Exploratory Analysis of Racial/Ethnic and Educational Differences in a Randomized Controlled Trial of a Mindfulness-Based Weight Loss Intervention

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ABSTRACT

Objective: People of color and lower socioeconomic groups have higher obesity prevalence, lose less weight compared with Whites and higher socioeconomic groups, and are underrepresented in randomized controlled trials of mindfulness-based interventions. We examined whether mindfulness approaches reduce disparities in weight loss interventions.

Methods: We analyzed data from a randomized controlled trial of 194 participants with obesity (41% participants of color, 36% without college degree) comparing a 5.5-month mindfulness-based weight loss intervention to an active-control with identical diet-exercise guidelines. We assessed attendance, 18-month attrition, and weight change at 6, 12, and 18 months by race/ethnicity and education level using linear mixed models, adjusting for baseline body mass index, age, and education or race/ethnicity, respectively.

Results: Participants without versus with a college degree attended fewer sessions and had higher attrition across interventions. Participants of color attended fewer intervention sessions in the mindfulness compared with the control intervention. Overall, participants of color lost significantly less weight at 12 and 18 months compared with Whites. However, during the 6- to 18-month maintenance period, we found an interaction of intervention arm, race/ethnicity, and time ($p = .035$), indicating that participants of color compared with Whites regained more weight in the control (0.33 kg/mo; $p = .005$) but not mindfulness intervention (0.06 kg/mo; $p = .62$). Participants without a college degree had greater initial weight loss in the mindfulness compared to control intervention from 0 to 6 months (−0.46 kg/mo; $p = .039$).

Conclusions: Although disparities persist, mindfulness approaches may mitigate some racial/ethnic and socioeconomic differences in weight loss compared with conventional diet-exercise programs.

Trial Registration: Clinicaltrials.gov registration: NCT00960414

Key words: race/ethnicity, education, mindfulness, obesity, weight loss.

INTRODUCTION

Obesity is a global epidemic and a costly health condition associated with increased risk for type 2 diabetes, cardiovascular disease, cancer, and musculoskeletal disorders (1–4). Socially disadvantaged groups are disproportionately affected by the obesity epidemic in the United States. The relationship between people of color and educational attainment is complex, but both seem to be distinct risk factors for obesity (5–7). Consistent with trends in racial/ethnic differences over the past two decades (5), age-adjusted obesity prevalence in 2015 to 2016 was 37.9% among non-Hispanic Whites compared with 46.8% among non-Hispanic Blacks, and 47.0% among Hispanics and Latinos/Latinas (8). Several studies have demonstrated an inverse relationship between obesity prevalence and level of education, in which those with less education have significantly higher rates of obesity (5,7). Despite persistent disparities, people of color and lower socioeconomic groups continue to be underrepresented in research on obesity and weight loss (9). Studies on weight loss interventions for people of color and lower socioeconomic groups are few in number, and the literature is hampered by small sample sizes, high rates of attrition, less rigorous study designs, and limited follow-up periods (9–13). The evidence that does exist suggests that underrepresented groups typically lose less weight in obesity interventions when compared with non-Hispanic Whites (14–18).

Disparities in obesity may be attributed in part to the lifetime burden of acute and chronic stress associated with being a person of color or member of a socially disadvantaged group (19). Keyes

BMI = body mass index, **CI** = confidence interval

SDC Supplemental Digital Content

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et al. (20), Mezuk et al. (21), and Jackson et al. (22) propose that poor health behaviors, including consuming diets high in fat and sugar, emerge as a coping strategy for this increased stress burden. Potential explanations for how social factors affect health behaviors are numerous and unresolved (23). However, it is known that chronic stress is itself linked to increases in obesity via biochemical and behavioral pathways (19,21,24), and that people of color are at high risk for chronic stress from discriminatory (25), socioeconomic, environmental, and neighborhood stressors (26).

Most behavioral weight loss interventions consist of a combination of diet, exercise, and counseling and minimally address stress management. Most people who initially lose weight, regain it over time, making maintenance of initial weight loss a high priority (27). More recently, a growing body of evidence has emerged to support the efficacy of mindfulness-based interventions in addressing obesity-related eating patterns and weight loss (28–33). Mindfulness meditation is a mental training technique that involves nonjudgmental awareness of present-moment experience, including thoughts, feelings, and bodily sensations with an attitude of acceptance. Robust evidence suggests that mindfulness-based interventions reduce psychological distress and depressive and anxiety symptoms (34,35). In mindful eating interventions, participants learn to increase awareness of physical sensations related to hunger, satiety, taste satisfaction, and situational and emotional factors that trigger overeating and other forms of nonhomeostatic eating to cultivate more adaptive eating patterns (28,29,32,36). Mindful eating interventions are effective for binge, emotional, and hedonic-driven eating, and some studies have demonstrated effects on weight loss (29,30,37–39).

Mindfulness-based approaches have been studied among racially/ethnically and economically diverse populations for a range of psychosocial conditions and health behaviors, including posttraumatic stress disorder, smoking cessation, and substance abuse with encouraging findings (40–44). Mindful eating intervention studies have been conducted among adolescent Latinos (45), African American women (46), and low-income pregnant women (47), also with encouraging results. To our knowledge, racial/ethnic or socioeconomic differences have not yet been examined in the context of a randomized controlled trial of a mindfulness-based intervention for weight loss. In a recent systematic review of 69 randomized controlled trials of mindfulness interventions, none reported results by race/ethnicity or socioeconomic status, and of studies reporting race/ethnicity, 79% of participants were White (48).

We sought to address the lack of studies reporting outcomes by race/ethnicity and socioeconomic status in randomized controlled trials of mindfulness interventions. We examined racial/ethnic and socioeconomic status differences in subgroup analyses of outcomes from a randomized controlled trial of a mindfulness-based weight loss intervention.

We conducted a randomized trial of a 5.5-month mindfulness-based weight loss intervention compared with an active control intervention with a 1-year follow-up period after the end of the intervention among adults with obesity and reported changes in metabolic risk factors elsewhere (33). In the design of the trial, we were interested in the impact of *adding* mindfulness training to diet and exercise-based weight loss interventions. Therefore, both interventions received identical diet and exercise guidelines, and the mindfulness intervention was augmented by mindfulness-based stress management and eating awareness training. To control for attention, social support, expectations of benefit, and a mindfulness approach to stress management, the active control intervention included additional diet-exercise information and limited progressive muscle relaxation and cognitive-behavioral training related to stress eating. In the current study, we examined racial/ethnic and educational background differences in initial weight loss and weight loss maintenance by intervention arm. We hypothesized that disparities in weight loss among participants of color and non–college-educated participants, as reflected in tests of interactions between the respective sociodemographic variable and intervention arm, would be reduced in the mindfulness compared with the active control condition. We explored racial/ethnic and educational differences in intervention attendance and attrition to assist with interpretation of weight loss findings given demographic differences found in prior studies of weight loss (13,49).

METHODS

Study Design and Participants

We used data from the Supporting Health by Improving Nutrition and Exercise study, a 194-person randomized controlled trial comparing an innovative mindfulness-based weight loss program with an active-control intervention with identical diet-exercise guidelines in adults with obesity (33). Detailed study design, recruitment, and primary outcomes of the Supporting Health by Improving Nutrition and Exercise study have been previously reported (33). In brief, eligible participants had body mass index (BMI) of 30 to 45.9 kg/m^2 and met the criteria for abdominal obesity based on National Cholesterol Education Program—Adult Treatment Panel criteria (waist circumference >102 cm for men or >88 cm for women) (50). Individuals were excluded if they had previous mindfulness training or were currently in a weight loss or mindfulness program. The University of California, San Francisco's Committee on Human Research (institutional review board) approved all of the study's procedures, and participants were compensated for assessments. Participants were enrolled in six rounds from July 2009 to February 2012. Assessments were completed in October 2013. The trial is described on ClinicalTrials.gov registration: NCT00960414. See Figure 1 for participant flowchart.

Intervention Groups

Both interventions received a total of 17 sessions during a 5.5-month period, distributed as 12 weekly group sessions (2–2.5 hours), 3 biweekly sessions, 1 follow-up session 4 weeks later, and an all-day weekend session near the eighth session (5.0 hours for the active control, 6.5 hours for the mindfulness intervention group). Participants set goals of reducing daily food intake by 500 calories per day by decreasing calorie-dense, nutrient-poor foods; increasing intake of fresh fruits and vegetables; decreasing refined carbohydrates and substituting whole grains; and increasing consumption of healthy fats and proteins. The exercise component focused on increasing moderate intensity exercise and aimed to increase walking using a pedometer.

Mindfulness Intervention

The mindfulness group received additional training based on Mindfulness-Based Stress Reduction (51) and Mindfulness-Based Eating Awareness Training (52). Meditation practices, modeled on Mindfulness-Based Stress Reduction, included mindful awareness of breath, thoughts, feelings, sounds, and body sensations; loving kindness; and yoga postures. Mindful eating practices, modeled on Mindfulness-Based Eating Awareness Training, were designed to promote awareness and self-regulation of eating-related thoughts and emotions, physical hunger, stomach fullness, taste satisfaction, food cravings, and other eating triggers in the context of

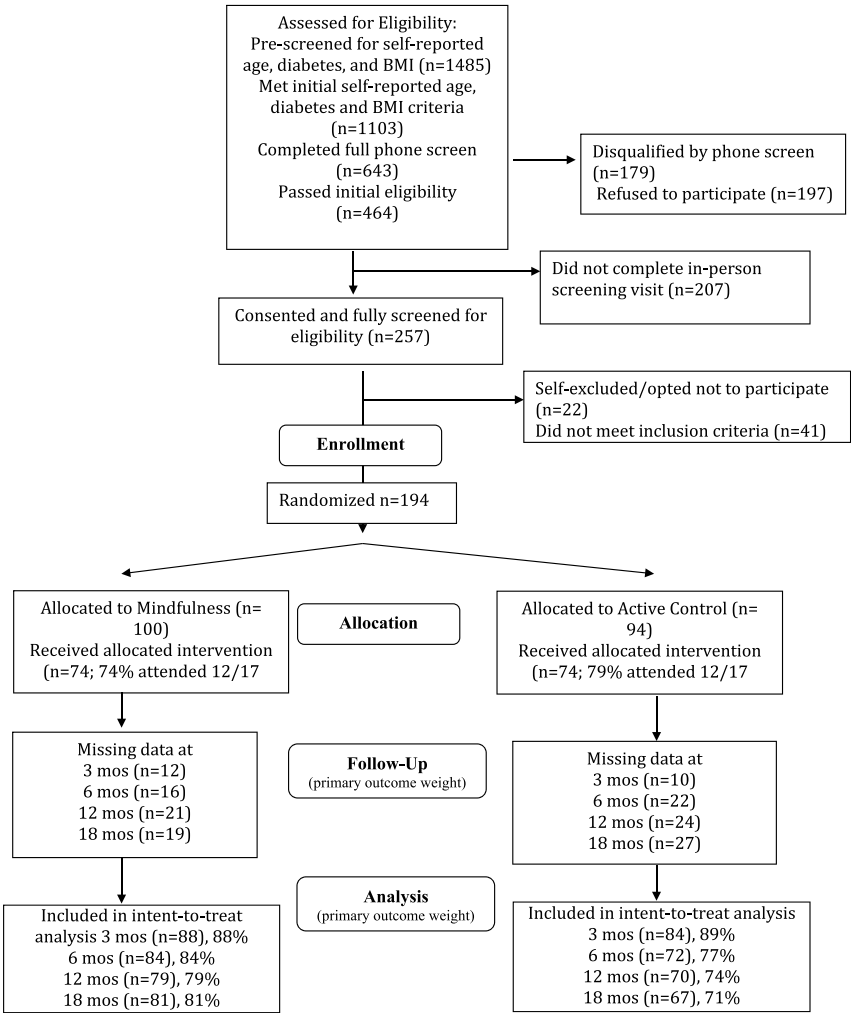

FIGURE 1. Participant flowchart. BMI = body mass index.

reduced caloric intake. Mindful walking included awareness of sensory experience, posture, and alignment (53). Home practice guidelines included meditation practice for up to 30 min a day/6 days a week, eating meals mindfully, and use of mini-meditations. Participants kept weekly adherence logs in which they reported the amount of time practicing meditation and mindful eating for each day of the week. As described previously, participants in this arm reported meditating 2.1 (standard deviation = 1.2) hours per week (70% of recommendations) and eating 57% of meals mindfully (33).

Active Control Intervention

To control for attention, social support, expectation of benefit, food provided during the mindful eating exercises, and home mindfulness practice, the control intervention included additional nutrition and physical activity information, strength training with exercise bands, discussion of societal issues concerning weight loss, snacks, and home activities. To satisfy expectations for stress management training in the control group and to control for a mindfulness approach to stress management, we included progressive muscle relaxation and cognitive-behavioral training in the control intervention, although at a lower dose than in the mindfulness intervention. Participants also had different homework assignments that included activities such as visiting a caloric-expenditure website and trying a vegetarian dinner.

Measures

Participant height in centimeters and body weight in kilograms were measured by study staff at baseline and 3-, 6-, 12-, and 18-month time points. We assessed adherence based on overall attendance during the 17-session intervention and home practice activities during the first 12 weeks of the intervention, including formal meditation practice (30 min/d, 6 days a week), eating most meals mindfully, and completion of optional food records in which participants recorded food and amount eaten each day to monitor dietary adherence (mindfulness intervention food records also included notes on awareness of body sensations, thoughts, and feelings related to eating). Participants in the mindfulness intervention kept weekly logs to record their meditation practice (total minutes of practice per week), mindful eating practice (number of meals eating mindfully), and number of food records they completed. Participants in the control intervention recorded number of food records completed. Attrition was operationalized as the proportion of participants who did not complete follow-up assessments at 18 months. Sociodemographic data, including race/ethnicity, age, sex, and highest level of education, were collected at the baseline assessment visit.

Participants were asked if they considered themselves White, Black, Hispanic/Latino, Asian/Pacific Islander, Native American, or other and were instructed to check one category that best applied.

Statistical Analysis

Study analysis was performed using Stata statistical software, Version 16.0. We calculated means, standard deviations, and percentages for baseline data and used t tests and χ^2 tests to test for differences between a) people of color and non-Hispanic Whites and b) education groups (4-year college degree versus none). To assess racial/ethnic and education differences in intervention attendance, we used linear regression for attendance, defined as the total number of classes attended, for unadjusted and adjusted analyses. To test whether race/ethnicity or education level moderated intervention effects on attendance, we computed interaction terms between study arm and each demographic variable and used linear regressions for both unadjusted and adjusted analyses. Home practice variables were all continuous and analyzed using the same linear regression approach.

For attrition, defined as whether participants completed the 18-month assessment (yes or no), we used Pearson χ^2 tests for unadjusted analyses and logistic regression for adjusted analyses. To test whether race/ethnicity or education level moderated intervention effects on attrition, we used logistics regressions that included interaction terms of study arm and each demographic variable, for unadjusted and adjusted analyses. We adjusted for education and age in the race/ethnicity analyses and race/ethnicity, baseline BMI, and age in the education analyses based on significant baseline differences for age and baseline BMI and prior literature on potential confounders (13,49,54).

Primary Analyses

For the primary analyses, we assessed racial/ethnic differences in the rate of weight loss over time. We used linear mixed-effects models including a piecewise linear spline of time with a single knot at 6 months, allowing the slope of weight change to differ from the period of active intervention (0–6 months) to the subsequent maintenance phase (6–18 months). We estimated different slopes in each of the two intervals. The models used maximum likelihood estimation and available data from all time points (baseline and 3, 6, 12, and 18 months) to increase reliability of slope estimates and minimize the impact of missing data. Interaction terms in the model between study arm (mindfulness versus control), dichotomized race/ethnicity (people of color versus White), and time allowed statistical testing of differences in weight change over time by demographic groups. We performed similar analyses for education groups. Joint χ^2 tests tests for the overall three-way interaction of intervention arm, race/ethnicity, and splines of time were used to compare the interactions of slopes of weight change (from 0 to 6 and 6 to 18 months) and, similarly, for education groups. Subsequent z tests were used to assess paired differences within the intervention arm across demographic groups and within the demographic group across intervention arms. We adjusted for baseline BMI (centered at its mean) in all mixed model analyses, as weight loss may be associated with baseline BMI (55). We also adjusted for education and age in the race/ethnicity analyses and race/ethnicity, baseline BMI, and age in the education analyses. We present the rate of weight change per month in tables, and, for ease of interpretation, total weight loss at 6 and 18 months in the text. To calculate total weight loss at 6 months, we multiplied rate of weight change per month by 6 for the 0- to 6-month period, and for the 6- to 18-month period, we multiplied by 12 and added this amount to 6-month total weight loss for total weight loss at 18 months.

Sensitivity Analyses

In sensitivity analyses, to examine effects at each time point, we conducted separate linear mixed-effects models to test two sets of three-way interactions on weight loss at 6, 12, and 18 months: a) intervention, race/ethnicity (participants of color versus White), and time at 6, 12, and 18 months, and b) intervention, education (4-year college degree versus none) and time at 6, 12, and 18 months, adjusting for age, baseline BMI, and the respective sociodemographic variable. The results are presented in Tables S1a and S1b (Supplemental Digital Content, http://links.lww.com/PSYMED/A665).

RESULTS

Sample Characteristics

The study enrolled 41% people of color and 59% non-Hispanic Whites (Table 1). Participants of color comprised 31.6% African Americans (n = 25), 29.1% Hispanic or Latinos (n = 23), 24.1% Asian/Pacific Islanders (n = 19), 2.5% Native Americans (n = 2), and 12.7% other race/ethnicities (n = 10). To maintain adequate sample sizes, participants of color were aggregated into a single category. We use the term "participants of color" as recommended by American Psychological Association guidelines and note that the study took place in a "majority-minority" state where the term "racial/ethnic minorities" is inaccurate (56,57). Although there is considerable heterogeneity between racial/ethnic groups, analysis of people of color as a single group is consistent with theoretical models of social disadvantage and prior research on social stress theory (58).

There were no statistically significant racial/ethnic differences (people of color versus Whites) in sex or BMI, and randomization achieved balanced intervention assignment. Participants of color were younger ($p < .001$), were less likely to have a college degree ($p = .028$), and tended to have a lower baseline weight ($p = .066$) compared with Whites. There were no significant education differences in sex (Table 2), and intervention assignment was balanced across education levels. Participants without a college degree were more likely to be younger ($p = .006$), be people of color ($p = .028$), and have a higher baseline BMI ($p = .006$).

Attendance and Attrition

Racial/Ethnic Groups

Attendance

The interaction between race/ethnicity and intervention arm with regard to attendance did not reach statistical significance in the unadjusted linear regression model ($t(190) = 1.87$, $p = .062$) or after adjustment for education and age ($t(187) = 1.73$, $p = .086$; Table 3). In the mindfulness intervention, participants of color attended significantly fewer sessions than did Whites; however, the significance level became nonsignificant after adjusting for education and age ($p = .42$). In the control intervention, attendance did not differ significantly by racial/ethnic groups in either unadjusted ($p = .66$) or adjusted models ($p = .12$). Participants of color in the mindfulness intervention attended fewer sessions compared with those in the control intervention in the unadjusted model (−1.76 mean difference, 95% confidence interval [CI] = −3.53 to 0.00, $p = .050$) and significantly fewer sessions after adjustment for covariates (−1.70 mean difference, 95% CI = −3.28 to −0.12, $p = .035$). White participants randomized to the mindfulness compared with the control intervention did not differ significantly in attendance in the unadjusted (0.47 mean difference, 95% CI = −1.07 to 2.02, $p = .54$) or adjusted models (0.18 mean difference, 95% CI = −1.29 to 1.65, $p = .81$). Across interventions, racial/ethnic groups did not differ significantly in attendance in unadjusted ($t(192) = -1.14$, $p = .26$) or adjusted models ($t(189) = 0.60$, $p = .55$).

TABLE 1. Baseline Characteristics of Study Participants by Race/Ethnicity

	Participants of Color (n = 79), % or Mean (SD)	Non-Hispanic White (n = 115), % or Mean (SD)	p
Intervention group			.094
Mindfulness	44.3%	56.5%	
Active control	55.7%	43.5%	
Age, y	43.0 (13.3)	49.8 (11.5)	<.001***
Sex (female)	81%	79.1%	.75
Education (bachelor's degree)	55.7%	71.1%	.028*
Baseline weight, kg	94.9 (15.1)	98.8 (13.7)	.066
Body mass index, kg/m^2	35.2 (3.7)	35.7 (3.5)	.39

SD = standard deviation.

t Tests for continuous and χ^2 tests for categorical variables were used to test for differences between participants of color and non-Hispanic White participants.

*$p < .05$.

***$p < .001$.

Attrition

The interaction between race/ethnicity and intervention with regard to attrition was not statistically significant in the unadjusted ($z = 0.92$, $p = .36$) or adjusted model ($z = 1.43$, $p = .15$; Table 3). In the mindfulness intervention, attrition did not differ significantly between racial/ethnic groups in unadjusted or adjusted models ($p = .47$ and $p = .88$, respectively). In the control intervention, participants of color were twice as likely to be lost to follow-up compared with White participants in the unadjusted model ($p = .027$) but not the adjusted model ($p = .12$). Participants of color in the mindfulness compared with the control intervention had nonsignificantly higher rates of attrition in unadjusted and adjusted models (p values = .090 and .078, respectively). White participants in the mindfulness compared with the control intervention did not differ significantly in attrition rates in unadjusted or adjusted models (p values = .67 and .98, respectively). Across both interventions, participants of color had significantly higher attrition at 18 months compared with White participants in the unadjusted model ($\chi^2(1) = 5.48$, $p = .019$); however, these differences were not significant after adjustment for covariates ($z = 0.80$, $p = .43$).

Education Groups

Attendance

The interaction between education and intervention with regard to attendance was not significant in the unadjusted model ($t(189) = -0.17$, $p = .87$) or after adjusting for race/ethnicity, baseline BMI, and age ($t(186) = -0.13$, $p = .90$; Table 4). Participants without compared with those with a college degree attended fewer intervention sessions across interventions in unadjusted ($t(191) = -4.53$, $p < .001$) and adjusted models ($t(188) = -3.79$, $p < .001$), within the mindfulness intervention (p values = .004 and .007 in unadjusted and adjusted models, respectively) and within the control intervention (p values < .001 and .003, in unadjusted and adjusted models, respectively). No significant differences were observed in attendance between education groups within the mindfulness or control intervention, with or without adjusting for covariates (p values > .25).

Attrition

The interaction between education group and intervention with regard to attrition was not significant in the unadjusted ($z = -1.02$, $p = .31$; Table 4) or adjusted model ($z = -1.19$, $p = .23$). In the mindfulness intervention, participants without a college degree were more likely to be lost to follow-up compared with those with a college degree ($p = .004$ and $p = .007$ in unadjusted and adjusted models, respectively). In the control intervention, the pattern was similar, although the difference was not statistically significant in unadjusted or adjusted models ($p = .091$ and $p = .73$, respectively). No significant differences were observed in attrition by intervention arm within the low-education or high-education group with or without adjustment for covariates (p values > .078). Across both interventions, those without a college degree had greater attrition than did those with a college degree, in unadjusted ($\chi^2(1) = 10.98$, $p < .001$) and adjusted models ($z = -2.39$, $p = .017$).

Initial Weight Loss and Maintenance

Race/Ethnicity Groups

Primary Analyses

In linear mixed models with a linear spline of time with a single knot at 6 months adjusting for education, baseline BMI, and age, the three-way interaction test among race/ethnicity, intervention, and time for rate of weight loss from 0 to 6 months was not significant ($\chi^2 = 5.94$; $p = .11$; Table 5, Figure 2). In the mindfulness intervention, participants of color tended to lose less weight than did White participants at 6 months, although this difference was not statistically significant ($p = .10$). In the control intervention, the rate of weight loss was similar between participants of color and White participants at 6 months ($p = .62$). Participants of color in

TABLE 2. Baseline Characteristics of Study Participants by Education

	No College Degree (n = 68), % or Mean (SD)	College Degree (n = 125), % or Mean (SD)	p
Intervention group			.14
Mindfulness	44.1%	55.2%	
Active control	55.9%	44.8%	
Age, y	43.6 (12.9)	48.8 (12.3)	.006**
Sex (female)	83.8%	77.6%	.30
Racial/ethnic minority	51.5%	35.2%	.028*
Weight, kg	100.6 (17.1)	95.4 (12.5)	.028*
Body mass index, kg/m^2	36.5 (4.1)	34.9 (3.2)	.006**

SD = standard deviation.

t Tests for continuous and χ^2 tests for categorical variables were used to test for differences between education groups.

Note: We are missing education level for one female, non-Hispanic White participant assigned to the mindfulness group.

*$p < .05$.

**$p < .01$.

TABLE 3. Adherence Variables and Attrition by Race/Ethnicity and Intervention Group With and Without Adjustment for Education Level and Age

	Participants of Color (P), No. (%) or Mean (SD)	Non-Hispanic White (W), No. (%) or Mean (SD)	Unadjusted Mean Difference (P – W; 95% CI)	Unadjusted *p*	Adjusted Mean Difference (P − W; 95% CI)	Adjusted *p*
All participants, *n* (%)	79 (40.7)	115 (59.3)				
Attendance, no. sessions	12.47 (3.99)	13.15 (4.14)	−0.68 (−1.85 to 0.50)	.26	0.34 (−0.78 to 1.46)	.55
Attrition at 18 mo, %	32.9	18.3	—	.019*	—	.43
Mindfulness, *n* (%)	35 (35.0)	65 (65.0)				
Attendance, no. sessions	11.49 (4.24)[a]	13.35 (4.00)	−1.87 (−3.57 to −0.17)	.031*	−0.69 (2.38 to −1.01)	.42
Attrition at 18 mo, %	22.9	16.9	—	.47	—	.88
Active control, *n* (%)	44 (46.8)	50 (53.2)				
Attendance, no. sessions	13.25 (3.64)[a]	12.88 (4.33)	0.37 (1.28 to 2.02)	.66	1.20 (−0.33 to 2.73)	.12
Attrition at 18 mo, %	40.9	20.0	—	.027*	—	.12

Linear regression models testing the interaction between race/ethnicity and intervention arm with regard to attendance did not reach statistical significance in the unadjusted linear regression model ($t(190) = 1.87$, $p = .062$) or after inclusion of education and age in the model ($t(187) = 1.73$, $p = .086$). White participants randomized to the mindfulness compared with the control intervention did not differ significantly in attendance in the unadjusted (0.47 mean difference, 95% CI = −1.07 to 2.02, $p = .54$) or adjusted model (0.18 mean difference, 95% CI = −1.29 to 1.65, $p = .81$) of linear regression. To test for differences in attrition, we used Pearson χ^2 tests for unadjusted analyses and logistic regression for adjusted analyses. The interaction between race/ethnicity and intervention with regard to attrition was not statistically significant in the unadjusted ($z = 0.92$, $p = .36$) or adjusted model ($z = 1.43$, $p = .15$). Participants of color in the mindfulness compared with the control intervention had nonsignificantly higher rates of attrition in unadjusted and adjusted models (p values = .09 and .078, respectively). White participants in the mindfulness compared with the control intervention did not differ significantly in attrition rates in unadjusted or adjusted models (p values = .67 and .98, respectively).

SD = standard deviation; CI = confidence interval.

[a] Participants of color in the mindfulness intervention attended significantly fewer sessions compared with those in the control intervention in the unadjusted (−1.76 mean difference, 95% CI = −3.53 to 0.00, $p = .050$) and adjusted models (−1.70 mean difference, 95% CI = −3.28 to −0.12, $p = .035$).

* $p < .05$.

the mindfulness compared with control intervention did not significantly differ in rate of weight loss (rate difference of 0.08 kg/mo, $p = .70$). White participants in the mindfulness intervention had significantly greater weight loss compared to those in the control intervention (difference of −0.37 kg/mo, 95% CI = −0.68 to −0.05 kg/mo, $p = .022$; total weight loss difference of −2.19 kg at 6 months, 95% CI = −4.07 to −0.31 kg/mo). Across interventions, participants of color did not differ significantly in rate of weight loss compared with White participants from 0 to 6 months (difference of −0.10 kg/mo, 95% CI = −0.36 to 0.16 kg/mo, $p = .44$).

During the 1-year maintenance period from 6 to 18 months, we found a significant interaction of race/ethnicity, intervention, and time adjusting for education, baseline BMI, and age ($\chi^2(3) = 8.62$; $p = .035$). In the mindfulness intervention, participants of color did not differ significantly from White participants in weight regain ($p = .62$): 0.09 kg/mo (total weight loss of −2.94 kg at 18 months, 95% CI = −6.97 to 1.10 kg) compared with 0.03 kg/mo (total weight loss of −5.50 kg at 18 months, 95% CI = −8.33 to −2.68 kg), respectively. In the control intervention, however, participants of color regained weight during the maintenance period (0.31 kg/mo; total weight loss of −0.79 kg at 18 months, 95% CI = −4.53 to 2.95 kg) that was significantly greater than that of White participants (−0.02 kg/mo; total weight loss of −3.97 kg at 18 months, 95% CI = −7.16 to −0.79 kg), a difference of 0.33 kg/mo (total weight loss difference of 3.54 kg at 18 months, $p = .005$). In addition, participants of color in the mindfulness compared with the control intervention tended to maintain greater weight loss, although this effect was not statistically significant (difference of −0.22 kg/mo and total weight loss difference of 2.04 kg at 18 months, $p = .10$). For White participants, maintenance of weight was similar between those in the mindfulness and control interventions (with a difference of 0.05 kg/mo and total weight loss difference of 1.53 kg at 18 months, $p = .58$). Across interventions during the 6- to 18-month period, participants of color had a higher rate of weight regain compared with Whites (difference of 0.20 kg/mo, 95% CI = 0.03–0.37 kg/mo, $p = .020$).

Sensitivity Analyses

In sensitivity analyses using linear mixed models, we did not find a significant three-way interaction among race/ethnicity, intervention arm, and time on weight change after adjusting for education, baseline BMI, and age at 6 ($p = .17$), 12 ($p = .85$), or 18 months ($p = .57$; Supplemental Table S1a, Supplemental Digital Content, http://links.lww.com/PSYMED/A665). Overall, across interventions, participants of color lost significantly less weight than did Whites at 12 and 18 months (p values = .027 and .007, respectively). In the mindfulness intervention, although participants of color compared with Whites lost less weight at 6, 12, and 18 months, these differences did not reach statistical significance (p values = .10, .091, and .12, respectively). In the control

TABLE 4. Adherence and Attrition by Education and Intervention Arm With and Without Adjusting for Race/Ethnicity, Age, and Baseline BMI

	No College Degree, (%) or Mean (SD)	College Degree, (%) or Mean (SD)	Unadjusted Mean Difference (95% CI)	Unadjusted *p*	Adjusted Mean Difference (95% CI)	Adjusted *p*
All participants, *n* (%)	68 (35.2)	125 (64.8)				
Attendance, no. sessions	11.15 (4.74)	13.81 (3.36)	−2.63 (−4.37 to −0.88)	<.001***	2.23 (1.07 to 3.40)	<.001***
Attrition at 18 mo, %	38.2	16.8	—	<.001***	—	.017
Mindfulness, *n* (%)	30 (30.3)	69 (69.7)				
Attendance, no. sessions	10.87 (4.93)	13.49 (3.56)	−2.63 (−4.37 to −0.88)	.004**	2.11 (0.40 to 3.82)	.016
Attrition at 18 mo, %	36.7	11.6	—	.004**	—	.007
Active control, *n* (%)	38 (40.4)	56 (59.6)				
Attendance, no. sessions	11.37 (4.63)	14.20 (3.08)	−2.83 (−4.41 to −1.25)	<.001***	2.50 (0.88 to 4.13)	.003
Attrition at 18 mo, %	39.5	23.2	—	.091†	—	.73

Linear regression models testing the interaction between education and intervention with regard to attendance was not significant in the unadjusted model ($t(189) = -0.17$, $p = .87$) or after inclusion of race/ethnicity, baseline BMI, and age in the model ($t(186) = -0.13$, $p = .90$). No significant differences were observed in attendance within the mindfulness or control intervention arms by education group with or without adjusting for covariates (p values > .25). To test for differences in attrition, we used Pearson χ^2 tests for unadjusted analyses and logistic regression for adjusted analyses. The interaction between education group and intervention with regard to attrition was not significant in the unadjusted ($z = -1.02$, $p = .31$; Table 4) or adjusted model ($z = -1.19$, $p = .23$). No significant differences were observed in attrition by intervention arm within the low-education or high-education group with or without adjustment for covariates (p values > .078).

BMI = body mass index; SD = standard deviation; CI = confidence interval.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

† $p < .10$.

intervention, participants of color lost significantly less weight than did Whites at 18 months ($p = .022$), but not at 6 or 12 months (p values = .73 and .19, respectively).

Education Groups

Primary Analyses

In linear mixed models with a linear spline of time with a single knot at 6 months adjusting for race/ethnicity, baseline BMI, and age, the three-way interaction test among education, intervention, and time for rate of weight loss was not significant from 0 to 6 months ($\chi^2(1) = 5.05$; $p = .17$) or 6 to 18 months ($\chi^2(1) = 3.73$; $p = .29$; Table 6, Figure 3). However, among participants without a college degree, those in the mindfulness intervention lost more weight from 0 to 6 months (−6.57 kg total weight loss) than did those in the control intervention (−3.80 kg total weight loss), a difference of −0.46 kg/mo (95% CI = −0.90 to −0.02 kg/mo,

TABLE 5. Estimated Change in Weight Per Month by Race/Ethnicity and Intervention Group for Initial Weight Loss and Weight Loss Maintenance Periods Adjusting for Baseline Body Mass Index, Education, and Age

	Estimated Slope (95% CI), kg/mo		Difference	
	Participants of Color	Non-Hispanic White	Estimated Mean (95% CI)	*p*
Mindfulness				
0–6 mo	−0.68 (−0.97 to −0.38)	−0.99 (−1.19 to −0.78)[a]	0.31 (−0.06 to 0.68)	.10
6–18 mo	0.09 (−0.10 to 0.28)[b]	0.03 (−0.10 to 0.17)	0.06 (−0.18 to 0.30)	.62
Active control				
0–6 mo	−0.75 (−1.02 to −0.49)	−0.62 (−0.86 to −0.38)[a]	−0.13 (−0.49 to 0.22)	.46
6–18 mo	0.31 (0.13 to 0.49)[b]	−0.02 (−0.17 to 0.13)	0.33 (0.10 to 0.56)	.005**

All participants with available data at all time points, including covariates, were included in analyses of linear mixed models with a linear spline of time with a single knot at 6 months, adjusting for education, baseline body mass index, and age. The three-way interaction test among race/ethnicity, intervention, and time for rate of weight loss from 0 to 6 months is not significant ($p = .11$), and weight lost maintenance of 6–18 months is significant ($p = .035$).

CI = confidence interval.

** $p < .01$.

[a] White participants in the mindfulness versus control intervention had significantly greater weight loss from 0 to 6 months (difference of −0.37 kg/mo; 95% CI = −0.68 to −0.05, $p = .022$).

[b] Participants of color in the mindfulness versus control intervention tended to regain less weight from 6 to 18 months, although not statistically significant (difference of −0.22 kg/mo, 95% CI = −0.48 to 0.04 kg/mo, $p = .10$).

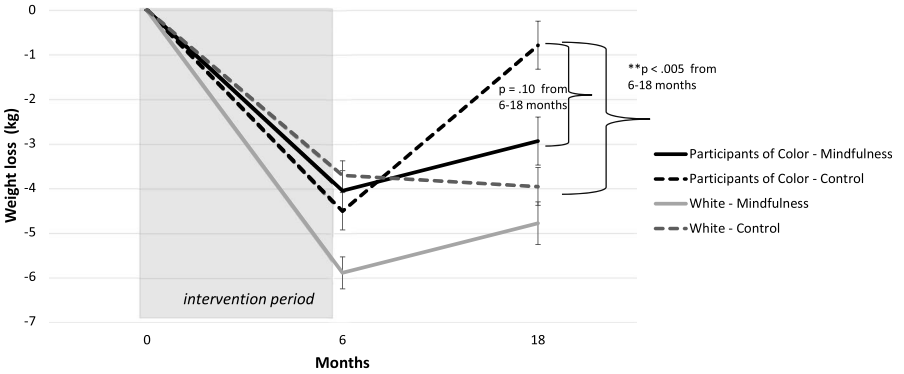

FIGURE 2. Weight loss by intervention and race/ethnicity group adjusted for baseline body mass index, education level, and age. Error bars indicate ±1 standard error from the mean.

p = .039; total weight loss difference of −2.77 kg). Mindfulness participants without a college degree also maintained greater weight loss from 6 to 18 months (−7.92 kg total weight loss at 18 months) compared to those with a college degree who regained weight (−3.21 kg total weight loss at 18 months), although the difference did not reach statistical significance (between-group difference of −0.24 kg/mo and total weight loss difference of 4.71 kg, p = .058). No other comparisons were statistically significant (p values > .12). Across interventions, participants without compared to those with a college degree did not significantly differ in rate of weight loss at 6 months (difference of −0.10 kg/mo, 95% CI = −0.37 to 0.18 kg/mo, p = .50) or 6 to 18 months (difference of −0.12 kg/mo, 95% CI = −0.30 to 0.06 kg/mo, p = .18).

Sensitivity Analyses

In sensitivity analyses using linear mixed model analyses, the three-way interaction between education, intervention, and time on weight change, adjusting for education, baseline BMI, and age, was not significant at 6 months (p = .49), but was significant at 12 months (p = .021) and approached statistical significance at 18 months (p = .059; Table S1b, Supplemental Digital Content, http://links.lww.com/PSYMED/A665). At 12 months, participants in the mindfulness intervention without a college degree lost significantly more weight than did those with a college degree (p = .018), whereas participants in the control intervention without a college degree lost similar amount of weight to those with a college degree (p = .47). The pattern was similar at 18 months.

Home Practices

We did not find statistically significant differences between racial/ethnic or education groups in home practice of minutes of meditation practice, number of meals eaten mindfully, or completion of food records among participants in the mindfulness intervention in the unadjusted model or after adjustment for covariates. Similarly, we did not find racial/ethnic or education group differences for number of food records completed in the control intervention in the unadjusted model or after adjustment for covariates. Furthermore, there was not a significant interaction between race/ethnicity and intervention or education and intervention with regard to number

TABLE 6. Estimated Change in Weight Per Month by Education Level and Intervention Group for Initial Weight Loss and Weight Loss Maintenance Periods Adjusting for Baseline Body Mass Index, Age, and Race/Ethnicity

	Estimated Weight Loss (95% CI), kg/mo			
	No College Degree	College Degree	Difference, Estimated Mean (95% CI)	p Value
Mindfulness				
0–6 mo	−1.10 (−1.42 to −0.77)[a]	−0.80 (−0.99 to −0.60)	−0.30 (−0.68 to 0.08)	.12
6–18 mo	−0.11 (−0.33 to 0.11)	0.13 (0.01 to 0.25)	−0.24 (−0.49 to 0.008)	.058
Active control				
0–6 mo	−0.63 (−0.94 to −0.33)[a]	−0.71 (−0.93 to −0.48)	0.07 (−0.31 to 0.45)	.71
6–18 mo	0.09 (−0.10 to 0.29)	0.11 (−0.03 to 0.25)	−0.02 (−0.26 to 0.22)	.90

All participants with available data at all time points, including covariates, were included in analyses of linear mixed models with a linear spline of time with a single knot at 6 months, adjusting for race/ethnicity, baseline body mass index, and age. The three-way interaction test among education, intervention, and time for rate of weight loss from 0 to 6 months was not significant (p = .17), and weight lost maintenance of 6 to 18 months was not significant (p = .29). Participants with a college degree in the mindfulness versus control intervention did not significantly differ in 0- to 6-month weight loss (difference of −0.9 kg/mo, 95% CI = −0.38 to 0.20 kg/mo, p = .54) or 6- to 18-month weight loss maintenance (difference of 0.02 kg/mo, 95% CI = −0.16 to 0.20 kg/mo, p = .83).

CI = confidence interval.

[a] Participants without a college degree in the mindfulness versus control intervention lost significantly more weight per month from 0 to 6 months (difference of −0.46 kg/mo, 95% CI = −0.90 to −0.02 kg/mo, p = .039), but the difference between 6 and 18 months was not significant (difference of −0.21 kg/mo, 95% CI = −0.50 to 0.09 kg/mo, p = .17).

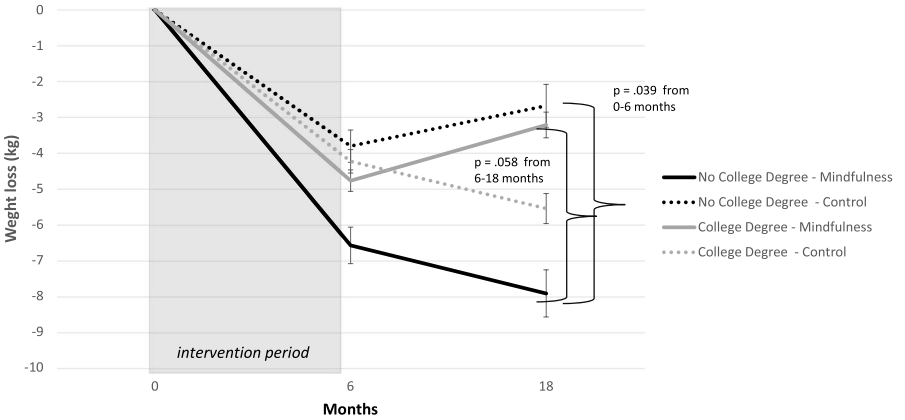

FIGURE 3. Weight loss by intervention and education group adjusted for race/ethnicity, baseline body mass index, and age. Error bars indicate ±1 standard error from the mean.

of food records completed (Tables S2a and S2b, Supplemental Digital Content, http://links.lww.com/PSYMED/A665).

DISCUSSION

We found evidence of racial/ethnic and education differences in a randomized controlled trial comparing a mindfulness-based weight loss intervention with an active control with identical nutrition and exercise guidelines. First, we found evidence of disparities in attendance, attrition, and weight loss across interventions. Consistent with prior studies (14), people of color lost significantly less weight overall compared with Whites across both interventions. Also, consistent with results of some previous studies (13), participants without a college degree attended fewer intervention sessions and had higher attrition rates than did those with a college degree across interventions. Second, despite these persistent disparities, however, we found some evidence that the mindfulness intervention improved maintenance of weight loss during the 6- to 18-month period for people of color relative to Whites. In addition, there was a trend toward improved weight maintenance among those with less versus more education in the mindfulness intervention, although the difference was just above statistical significance so the finding must be viewed cautiously. We did find a statistically significant advantage in weight loss in the first 6 months in persons without a college education if they were randomized to the mindfulness versus control intervention. We note that these results should be interpreted cautiously as exploratory analyses, as we did not prespecify these hypotheses and the study was not powered for subgroup analyses.

We did not find strong evidence that participants of color compared with White participants had lower attendance or higher attrition after adjustment for education and age, although the interaction between race/ethnicity and intervention was close to statistically significant for attendance. We did find that participants of color assigned to the mindfulness intervention attended significantly fewer sessions than did those assigned to the control intervention. All instructors across both interventions were White. The explanation for these findings is not clear, although the mindfulness intervention, with its focus on emotional and other internal experiences, could have caused participants of color to feel less comfortable discussing particular issues in a predominately White group setting. We acknowledge that this explanation is speculative and results could have occurred because of chance; however, at the same time, we note the growing literature on cultural sensitivity in the content and delivery of mindfulness interventions (59) and potential reinforcement of individualistic values contrary to values in communities of color (60). Cultural relevance and instructors having similar experiences and background as participants may improve attendance to mindfulness interventions. However, if a lack of cultural or racial/ethnic sensitivity in the mindfulness intervention affected attendance for participants of color, it did not seem to affect their engagement with home practices of meditation, mindful eating, and keeping food records to monitor dietary adherence, as their amount of home practice was similar to White participants.

With regard to educational background, participants without a college degree had lower attendance and higher attrition rates across both interventions. Barriers to study participation may include realities of juggling work and family responsibilities, lower income, transportation, increased chronic stress burden, and other factors. Future studies may consider means of increasing accessibility in lower socioeconomic groups such as participation through mobile phones, offering childcare, or conducting focus groups to learn more about barriers to participation (47,61).

Unfortunately, our results also corroborate earlier findings that people of color tend to have suboptimal outcomes in behavioral weight loss interventions compared with Whites. For example, in recent National Institutes of Health–funded randomized controlled trials of behavioral interventions for weight loss, African Americans lost an average of 2 to 3 kg less than did non-Hispanic Whites at 6 to 12 months (14). Similarly, we found that participants of color lost significantly less weight than did Whites overall across both interventions (3.37 kg less at 18 months). During the initial 6-month intervention period, there was no significant difference between participants of color and White participants in weight loss, although there was a nonsignificant trend in that participants of color lost less weight during this period in the mindfulness intervention compared with White participants.

Weight loss maintenance is challenging; most people regain at least 30% of initial weight loss in the first year, and more than half return to their baseline weight in 5 years (27,62). Weight regain may also attenuate any health benefits from initial weight loss (63). Previous studies have shown that African American women

are generally less successful in weight loss interventions than White women, both in initial weight loss and in maintenance (15–17,64). Interestingly, however, we found evidence that race/ethnicity moderated the intervention effect on weight loss maintenance during the 6- to 18-month period, such that people of color had improved weight maintenance in the mindfulness versus control intervention relative to White participants. In the control intervention, participants of color regained more weight than did White participants during the 1-year maintenance period consistent with prior studies. However, in the mindfulness intervention, participants of color maintained their weight loss at levels comparable to those of White participants. Furthermore, they showed a nonsignificant trend of having greater weight loss maintenance compared with participants of color in the control intervention who were essentially back to their baseline weight at the end of the 18-month period. These findings are meaningful if replicated, suggesting that mindfulness training incorporated into behavioral weigh loss interventions may promote improved weight loss maintenance among people of color.

Previous reviews of obesity interventions for participants of color have identified certain characteristics that yield better outcomes, including cultural tailoring (64,65), group and social support (66), comprehensive individualized support of changes to daily behavior (10), and increasing self-efficacy (67). Mindfulness training incorporates self-awareness and an ethos of self-care, which we hypothesize could approximate an individualized or culturally tailored approach as participants apply the practices and concepts to their own lives (68). In two separate qualitative studies, African American women confirmed that they felt mindfulness-based strategies had a variety of benefits for their communities (69,70). There was also an emphasis on cultivating a regular mindfulness practice in daily life, which may have led to more successful behavior change. Mindful eating interventions have been tested in a number of different samples with a range of health conditions (e.g., binge eating disorder, obesity, and diabetes) (32,71,72). However, they have not been widely tailored specifically for people of color. As highlighted by prior studies, intervention adaptions—such as incorporating values, materials, and instructors reflective of the target population—may be warranted to ensure cultural relevance, to support engagement and retention, and to reduce health disparities (69,73). Future studies should examine the effects of incorporating mindfulness training into maintenance phases of weight loss interventions in diverse populations and explore more culturally tailored approaches and potential mechanisms of action.

Our weight loss findings for education background, somewhat surprisingly, differed from those of race/ethnicity. The three-way interaction among education, intervention, group, and time was statistically significant at 12 months, suggesting that educational background moderated the intervention effects on weight loss. At 12 months, participants in the mindfulness intervention without a college degree lost significantly more weight than did those with a college degree, whereas participants in the control intervention with or without a college degree lost similar amount of weight. The pattern was similar at 18 months, although just above statistical significance. During the maintenance period from 6 to 18 months, those without a college degree in the mindfulness group continued to lose weight, whereas those with a college degree regained a small amount of weight, although this difference was also just above statistical significance and should be viewed cautiously.

These results were surprising given the overall lower attendance and higher attrition rates among participants without a college degree. However, one group of researchers suggest that socioeconomic status exerts a powerful influence over the amount of control one has over circumstances, and emotion regulation strategies may be more important for health among individuals in lower socioeconomic groups because they have less direct control over circumstances to effect positive change (74). Thus, mindfulness training may have potentially greater benefits for individuals of lower socioeconomic status, an area worthy of further research.

Our analysis also makes several new contributions to the literature. First, these exploratory findings suggest the value of examining the moderating role of race/ethnicity and education in future randomized controlled trials of mindfulness interventions. Given the overrepresentation of White and college-educated participants in randomized controlled trials of mindfulness interventions (48), we need to be cautious about generalizability of effects to diverse populations. We hope this study may inspire other researchers to examine racial/ethnic and socioeconomic differences in their trials, plan new studies with this goal in mind, or culturally tailor mindfulness programs for underrepresented populations using rigorous study designs.

These data from the current study derive from a strong study design. Whereas much of the existing literature on people of color, lower socioeconomic groups, and obesity and/or mindfulness interventions suffers from small sample sizes, short follow-up periods, and a lack of a comparison group (10,28), these data come from a randomized controlled trial with an active control condition with nearly 200 participants and 1-year follow-up period after intervention.

Several limitations of this analysis should be considered. First, the subgroup analysis was not prespecified, and the study was not originally powered for subgroup analysis by race/ethnicity or educational background. Thus, our subgroup samples were small, and results should be considered to be hypothesis generating for future research rather than conclusive findings. Second, because of small sample sizes, it was necessary to group all participants of color together. This is not ideal because groups differ in cultural experiences and there are racial/ethnic differences in distribution of adipose tissue and associated health risks at a given BMI (75). However, these individuals do share membership in disadvantaged social groups that causes stress from inequality and prejudice (58). Third, higher attrition among participants of color and participants without a college degree could have skewed estimates. We were able to estimate missing data by including all other available time points in estimates and using statistical approaches such as mixed-effects models, thereby minimizing the effect of missing data on group differences. However, disproportionate missing data between groups are an important caveat in our findings. Finally, we note the limitations of considering race/ethnicity and education as independent predictors of weight loss, given the significant overlap among these categories (54). In our limited sample size and statistical modeling procedures, we may have missed potential synergistic relations between race/ethnicity and education level on study outcomes. Future research, for example, could examine racial/ethnic group differences within education level or vice versa.

This analysis of racial/ethnic and educational differences in outcomes of a rigorously designed randomized controlled trial of

a mindfulness-based weight loss intervention suggests that disparities persist, yet mindfulness-based interventions may have some potential to minimize health disparities related to obesity. Results also suggest that greater cultural tailoring or other efforts may be needed to strengthen benefits for people of color and less educated groups. Future research is warranted to determine whether mindfulness training could help lessen the differential burden of the obesity epidemic borne by people of color and members of lower socioeconomic status groups in the United States.

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