses across conditions, which is consistent with previous results in other weight loss samples (Forman, Butryn et al., 2013; Schultes, Ernst, Wilms, Thurnheer, & Hallschmid, 2010). Furthermore, MD appeared to provide a trend level advantage in reducing caloric intake among individuals higher in baseline hedonic hunger. MD emphasized increased awareness and acceptance of both internal (cognitive, affective) and external (environmental cues) triggers for eating, and it is possible that this approach proved most effective among individuals who struggle more with these triggers.

This research must be considered in the context of important strengths and limitations. This is the first study to our knowledge that has conducted a component analysis of mindful cultivation of homeostatic cues versus mindful decision-making. Our study was also strengthened by the use of an active control group, which allowed for direct comparison of the two strategies, as well as consideration of their effects relative to skills provided in standard behavioral weight loss treatments. In addition, treatment groups were characterized by high rates of participant retention, and similar satisfaction rates across groups; thus, differences in outcome are likely not attributable to differential levels of participant treatment engagement. Despite significant strengths, this study has several limitations. Recruitment was limited from the outset by personnel, time and money, which likely led to limited power to detect significant effects. Even when assuming a medium-large true effect size, an a priori power analysis indicated that a total of 84 participants would have been required to achieve a power of .80 to detect a significant effect at an α-level of .05. (computer with G*Power software v3.1.9.2). For this reason, we sought to emphasize effect size in combination with significance levels, but also acknowledge that results should be interpreted with caution. The study was also limited by the brief nature of the workshop intervention. To demonstrate clinically significant effects on weight and food intake, most behavioral weight loss treatments require treatment lasting several months to one year (Butryn et al., 2011). Replication with larger sample sizes, as well as longer intervention and follow-up periods, is warranted.

In summary, the present study contributes to a growing body of evidence for the potential value of mindfulness-based intervention components for behavioral weight loss. This investigation is the first to examine the specific comparative effects of two distinct mindfulness-based treatment approaches. Results from this study suggest that different intervention strategies that are captured under the umbrella of “mindfulness-based interventions” may have differential effects on weight-related treatment outcomes. Specifically, our findings provide modest preliminary evidence for the utility of acceptance-based mindful decision-making strategies over mindful eating for the promotion of short-term weight loss. Reliance on the body's physiological hunger and satiety cues may not provide an accurate indication of what and how much to eat in order to achieve a negative energy balance. Instead, learning to override one's internal cues (including but not limited to homeostatic sensations) in the interest of reducing consumption, may be a more effective strategy. Though both of these strategies are considered to be mindfulness-based, they appeared to yield different effects on short-term weight loss outcomes. As mindfulness-based interventions continue to grow in popularity and empirical support, it will be important for future researchers to identify which components of mindfulness-based interventions are the most effective in promoting weight loss and weight loss maintenance, and also in determining whether these interventions show any benefit beyond that of standard behavioral weight loss interventions.

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