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A mindfulness-based intervention to control weight after bariatric surgery: Preliminary results from a randomized controlled pilot trial

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Abstract

Objective—This study aimed to develop and test a novel mindfulness-based intervention (MBI) designed to control weight after bariatric surgery.

Design—Randomized, controlled pilot trial.

Setting—Beth Israel Deaconess Medical Center, Boston, MA, USA.

Interventions—Bariatric patients 1–5 years post-surgery (n=18) were randomized to receive a 10-week MBI or a standard intervention.

Main outcome measures—Primary outcomes were feasibility and acceptability of the MBI. Secondary outcomes included changes in weight, eating behaviors, psychosocial outcomes, and metabolic and inflammatory biomarkers. Qualitative exit interviews were conducted post-intervention. Major themes were coded and extracted.

Results—Attendance was excellent (6 of 9 patients attended 7 of 10 classes). Patients reported high satisfaction and overall benefit of the MBI. The intervention was effective in reducing emotional eating at 6 months (-4.9 ± 13.7 in mindfulness vs. 6.2 ± 28.4 in standard, p for between-group difference = 0.03) but not weight. We also observed a significant increase in HbA1C (0.34 ± 0.38 vs. -0.06 ± 0.31 , $p = 0.03$). Objective measures suggested trends of an increase in perceived stress and symptoms of depression, although patients reported reduced stress reactivity, improved eating behaviors, and a desire for continued mindfulness-based support in qualitative interviews.

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Conflict of Interest Statement

Dr. Chacko has received payment for instructing mindfulness classes at Beth Israel Deaconess Medical Center. All other authors have no conflicts of interest to declare.

Conclusions—This novel mindfulness-based approach is highly acceptable to bariatric patients post-surgery and may be effective for reducing emotional eating, although it did not improve weight or glycemic control in the short term. Longer-term studies of mindfulness-based approaches may be warranted in this population.

Keywords

Mindfulness; obesity; weight; bariatric surgery

Introduction

Bariatric surgery is the most effective treatment for severe obesity,¹ yet weight regain is common and typically begins 1–2 years post-surgery. Approximately 30% of patients regain weight at 18 months to 2 years after surgery² with a small minority regaining most of their weight. Although factors driving weight regain are not fully understood, it is widely believed that psychological and behavioral factors play a major role.³ Studies suggest weight regain is more likely among patients who fare worse psychologically after surgery.³

Treatment options to prevent weight regain, however, are not well studied. Traditional behavioral strategies incorporating diet, physical activity, and behavioral modification, although effective in the short term, are generally not successful in maintaining weight loss in the long term and are not effective in patients with severe obesity.⁴ These approaches may lack effectiveness because they do not adequately emphasize coping skills for handling stress, a frequent trigger of disordered eating behaviors.

Mindfulness-based approaches, in contrast, provide a systematic method of stress reduction that may be particularly well suited for bariatric patients who face unusually high levels of obesity-related stigma, discrimination, and social bias.^{5,6} Mindfulness, or “nonjudgmental awareness of the present moment”,⁷ is an awareness-based practice rooted in Buddhist tradition that espouses a non-reactive, compassionate, and accepting stance to life. Mindfulness-based approaches have been shown clinically to be effective for chronic pain,⁸ stress,⁹ depression,¹⁰ and anxiety.¹⁰ Increasingly, these approaches are being applied to obesity treatment. Emerging research suggests acceptance and mindfulness-based approaches may be effective for reducing emotional and binge eating,¹¹ and early evidence, although mixed, suggests promise for weight control.¹² However, few studies have tested this approach in bariatric patients post-surgery.

In this context, we developed a novel mindfulness-based intervention designed to prevent weight regain after bariatric surgery. We conducted a randomized controlled pilot trial to test the feasibility, acceptability, and efficacy of the novel intervention as compared to a standard intervention in bariatric patients 1–5 years post-surgery. To explore the efficacy of the intervention, we examined changes in weight, eating behaviors, psychosocial outcomes, and metabolic and inflammatory biomarkers.

Methods

Study Design

This was a randomized controlled clinical trial designed to test the feasibility, acceptability, and efficacy of a novel 10-week mindfulness based intervention (MBI) as compared with a standard intervention.

Recruitment of Study Participants—Eligible bariatric patients were recruited from the Weight Loss Surgery Center at Beth Israel Deaconess Medical Center (BIDMC) through targeted mailings and recruitment fliers. Eligible participants had undergone bariatric surgery 1–5 years prior to the start of the intervention, were between the ages of 18–65, and reported < 5 lbs weight loss in the past 3 months. We excluded patients with serious psychiatric illness measured by self-report of hospitalization for psychiatric reasons in the past year and medical record review, personality disorders assessed by medical record review, severe depression assessed by an adapted version of the PHQ-9, current alcohol or substance abuse, >1 weight loss surgery, and prior experience with meditation in the past six months or a regular meditation practice. Exclusion criteria were assessed via medical record review and phone screening. All patients provided written informed consent. The BIDMC institutional review board reviewed and approved the study protocol.

After screening eligible, potential participants attended a run-in session to assess motivation, commitment, and availability. This 1-hour nutrition class was also intended to balance nutrition knowledge in participants at study start. Participants were given a pedometer and instructed on its use. After attendance at the run-in session, participants underwent baseline testing at the BIDMC Harvard Catalyst Clinical Research Center (CRC) and were then randomly assigned to receive either the MBI or the standard intervention consisting of a 1-hr nutritional counseling session with a registered dietician. Treatment assignments for randomization were generated in SAS by the study statistician using permuted blocks with randomly-varying block sizes. Treatment assignments were sealed in sequentially-numbered, opaque envelopes. Randomization was stratified by surgery type. Study staff opened sealed envelopes immediately after baseline testing to determine the final treatment assignment. Study outcomes were assessed at baseline, 12 weeks, and 6 months. Nutrition and lifestyle handouts were sent to participants in both groups several times throughout the study.

Mindfulness-based Intervention—As a pilot program, we developed a novel mindfulness-based intervention designed to prevent weight regain after bariatric surgery. The intervention integrated mindfulness with adapted versions of traditional behavioral strategies for obesity (e.g. goal setting, problem-solving, stimulus control, self-monitoring, social support). The primary aim of the intervention was to improve coping skills to support long-term weight maintenance. The conceptual model underlying the intervention is shown in Figure 1.

To target a model of weight regain¹³ that may be particularly relevant to bariatric patients (Figure 2), we emphasized coping attitudes of mindfulness including patience, acceptance, and self-compassion to help mitigate life stressors. Formal meditative practices were taught

alongside behavioral skills explained through the lens of mindfulness. For example, setting small and achievable goals, a traditional behavioral skill, was taught with a focus on cultivating self-kindness and patience with setbacks. These attitudes were emphasized specifically to target the discouragement and unrealistic expectations that often undermine efforts toward behavior change (Figure 2). Other behavioral skills were taught in a similar vein. Formal mindfulness practices reinforced these attitudes.

The structure of the intervention was adapted from the established Mindfulness-based stress reduction (MBSR)⁷ course. We also incorporated elements from Mindfulness-based eating awareness (MB-EAT),¹⁴ although our intervention focused more heavily on traditional behavioral skills than MB-EAT. Unlike standard behavioral therapy, we did not include explicit calorie and exercise goals since our target was not intensive weight loss but rather long-term weight maintenance. Concepts from the Mindful Self-Compassion (MSC)¹⁵ course were also included.

Classes were held once a week for ten weeks, and each session lasted 90 minutes. Sessions began with formal mindfulness practice (sitting meditation, loving-kindness meditation, body scan, mindful chair yoga, walking meditation), followed by group sharing on the week's experience, and ended with a didactic portion covering a behavioral concept or skill taught from the perspective of mindfulness. A half-day retreat (4 hours) of extended silent meditation practice was held mid-way through the course. Participants were asked to meditate at home at least six days/week, and audio recordings of guided meditations were provided for home practice. Meditation lengths were increased incrementally each week, and meditations were taught in a similar style as in MBSR. Table S1 shows an outline of the intervention. A qualified mindfulness instructor (SC) trained through the Center for Mindfulness at the University of Massachusetts Medical School led the intervention.

Standard Intervention—Participants assigned to the standard intervention received a 1-hour individualized counseling session with a registered dietician at BIDMC. In this session, participants spoke privately to the dietician about their efforts in weight management. The dietician provided guidance on nutrition, exercise and lifestyle strategies tailored to post-surgical patients. This intervention was chosen as a control to mirror the usual nutrition standard-of-care that bariatric patients receive annually post-surgery.

Study Outcomes

Measures of Feasibility and Acceptability—The primary outcome was feasibility and acceptability of the study intervention as measured by success meeting recruitment goals (>20 patients within 3–4 months), willingness to participate (>10% of eligible), adherence rate (70% attendance, 7 of 10 classes), and retention (25% drop-out). We also explored acceptability of the intervention in qualitative exit interviews. Adverse events were tracked at 12-week and 6-month follow-up visits.

Anthropometric Measures—Height was measured using a wall-mounted stadiometer. Weight was measured to 0.1 kg using a digital scale with the participant clothed in light clothing or a hospital gown. Waist circumference was measured in duplicate to the nearest 0.1 cm on a horizontal plane around the abdomen at the level of the iliac crest.

Behavioral and Psychosocial Measures—Eating behaviors were measured using two validated questionnaires. The Three Factor Eating Questionnaire Revised-18 (TFEQ-R18)¹⁶ is an 18-item questionnaire (Scores 0–100) that captures three eating behaviors including 1) cognitive restraint; 2) uncontrolled eating; and 3) emotional eating. The Binge Eating Scale (BES)¹⁷ is a 16-item scale (Scores 0–32) that assesses behavioral, emotional, and cognitive symptoms of binge eating. We measured eating self-efficacy using the Weight Efficacy Lifestyle Questionnaire (WEL),¹⁸ a 20-item validated questionnaire (Scores 0–180) that assesses confidence in resisting the desire to eat in different situations. We tracked physical activity level using an adapted version of the 7-day physical activity recall¹⁹ and calculated total energy expenditure (kcal/kg) based on metabolic equivalents (METs) for moderate-intensity (4 METs) and vigorous-intensity (8 METs) activity.

Quality of life (QOL) was assessed using the validated Medical Outcomes Study Short-Form-36 (SF-36) questionnaire (Scores 0–100)²⁰ and the Impact of Weight on Quality of Life-Lite (IWQOL-Lite) (Scores 0–100).²¹ Depression was measured using the Center for Epidemiologic Studies Depression Scale (CES-D),²² a validated 20-item self-report measure (Scores 0–60). Stress was assessed using the Perceived Stress Scale,²³ a widely used instrument (Scores 0–40) that measures the degree to which life situations are appraised as stressful. Coping ability was assessed using the Brief COPE,²⁴ a validated questionnaire (Scores 1–4) that measures various strategies used to deal with stressful situations.

Biochemical Assays—We measured biomarkers of metabolic functioning [hemoglobin A1C (HbA1C) and adiponectin], and inflammation [high-sensitivity C-reactive protein (hs-CRP), interleukin-6 (IL-6) and tumor necrosis factor alpha (TNF-α)]. HbA1C was measured by turbidimetric inhibition immunoassay (Roche Diagnostics, Indianapolis, IN).

Adiponectin was measured by enzyme-linked immunosorbent assay (ELISA) (ALPCO Diagnostics Inc, Salem, NH). hs-CRP was measured using particle enhanced turbidimetric assay (Roche Diagnostics, Indianapolis, IN). IL-6 was measured by paramagnetic particle, chemiluminescent immunoassay (Beckman Coulter, Fullerton, CA). TNF-α was measured using quantitative sandwich enzyme immunoassay (R&D Systems Inc., Minneapolis, MN).

Qualitative Outcomes—We conducted a semi-structured exit interview via telephone in all participants who completed the mindfulness-based intervention (n=7). Given the pilot nature of this intervention, the intent of the interview was to gather information on participant experiences to inform future iterations of the intervention. Thus, the primary intervention developer and instructor (SC) administered the interview. Interview questions were open-ended and theme-based, and participants were encouraged to share both positive and negative experiences. All interviews were audiotaped and transcribed. Three study coders (SC, GY, CW) read the interviews. We used a grounded theory approach to identify emergent themes through an iterative process. In the first read, coders extracted themes in an emergent manner and then read the transcripts a second time for confirmation and to identify new themes. A secondary coder (Lisa Conboy) reviewed and validated the identified themes using the original transcripts. A final list of condensed themes was compiled and approved by all coders.

Statistical Analysis

Descriptive statistics were used to determine the feasibility and acceptability of the MBI. Baseline characteristics were reviewed to ensure approximate balance across groups. Change scores were calculated for all outcomes at 12 weeks (12 weeks-Baseline) and 6 months (6 months-Baseline). We compared change scores between groups using the t-test for normally distributed changes and the Wilcoxon rank-sum test for non-normally distributed changes.

To account for potential confounding by variables imbalanced at baseline, we performed a series of linear mixed models. The base model included time and group, the interaction between time and group, and an autoregressive covariance matrix. We added covariates (baseline weight, depression, stress, emotional and uncontrolled eating, time since surgery) to the model individually and examined the magnitude of change in the time-by-group interaction term. None of the estimates were substantially different and therefore are not presented.

We conducted sensitivity analyses including a ‘completers analysis’ excluding two mindfulness participants who attended <5 classes and an analysis excluding one mindfulness participant who experienced surfacing of repressed traumatic memories. All primary analyses were performed on an intention-to-treat basis. Statistical significance was indicated by a two-sided p-value < 0.05.

Results

Between January 2014 and March 2014, we screened 43 patients by telephone. After excluding 25 patients for eligibility and scheduling reasons, we randomized 18 patients to the MBI (n=9) or the standard intervention (n=9). Figure S1 shows recruitment numbers and study flow.

Baseline Characteristics

Baseline characteristics are shown in Table 1. Participants had bariatric surgery, on average, 2.7 ± 0.8 years prior to the start of the study. Surgery types were well balanced across groups. On average, participants reported no clinical binge eating at baseline (Mean BES = 9.4 ± 6.0 , cut point for ‘mild to moderate’ binge eating = 18) and mild levels of depression (Mean CES-D score = 16.1 ± 4.3 , Cut point for depression = 16).

Measures of Feasibility and Acceptability

Of 43 patients screened, 31 were eligible to participate. Of these, 18 (58%) were willing and able to participate. Our recruitment numbers (n=18) were just below our target of 20, primarily due to scheduling conflicts. Adherence and retention were excellent. Six of nine patients attended 7 of 10 mindfulness classes; two patients attended < 5 classes due to unexpected life circumstances. 100% completed all study follow-up visits and were included in the intention-to-treat analysis.

Adverse Events

Two adverse events related to the MBI were reported. One participant reported transitory vertigo while gentle head rolling during yoga which she stated subsided after focusing attention on her breath. Another participant experienced surfacing of repressed memories and depression during the MBI and was referred to a social worker for counseling. She continued attending classes and practicing meditation and stated the mindfulness helped her to cope with the traumatic memories.

Weight-related, Behavioral, and Psychosocial Outcomes

Table 2 shows 12-week and 6-month changes from baseline in weight-related, behavioral, and psychosocial outcomes. We observed no significant between-group difference in changes in weight at 12 weeks and 6 months, although trends suggested an increase in weight in the mindfulness group. In sensitivity analyses, the increase in weight in the mindfulness group at 6 months was less pronounced among completers (1.8 ± 3.5 kg, p for difference = 0.30) and further attenuated after excluding one participant who experienced surfacing of trauma (1.5 ± 2.7 kg, p for difference = 0.31).

We observed a decrease in emotional eating after mindfulness that was statistically significant at 6 months (-4.9 ± 13.7 in mindfulness vs. 6.2 ± 28.4 in standard, p for difference = 0.03) but a trend toward a marginal increase in binge eating at 12 weeks that dissipated at 6 months (Table 2). Changes in total energy expenditure per week from physical activity did not vary significantly across groups, however trends suggested modest increases at 12 weeks in both groups [Median (IQR) = 2 kcal/kg ($-3, 31$) in mindfulness; 8 kcal/kg ($-4, 14$) in standard, p for difference = 0.73]. This change was sustained in the mindfulness but not the standard group at 6 months [3 kcal/kg ($-14, 102$) in mindfulness; 0 kcal/kg ($-8, 45$) in standard, p for difference = 0.56].

On psychosocial measures, at 12 weeks the mindfulness group reported trends toward higher scores on perceived stress and depression. After excluding one participant with trauma, the trend in depression attenuated (1.5 ± 5.9 kg, p for difference = 0.17). We found no consistent effect on coping ability (Table 2).

Biomarker Outcomes

Changes in metabolic and inflammatory biomarker concentrations are shown in Table 3. At 6 months, we observed a significant increase in HbA1C concentrations in the mindfulness group (0.34 ± 0.38 in mindfulness vs. -0.06 ± 0.31 , p for difference = 0.03). Trends in inflammatory biomarkers were less clear and not statistically significant.

Qualitative Data

Qualitative themes and illustrative quotes are shown in Table 4. Participants universally reported high acceptability and perceived benefit of the intervention, as well as a desire for continued mindfulness support. In contrast to quantitative data, all 7 participants reported reduced stress reactivity, including the ability to cope more effectively with life's struggles, feelings of calm and peace, and a greater sense of perspective.

Similarly, all 7 participants reported improvements in eating behaviors, with ‘healthier food choices’ most commonly mentioned, followed by ‘portion control’, ‘planning ahead’, and ‘moderation and restraint’ mentioned by the majority. Likewise, all 7 participants reported greater awareness of eating patterns, bodily cues, and environmental triggers, and the majority mentioned greater self-care. More than half of participants reported behavioral changes e.g. changing diet, self-weighing, monitoring nutrient composition of diet, not specifically prescribed by the intervention.

Participants universally highlighted the importance of the group, specifically the benefit of hearing others’ experiences, trust and safety, and cohesion and friendship. Over half shared that mindfulness helped to improve their relationships. Although participants expressed challenges including difficulty sitting still and finding time for meditation, all 7 participants reported a strong sense of self-efficacy regarding maintaining lifestyle changes.

Discussion

Findings from this randomized controlled pilot trial show that a novel mindfulness-based intervention to control weight after bariatric surgery is highly acceptable to bariatric patients. Our findings suggest this intervention may be effective for reducing emotional eating but not weight. Objective measures suggested trends in an increase in perceived stress and symptoms of depression, although patients reported reduced stress reactivity, improved eating behaviors, and a desire for continued mindfulness-based support in qualitative interviews.

To our knowledge, this is the first randomized trial to test a mindfulness-based intervention to prevent weight regain in bariatric patients post-surgery. Our data showing an improvement in emotional eating are consistent with prior studies that show that mindfulness training can be effective for reducing disordered eating behaviors.¹¹ Emotional eating, or eating in response to psychological distress (e.g. sadness, loneliness, anxiety) is hypothesized to be a maladaptive coping mechanism for dealing with distressing mind states. Among bariatric patients, emotional eating has been reported as an important factor contributing to weight gain²⁵ and a risk factor for poor post-surgical outcomes.²⁶ An uncontrolled, pre-post study of a cognitive-behavioral mindfulness intervention in bariatric patients post-surgery reported improvements in emotional eating after 10 weeks of treatment.²⁷ Similarly, a randomized study of an internet-based acceptance-based intervention targeting disordered eating post-surgery improved emotional eating after six weeks.²⁸ Our findings provide further support for the use of mindfulness-based strategies for treating emotional eating.

In contrast to prior studies,^{27,29–32} we did not observe a significant improvement in binge eating. This may be, in part, because baseline levels of binge eating in our sample were lower than in nonsurgical populations likely because bariatric patients are screened for binge eating and potentially excluded before surgery. Furthermore, it is physically difficult for patients to continue binge eating after surgery due to a smaller gastric pouch and narrowed gastric outlet. That said, one study reported an improvement in binge eating after mindfulness training post-surgery,²⁷ so further exploration is warranted.

Mindfulness is hypothesized to facilitate weight loss through several mechanisms including greater awareness of unhealthy behavioral patterns, recognition of internal hunger and satiety cues, and improved coping skills.¹² Findings on weight loss after mindfulness have been mixed, with some^{31–37} but not all^{38,39} studies reporting improvements in weight. In this study, we did not see a significant difference in weight change. Rather, we observed a slight trend toward increased weight and a statistically significant, modest increase in HbA1C levels.

In an interesting case, one mindfulness participant who experienced surfacing of repressed psychological trauma during the intervention also reported increased depressive symptoms. Despite these symptoms, the participant continued attending classes and practicing mindfulness, and in the exit interview, she reported high overall benefit from the intervention. This case highlights an important nuance of mindfulness in the treatment of obesity. For patients with deeply rooted psychological issues, mindfulness may help to uncover these issues, yet in doing so, may intensify psychological symptoms in the short-term and adversely affect eating behaviors and weight loss. Longer-term studies are needed to explore the balance of short-term exacerbations of underlying mental health issues with potentially delayed beneficial effects of mindfulness.

Regarding stress and coping ability, we observed an intriguing discordance between our qualitative and quantitative findings where participants reported reduced stress and improved coping in qualitative interviews, but on objective measures of stress and coping, they reported a significant increase in stress at 12 weeks and no change in coping. This discordance may reflect the different ways stress and coping can be conceptualized. While participants may have experienced a greater ability to step back and not react immediately, as reported qualitatively, they may also have become more aware of their stressors. Mindfulness involves bringing awareness to behavioral and emotional patterns, both positive and negative, which can be, paradoxically, stressful. In addition, some studies have reported a phenomenon of ‘relaxation-induced anxiety’ whereby anxiety symptoms increase during meditative and relaxation practices.⁴⁰ Furthermore, although mindfulness is one type of coping that emphasizes acceptance and reduced reactivity, coping skills vary widely. Patients may benefit from more explicit instruction in complementary coping skills e.g. ‘positive reframing’ in future studies. These nuanced factors may, in part, explain the mixed findings regarding stress after mindfulness in the literature.⁹

There are several limitations to our study. This was a small pilot trial with limited power to detect clinically meaningful changes, thus our findings should be considered preliminary. Our study sample was primarily women and Caucasian so our results are not generalizable to other populations. Given the nature of this pilot trial, we did not have a time-matched control group so we cannot disentangle specific effects of mindfulness from standard behavioral therapy or the effect of time spent in a group. To maximize insight into future iterations of the intervention, the intervention developer and instructor conducted the qualitative interviews. Although an intentional decision, this allowed for the possibility of response bias.

In sum, we found that this novel mindfulness-based intervention was highly acceptable to bariatric patients post-surgery. We observed a significant reduction in emotional eating at 6 months but also trends towards increased perceived stress and depression. Nevertheless, participants universally expressed improved eating behaviors, reduced stress reactivity, and a desire for continued mindfulness-based support in qualitative interviews. While mindfulness may uncover underlying psychological issues in some cases, our findings suggest that mindfulness-based interventions for weight control after bariatric surgery may merit further exploration in longer-term studies.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Study Highlights

- We tested a mindfulness-based approach to control weight after bariatric surgery.
- The intervention was highly acceptable to bariatric patients.
- This approach may be effective for reducing emotional eating but not weight.
- Longer-term studies in the bariatric population may merit further exploration.

HPA: Hypothalamic-pituitary-adrenal axis

Figure 1.
Conceptual model underlying novel mindfulness-based intervention.

Adapted from Cooper and Fairburn, 2001.

Figure 2.
Model of weight regain.

Table 1

Baseline characteristics of study participants enrolled in trial

	Mindfulness Group (n=9)	Standard Group (n=9)
Age (yr)	53.4 ± 5.6 ¹	54.5 ± 7.8
Sex (% female)	90%	78%
Weight at baseline (kg)	89.1 ± 20.7	97.2 ± 26.2
Waist circumference (cm)	102.3 ± 17.5	111.2 ± 19.8
BMI (kg/m ²)	32.3 ± 6.2	36.6 ± 8.0
Type of surgery		
Gastric Bypass (%)	44%	56%
Lap band (%)	33%	33%
Sleeve Gastrectomy (%)	22%	11%
Time since surgery (yr)	2.5 ± 0.9	3.0 ± 0.70
Race/ethnicity		
White (%)	67%	78%
Black (%)	11%	22%
Asian/ Other (%)	22%	0%
Education		
High school or less (%)	0%	33%
Some college or 2-yr degree (%)	22%	0%
4-yr college or more (%)	78%	67%
Income		
< \$25,000 (%)	0%	11%
\$25,000 – \$49,999 (%)	11%	18%
\$50,000 – \$74,999 (%)	11%	11%
\$75,000 or more (%)	67%	56%
Alcohol Use		
Abstainers (%)	11%	33%
Light (%)	89%	56%
Moderate (%)	0%	0%
Heavy (%)	0%	11%
Smoking		
Nonsmokers (%)	89%	100%
Smokers (%)	11%	0%
Eating Behaviors		
TFEQ - Emotional Eating ²	42.0 ± 21.3	38.3 ± 23.6
TFEQ - Cognitive Restraint ²	65.1 ± 19.7	64.5 ± 16.9
TFEQ - Uncontrolled Eating ²	25.5 ± 13.0	21.8 ± 13.9
Binge Eating Scale ³	8.7 ± 5.7	10.1 ± 6.5
WEL - Eating Self-Efficacy ⁴	135.4 ± 29.4	139.1 ± 27.9

	Mindfulness Group (n=9)	Standard Group (n=9)
SF-36 Quality of Life ⁵		
Physical Component	49.2 ± 13.0	49.1 ± 10.5
Mental Component	52.5 ± 5.2	54.0 ± 9.8
IWQOL - Weight Related QOL ⁶	78.4 ± 23.1	81.8 ± 13.8
CES-D - Depression ⁷	17.0 ± 4.1	15.1 ± 4.4
Perceived Stress Scale ⁸	12.0 ± 6.5	10.2 ± 6.0

¹ Values are means ± standard deviations unless otherwise noted.

² Eating behaviors assessed using Three Factor Eating Questionnaire (TFEQ). Scores range from 0–100. Higher scores indicate higher levels of eating behavior.

³ Binge eating assessed using Binge Eating Scale (BES). Scores range from 0–32. Higher scores indicate more severe binge eating.

⁴ Eating self-efficacy measured using Weight Efficacy Lifestyle Questionnaire (WEL). Scores range from 0–180. Higher scores indicate greater confidence to control eating in specific situations.

⁵ Quality of life (QOL) assessed using SF-36 Scale. Scores range from 0–100. Higher scores indicate better quality of life.

⁶ Assessed using Impact of Weight on Quality of Life-Lite (IWQOL-Lite). Scores range from 0–100. Higher scores indicate better quality of life.

⁷ Depression measured using Center for Epidemiologic Studies-Revised Scale (CES-D). Scores range from 0–60. Higher scores indicate a greater number of depressive symptoms.

⁸ Assessed using Perceived Stress Scale. Scores range from 0–40. Higher scores indicate greater perceived stress.

Table 2

Changes in weight-related, behavioral, and psychosocial outcomes in mindfulness and standard group

	Mean Change from Baseline ($\pm$ SD) ¹		
	Mindfulness Group (n=9)	Standard Group (n=9)	P value ²
Weight-Related Measures			
<i>Weight (kg)</i>			
12 weeks	1.0 $\pm$ 1.76	-0.1 $\pm$ 2.4	0.27
6 months	2.3 $\pm$ 3.5	0.3 $\pm$ 2.1	0.15
<i>Waist Circumference (cm)</i>			
12 weeks	1.7 $\pm$ 4.3	0.03 $\pm$ 4.4	0.42
6 months	2.6 $\pm$ 3.6	4.4 $\pm$ 7.6	0.52
<i>BMI (kg/m²)</i>			
12 weeks	0.7 $\pm$ 0.6	0.6 $\pm$ 0.9	0.92
6 months	1.4 $\pm$ 1.1	0.8 $\pm$ 1.1	0.28
Eating Behavior Measures			
<i>TFEQ- Emotional Eating⁴</i>			
12 weeks	-6.2 $\pm$ 22.3	2.5 $\pm$ 22.1	0.42
6 months	-4.9 $\pm$ 13.7	6.2 $\pm$ 28.4	0.03³
<i>TFEQ - Cognitive Restraint⁴</i>			
12 weeks	2.4 $\pm$ 17.7	-3.4 $\pm$ 17.2	0.50
6 months	1.9 $\pm$ 15.4	-8.2 $\pm$ 21.5	0.27
<i>TFEQ - Uncontrolled Eating⁴</i>			
12 weeks	0.4 $\pm$ 11.2	-3.2 $\pm$ 12.0	0.52
6 months	3.3 $\pm$ 13.5	3.4 $\pm$ 12.4	0.98
<i>Binge Eating Scale⁵</i>			
12 weeks	1.1 $\pm$ 2.9	-2.1 $\pm$ 3.4	0.06
6 months	-0.2 $\pm$ 5.1	-1.7 $\pm$ 2.8	0.47
<i>WEL - Eating Self-Efficacy⁶</i>			
12 weeks	0.1 $\pm$ 19.5	0.7 $\pm$ 13.5	0.95
6 months	1.9 $\pm$ 24.6	-2.8 $\pm$ 16.1	0.64
Psychosocial Measures			
<i>SF-36 Physical QOL⁷</i>			
12 weeks	1.0 $\pm$ 3.7	0.2 $\pm$ 2.3	0.56
6 months	1.4 $\pm$ 7.9	-0.5 $\pm$ 4.0	0.93 ³
<i>SF-36 Mental QOL⁷</i>			
12 weeks	-2.5 $\pm$ 10.3	2.5 $\pm$ 4.2	0.23
6 months	-3.6 $\pm$ 10.2	2.1 $\pm$ 7.3	0.30 ³
<i>IWQOL - Weight Related QOL⁸</i>			
12 weeks	-0.1 $\pm$ 7.6	3.2 $\pm$ 6.3	0.36

		Mean Change from Baseline ($\pm$ SD) ¹		
		Mindfulness Group (n=9)	Standard Group (n=9)	P value ²
Author Manuscript	6 months	1.3 $\pm$ 7.4	1.1 $\pm$ 2.9	0.95
	<i>CES-D - Depression</i> ⁹			
	12 weeks	4.3 $\pm$ 9.9	-1.1 $\pm$ 3.2	0.10 ⁻³
Author Manuscript	6 months	3.4 $\pm$ 9.3	2.3 $\pm$ 4.5	0.74
	<i>Perceived Stress Scale</i> ¹⁰			
	12 weeks	3.6 $\pm$ 5.4	-0.8 $\pm$ 3.1	0.05
Author Manuscript	6 months	3.8 $\pm$ 11.8	-0.6 $\pm$ 4.1	0.43 ⁻³
	<i>Brief Cope - Coping Skills</i> ¹¹			
	<i>Self Distraction</i>			
Author Manuscript	12 weeks	0.1 $\pm$ 2.3	-0.1 $\pm$ 1.8	0.82
	6 months	-0.6 $\pm$ 1.5	0 $\pm$ 1.4	0.41 ⁻³
	<i>Active coping</i>			
Author Manuscript	12 weeks	0.2 $\pm$ 1.5	0.4 $\pm$ 1.5	0.84
	6 months	0.4 $\pm$ 0.9	0.4 $\pm$ 1.1	0.71 ⁻³
	<i>Denial</i>			
Author Manuscript	12 weeks	0.4 $\pm$ 0.9	0.2 $\pm$ 0.4	0.72 ⁻³
	6 months	0.9 $\pm$ 2.1	0.4 $\pm$ 0.9	0.99 ⁻³
	<i>Substance Use</i>			
Author Manuscript	12 weeks	0.6 $\pm$ 1.1	-0.1 $\pm$ 0.3	0.26 ⁻³
	6 months	0.7 $\pm$ 1.4	0 $\pm$ 0	0.47 ⁻³
	<i>Emotional Support</i>			
Author Manuscript	12 weeks	0.2 $\pm$ 1.4	-1.1 $\pm$ 1.7	0.10
	6 months	0 $\pm$ 0.9	0.3 $\pm$ 1.6	0.47 ⁻³
	<i>Instrumental Support</i>			
Author Manuscript	12 weeks	0.4 $\pm$ 2.5	-0.3 $\pm$ 2.1	0.49
	6 months	-0.4 $\pm$ 1.2	0.4 $\pm$ 1.1	0.23 ⁻³
	<i>Behavioral Disengagement</i>			
Author Manuscript	12 weeks	-0.2 $\pm$ 1.9	0 $\pm$ 0	0.99 ⁻³
	6 months	-0.3 $\pm$ 2.3	0.1 $\pm$ 0.8	0.68 ⁻³
	<i>Venting</i>			
Author Manuscript	12 weeks	0 $\pm$ 1.6	-0.4 $\pm$ 1.6	0.65
	6 months	0.3 $\pm$ 2.1	0.5 $\pm$ 1.3	0.78
	<i>Positive reframing</i>			
Author Manuscript	12 weeks	-0.4 $\pm$ 1.8	-0.1 $\pm$ 1.6	0.78
	6 months	-0.8 $\pm$ 1.5	0 $\pm$ 1.1	0.24
	<i>Planning</i>			
Author Manuscript	12 weeks	0.9 $\pm$ 2.2	0.2 $\pm$ 1.3	0.45

	Mean Change from Baseline ($\pm$ SD) ¹		
	Mindfulness Group (n=9)	Standard Group (n=9)	P value ²
6 months	0.1 $\pm$ 1.5	0.1 $\pm$ 1.3	0.99
<i>Humor</i>			
12 weeks	-1.1 $\pm$ 2.4	-0.1 $\pm$ 1.6	0.44 ³
6 months	-1.3 $\pm$ 1.4	0.1 $\pm$ 1.8	0.08 ³
<i>Acceptance</i>			
12 weeks	-0.9 $\pm$ 1.7	0.5 $\pm$ 1.3	0.08
6 months	-0.8 $\pm$ 2.0	0.3 $\pm$ 1.6	0.22
<i>Religion</i>			
12 weeks	0.8 $\pm$ 1.3	0.3 $\pm$ 0.5	0.71 ³
6 months	-0.3 $\pm$ 1.7	0.9 $\pm$ 1.1	0.12 ³
<i>Self-blame</i>			
12 weeks	0.3 $\pm$ 1.5	-0.6 $\pm$ 1.3	0.27
6 months	1.0 $\pm$ 2.1	0 $\pm$ 0.9	0.40 ³

¹ Mean changes from baseline calculated as '12 week-Baseline' and '6 month-Baseline.'

² P-values for between-group differences calculated using t-tests for normally distributed differences and Wilcoxon rank sum test for non-normally distributed differences.

³ Indicates p-value calculated using Wilcoxon-rank sum test. All others calculated using t-test.

⁴ Eating behaviors assessed using Three Factor Eating Questionnaire (TFEQ). Scores range from 0–100. Higher scores indicate higher levels of eating behavior.

⁵ Binge eating assessed using Binge Eating Scale. Scores range from 0–32. Higher scores indicate more severe binge eating.

⁶ Eating self-efficacy measured using Weight Efficacy Lifestyle Questionnaire (WEL). Scores range from 0–180. Higher scores indicate greater confidence to control eating in specific situations.

⁷ Quality of life (QOL) assessed using SF-36 Scale. Scores range from 0–100. Higher scores indicate better quality of life.

⁸ Assessed using Impact of Weight on Quality of Life-Lite (IWQOL-Lite). Scores range from 0–100. Higher scores indicate better quality of life.

⁹ Depression measured using Center for Epidemiologic Studies-Revised Scale (CESD-R). Scores range from 0–60. Higher scores indicate a greater number of depressive symptoms.

¹⁰ Assessed using Perceived Stress Scale. Scores range from 0–40. Higher scores indicate greater perceived stress.

¹¹ Coping skills measured using Brief Cope Scale. Scores range from 1–4. Higher scores indicate better coping skills.

Table 3

Changes in metabolic and inflammatory biomarker outcomes in mindfulness and standard group

	Mean Change from Baseline ($\pm$ SD) ¹		
	Mindfulness Group (n=9)	Standard Group (n=9)	P-value ²
Metabolic Biomarkers			
<i>HbA1C (%)</i>			
12 weeks	0.27 $\pm$ 0.70	-0.12 $\pm$ 0.20	0.07 ³
6 months	0.34 $\pm$ 0.38	-0.06 $\pm$ 0.31	0.03
<i>Adiponectin (ug/mL)</i>			
12 weeks	-0.10 $\pm$ 1.50	0.06 $\pm$ 0.69	0.78
6 months	-0.13 $\pm$ 1.68	-0.35 $\pm$ 0.67	0.73
Inflammatory Biomarkers			
<i>Hs-CRP (mg/L)</i>			
12 weeks	0.17 $\pm$ 2.80	0.09 $\pm$ 0.89	0.74 ³
6 months	0.12 $\pm$ 1.37	0.26 $\pm$ 0.57	0.79
<i>IL-6 (pg/ml)</i>			
12 weeks	0.70 $\pm$ 2.86	-1.17 $\pm$ 5.47	0.67 ³
6 months	0.26 $\pm$ 1.61	-1.08 $\pm$ 6.47	0.49 ³
<i>TNF-α (pg/mL)</i>			
12 weeks	0.12 $\pm$ 0.22	-0.06 $\pm$ 0.29	0.16
6 months	-0.02 $\pm$ 0.34	0.09 $\pm$ 0.38	0.52

¹ Mean changes from baseline calculated as '12 week-Baseline' and '6 month-Baseline'.² P-values for between-group differences calculated using t-tests for normally distributed differences and the Wilcoxon rank sum test for non-normally distributed differences.³ Indicates p-value calculated using Wilcoxon-rank sum test. All others calculated using t-test.

Table 4
Themes identified from qualitative exit interviews of study participants in mindfulness group

Themes	Selected Quotes
High acceptability, Perceived Benefit	<ul style="list-style-type: none"> • "By the end of it, by the end of the ten weeks, I was a different person." • "It's very beneficial. It's really made a big impact on me. I'm meditating every day." • "The program is very beneficial to people. I don't think it should be put on a back page and left. Continue it." • "I found it amazing. I mean, I really got a lot out of it." • "It's had a big impact, the whole study." • "I thought it was great. I really enjoyed it." • "We always learned something new, something different about ourselves."
Desire for Continued Mindfulness	<ul style="list-style-type: none"> • "I really hope that, you know, whoever set up this program, I hope that they continue, because a lot of people out there can benefit from this. I know I did... I wished that the program didn't end." • "I think it should be a prerequisite. If you want the surgery, you need to do this." • "This should be part of the pre-and post bariatric surgical program. Really, really should be."
Reduced Stress Reactivity	<ul style="list-style-type: none"> • "I just don't think things bother me as much." • "I can deal with a lot more than I was dealing with before." • "I think I'm a little more relaxed.. I just have to pick my fights." • "Now I can take the time to step back from situations..it could be eating, it could be stress from work, it could be stress from one of my patients, it could be anything."
Improved Eating Behaviors	<ul style="list-style-type: none"> • "My eating has been more in control." • "I'll have one and as soon as I feel that tug, I'll stop." • "I don't snack anymore like I used to." • "I parcel out the exact amount I need to have, and I stick to that." • "I've cut down on a lot of stuff that I know is not going to benefit me in the long run." • "I've learned that once I started to feel that I was getting full, I just put the plate and cover over the top of it..."
Greater awareness	<ul style="list-style-type: none"> • "I'm definitely more aware of what I'm eating." • "It made me aware of my body, to let myself know, 'Okay, you need to stop now.'" • "It makes you more aware of everything that you do - eating, you know, being stressed..."

Themes	Selected Quotes
	<ul style="list-style-type: none"> • “Before I might have haphazardly just picked something up and kind of numbingly eaten it, and not even been aware. I’ve made the choice that if I’m gonna eat something that I ‘shouldn’t eat’, I’m gonna be conscious of and purposeful of it, rather than just walking through life unaware of what I’m doing.”
Self-Care	<ul style="list-style-type: none"> • “It was something I was doing for me, not for anybody else. It was something I could concentrate on my own self.” • “By cultivating that, you know, self-love, you stop before you do stuff that is going to be injurious to you, you don’t do it as often, or you eliminate it altogether.”
Self-compassion, Self-love*	<ul style="list-style-type: none"> • “Mindfulness is a way of becoming friendlier with yourself, you know. And happier with yourself. And understanding that you’re like a small child who is learning to walk. Take two steps, you get up, take two more. In other words, you become more reasonable with yourself.”
Increased Physical Activity	<ul style="list-style-type: none"> • “Exercise is now more a part of my life.” • “I’ve increased my walking. I do three walks a day.”
Increased Self-Monitoring	<ul style="list-style-type: none"> • “I’m paying more attention to the percentage of protein and fat in my diet.” • “I bought a scale.it helps you keep an eye on things, which before I wasn’t doing. I had no scale.”
Eating as a Secondary Issue*	<ul style="list-style-type: none"> • “I believe that eating is the secondary thing... so if you learn to deal with, like I say, the stress, the everyday problems that you’re having and you know, just life in general, that secondary thing, the food, is no longer an issue with you because you’re dealing with what’s making you go to the eating.”
Group Cohesion, Support	<ul style="list-style-type: none"> • “We were a good group.” • “I feel like I made some long-term friendships.” • “Because of the group and the dynamics of the group, it was very easy to talk and share experiences.” • “It’s like you’re carrying around a hundred pound brick, cut it in half, you give somebody else half, now you’re carrying only fifty.”
Family Support	<ul style="list-style-type: none"> • “For me, I liked bringing my family member. A lot.” • “I brought my sister with me... it was good because now we were able to do the meditations together.” • “I’ve actually shared some of the meditation things with my daughter. And so, a couple of days during the week, at least two, we do it together.”
Improved Relationships	<ul style="list-style-type: none"> • “It really has helped me, I feel, in my relationship with my daughter.. because I’ve had to kind of stop, slow down, and think.”
Gradual Change and Small Steps	<ul style="list-style-type: none"> • “In my case, it was sort of this gradual transformation that took place over time.” • “I can set these goals, one step at a time and accomplish that, as opposed to setting these fantasy goals and always failing at all of them.”
Challenges	<ul style="list-style-type: none"> • “At first, I couldn’t get relaxed. I couldn’t sit still... and as the thing progressed, I became better at it.”

Themes	Selected Quotes
	<ul style="list-style-type: none">• "I never have that that time where there's, like, nobody around or nothing that could distract me. So I had to find, create it (a space to meditate) within the chaos of life."
Self-Efficacy	<ul style="list-style-type: none">• "I definitely do (think I'll be able to maintain the changes). Just the fact that I started implementing some of the techniques, there's no way I can stop at this point, because it's really helpful."• "I'll believe that I'll be able to maintain (the changes), and take the things I've learned out of the class useful to my lifestyle and the things that I do."
Integration into Life	<ul style="list-style-type: none">• "It becomes a way of life."

Quotes are intended to illustrate the themes rather than comprehensively describe all study participants' experiences, however all group members are represented in this table. Selected quotes within each theme are from unique study participants.

All themes were mentioned by > 50% of participants except those denoted by an asterisk (*) which were mentioned by < 50% of participants.