

Reduction of Internalized Weight Bias via Mindful Self-compassion: Theoretical
Framework and Results from a Randomized Controlled Trial

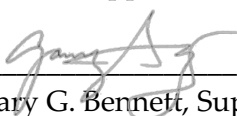
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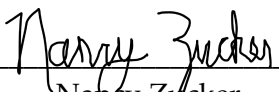
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Nancy Zucker

Dissertation submitted in partial fulfillment of
the requirements for the degree of Doctor
of Philosophy in the Department of
Psychology and Neuroscience in the Graduate School
of Duke University

2022

ABSTRACT

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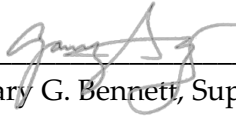
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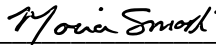
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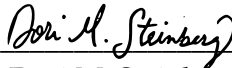
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An abstract of a dissertation submitted in partial
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Abstract

Weight bias internalization is considered a chronic discriminatory stressor and a threat to health. Weight bias internalization has known associations with health-depleting behaviors (i.e., disordered eating, social isolation) and avoidance of health-promoting behaviors (i.e., physical activity, adherence to healthcare guidelines). Despite the numerous deleterious health effects of weight bias internalization, relatively few efficacious interventions have been identified for this critical treatment target. Self-compassion training presents itself as a potential intervention, though has not been rigorously tested in those with elevated internalized weight bias.

Ruby was a two-arm randomized control designed to reduce internalized weight bias. Ruby tested the efficacy of a 4-week digitally delivered self-compassion intervention compared to wait list control. Participants in the intervention group received daily text messages which included psychoeducation videos, writing prompts, and guided mindfulness audio files to facilitate daily mindful self-compassion practices ranging from 4-23 minutes per day. The main outcome of this trial was the 4-week reduction in weight bias internalization as measured by the Weight Bias Internalization Scale, compared to wait list control. Trial outcomes were analyzed using linear mixed models and multiple linear regressions using an intent-to-treat framework.

Ruby participants were 121 adults with elevated internalized weight bias (i.e., WBIS score ≥ 4.0) and a body mass index over 30 kg/m². Participants in the intervention demonstrated greater reductions in weight bias internalization compared to the wait list control (Net difference: -0.84, CI: -1.21 to -0.48, $p < .0001$). Participants in the intervention demonstrated similar reductions in secondary outcomes, including weight self-stigma, weight-related experiential avoidance, and fear of self-compassion (p 's $< .05$). Additionally, they reported increases in self-compassion, mindfulness, body appreciation, intuitive eating, and physical activity. Mediation analyses suggest that reductions in weight bias internalization are likely partially driven by increases in self-compassion.

Ruby was the first digital standalone self-compassion-based intervention targeting weight bias internalization. Results suggest that a brief mindful self-compassion intervention can reduce internalized weight bias over 4 weeks. Additionally, a mindful self-compassion intervention can reduce several other secondary outcomes related to internalized weight bias. Due to its standalone digital delivery, Ruby may be a highly scalable treatment for internalized weight bias that can be delivered on its own or combined with other treatments. Ruby is poised to expand a burgeoning body of literature related to psychological intervention for internalized weight bias.

Dedication

For Ro, and many others.

Cent'anni.

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1. Introduction

1.1 Background

The psychosocial burden of obesity is a significant contributor to poor health outcomes. Many of the health consequences that have historically been attributed to obesity itself — metabolic syndrome, insulin resistance, type II diabetes — may be at least partially explained by the experience of chronic weight stigmatization. Weight-based stigmatization is the persistent devaluation, stereotyping, or discrimination based on weight status. Weight stigma can manifest as societal attitudes about weight, anti-fat policies and laws, interpersonal prejudice, harassment, discrimination, and more. Figure 1 summarizes common experiences of weight stigmatization inspired by Bronfenbrenner's Ecological Systems Theory and Cook et al.'s multilevel formulation of stigma and public health.^{1,2}

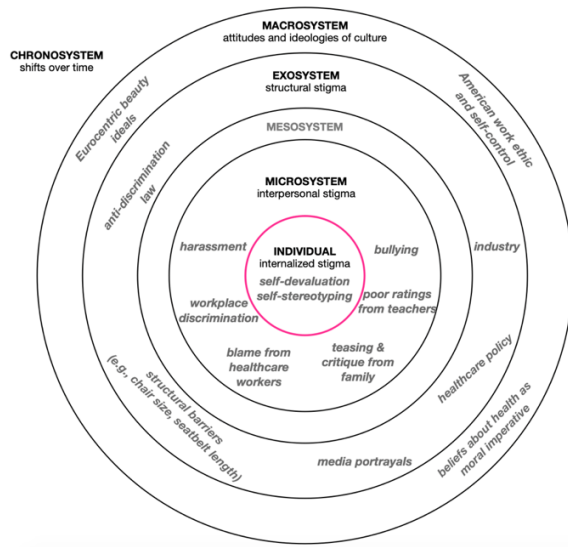


Figure 1: Ecological model of weight stigma and internalization

The experience of weight stigma can occur as early as 3 years of age.³ Prevalence estimates of weight-based teasing or discrimination across all demographics are around 40%. Rates of experiencing weight stigma tend to be higher in younger adults than older adults, in women, in white rather than non-white groups, and in people in higher weight classes than class I obesity.⁴ These attitudes are commonly accepted in society due to a belief that bodily shame will result in motivation to lose weight.⁵ Evidence indicates that the opposite is true; experience of weight stigma is associated with weight gain, social isolation, increased binge eating episodes, and avoidance of healthcare services and physical activity.^{6,7}

Additionally, the psychological effects of continuous experience of and rumination about body-related shame take a significant physical toll. Tomiyama and colleagues developed the Cyclic Obesity and Weight-Based Stigma model (COBWEBS model)⁸ to describe the feedback loop that exists in many individuals with overweight and obesity when experiencing the chronic stress of weight stigma and thus, persistent dysregulation of the hypothalamic-pituitary-adrenal axis. In brief, those in bigger bodies often experience significant stress and shame, which leads to increased production of the stress hormone cortisol and eating in excess, which in tandem contribute to weight gain, which then leads to additional stress and shame. In addition to these behavioral and physiological consequences of weight stigma, the emotional experience of persistent judgment and shame is associated with increased rates of depression, decreased self-

efficacy, and increased negative attentional bias such that stigmatizing situations are more salient.⁹

Approximately 52% of adults with obesity who *experience* weight stigmatization *internalize* these experiences and beliefs, resulting in a self-stigmatization process referred to as **internalized weight bias**. Individuals with internalized weight bias incorporate societal messages and anti-fat stereotypes into their own understanding of their worth and their identity, resulting in a set of internal processes laden with self-critical thoughts, emotional distress, and dysregulation of the nervous system due to the chronicity of both experienced and internalized weight bias. For example, self-judgment is pervasive in those who internalize weight bias; central to internalized weight bias is the self-judgement of not only the body and physicality (e.g., “I’m morbidly obese.”), but of the global character attributions that are made thereafter (e.g., “I’m morbidly obese and therefore unworthy of love and care.”). Self-judgment of the body expands to other maladaptive thinking patterns that may shape behavior (e.g., “I’m not going to get that promotion because I’m fat and lazy, and my boss knows it. I won’t even apply for it.”).

The persistence of these patterns of negative thoughts and emotions may lead to maladaptive coping mechanisms in an effort to feel relief. Internalized weight bias is often accompanied by significant experiential avoidance (i.e., intentional or unintentional avoidance of unwanted internal stimuli). Internalized weight bias is

associated with increased rates of food-related coping (e.g., “comfort eating” or “emotional eating”), and avoidance of healthful behaviors at higher rates than those who simply experience (but do not internalize) weight bias.¹⁰ Individuals with internalized weight bias are less likely to attend preventive care visits to their doctor, less likely to complete health screenings in accordance with guidelines, and more likely to switch healthcare providers.⁶ Further, they are less likely to engage in physical activity.¹¹

In adults, internalized weight bias has been shown to result in a three-fold increased risk of metabolic syndrome, increased risk of eating disorder development, elevated triglycerides, decreased quality of life, and more.^{6,12} The stress of internalized weight bias is often compared to other chronic discriminatory stressors (e.g., racism). Dysregulation of the hypothalamic-pituitary-adrenal axis and consequent long-term elevation in cortisol levels have been observed in individuals who internalize weight bias, replicating findings in investigations of caregiver burden, employee burnout, childhood bullying, and persistent racism.^{13–16} This set of factors in aggregate - increased caloric intake, fewer doctor’s visits, less physical activity, and chronic nervous system dysregulation – may contribute to poorer health and well-being of those with internalized weight bias.

1.2 Theoretical Framework

Recent evidence demonstrates that adaptive coping responses mediate the association between experiencing weight stigma and negative health and psychological outcomes. Himmelstein and colleagues surveyed participants who have experienced weight stigma on eighteen different coping responses and self-reported health outcomes (e.g., depressive symptoms, self-rated physical health).¹⁰ Coping behaviors were divided into four classes: maladaptive eating behaviors, healthy lifestyle behaviors, exercise avoidance, and negative affect (e.g., feeling sad, angry, or badly about one's body). Himmelstein et al. found that health outcomes were directly associated with how an individual *responded* to experiences of weight stigma. For instance, experiencing weight stigma was associated with greater depressive symptoms, but this effect was mediated by coping via negative affect. Further, experienced weight stigma was indirectly associated with lower depressive symptoms through the mediating effect of coping via healthy lifestyle behaviors such as eating healthy foods and exercising.

These results from Himmelstein and colleagues suggest that the consequences of experiencing weight stigma can more readily be attributed to an individual's *response* to stigma than the stigma alone. In development of the present study, we conceptualized internalization of weight bias as a maladaptive coping response to experiencing weight bias. However, this process may be unconscious, automatic, and habitual rather than conscious and intentional, and may speak to a broader pattern of responses to distress

within an individual. There is minimal research exploring risk factors for internalization of weight bias. Drawing from the broader literature on internalization disorders, one could hypothesize that certain vulnerabilities may contribute to the development of internalized weight bias, such as rejection sensitivity, chronic emotion dysregulation, or trauma. Further, one may be more likely to develop internalized weight bias if they experience weight stigma with more frequency or intensity than others, though this has not yet been examined empirically. If internalization of weight bias is conceptualized as a response to experiences of weight stigma (in the way that Himmelstein et al. conceptualize negative affect), it becomes clear that intervention on the internalization of weight bias is essential to prevent or reverse the negative health consequences of weight stigma.

From a clinical standpoint, internalized weight bias can be distilled into two core treatment targets: self-stigmatizing cognitions and chronic nervous system dysregulation. Self-stigmatizing cognitions might sound like “Why bother going to the gym, I’m too lazy to work hard enough anyway,” or “I don’t deserve a romantic partner while I’m this fat.” Further, the self-stigmatizing cognitions magnify chronic stress and other negative emotions, compounding dysregulation of the nervous system. In a feedback loop, the dysregulation of the nervous system may give rise to additional negative cognitions as an individual’s mind attempts to integrate and make sense of physical sensations of distress such as a racing heart, sweaty palms, or nervous energy.

This chronic state of distress then leads to development of a maladaptive coping repertoire. These cognitions can lead to functional impairment and disengagement from life-giving and healthful activities such as physical activity, social engagement, and attending visits to the doctor for fear of stigmatizing experiences. Additionally, individuals may learn strategies to cope with acute distress temporarily, such as eating to cope with distress. Figure 2 summarizes our theoretical model.

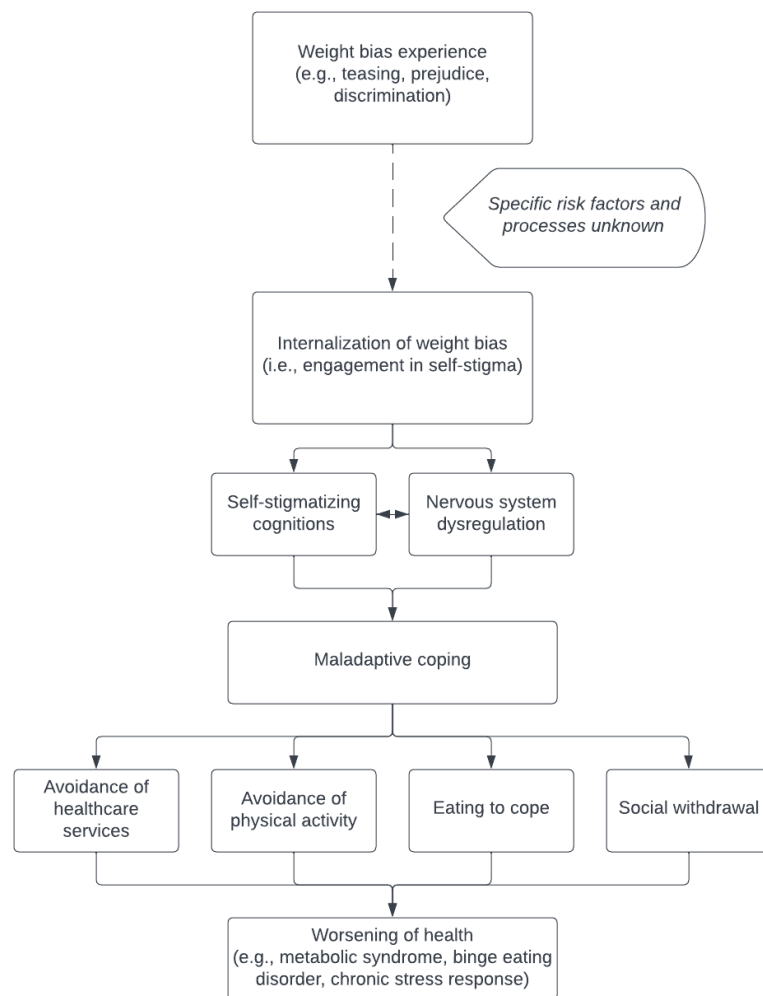


Figure 2: Theory of weight bias internalization and sequelae

Given the interrelated nature of self-stigmatizing cognitions and chronic nervous system dysregulation, intervention on weight bias internalization should incorporate both cognitive and somatic strategies. Mindfulness-based intervention is one skill that combines both cognitive and somatic components.

Acceptance- and mindfulness-based psychotherapies are well-positioned to disrupt the pathway from internalized weight bias to its negative health consequences. Mindfulness is an essential skill in evidence-based cognitive behavioral therapies such as Dialectical Behavior Therapy and Acceptance and Commitment Therapy. Independent of those treatment approaches, mindfulness has been used in psychotherapy since the 1970s (and beyond the scope of psychotherapy, since 500 BCE).¹⁷ Mindfulness-based Cognitive Therapy (MBCT)¹⁸ and Mindfulness-based Stress Reduction (MBSR)¹⁹ have been used to treat depression, anxiety, social phobia, and a variety of other psychological disorders.^{20,21} Mindfulness skills are also known to increase several aspects of metacognition, including decentering from thoughts and emotions and re-perceiving negative experiences. For instance, mindfulness of thought practices have been shown to facilitate cognitive defusion and allow for distance between an individual and their thoughts, such that thoughts are less emotionally evocative and thus less painful to experience.²² For this reason, mindfulness tools have played an important role in evidence-based psychotherapies to facilitate greater access to cognitive defusion and reduce the negative impacts of painful thoughts.

Acceptance-based approaches to weight stigma may be especially validating given the pervasive nature of anti-fat attitudes. Acceptance-based therapies de-emphasize cognitive restructuring, a core component of traditional Cognitive Behavioral Therapy as designed by Beck. Cognitive restructuring encourages cognitive reappraisal and scripting of thoughts that are more true, balanced, and thus potentially less distressing to an individual. In a population of individuals experiencing discrimination, however, patients may find cognitive restructuring and similar cognitive change strategies in direct contrast with their lived experience of judgment, stereotyping, and discrimination based on size and shape. For this reason, radical acceptance and a focus on cognitive distancing or defusion techniques may serve as a better fit for particular patients than cognitive change strategies or encouragement of emotion regulation. The effects of mindfulness training -- namely increases in metacognitive awareness, decreases in rumination, decreased automaticity of responding to thoughts or emotions -- may further support an individual's efforts to reduce suffering in the face of stigmatizing stimuli.

1.3 Existing Interventions

Interventions designed specifically to reduce internalized weight bias are limited. Pearl and colleagues have developed a cognitive-behavioral intervention called BIAS delivered alongside behavioral weight loss intervention.^{23,24} The BIAS intervention has demonstrated promising results, though it is difficult to discern whether reductions in

weight bias internalization are attributable to weight losses or cognitive-behavioral intervention. Given the limited literature base exploring interventions for internalized weight bias specifically, we can look to the broader literature exploring related treatment targets, such as body dissatisfaction. Recent investigations have begun to test effects of acceptance- and mindfulness-based psychotherapies on body dissatisfaction and related constructs (e.g., body image shame, body image avoidance). Tables 1 and 2 summarizes findings from a scoping review of extant randomized clinical trials testing the efficacy of acceptance and/or mindfulness intervention strategies with regard to body dissatisfaction, broadly construed (Hopkins et al., in preparation).

Table 1: Summary of existing acceptance/mindfulness-based interventions for body dissatisfaction

Authors	Type	Duration	Follow up assessment	Modality	Frequency of treatment	No. of groups	Control group
Levin et al. ²⁵	ACT	7 Weeks	EOT; 3-month follow-up	Self-guided. Initial in-person orientation. Weekly phone coaching calls. Self-paced reading of ACT workbook. A	Self-paced. Weekly chapters with daily readings.	1	No control group

Lillis et al. ²⁶	ACT	6 hours	3 months	Self-guided. Exercises in general ACT workbook ^B	One-time session. Self-paced workbook content.	2	Wait list control
Palmeira et al. ²⁷	ACT	10 Weeks	EOT	Face-to-face group sessions	Weekly	2	TAU
Pinto-Gouveia et al. ²⁸	ACT	12 Weeks	EOT; 3- and 6- months	Face-to-face group sessions	Weekly	2	Wait list control
Potts ²⁹	ACT	8 Weeks	EOT	Self-guided vs self-guided + phone coaching. Self-paced reading of ACT workbook. ^A	Self-paced, recommended weekly check-ins	3	Wait list control
Strandskov et al. ³⁰	ACT	8 Weeks	EOT	Website, with phone calls at coach discretion	Weekly	2	Wait list control
Weineland et al. ³¹	ACT	6 Weeks	EOT	Website. Two sessions in person with support via phone.	Weekly	2	TAU
Alberts et al. ³²	MBCT (adapted for eating concerns)	8 Weeks	EOT	Face to face	Weekly, with daily practice	2	Wait list control

Albertson et al. ³³	Mindfulness: compassion	3 Weeks	EOT; 3-months	Digital Podcasts, 20 min practice daily	Weekly, with daily practice	2	Wait list control
Duarte et al. ³⁴	Mindfulness: compassion, awareness, attention	4 Weeks	EOT	Group orientation, followed by self-paced 4-week content online	Weekly, with daily practice	2	Wait list control
McMahan ³⁵	Mindfulness and exposure	2 Weeks	EOT	Internet and Multi-media technology	Daily	2	Active control
Tsai et al. ³⁶	Mindfulness-based metacognitive training	1 day	Pre- and post-manipulation	Laboratory-based computer experiment	One-time session	2	Active control
Atkinson et al. ³⁷	Acceptance-based metacognitive training	1 day	Pre- and post-manipulation	Laboratory-based computer experiment	One-time session	2*	Wait list control
Svaldi et al. ³⁸	Acceptance-based metacognitive training	1 day	Pre- and post-manipulation	Laboratory-based computer experiment	One time	2	Active control
Wade et al. ³⁹	Acceptance-based metacognitive training	1 day	Pre- and post-manipulation	Laboratory-based computer experiment	Onetime	5	Active and inactive control groups:

^A *The Diet Trap*⁴⁰

^B *Get Out of Your Mind and Into Your Life*⁴¹

EOT = End of treatment. TAU = Treatment as usual.

Table 2: Results from extant acceptance/mindfulness-based trials

Authors	Type	Did intervention reduce body dissatisfaction?	<i>p</i> value	Effect Size	Measurement of Body Dissatisfaction
Levin et al. ²⁵	ACT	Yes*	< .001*	d = 3.03*	Weight Self-Stigma Questionnaire
Lillis et al. ²⁶	ACT	Yes	< .001	d = 1.07	Weight Self-Stigma Questionnaire
Palmeira et al. ²⁷	ACT	Yes	0.001	d = 0.58	Weight Self-Stigma Questionnaire
Pinto-Gouveia et al. ²⁸	ACT	Yes	0.014	$\eta^2 = 0.16$	Body Image Acceptance and Action Questionnaire
Potts ²⁹	ACT	Yes	< .01***	$\eta^2 = 0.14$	Weight Self-Stigma Questionnaire
Strandskov et al. ³⁰	ACT	Yes	< .05	d = 0.48	Body Shape Questionnaire

Weineland et al. ³¹	ACT	Yes	0.023	$\eta^2 = 0.13$	Body Shape Questionnaire
Alberts et al. ³²	Mindfulness	Yes	< .01	$\eta^2 = 0.29$	Body Shape Questionnaire
Albertson et al. ³³	Mindfulness	Yes	< .001	d = 0.73	Body Shape Questionnaire
Duarte et al. ³⁴	Mindfulness	No	NS	NS	Body Image Shame Scale
McMahan ³⁵	Mindfulness	No	NS	NS	Eating Disorder Inventory II - Body Dissatisfaction
Tsai et al. ³⁶	Mindfulness	No	NS	NS	Body Image Shame Scale
Atkinson et al. ³⁷	Acceptance-based	Yes	Engagers: .027 ** Non-engagers: .036 **	d = 0.22 d = 0.24	VAS
Svaldi et al. ³⁸	Acceptance-based	No	NS	NS	VAS (three questions averaged)
Wade et al. ³⁹	Acceptance-based	Yes	< .001 **	0.56	VAS

* Within-group changes reported, no control group.

** Compared to control group.

*** Active groups compared to wait list control.

NS = not significant; NR = not reported

Mindfulness, broadly speaking, has been only minimally applied to self-directed weight stigma specifically. Palmeira et al. demonstrated increases in mindfulness and reductions in self-directed stigma in the context of a weight management trial, suggesting that mindfulness would be a reasonable and potentially efficacious approach to treat the internalization of weight bias.²⁷ Beyond constructs related to body concerns, Mindfulness-based Cognitive Therapy and Mindfulness-based Stress Reduction have been used to treat depression, anxiety, social phobia, and a variety of other psychological disorders.^{20,21,42} Mindfulness skills are known to increase several aspects of metacognition, including decentering from thoughts and emotions and reperiencing negative experiences; these skills could significantly impact an individual's response to experiences of weight stigma and thus, development of internalized weight bias.

Two of the trials reviewed used mindfulness skills to reduce body shape concerns to a statistically significant degree when compared to a control group.^{32,33} In these trials, the outcome of interest was measured via the Body Shape Questionnaire, an inventory typically used in eating disorder research capturing preoccupation with body size and shape. While this construct is likely distinct from internalized weight bias (e.g., can occur across weight classes, may not originate from social stigma), we can look to these results for clues as to how mindfulness may affect other body concerns such as internalized weight bias. Alberts et al.³² followed an approach similar to traditional MBCT¹⁸; treatment was 8 weeks long and included weekly in-person group meetings as

well as assigned daily mindfulness practice. Participants in this trial demonstrated significant improvements in body image concern when compared to wait list control ($F(1,24) = 9.64, p < .01, \eta^2 = .29$ - small effect). Albertson et al.³³ selected a more self-guided approach, delivering 20-minute audio files via podcast of guided self-compassion mindfulness practice. Participants in this trial also demonstrated reductions in body image concerns when compared to wait list control, with a larger effect size than Alberts et al. ($p < .001$, Cohen's $d = 0.73$). In McMahan, Duarte, and Tsai et al.'s trials, the intervention groups did not significantly outperform control groups. Duarte's design was similar to Albertson's; the central difference between these two interventions was in the specifics of the mindfulness practice. Albertson et al. focused on self-compassion practices, while Duarte et al. incorporated many different styles of meditation practice. These results suggest that self-compassion may be a particularly useful mindfulness practice for this clinical issue, and that focusing on this aspect of mindfulness more readily confers benefits for body image concerns and associated shame.

Prior investigations have highlighted self-compassion as an important treatment target in those with internalized weight bias. Puhl et al. analyzed data from Project EAT, a large-scale, longitudinal study of weight trajectories and associated health outcomes in young adults. Cross-sectional investigation of this dataset demonstrated that those who had experienced weight stigma reported lower levels of self-kindness and self-compassion.⁴³ Though the causal direction is not yet known, these results may indicate

that self-compassion and experienced weight stigma are related conceptually, which may extend to internalized weight bias.

Self-compassion is a multidimensional mindfulness-based construct consisting of three parts: self-directed kindness, a sense of common humanity, and mindfulness.⁴⁴ Meta-analysis indicates that self-compassion is uniquely associated with greater overall psychological health,⁴⁵ and a more recent review suggests that amplifying self-compassion can ameliorate body image disturbance and eating pathology.⁴⁶ This evidence indicates that self-compassion may improve well-being and prevent maladaptive coping strategies, yet no investigation to date has tested the efficacy of a brief self-compassion intervention on internalized weight bias.

1.4 Rationale for Present Study

The present study aims to answer several empirical questions. Primarily, Ruby asks: can a standalone mindful self-compassion intervention significantly reduce internalized weight bias in 4 weeks? No study to date has delivered a mindful self-compassion intervention using exclusively digital tools in the absence of human clinician guidance, and many mindfulness studies tested previously across treatment targets are longer than 4 weeks. If Ruby can reduce internalized weight bias, we may establish an initial evidence base to support future testing of mindful self-compassion and its effect on internalized weight bias. By developing this research base and incorporating digital tools, we may be able to deliver a low-cost, highly scalable

intervention to the many individuals who suffer from elevated internalized weight bias and its sequelae. In the present randomized controlled trial, we will assess changes in weight bias internalization by comparing pre- to post-treatment self-report scores in the intervention group to a wait-list control.

1.5 Specific Aims and Hypotheses

Aim 1: To determine the effect of a brief mindful self-compassion intervention on change in weight bias internalization, compared to wait list control

Hypothesis 1: The intervention group will demonstrate greater reductions in weight bias internalization than the wait-list control group over the course of 4 weeks.

Aim 2: To determine the effect of a brief mindful self-compassion intervention on change in secondary health and psychological outcomes (i.e., self-compassion, depression, intuitive eating, mindfulness, body appreciation, cognitive flexibility related to weight, physical activity)

Hypothesis 2: The intervention group will demonstrate greater increases in self-compassion, intuitive eating, mindfulness, body appreciation, cognitive flexibility related to weight, and physical activity, while it will demonstrate greater reductions in depression, compared to wait list control over the course of 4 weeks.

Aim 3: To identify constructs that: (1) mediate the effect of the intervention on weight bias internalization (i.e., changes in self-compassion) and (2) moderate the effect

of the intervention on weight bias internalization (i.e., depression, fear of self-compassion, and childhood trauma).

Hypothesis 3: The intervention effects will be partially mediated by self-compassion such that reductions in weight bias internalization will be partially attributable to increases in self-compassion. The intervention effects will also be moderated by depression, fear of self-compassion, and childhood trauma, such that baseline scores on these constructs will be associated with lesser reductions in internalized weight bias.

2. Methods

2.1 Overall Study Design

The present intervention, called Ruby, was a 28-day, 2-arm randomized controlled trial ($N = 121$) testing the preliminary efficacy of a mindful self-compassion intervention designed to reduce internalized weight bias, compared to wait list control. The primary outcome was 4-week change in self-report weight bias internalization as measured by the Modified Weight Bias Internalization Scale.⁴⁷ Secondary outcomes included 4-week changes in self-compassion, body appreciation, cognitive flexibility related to weight, and other related constructs. All study procedures were completed remotely using digital tools in a standalone fashion (i.e., without human support or coaching). Primary trial assessments were completed on days 0 and 28, immediately pre- and post-intervention or waiting period. All study procedures were designed in May 2020, approved by the Duke University Institutional Review Board in December 2020, and registered with ClinicalTrials.gov (NCT 04678973).

2.2 Participants

Eligible participants were adults with obesity and elevated internalized weight bias. Eligible participants were at least 18 years of age, reported a body mass index of at least 30 kg/m², have experienced weight stigma, reported elevated internalized weight bias as determined by a score of at least 4.0 on the Weight Bias Internalization Scale, owned a smartphone, were willing to receive multiple text messages per day and engage

in mindfulness practice for up to 20 minutes per day, lived in the United States Eastern Standard Time zone, and were able to read and write in English fluently. A Weight Bias Internalization Scale cutoff score of 4.0 has been used in prior research to determine “high” internalization of weight bias.²³ Reports on population norms of this measure indicate a cutoff score of 4.0 likely captured women in the 80th percentile and men in the 90th percentile of internalized weight bias.⁴⁷ Participants were excluded if they did not meet the eligibility criteria listed above, if they were already regular meditators (i.e., meditated for at least 1 day per week for more than 1 week), were currently engaged in other treatments similar to Ruby (i.e., in a mindfulness program, working on weight related distress, actively trying to lose weight), or had recently undergone bariatric surgery. See Table 3 for detailed inclusion and exclusion criteria.

Table 3: Eligibility criteria

Construct	Exclusion Criterion	Inclusion Criterion
Age	< 18 years	≥ 18 years
Body mass index (kg/m²)	< 30 kg/m ²	≥ 30 kg/m ²
Experienced weight bias	No experiences reported	At least one of three experiences reported
Internalized weight bias	Mean < 4.0 on WBIS	Mean ≥ 4.0 on WBIS
Smartphone	Does not own smartphone	Does own smartphone
Willingness	Not willing to receive texts or practice mindfulness daily	Willing to receive multiple texts per day and practice mindfulness daily

Location	Does not live in Eastern Time Zone	Lives in Eastern Time Zone
Language fluency	Not able to read/write fluently in English	Fluency in English reading/writing
Meditation background	Already a regular meditator (i.e., meditated for at least 1 day/week for more than 1 week in the last month)	No regular meditation practice
Concurrent interventions	Enrolled in a mindfulness or weight-related program	Not enrolled in any similar intervention
Recent weight change	Actively attempting weight loss in any way; recent or planned bariatric surgery	No recent or planned weight changes

2.3 Study Procedures

2.3.1 Recruitment

Initial recruitment goals were 80 adults over the age of 18 who met inclusion criteria as stated above. Sample size was calculated based on the primary outcome using G*Power with a medium effect size, determined based on the literature [effect size = 0.5; power = 0.95]. We needed a minimum of 55 participants to be adequately powered; we estimated a retention rate of 70%, and thus inflated sample size to account for attrition for a final sample size of 80 participants. Due to speed and ease of recruitment and a desire to explore secondary and tertiary aims, we acquired approval from Duke

University's Institutional Review Board to increase the sample size to 120 participants. Our final sample size was 121 participants.

Participants were recruited between January-June 2021 from anywhere within the Eastern Standard Time zone in the United States to ensure consistent timing of text messages across participants while maximizing reach. In order to recruit eligible participants, we used a multi-pronged online approach. We listed information about Ruby on a clinical trial registry from the National Institutes of Health and used social media platforms (i.e., Instagram, Twitter, Facebook) and professional networks to distribute recruitment materials. We also used ResearchMatch, a national health volunteer registry, to identify potentially eligible participants and notify them about Ruby. ResearchMatch registrants are 75% White, 70% women, and 90% Non-Hispanic or Latino and ResearchMatch allows for targeted recruitment based on body mass index, location, age, race/ethnicity, and other factors we believed would aid in attempts to recruit a diverse sample. All recruitment sources directed interested participants to the study website to provide details about the intervention, eligibility criteria, and contact information for study staff should they have questions about Ruby before continuing to the remaining screening procedures.

2.3.2 Eligibility Screening

Interested participants were directed to an eligibility screening survey via Research Electronic Data Capture (REDCap) website, a secure web-based software

platform designed for data collection and management in research studies. Participants completed a brief survey collecting data about inclusion and exclusion criteria. Upon submission of the screening survey, participants who met any exclusion criterion were automatically directed to a page that notified them of their ineligibility and directed them to a Resources page hosted on the study website that included nationally available resources for body image concerns, mental health resources, and reading materials that they might find supportive. If REDCap detected a new survey attempt with a phone number that duplicated a prior survey attempt, we assumed this was the same participant attempting to re-take the survey to “become eligible” and thus these surveys were automatically marked as ineligible. Participants who met all inclusion criteria were automatically notified of their eligibility and forwarded to the Informed Consent document via REDCap.

2.3.3 Informed Consent

Once directed to the Informed Consent document, participants were encouraged to read the document thoroughly and to reach out to study staff with questions or concerns prior to signing the document. If a participant provided consent, they completed the Informed Consent document via electronic signature. A copy of the Informed Consent document was automatically sent to them via email with an explanation of upcoming baseline assessment.

2.3.4 Baseline Assessments

Once a participant provided informed consent, REDCap automatically emailed a unique survey link to the series of baseline surveys and instructions for completion. Participants were asked to set aside 20-30 minutes to complete these surveys within the next 24 hours. The baseline surveys included several instruments to measure baseline values on a variety of constructs, outlined in more detail below (Table 4). Automated reminder emails were sent each morning for up to three days following initial invitation to complete the surveys. If a participant did not complete the surveys within four days of informed consent, they were considered no longer interested in Ruby. Once the final baseline survey was complete, participants were instructed to wait for study staff to randomly assign them to one of two groups.

2.3.5 Randomization and Enrollment

Upon completion of the baseline assessments, REDCap automatically notified study staff that a participant was eligible for randomization and enrollment. Study staff would then manually confirm eligibility, informed consent, and completion of baseline assessments. If these were complete as expected, study staff (CMH) would then proceed with random assignment using the pre-programmed randomization module within REDCap.

The REDCap randomization module is designed to provide maximum fidelity to the randomization scheme. We used a simple random sampling scheme to randomly

assign eligible participants in a 1:1 ratio to Group A (Ruby intervention) or Group B (Wait list control). The randomization allocation table was created using Microsoft Excel and was uploaded to REDCap and locked to prevent tampering. Study staff were blinded to the allocation table, though were not blinded to random assignment. (However, given that the intervention was pre-programmed, we do not expect that this had any impact on trial outcomes.) Once study staff initiated the randomization within REDCap, the participant's group assignment was locked, and automated text messages were initiated. Participants were notified via text message of their group assignment and oriented to the next steps of Ruby. See Figure 3 for a summary of overall study procedures.

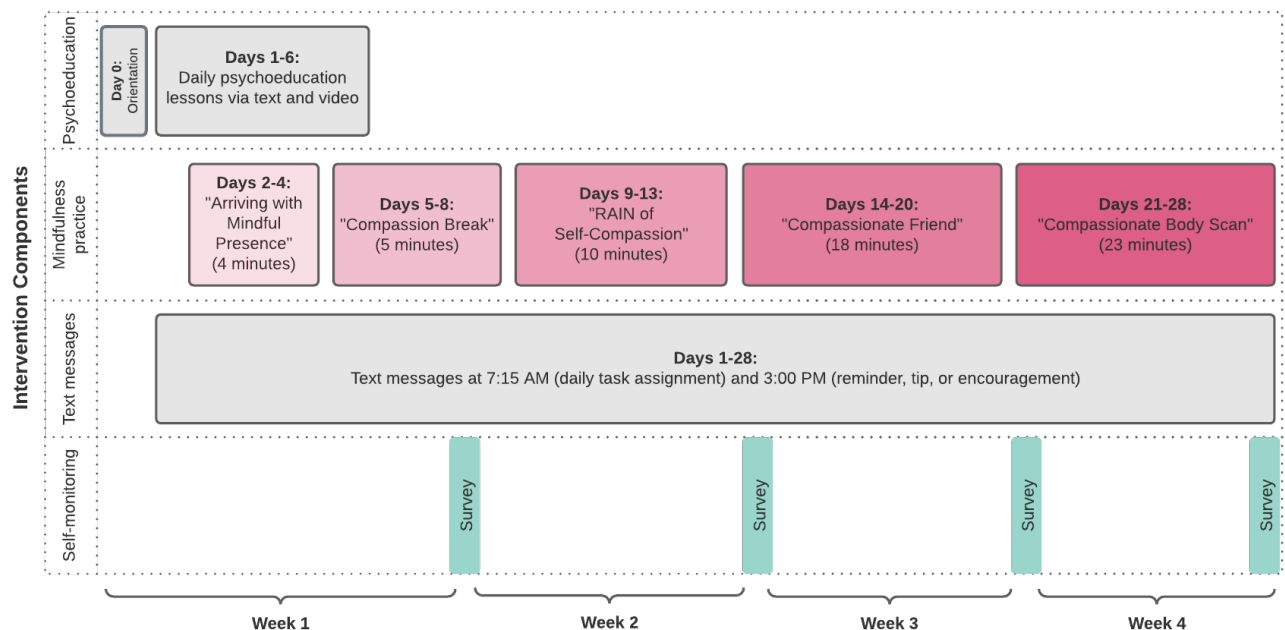


Figure 3: Overview of intervention components

2.3.6 Retention Strategies

Due to the standalone nature of this trial design, all retention efforts were built into the trial and preprogrammed. The language within daily reminder messages sent each afternoon (discussed in more detail below) was crafted to target waning motivation by providing reassurance, gentle reminders about how to get back on track, and reorientation to potential values (e.g., self-care, personal health). Messages were preprogrammed to be sent at the same time every day and were not responsive to any user behavior. Message content included details about how far along they were in their four-week period in both groups to give participants a sense of their accomplishments so far and set expectations about how much more time would need to be invested in the trial. In the control group, these were coupled with gratitude for their patience during the waiting period. When assessments were administered (i.e., baseline assessments, weekly self-monitoring, and end-of-treatment assessments), reminders were preprogrammed if the participant did not complete assessments within the expected 24 hours. For end-of-treatment questionnaires, participants were reminded of potential compensation in an effort to highlight potential reward for completion of trial expectations. At no point did study staff reach out personally to trial participants to increase retention to maintain purity of standalone design.

2.3.7 Data Collection

Data collection for primary and secondary outcomes were assessed at baseline (day 0) and end-of-treatment (day 28). All surveys were administered via REDCap and were estimated to take 15-30 minutes to complete. A complete list of surveys administered are listed in Table 4. Participants were instructed to complete their baseline assessments the same day as they were deemed eligible. If a participant did not complete the baseline assessments that day, they received an automated email reminder that included the link to the assessments. This reminder was sent every 24 hours up to three times. If a participant did not complete the baseline assessments during that four-day window, they were deemed no longer interested.

Table 4: Assessments and measurement timepoints

	Screening	Baseline – Day 0	Day 7	Day 14	Day 21	End of Treatment – Day 28
Date of Birth	x					
Anthropometric Data	x					x
Weight Bias Internalization Scale - Modified ⁴⁷	x	x				x
Demographics		x				
Self-Compassion Scale ⁴⁸		x				x
Weight Self-Stigma Questionnaire ⁴⁹		x				x
Fear of Compassion Scale – Self subscale ⁵⁰		x				x

Patient Health Questionnaire - 2 ⁵¹		x				x
Weight and dieting history		x				
Intuitive Eating Scale - 2 ⁵²		x				x
International Physical Activity Questionnaire - Short Form ⁵³		x				x
Five Facet Mindfulness Questionnaire - Short Form ⁵⁴		x				x
Body Appreciation Scale ⁵⁵		x				x
Acceptance and Action Questionnaire for Weight ⁵⁶		x				x
Childhood Trauma Questionnaire ⁵⁷		x				
Weekly Adherence Survey			x	x	x	x
Acceptability and Feasibility Ratings						x
Engagement and Feedback						x

After completing the intervention, participants received additional text messages with instructions to complete the end-of-treatment surveys, as well as a link to these surveys in their email. The participants were encouraged to respond to the surveys within 24 hours. If a participant did not complete the surveys that day, they received an automated email reminder that included the link to the surveys every 24 hours up to

five more times. After 5 days of automated email attempts, study staff personally reached out to participants via email to provide context about end-of-treatment surveys, remind them of the compensation they would be eligible to receive if they complete these surveys, and provide an opportunity for the participant to voice questions or concerns they may have about completing these surveys.

2.4 Intervention Design

Immediately following randomization, participants randomized to the intervention group were sent a series of text messages notifying them of their group assignment. They also received a link to a Ruby orientation page on the study website. The orientation page outlined participation expectations and study details, including when text messages will be sent and from what phone number, what participants' daily time commitment would be, and how to get in touch with study staff if they need technical assistance. Participants were not required to engage in any specific way with this stage of the intervention; orientation was provided simply to remind participants what they agreed to do when they provided informed consent for this trial, and to provide contact information for study staff. See an outline of intervention activities each day in Figure 3 and detailed summary of text messages in Appendix B.

2.4.1 Psychoeducation

Participants in the intervention group received text messages on days 1 through 6 of the intervention that included a link to psychoeducation material. These materials

were hosted on a hidden page on the study website to ensure control group participants could not access the materials. The purpose of the psychoeducation material was to orient users to their upcoming experience, provide education about internalized weight bias, the nervous system, and weight bias as a chronic stressor, the utility of self-compassion practice to regulate physiological and psychological targets, and guidance on establishing and maintaining a mindfulness practice. Psychoeducation was delivered in written and animated video formats. A sample of these materials can be viewed in Appendix A or accessed via www.textruby.com/week-1. Each lesson ended with a reflection prompt which participants were encouraged to respond to in a journal of their choosing (i.e., notebook, notes app on their phone, or other easily accessible location) to help generalize each lesson and apply them to their daily life.

2.4.2 Mindfulness Practices

Beginning on day 2 of the intervention, participants also received a link to an audio file of a guided mindfulness practice via an automated text message each day. These mindfulness audio files were hosted on Soundcloud, and a link was texted to participants every morning. Mindfulness practices ranged in duration and focus; the progression was designed to build intensity slowly over the course of the intervention. For example, day 2 included a 4-minute mindfulness of breath practice to complete after reading psychoeducation materials. Participants were instructed to use the brief mindfulness practices during week 1 to get acquainted with what it feels like to be

engaged in mindfulness, to troubleshoot logistical barriers (e.g., finding the ideal location and time of day), and to identify additional barriers that may come up over the course of their participation in Ruby (e.g., noticing more unwanted unpleasant emotions) while engaging in supportive psychoeducation. As participants progressed, mindfulness practices began to focus on self-compassion and finally, self-compassion as applied to body image and weight. These practices are publicly-available mindfulness practices written and recorded by Tara Brach⁵⁸ and Kristin Neff.⁵⁹ Several of these practices were previously used in other investigations of compassion and body image concerns.³³

2.4.3 Daily Prompts

Daily tasks over days 1-28 were automatically texted to every participant at 7:15 am each morning. Daily tasks included links to psychoeducation materials, the accompanying animated video and/or mindfulness practice, depending on their intervention day. All participants received their daily prompts at the same time (i.e., 7:15 am), but participants were instructed to complete their daily task or mindfulness practice at the most convenient time of day each day. There is little extant literature providing guidance about preferred timing of text messages in clinical trials. There is some evidence that participants respond more favorably to text message prompts sent during waking hours rather than during sleeping hours;⁶⁰ thus, 7:15 am was chosen as the most ideal time given that many people are awake and not yet at work at this hour.

Participants were invited to reach out to study staff if they would like assistance troubleshooting the best time of day to complete their daily practice (e.g., if they are shift workers or otherwise have an atypical schedule).

Participants received an additional text daily at 3:00 pm that included a reminder of their reflection for the day, a tip to troubleshoot mindfulness practice, a poem, or a note of compassion. In orientation materials, participants were instructed to continue to follow the daily prompts even if they miss a day (rather than try to catch up on missed material). The additional texts (at 3:00 pm) reminded them of this instruction on an approximately weekly basis, and they were reoriented to these instructions during their weekly self-monitoring feedback.

2.4.4 Weekly Self-monitoring

At the end of each week, participants were sent an automated text at 7:00 pm with a link to a weekly self-monitoring survey hosted on REDCap. Participants reported how many days that week they were able to complete their assigned tasks and were provided automated feedback based on their response. Feedback was separated into three categories: low engagement (i.e., 0-3 days), medium engagement (i.e., 4-6 days), and high engagement (i.e., 7 days) and the content of feedback was adjusted for each category. Feedback was preprogrammed did not change over the course of the intervention unless they moved from one category to another.

If they practiced 0-3 days, they were provided feedback that included encouraging messages and prompts to use self-compassion, identify specific barriers that got in the way of their practice, and create an action plan for how they could improve their adherence in the coming week. If they practiced 4-6 days, they were provided with reinforcement and praise for completing their practice at least half of the week and were asked to identify specific barriers on the days they did not practice and create an action plan for the coming week. If they practiced every day, they were provided with reinforcement and praise and were asked to identify how they were able to practice every day and commit to doing the same in the coming week. If the participant did not respond to this survey, they were automatically sent the survey again the following evening.

2.4.5 Intervention Delivery

Ruby was an entirely standalone digital intervention delivered via text messages. At no point did participants receive human feedback, coaching, or support. While participants were able to reach out to study staff for technical support (e.g., if they did not receive a text when one was expected), this was rare and did not include any intervention content. All recruitment, screening, data collection, and intervention content was delivered via automated pre-programmed surveys and messages. Surveys were able to be completed via web browser on a user's smartphone or computer, based on the participant's preferences. Intervention content was delivered via text message

each morning, with links to additional intervention content such as psychoeducation videos and guided mindfulness audio files and instructions on what to do that day. See Appendix B for text message content in its entirety, along with the scheduling of each message. This method of preprogramming and automated delivery minimizes staff burden and increases potential reach.

2.4.6 Comparator Group

Participants randomized to the wait list control group received brief orientation via text messages instructing them on the timeline of the study. An additional message was sent halfway through their waiting period (i.e., day 14) to thank them for their patience and notify them of remaining wait time. At the end of their waiting period (i.e., day 28), participants were sent a link to their end of treatment surveys. After completion of their end-of-treatment surveys, participants were offered access to the Ruby intervention. If they opted in, they began receiving the intervention the next day.

2.4.7 Compensation

Participants who completed all required study tasks (i.e., informed consent, randomization, baseline surveys, and end-of-treatment surveys) were entered into a raffle to win one of twenty Amazon e-gift cards valued at \$45 each. After study completion, twenty participant identifiers were randomly selected using a random number generator. The participants then had 72 hours to claim their compensation; if

they were not responsive to emails in ≤ 72 hours, additional participant identifiers were selected to maximize the number of participants who could receive compensation.

2.5 Outcome Measures

2.5.1 Primary Outcomes

2.5.1.1 Weight Bias Internalization

Participants completed the Modified Weight Bias Internalization Scale,⁴⁷ a 10-item version of the prior Weight Bias Internalization Scale. This is a psychometrically validated assessment of weight bias internalization in people of all weight statuses; the 10-item version of the original scale⁶¹ was created to capture weight bias internalization regardless of whether or not the respondent identifies as overweight or obese.⁶²

Participants were asked to rate their agreement with statements such as “My weight is a major way that I value myself as a person.” The Modified Weight Bias Internalization Scale is scored by computing the mean of 10 item responses, rated on a 1-7 scale, with higher scores signifying greater weight bias internalization.

2.5.1.2 Weight Self-Stigma

Participants completed the Weight Self-Stigma Questionnaire⁴⁹ a 12-item assessment of self-directed weight stigma. The Weight Self-Stigma Questionnaire captures different aspects of weight bias internalization and self-directed stigma when compared to Weight Bias Internalization Scale. Notably, in addition to a total score, the Weight Self-Stigma Questionnaire measures two distinct subscales: fear of enacted

stigma and self-devaluation. While both instruments are sound measures of weight bias internalization,⁶³ they demonstrate different sensitivity to change in recent interventions for weight bias internalization.²³ Participants were asked to rate their agreement with statements such as “I became overweight because I’m a weak person.” Higher scores indicate greater levels of weight self-stigma.

2.5.1.3 Self-compassion

Participants completed the Self-Compassion Scale,⁴⁸ a 26-item assessment of an individual’s capacity to direct compassion toward themselves. Participants were asked how frequently they behave in a self-compassionate manner by responding to statements such as “I try to be loving toward myself when I am feeling emotional pain.” Per Neff’s recommendations, we used the total score comprising all six factors in our primary outcome analysis (after reverse scoring the uncompassionate responding subscales).⁶⁴ To understand specific mechanisms that conferred changes in self-compassion global score, we will also analyze each of the six subfactors: the three compassionate self-responding factors (self-kindness, common humanity, and mindfulness) and the three uncompassionate self-responding factors (i.e., self-judgment, isolation, and over-identification). Higher total scores indicate greater levels of self-compassion.

2.5.2 Secondary Outcomes

2.5.2.1 Experiences of Weight Bias

Within the screening survey, participants were asked to report whether or not they have experienced weight bias in their lifetime. This measurement was conducted via three yes/no questions that assessed verbal harassment, unfair treatment, and discrimination: (1) Have you ever had the experience of being teased because of your body weight?; (2) Have you ever had the experience of being treated unfairly because of your body weight?; and (3) Have you ever had the experience of being discriminated against because of your body weight? These questions have been used in prior weight bias research to assess experiences of weight bias.²³

2.5.2.2 Mindfulness

Participants completed the Short Form Five Facet Mindfulness Questionnaire,⁵⁴ a 24-item instrument which measures five facets of a tendency to be mindful in daily life. The five facets assessed are: observing internal experience, describing internal experience, acting with awareness, non-judging of inner experience, and non-reactivity to inner experience. Participants rated their agreement with statements such as “When I have distressing thoughts or images, I don’t let myself be carried away by them.” Items are rated on a scale of 1 to 5, with higher scores indicating more mindfulness. Subscale scores and total scores were computed.

2.5.2.3 Weight-related Experiential Avoidance

Participants completed the Acceptance and Action Questionnaire for Weight-Related Difficulties – Revised,⁵⁶ a 10-item measure of avoidance of unwanted thoughts, feelings, and actions related to weight (i.e., experiential avoidance). Data suggest using a domain-specific inventory of experiential avoidance is more accurate than using the general Acceptance and Action Questionnaire. On this instrument, participants were asked to rate their agreement with statements such as, “When I evaluate my weight or appearance negatively, I am able to recognize that this is just a reaction, not an objective fact.” Items are rated from 1 (never true) to 7 (always true). Higher global scores reflect more experiential avoidance.

2.5.2.4 Fear of Compassion

Participants completed one subscale from the Fear of Compassion Scale.⁵⁰ The Fear of Compassion Scale measures compassion in three domains: from others, for others, and for self. We administered the 17-item fear of compassion for self subscale. Participants rated their agreement with statements such as “I feel that I don’t deserve to be kind and forgiving to myself.” Items are rated from 0 (don’t agree at all) to 4 (completely agree) and summed, with lower scores indicating lower fear of compassion.

2.5.2.5 Body Appreciation

Participants completed the Body Appreciation Scale 2,⁵⁵ a 10-item inventory assessing a sense of gratitude, appreciation, and positive attitudes toward the body. The

original Body Appreciation Scale was updated to eliminate gendered language and to update language that assumed that all respondents had “body flaws” that were inherently negative or looked upon unfavorably by the respondent. Participants rated their agreement with statements such as “I appreciate the different and unique characteristics of my body.” Items are rated on a scale of 1 (never) to 5 (always); responses are averaged for a total score, with higher scores indicating higher body appreciation.

2.5.2.6 Intuitive Eating

Participants completed the Intuitive Eating Scale – 2,⁵² a 23-item assessment of an individual’s tendency to eat in alignment with internal cues versus external cues. Participants rated their agreement with statements such as, “When I am craving a certain food, I allow myself to have it,” on a scale of 1 (strongly disagree) to 5 (strongly agree) and a global score was calculated, with higher scores indicating more intuitive eating patterns. We also calculated each of the four subscales: unconditional permission to eat, eating for physical rather than emotional reasons, reliance on hunger and satiety cues, and body-food choice congruence.

2.5.2.7 Weight and Dieting History

Participants responded to a series of questions adapted from the Weight and Lifestyle Inventory.⁶⁵ We selected items that inquire about: age of obesity onset, frequency of weight cycling episodes, history of eating disorder diagnosis, and family

history of weight. One weight cycle was defined as a loss and regain of at least 10 pounds.⁶⁶

2.5.2.8 Physical Activity

Participants completed the International Physical Activity Questionnaire – Short Form,⁵³ a self-report inventory of recent physical activity across different domains (vigorous activity, moderate activity, walking, and leisure) in the past week. Participants reported the number of days they engaged in each type of physical activity in the last 7 days and reported the usual number of minutes they engaged in that type of activity on one of those days. These responses were used to compute the overall standardized volume of activity by weighting each type of activity according to its energy expenditure (called MET) and producing a score in MET-minutes per week, with higher scores indicating more energy expenditure.

2.5.2.9 Depression

Participants completed the Patient Health Questionnaire 2,⁵¹ a self-report instrument measuring depressive symptoms derived from the diagnostic criteria in the DSM-IV. The 2-item version (abbreviated from the original 9-item Patient Health Questionnaire) does not include the suicidal ideation item and demonstrates good predictive validity with a cutoff score of > 2 .⁶⁷ We selected the shortest version of this instrument to minimize participant burden.

2.5.2.10 Trauma History

Participants completed the Childhood Trauma Questionnaire,⁵⁷ a 28-item retrospective assessment of childhood experiences of abuse, neglect, and maltreatment. The Childhood Trauma Questionnaire assesses experiences that are often not captured in other assessments of trauma, such as chronic neglect, invalidation, psychological abuse, and other experiences that may not meet DSM Criterion A trauma thresholds, yet significantly impact an individual's capacity for healthy attachment, sense of self, and other measures of wellbeing. The Childhood Trauma Questionnaire has five subscales: emotional abuse, physical abuse, sexual abuse, emotional neglect, and physical neglect. A total score will also be computed; higher scores indicate more childhood trauma.

2.5.2.11 Engagement and Feedback

We assessed weekly adherence using surveys wherein participants were asked to report the number of days they practiced mindfulness. Self-report engagement was assessed retrospectively in the engagement and feedback survey provided at study completion. In these surveys, we asked participants to report what total percent of Ruby they completed and provide feedback on intervention content. We were not able to measure unique momentary engagement with Ruby content (e.g., tracking how often a specific participant clicked through to a psychoeducation page or mindfulness audio track) or otherwise objectively measure engagement. We also assessed the perceived usability and acceptability of Ruby at the end of treatment.

2.5.3 Broad Analytical Approach

To describe baseline characteristics, we computed descriptive statistics stratified by treatment arm. To determine whether baseline characteristics differed by group assignment, we used Pearson chi-square tests for categorical variables and independent samples t tests for continuous variables. We conducted Pearson correlations to determine the associations between baseline levels of weight bias internalization and all secondary constructs.

We used intent-to-treat analyses to test our primary study aim using linear mixed models to examine changes in weight bias internalization over time by treatment arm. Linear mixed models were fitted with a full maximum likelihood estimation and we assumed missingness at random. We used an unstructured covariance matrix. We did not control for any additional variables. We used the same linear mixed modeling strategy to conduct secondary analyses assessing the impact of the intervention on other outcome variables of interest (i.e., weight self-stigma, mindfulness, self-compassion, fear of self-compassion, body appreciation, intuitive eating, depression, weight-related experiential avoidance, and physical activity). We assessed the impact of moderating variables using multiple linear regression. We hypothesized that the intervention effect may be moderated by certain psychological variables (i.e., depression, fear of self-compassion, childhood trauma). We also hypothesized that the effect of the intervention was partially mediated by an increase in self-compassion. We conducted a simple

mediation analysis using the SPSS PROCESS macro (Model 4) with 5000 bootstrapping samples. The sample size was likely not large enough to be fully powered for these exploratory analyses, though they are worthy of investigation given the lack of clinical trials in this area.

We computed engagement based on retrospective data assessing how many days per week participants engaged in Ruby. Individuals were coded as high engagers if they engaged on 4 or more days per week, with the justification that they would be completing mindfulness practices at least half of the week. Those who practiced 3 or fewer days per week were coded as low engagers. We used independent samples t tests to identify differences in weight bias internalization change score between high and low engagers. We also reported weekly responses to adherence surveys to identify patterns in engagement over time in aggregate.

3. Baseline Results

3.1 *Methods*

For sociodemographic and clinical variables measured at baseline, we computed descriptive statistics to characterize the sample (mean, SD for continuous variables; *n*, % for categorical variables). We conducted Pearson correlations to determine the associations between baseline levels of weight bias internalization and all secondary constructs (i.e., Pearson's product-moment correlations for continuous variables, and point-biserial correlations for dichotomous variables). We examined whether baseline

values on clinical constructs differed by race, gender, or identification with the LGBTQIA+ community. To evaluate group differences, we used independent samples t-tests for continuous variables and Pearson chi-square tests for categorical variables. $P < .05$ was considered statistically significant. Investigators remained blinded to trial outcomes until all data were collected. Baseline data were analyzed using IBM SPSS 22.

3.2 Results

3.2.1 Enrollment

Through ResearchMatch contacts, ClinicalTrials.gov, our study website, word of mouth, and other recruitment channels, we received 498 inquiries via REDCap screening survey. Of those, 476 participants were unique users who completed the screening survey. 35% of screened participants were deemed eligible for Ruby ($n = 166$). See CONSORT diagram (Figure 4) for details regarding reasons for ineligibility. 122 participants provided informed consent and completed their baseline surveys. 121 participants were enrolled (i.e., randomized, assigned to a treatment arm, and received one text message; Intervention = 61; Wait list control = 60). 99 participants (81.8%) completed the entire trial (i.e., baseline and end-of-treatment surveys) and 22 participants were lost to follow-up (Intervention: 10; Control: 12). Participant retention did not differ significantly by treatment arm.

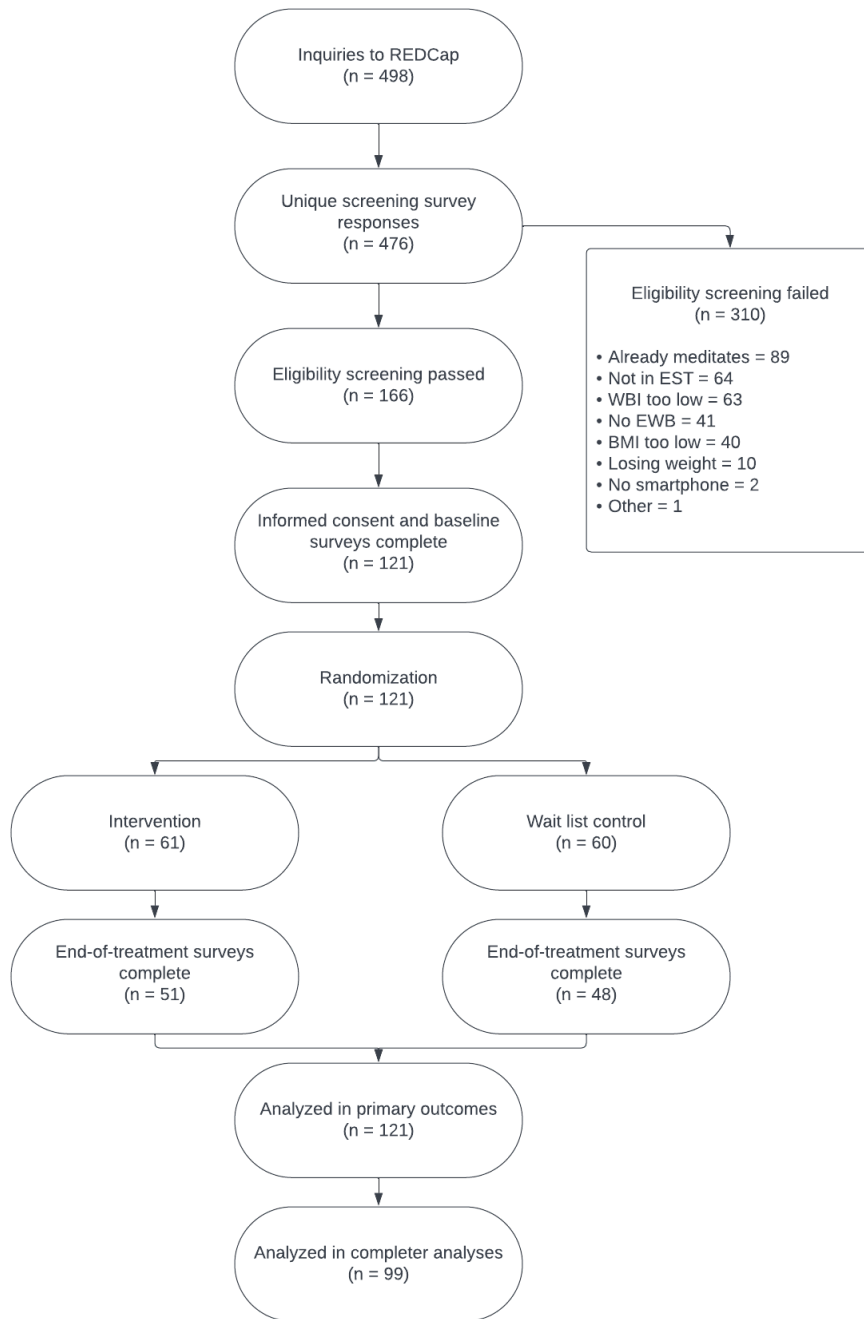


Figure 4: CONSORT diagram of enrollment

3.2.2 Sample Characteristics

Detailed baseline characteristics of Ruby participants can be found in Table 5. No statistically significant differences were observed on any baseline value between treatment arms (p values > 0.05). At baseline, participants had a mean (SD) age of 44.9 (15.0) years. Participants were predominantly female (77.7%), white (72.9%), married (42.1%), and reported having an undergraduate degree (47.9%). 19.8% of Ruby participants reported identifying as part of the LGBTQIA+ community.

Table 5: Sample Characteristics and Demographics

	Total (N = 121)
Age, mean (SD), y	44.9 (15.0)
Body mass index, mean (SD), kg/m ²	37.9 (6.7)
Education, No. (%)	
Middle school	1 (0.8)
High school/GED	21 (17.4)
Undergraduate	58 (47.9)
Master's degree	28 (23.1)
PhD or comparable	13 (10.7)
Race, No. (%)	
American Indian or Native American	2 (1.7)
South Asian	3 (2.5)
East Asian	1 (0.8)
Black or African American	20 (16.5)
White	87 (71.9)
Multiracial	4 (3.3)
Other	3 (2.5)
Ethnicity, No. (%)	
Latin American	4 (3.3)
Not Latin American	116 (95.9)
Marital status, No. (%)	
Single	41 (33.9)
Domestic partnership	5 (4.1)

	Married	51 (42.1)
	Divorced	18 (14.9)
	Widowed	6 (5.0)
Gender identity, No. (%)		
	Male	23 (19.0)
	Female	94 (77.7)
	GNC or Non-binary	2 (1.7)
	Prefer to self-describe	2 (1.7)
Sexual Identity, No. (%)		
	LGBTQIA+	24 (19.8)
	Non LGBTQIA+	97 (80.2)

SD: Standard deviation. GNC: Gender non-conforming.

LGBTQIA+: Identifies as lesbian, gay, bisexual, transgender, queer, intersex, asexual, or another gender/sexual minority group.

3.2.3 Weight Bias Internalization and Weight-related Outcomes

Baseline values of all secondary outcomes and their correlation with weight bias internalization are summarized in Table 6. Participants reported three types of experiences of weight bias. 97.5% of participants reported experiencing weight-based teasing, 83.5% reported unfair treatment based on their weight, and 63.6% reported experiencing weight-based discrimination. Of these three types of experienced weight stigma, only weight-based discrimination was significantly correlated with baseline weight bias internalization, such that those who have experienced weight-based discrimination reported a mean (SD) weight bias internalization score of 5.6 (0.8) and who have not reported a mean weight bias internalization score of 5.2 (0.8); $r_{pb}(119) = 0.24, p = 0.008$. Participants also indicated elevated levels of weight bias *internalization*; they reported a weight bias internalization score of 5.5 (0.8) on the Weight Bias

Internalization Scale and a 43.7 (7.2) on the Weight Self-Stigma Questionnaire.

Participants reported a mean body mass index of 37.9 (6.7) kg/m² and a mean (SD) age of obesity onset of 17.0 (11.4). Individuals reported losing and gaining weight many times over the course of their lives; the mean number of weight cycles (i.e., a loss and regain of at least 10 lb.) was 10.7 (14.4) which was somewhat correlated with weight bias internalization, $r(119) = 0.23, p = 0.03$. 5.6% of participants reported receiving an eating disorder diagnosis at some point in their lifetimes

3.2.4 Self-compassion

Participants reported mean (SD) self-compassion scores of 2.4 (0.8) which falls within the low range according to Neff. Suggested cutoffs to determine clinical meaning are Low = 1.0-2.49, Moderate = 2.5-3.5, and High = 3.51-5.0. Participants reported low levels of self-kindness (Mean = 2.4, SD = 0.8), and moderate levels of common humanity (Mean = 2.7; SD = 0.8) and mindfulness (Mean = 2.8, SD = 0.7). Total self-compassion score was inversely correlated with weight bias internalization, $r(119) = -0.46, p < .001$. All subscales with the exception of common humanity were also correlated with weight bias internalization, such that compassionate responding subscales were positively correlated and uncompassionate responding subscales were negatively correlated. Participants also reported moderate fear of self-compassion (Mean = 23.3, SD = 12.3) which was correlated with weight bias internalization, $r(119) = 0.44, p < .001$.

3.2.5 Mindfulness

Participants reported low levels of mindfulness at baseline (Mean = 69.6, SD = 12.7). Scores were similar to those found in samples of individuals who meet clinical thresholds for depression and/or anxiety. Participants reported the highest mean on the describing subscale (Mean = 16.1; SD = 4.4), and lowest on the non-reacting subscale (Mean = 12.7, SD = 3.3). Participants reported similar means for the observing internal experiences subscale (Mean = 13.7, SD = 3.7), acting with awareness subscale (Mean = 13.7, SD = 4.0), and non-judging subscale (Mean = 13.4, SD = 4.1). Total mindfulness score and all subscales were inversely correlated with weight bias internalization (p 's < .05)

3.2.6 Secondary Outcomes

At baseline, participants reported a mean (SD) weight-related experiential avoidance score of 72.7 (13.2) which was highly correlated with weight bias internalization, $r(119) = 0.66, p < .001$. Participants reported a body appreciation score of 2.3 (0.7) which was highly inversely correlated with weight bias internalization $r(119) = -0.65, p < .001$. When reporting total scores on intuitive eating, mean (SD) scores were 2.7 (0.5). Mean (SD) scores on each subconstruct of intuitive eating were 3.4 (0.7) on unconditional permission to eat, 2.3 (0.8) on eating in response to physical cues rather than emotional cues, 2.6 (0.9) on reliance on hunger and satiety cues, and 2.7 (1.0) on making food choices to meet the needs of their body. Total intuitive eating score was

moderately inversely correlated with baseline weight bias internalization, $r(119) = -0.34$, $p < .001$. Three of the four subscales, excluding unconditional permission to eat, were also inversely correlated with weight bias internalization (p 's $< .05$).

Participants reported low levels of physical activity. On average, participants reported a mean (SD) total of 16.5 (67.4) minutes per week of vigorous activity, 38.1 (80.9) minutes per week of moderate activity, 149.3 (286.5) minutes per week of walking, and 799.1 (1317.9) minutes per week of sitting. (Standardized values of total volume of energy expenditure per week are reported in Table 6.) Of the various activity types measured, only vigorous activity was correlated with weight bias internalization, $r(119) = -0.21$, $p = .03$.

With respect to depression and trauma constructs, participants reported a mean (SD) depression score of 2.8 (1.8), which is slightly above the cutoff for prediction of a clinical diagnosis of depression. Depression was significantly correlated with weight bias internalization in this sample, $r(119) = 0.41$, $p < .001$. Participants reported total mean (SD) childhood trauma scores of 48.7 (19.1). Mean (SD) scores on subscales were 11.8 (6.0) for emotional abuse, 8.3 (4.9) for physical abuse, 8.4 (5.6) for sexual abuse, 12.7 (4.9) for emotional neglect, and 7.5 (3.0) for physical neglect. When exploring correlations between various types of childhood trauma and weight bias internalization, only the two emotional abuse subscales were significantly correlated: emotional abuse [$r(119) = 0.24$, $p < .001$] and emotional neglect [$r(119) = 0.26$, $p < .001$]

Table 6: Baseline values on primary and secondary outcomes

	Total (N = 121)	Correlation with WBIS
Weight bias internalization, mean (SD)	5.5 (0.8)	
Weight self-stigma, mean (SD)		
Self-devaluation	21.9 (4.3)	0.60**
Fear of enacted stigma	21.8 (4.5)	0.51**
Total score	43.7 (7.2)	0.66**
Self-compassion, mean (SD)		
Self-kindness	2.4 (0.8)	-0.38**
Common humanity	2.7 (0.8)	-0.12
Mindfulness	2.8 (0.7)	-0.26**
Self-judgment	2.1 (0.8)	0.50**
Isolation	2.2 (0.7)	0.43**
Overidentification	2.3 (0.9)	0.39**
Grand mean score	2.4 (0.6)	-0.46**
Mindfulness, mean (SD)		
Observing	13.7 (3.7)	-0.20*
Describing	16.1 (4.4)	-0.28**
Acting with awareness	13.7 (4.0)	-0.28**
Non-judging	13.4 (4.1)	-0.35**
Non-reacting	12.7 (3.3)	-0.23**
Total score	69.6 (12.7)	-0.42**
Weight-related experiential avoidance, mean (SD)	72.7 (13.2)	0.66**
Fear of self-compassion, mean (SD)	23.3 (12.3)	0.44**
Age of obesity onset, mean (SD), y	17.0 (11.4)	0.02
Weight cycles, mean (SD)	10.7 (14.4)	0.23*
Experiences of weight bias, No. (%)		
Weight-based teasing	118 (95.7)	-0.05
Unfair treatment based on weight	101 (83.5)	0.10
Weight-based discrimination	77 (63.6)	0.24**
Eating disorder diagnosis, No. %	6 (5.6)	-0.00
Anorexia nervosa	3 (2.5)	0.02
Bulimia nervosa	2 (1.7)	0.03
Binge eating disorder	2 (1.7)	-0.01

Night eating syndrome	1 (0.8)	-0.04
Excessive exercise	2 (1.7)	-0.05
Other eating disorder	2 (1.7)	-0.13
Body appreciation, mean (SD)	2.3 (0.7)	-0.65**
Intuitive eating, mean (SD)		
Unconditional permission to eat	3.4 (0.7)	0.06
Eating for physical vs. emotional reasons	2.3 (0.8)	-0.33**
Reliance on hunger/satiety cues	2.6 (0.9)	-0.20*
Body/food congruence	2.7 (1.0)	-0.37**
Total score	2.7 (0.5)	-0.34**
Physical activity, mean (SD)		
Min/week of vigorous activity	16.5 (67.4)	-0.21*
MET-min/week of vigorous activity	131.7 (539.6)	
Min/week of moderate activity	38.1 (80.9)	-0.10
MET-min/week of moderate activity	152.6 (323.9)	
Min/week of walking activity	149.3 (286.5)	-0.10
MET-min/week of walking activity	492.6 (945.6)	
Min/week of sitting	799.1 (1317.9)	-0.02
Depression, mean (SD)	2.8 (1.8)	0.41**
Childhood trauma, mean (SD)		
Emotional abuse	11.8 (6.0)	0.24**
Physical abuse	8.3 (4.9)	0.13
Sexual abuse	8.4 (5.6)	0.14
Emotional neglect	12.7 (4.9)	0.26**
Physical neglect	7.5 (3.0)	0.10
Total score	48.7 (19.1)	0.23*

* $p < .05$, ** $p < .01$

3.2.7 Baseline Differences by Demographic Group

Few differences were observed when comparing various demographic groupings. We explored group differences on baseline variables by race, gender, and identification as LGBTQIA+. Any variables not reported here did not differ by demographic group.

When exploring differences by race, we observed differences on the mindfulness skill of describing internal experience and minutes per week of sitting time. No other differences by race were identified. ANOVA revealed overall group differences on describing internal experience [$F(4,115) = 3.2, p = .015$]. Group means (SD) were as follows: American Indian or Native American = 6.5 (2.1), East or South Asian = 13.5 (3.3), Multiracial = 16.0 (2.2), White = 16.5 (4.3), Black or African American = 16.6 (4.3). Overall differences were driven by significantly lower mean scores reported by American Indian/Native American participants compared to Multiracial participants (mean difference = -9.5, CI: -18.8 to -0.16, $p = 0.044$), White participants (mean difference = -9.9, CI: -18.8 to -0.16, $p = .011$) and Black or African American participants (mean difference = -10.1, CI: -18.7 to -1.46, $p = 0.013$).

ANOVA results also revealed overall differences by race in weekly minutes of sitting [$F(4,114) = 3.1, p = .019$]. Group means (SD) were as follows: Multiracial = 342.1 (267.3), White = 674.9 (1157.3), Black or African American = 1129.3 (1566.1), East or South Asian = 1635.0 (1837.9), American Indian or Native American = 3210.0 (3945.7). Overall differences were driven by significantly higher minutes of sitting reported by American Indian or Native American individuals when compared to Multiracial individuals (mean difference = 2966.9, CI: 123.7 to 5819.0, $p = .036$.)

When exploring differences by gender, we observed differences by gender identity on overall weight self-stigma and fear of enacted stigma. No other differences

by gender identity were observed. ANOVA revealed overall group differences by gender identity on weight self-stigma total score [$F(2,108) = 5.34, p = .006$]. Group means (SD) were as follows: Female = 42.86 (6.9), Male = 44.9 (7.3), Gender non-binary or non-conforming = 54.0 (3.7). Group means reported by gender non-binary or non-conforming individuals were significantly higher than those who identified as men (mean difference 9.1, CI: 0.9 to 18.1, $p = 0.47$) and women (mean difference = 11.1, CI: 2.7 to 19.6, $p = .006$).

A similar pattern was identified for fear of enacted stigma, such that overall group differences were observed by gender identity [$F(2,116) = 5.05, p = .008$]. Group means (SD) were as follows: Male = 22.1 (4.5); Female = 21.5 (4.4); Gender non-binary or non-conforming = 28.5 (1.3). Group means reported by gender non-binary or non-conforming individuals were significantly higher than those reported by men (mean difference = 6.4, CI: 0.8 to 12.0, $p = 0.021$) and women (mean difference = 7.0, CI: 1.8 to 12.3, $p = .006$).

Individuals identifying as part of the LGBTQIA+ community differed from those who did not on three constructs: the mindfulness skill of observing one's internal experience, fear of enacted stigma, and body appreciation. No other group differences by LGBTQIA+ status were observed on other baseline variables. LGBTQIA+ individuals reported higher mean scores on mindful observation (Mean = 15.5, SD = 3.2) when compared to non-LGBTQIA+ individuals (Mean = 13.2, SD = 3.6, $t(119) = -2.8, p = .005$). Further, LGBTQIA+ individuals reported higher mean body appreciation (Mean = 2.6,

SD = 0.7) when compared to non-LGBTQIA+ individuals (Mean = 2.2, SD = 0.7, $t(119) = -2.6$, $p = .009$). LGBTQIA+ individuals also reported higher mean scores on fear of enacted stigma (Mean = 23.5, SD = 3.6) when compared to non-LGBTQIA+ individuals (Mean = 21.4, SD = 4.6, $t(117) = -2.1$, $p = .036$).

3.3 Interim Discussion

Thus far, we have described our recruitment strategies, intervention design, enrollment statistics, participant sample, and baseline associations between weight bias internalization and secondary constructs. The present trial has several strengths and limitations and is poised to contribute meaningful empirical and clinical conclusions to a nascent field of research. Ruby was the first trial to our knowledge that specifically targeted internalized weight bias with a mindful self-compassion intervention. Further, the standalone digital delivery of the intervention was an essential piece of building a treatment that has potential to be not only efficacious, but low-cost, scalable, and highly disseminable.

3.3.1 Baseline Associations between Weight Bias Internalization and Other Outcomes

Several constructs of interest were significantly correlated with baseline weight bias internalization. Though these associations do not signify causation between one construct and another, we can explore these correlations to better understand secondary difficulties within those who have internalized weight bias. Notably, only one of the three types of experienced weight bias was correlated with weight bias internalization

scores: weight-based discrimination. Though the correlation is relatively small ($r = 0.24$), this might suggest that the experience of discrimination has a more significant impact on weight bias internalization than non-discriminatory types of weight stigma, such as teasing. Given the lack of evidence explaining who internalizes weight bias and why, this may provide an avenue of further exploration.

Self-compassion and mindfulness were also moderately inversely associated with weight bias internalization with correlations of about 0.4. Along these lines, fear of self-compassion was positively correlated with weight bias internalization at the same level (0.4). Taken together, these associations lend support toward our theoretical framework and intervention strategy and suggest that mindful self-compassion may play a critical role in weight bias internalization. These findings replicate those published by Puhl et al. in her cross-sectional exploration of self-compassion and weight stigma.⁴³

Weight constructs were somewhat associated with weight bias internalization. There was no significant association between body mass index and weight bias internalization, and there was a small correlation between the number of weight cycles one reported and their weight bias internalization score ($r = 0.2$). Weight-related experiential avoidance, however, was strongly correlated with weight bias internalization ($r = 0.7$). Similarly, body appreciation was strongly inversely correlated with weight bias internalization ($r = -0.7$). These results indicate that weight bias

internalization is more strongly associated with internal processes related to weight (i.e., avoidance and appreciation) rather than objective weight data (i.e., BMI and number of weight cycles). Again, this supports our theoretical foundation that posits that weight bias internalization is more readily attributable to one's *internal response* to their weight and experiences of weight stigma.

Eating and activity behaviors were somewhat correlated with weight bias internalization, though to a lesser degree. Intuitive eating and minutes of vigorous physical activity were inversely correlated with weight bias internalization (r 's = -0.2-0.3). Though these associations are small, they support existing data that those with internalized weight bias are likely to engage in avoidant coping strategies such as emotional eating and avoidance of physical activity.

Depression and childhood trauma were also somewhat related to weight bias internalization. Depression was moderately correlated ($r = 0.4$) which is consistent with previous literature on comorbid depression and weight bias internalization. Little research has explored the impact of childhood trauma on weight bias internalization. Of the types of trauma assessed, only metrics of emotional abuse and neglect were correlated. This may provide clues as to underlying processes that make an individual more vulnerable to internalization of weight bias.

3.3.2 Strengths and Limitations of Study Sample

A known issue of clinical research is limited demographic variability in study samples which inhibits generalizability of findings. We made efforts to broaden demographic variability by using a national website-based recruitment method (ResearchMatch.com) to target individuals who are traditionally underrepresented in clinical research, for example Black, Indigenous, and Latin American populations, LGBTQIA+ individuals, and individuals identifying as male or non-binary. Despite these efforts, the demographics of participants who enrolled in Ruby were primarily white women who were highly educated, as is often the case in psychological clinical research. This limits the generalizability of our results to this population, and indicates further efforts are needed to recruit samples that more accurately reflect the demographics of the United States. Despite these limitations, there are some notable strengths. First, we were able to recruit from the entire Eastern Time zone, rather than limiting to a small radius surrounding our university. While participants were not evenly distributed across the time zone, we might hope that this geographic variability allowed for a broader picture of weight bias internalization across regions. Further, nearly 20% of our sample identified as a member of the LGBTQIA+ community. Several studies have highlighted the importance of exploring patterns of internalized weight bias within the LGBTQIA+ community in an effort to minimize existing healthcare disparities that may be exacerbated by experienced and internalized weight bias.⁶⁸⁻⁷⁰

Inclusion of participants from this community potentially allowed for a more representative sample with respect to gender and sexual minority participants, thus improving accuracy of our understanding of weight bias internalization and its relation to other psychological constructs.

3.3.3 Comparison to Other Samples

The sample of the present trial is comparable to similar trials exploring interventions on internalized weight bias. In Pearl's BIAS program,²³ participants were also in their mid-40s on average (Mean = 47.1 years, SD = 11.5) and primarily female (84.7%). However, in contrast to Ruby, Pearl et al. recruited a significantly more racially diverse sample, with primarily Black participants (66.7%). Scores on measures of weight bias internalization were also comparable between Ruby and BIAS; Pearl et al. reported a mean (SD) baseline Weight Bias Internalization Scale score of 5.1 (0.7) and Weight Self-Stigma Questionnaire score of 38.6 (6.7). Our results are similar, though slightly (but perhaps not meaningfully) elevated on both measures.

Ruby participants reported low levels of self-compassion overall and across subscales. To contextualize our results -- a self-compassion grand mean (SD) of 2.4 (0.6) -- we can compare to other measurements of self-compassion using the same instrument in various populations. Low self-compassion is linked to depression, anxiety, stress, poor well-being, and other psychopathology.⁷¹ For instance, Døssing and colleagues compared self-compassion levels in adults with bipolar disorder compared to age- and

gender-matched healthy controls.⁷² In this sample, healthy controls reported a grand mean (SD) self-compassion score of 3.21 (0.61) while those with a bipolar disorder diagnosis reported a grand mean (SD) self-compassion score of 2.53 (0.59). Our sample had lower self-compassion than both groups. Similarly, Krieger and colleagues compared self-compassion scores in individuals engaged in outpatient psychotherapy for depression versus those who have never had a depressive episode.⁷³ Participants who had never been depressed reported mean (SD) self-compassion scores of 3.31 (0.36) while those with depression reported mean (SD) self-compassion scores of 2.75 (0.41). Again, our sample reported lower scores than both of these groups. Further, our sample reported moderate levels of fear of self-compassion, suggesting some internal resistance to the concept at baseline. Taken together, we can conclude that those in our sample have relatively low levels of self-compassion at baseline, even when compared to those with clinical levels of psychopathology.

To interpret baseline results on weight, eating, and activity variables, we can compare our results to another sample of adults with obesity. Pearl et al. summarized patterns in a nationally-representative sample of adults with obesity engaged in a commercial weight management program ($N = 18,769$).⁷⁴ In this sample, high weight bias internalization was associated with poorer health and well-being outcomes. Participants in this sample reported a mean (SD) history of 3.17 (0.91) weight cycles in their life (i.e., a loss and regain of at least 10 pounds). In our sample, participants reported a mean (SD)

of 10.7 (14.4) weight cycles. Differences in these results may be partially attributable to different measurement approaches. While Pearl and colleagues queried participants about number of lifetime weight cycles in a multiple-choice format (i.e., never, once, twice, three times, four times, five times or more), we queried for a raw number. It is possible that our elevation is due to increased variability in responses due to our assessment approach. Given these differing approaches to measurement of weight cycling, it is difficult to extract meaning from the comparison of weight cycling in these samples. Weight cycling is a significant contributor to poor health, and is associated with elevated weight bias internalization, increased risk of diabetes, and other comorbidities that are often attributed to obesity alone.⁷⁵

In addition to high frequency of weight cycling, participants in our sample were minimally physically active. National guidelines from the Department of Health and Human services indicate adults should complete at least 150 to 300 minutes of moderate activity per week, or 75 to 150 minutes of vigorous activity per week. Our participants reported approximately 38 minutes per week of moderate activity, and 16 minutes per week of vigorous activity on average. These numbers are far below the minimum national guidelines for activity. National guidelines also recommend adults walk 10,000 steps per day, equivalent to 100 minutes per day or 700 minutes per week of walking. Participants in our sample reported walking 149 minutes per week on average. Taken

together, average minutes per week of walking, moderate activity, and vigorous activity did not meet national recommendations for physical activity.⁷⁶

3.3.4 Demographic Differences in Constructs of Interest

Notably, only very few differences were observed by demographic variables. This is consistent with the broader body of literature which has reported inconsistent results in this area, sometimes suggesting that White or Asian populations have elevated weight bias internalization and that Black or African American individuals have relatively low levels of weight bias internalization. Some have posited that Black individuals report lower levels of weight bias internalization due to a potential “buffering effect” of intersecting discriminatory stressors (e.g., weight- and race-based discrimination).⁷⁷ Those differences were not replicated here. Race differences were only identified on two variables: mindfully describing one’s internal experience and total minutes per week of sitting time. These differences were primarily driven by relatively worse scores on both metrics by American Indian or Native American individuals (i.e., lower mindful describing and more minutes of sitting).

Gender differences were observed on overall weight self-stigma and fear of enacted stigma, such that gender non-binary or gender non-conforming individuals reported significantly higher levels of each when compared to both men and women. Notably, men and women did not differ from each other. Prior investigations have reported mixed results with respect to gender differences, though there appears to be

consensus that individuals who do not conform to the gender binary are more likely to report weight self-stigma.^{68,70} Similar patterns in fear of enacted stigma were observed when comparing LGBTQIA+ individuals to non-LGBTQIA+ individuals, such that LGBTQIA+ individuals reported more fear of enacted stigma. Notably, there were no group difference on the self-devaluation subscale, only on the fear of enacted stigma subscale, when comparing LGBTQIA+ or gender non-binary participants to their non-LGBTQIA+ or gender conforming peers. This could indicate that differences in weight self-stigma are driven by the anticipatory fear of stigma rather than the internal process of self-stigmatization in these populations. Perhaps fear of stigma is compounded by membership in a vulnerable community that is already at risk of discrimination and violence, which may drive hypervigilance and heightened awareness and prediction of stigmatizing situations in an effort to maintain safety.

4. Intervention Results

4.1 Methods

Participants were recruited between January-June 2021 via several online methods, described above. Sample size was calculated based on the primary outcome using G*Power with a medium effect size, determined based on the literature [effect size = 0.5; power = 0.95]. We needed a minimum of 55 participants to be adequately powered; we estimated a retention rate of 70%, and thus inflated sample size to account for attrition for a final sample size of 80 participants. Due to speed and ease of recruitment

and a desire to explore secondary and tertiary aims, we acquired approval from Duke University's Institutional Review Board to increase the sample size to 120 participants. 498 interested participants were screened for eligibility and our final sample size was 121 participants. See Figure 4 for detailed enrollment and screening information.

Detailed trial procedures are outlined above. In brief, participants were randomly assigned to the Intervention group or Wait list control. Participants in the intervention group received daily intervention tasks assigned via text message. On day 1, this included psychoeducation via written and video formats. On days 2-6, this included psychoeducation and brief mindfulness practices. On days 7-28, this included mindfulness practices that increased gradually in terms of duration and specificity. By the end of the trial, participants were engaging in 23-minute daily mindfulness practices. In addition to daily text messages each morning with their daily assignment, participants received reminder text messages daily in the afternoon to remind them of their task or provide encouragement, support, or motivation. All messages were preprogrammed and not tailored in any way.

Participants were queried weekly about their study engagement. At the end of each week at 7pm EST, participants were sent a questionnaire via REDCap asking how many days they had completed their assigned daily tasks from 0-7 days, including that day. Participants who did not respond to the survey within 24 hours were queried twice more over the next 48 hours. Participants reported the number of days they completed

their assigned task(s) and received feedback based on whether they engaged with low (0-3 days), medium (4-6 days), or high (7 days) frequency. Feedback was accompanied by action planning questions if they reported low or medium engagement that week. In these surveys, participants were also provided with the link to orientation instructions and encouraged to reach out to study staff if they were encountering technical difficulties.

The primary aim of this trial was to determine efficacy of a mindful self-compassion intervention on internalized weight bias, compared to wait list control. We used intent-to-treat principles to test our primary aim using linear mixed modeling. We used an unstructured covariance matrix and restricted maximum likelihood estimates to examine changes in weight bias internalization score over time by treatment arm. We assumed missingness at random. Linear mixed model analyses were completed using R and R Studio.

We conducted linear mixed models to test the effect of the intervention on several secondary outcomes of interest, i.e., a secondary measure of internalized weight bias, self-compassion, body appreciation, cognitive flexibility related to weight, mindfulness, intuitive eating, physical activity, and depression. We conducted multiple linear regression analyses to identify the moderating effect of two variables of interest (baseline fear of self-compassion, and childhood trauma) on trial outcomes. Finally, we conducted a simple mediation analysis using SPSS PROCESS macro (Model 4) to

determine the mediating effect of change in self-compassion on change in weight bias internalization. Multiple linear regression and mediation analyses were conducted using SPSS 22. All constructs were assessed using validated self-report measures as detailed above and outlined in Table 4. Participants were coded as overall high engagers (i.e., practiced ≥ 4 days per week) or low engagers (i.e., practiced ≤ 3 days per week); we conducted independent samples t-tests to determine differences in weight bias internalization change over time based on engagement level.

In addition to quantitative data, participants were invited to share qualitative feedback in response to survey questions and other open-ended prompts. These responses were evaluated using a qualitative immersion/crystallization strategy. Themes will be summarized narratively.

4.2 Results

4.2.1 Primary Outcomes

Figure 5 displays change in weight bias internalization over time by treatment arm. At baseline, participants in the control group reported a mean (SD) score of 5.53 (0.9) and participants in the intervention group reported a mean (SD) score of 5.39 (1.22); there was no significant difference in weight bias internalization between groups at baseline. Participants in the control group reported no statistically significant within-group change in weight bias internalization from pre- to post-treatment. Participants of the intervention group demonstrated a significant within-group difference, reporting a

mean (SD) score of 4.42 (1.42) at end-of-treatment resulting in a reduction of 0.97 units [$t(48) = 6.8, p < .0001$]. Linear mixed modeling results indicate a greater mean reduction in weight bias internalization in the intervention group (Net difference: -0.84, CI: -1.21 to -0.48, $p < .0001$).

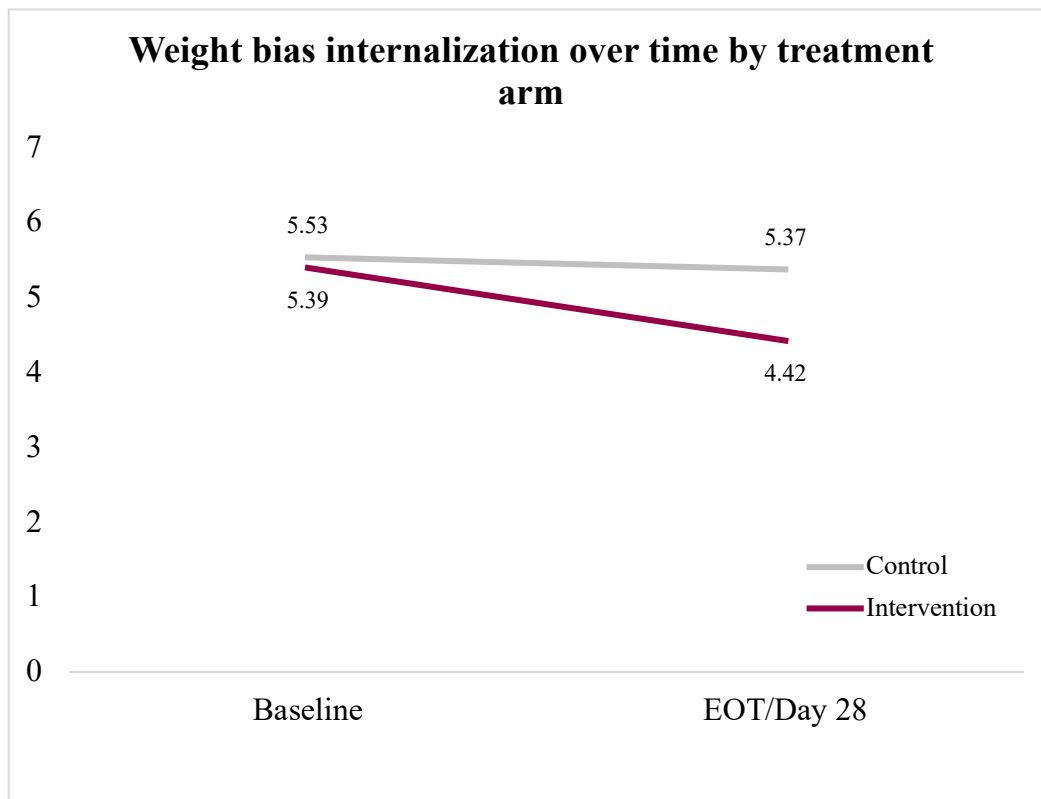


Figure 5: Weight bias internalization over time by treatment arm

4.2.2 Secondary Outcomes

Similar reductions were observed among most of the assessed secondary outcomes. Participants in the intervention group showed a mean (SD) reduction of 7.7 (7.7) units of weight self-stigma, while those in the control group had a reduction of 0.7

(5.0) units (Net difference: -6.87, CI: -9.44 to -4.30, $p < .0001$). All linear mixed modeling outcomes are summarized in Table 7 with net differences between groups displayed.

Table 7: Primary and secondary outcome results from linear mixed modeling

Construct	Net difference between groups (b)	Standard Error	Lower CI	Upper CI	<i>p</i> value
Weight bias internalization	-0.84	0.19	-1.21	-0.48	< .0001
Weight self-stigma					
Self-devaluation	-4.85	0.77	-6.37	-3.33	< .0001
Fear of enacted stigma	-2.19	0.77	-3.72	-0.67	0.005
Total	-6.87	1.30	-9.44	-4.29	< .0001
Self-compassion					
Self-kindness	0.40	0.14	0.12	0.68	0.005
Common humanity	0.36	0.14	0.09	0.64	0.01
Mindfulness	0.19	0.12	-0.05	0.43	0.13
Self-judgment*	0.45	0.13	0.20	0.71	0.0005
Isolation*	0.49	0.15	0.18	0.79	0.002
Over-identification*	0.25	0.13	0.00	0.50	0.05
Total	0.34	0.10	0.15	0.54	0.0005
Body appreciation	0.47	0.10	0.28	0.67	< .0001
Weight-related experiential avoidance	-15.71	-10.91	2.44	-20.51	< .0001
Physical activity**					
Vigorous activity volume	152.93	117.45	-78.23	384.58	0.19
Moderate activity volume	288.61	174.82	-56.43	633.65	0.1
Walking volume	537.31	214.42	113.67	960.95	0.01
Total	1168.94	451.95	274.94	2062.93	0.01
Fear of self-compassion	-7.97	1.80	-11.53	-4.42	< .0001
Intuitive eating					
Unconditional permission to eat	-0.09	0.10	-0.29	0.12	0.418
Physical vs emotional reasons	0.44	0.13	0.19	0.69	0.0005
Reliance on hunger/satiety cues	0.45	0.13	0.20	0.71	0.0005

	Body-food choice congruence	0.48	0.13	0.22	0.74	0.0003
	Total score	0.33	0.08	0.16	0.49	< .0001
Depression		-0.47	0.29	-1.04	0.11	0.11
Mindfulness						
	Observing	1.14	0.44	0.28	2.00	0.01
	Describing	0.52	0.57	-0.61	1.64	0.367
	Non-judging	1.15	0.57	0.02	2.28	0.047
Acting with awareness		0.53	0.56	-0.57	1.62	0.343
	Non-reacting	0.68	0.54	-0.38	1.73	0.207
	Total score	3.64	1.62	0.45	6.83	0.03

* Reverse coded such that positive numbers signify reductions of these constructs.

b: beta coefficient; CI: confidence interval;

4.2.2.1 Self-compassion, Mindfulness, and Depression

As expected, participants in the intervention demonstrated increases in self-compassion compared to wait list control. Ruby participants reported a mean (SD) 0.4 (0.6) unit increase in self-compassion while those in the control group reported a 0.09 (0.4) unit increase (Net difference: 0.34, CI: 0.15 to 0.54, $p = 0.0005$). Similar increases were observed on two of the three positive subscales of self-compassion, i.e., Self-kindness (Net difference = 0.40, CI: 0.12 to 0.68, $p = 0.005$) and Common humanity (Net difference = 0.36, CI: 0.09 to 0.64, $p = 0.01$), however there was no significant between group difference on the Mindfulness subscale (Net difference = 0.19, CI: -0.05 to 0.43, $p = 0.13$). As expected, we observed reductions in the three negative subscales of self-compassion: self-judgment (Net difference = -0.45, CI: 0.20 to 0.71, $p = 0.0005$), isolation

(Net difference = 0.49, CI: 0.18 to 0.79, $p = .002$), and overidentification (Net difference = 0.25, CI: 6.63E-05 to 0.50, $p = 0.049$).

Some improvements were observed in other mindfulness and compassion constructs. The Five Facet Mindfulness Questionnaire includes five components of mindfulness skills: observing, describing, non-judgment, acting with awareness, and non-reactivity. We observed improvements in observing (Net difference = 1.14, CI: 0.28 to 1.99, $p = 0.009$) and non-judging skills (Net difference = 1.15, CI: -0.57 to 1.62, $p = 0.047$), and no significant changes in describing (Net difference = 0.52, CI: -0.61 to 1.64, $p = 0.37$), acting with awareness (Net difference = 0.53, CI: -0.57 to 1.62, $p = 0.34$), or non-reactivity (Net difference = 0.68, CI: -0.38 to 1.73, $p = 0.21$). Additionally, we measured fear of self-compassion to assess any internal resistance to the concept of compassion. We observed significant reductions in fear of self-compassion over the course of treatment (Net difference = -7.97, CI: -11.53 to -4.42, $p < .001$). We did not observe between group differences on reduction of depression (Net difference = -0.47, CI: -1.04 to 0.11, $p = 0.11$).

4.2.2.2 Weight and Eating Constructs

We observed significant reductions in weight-related experiential avoidance in this intervention (Net difference = -15.71, CI: 2.44 to -20.51, $p < .001$). Similarly, we observed significant increases in body appreciation (Net difference = 0.47, CI: 0.28 to 0.67, $p < .001$). Intuitive eating also improved overall for those in the intervention group

(Net difference = 0.33, CI: 0.16 to 0.49, $p = 0.0001$). Intuitive eating consists of four unique constructs: unconditional permission to eat, eating in response to physical cues rather than emotional cues, reliance on physical hunger and satiety cues, and body-food choice congruence. We observed improvements on three of these four constructs. There was no significant change in unconditional permission to eat (Net difference = 0.09, CI: -0.29 to 0.12, $p = 0.42$). However, we observed improvements on eating for physical rather than emotional reasons (Net difference = 0.44, CI: 0.19 to 0.69, $p = 0.0005$), reliance on internal hunger and satiety cues (Net difference = 0.45, CI: 0.20 to 0.71, $p = 0.0005$) and body-food choice congruence (Net difference = 0.48, CI: 0.22 to 0.74, $p < .001$).

4.2.3 Moderation and Mediation

4.2.3.1 Moderating Effect of Psychological Variables

To explore the role of moderating variables, we ran a multiple linear regression analysis to predict change in weight bias internalization from childhood trauma, baseline fear of self-compassion, depression, and assigned treatment arm. All assumptions of multiple linear regression were met when exploring the data. The multiple regression model statistically significantly predicted change in weight bias internalization from baseline to end of treatment, $F(4,92) = 11.68$, $p < .0001$, adj. $R^2 = 0.31$. Three of the four variables added to the model significantly ($p < .05$); depression did not significantly impact change in weight bias internalization over time. Regression coefficients and standard errors are displayed in Table 8. For every 1 unit increase in fear

of self-compassion, we observed a 0.031 unit increase in change in weight bias internalization over time. For every one unit increase in childhood trauma, we observed a 0.011 unit decrease in change in weight bias internalization over time. Consistent with linear mixed model results, linear regression indicates that participants in the intervention group demonstrated a 0.837 unit reduction in weight bias internalization.

To explore whether these variables moderated the effect of the intervention, we computed interaction terms (i.e., trauma*group, fear of self-compassion*group) and added these terms to the model. The interaction terms were not significant ($p > .05$), indicating that while these constructs may have an overall impact on the change in weight bias internalization over time, they do not modify treatment effects significantly.

Table 8: Moderation analyses via multiple linear regression

	<i>B</i>	Lower CI	Upper CI	SE	<i>p</i> value	R ²	Adj. R ²
Model					< .001	0.33	0.31**
Constant	-0.449	-1.011	0.113	0.283	0.116		
Group	-0.837**	-1.177	-0.497	0.171	< .001		
Childhood trauma	-0.011*	-0.021	-0.002	0.005	0.022		
Fear of self-compassion	0.031**	0.015	0.048	0.008	< .001		
Depression	0.043	-0.057	0.143	0.050	0.391		
Childhood trauma * Group	-0.003	-0.023	0.017	0.010	0.76		

Fear of self-compassion *

Group	-0.002	-0.033	0.029	0.015	0.899
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B = unstandardized regression coefficient; CI = confidence interval; SE = standard error of the coefficient.

* $p < .05$, ** $p < .001$

4.2.3.2 Mediating Effect of Change in Self-Compassion

Changes in self-compassion partially mediated the effect of treatment group on change in weight bias internalization. Using simple mediation model analysis (via Hayes' SPSS PROCESS macro model 4), we found that the indirect effect of group on change in weight bias internalization through change in self-compassion was significant ($B = -0.248$, $SE = 0.093$, $CI: -0.446$ to -0.085). According to these results approximately 29.06% of the overall effect of treatment group on weight bias internalization is attributable to change in self-compassion. See Figure 6 for a summary of direct and indirect path coefficients for the overall mediation model.

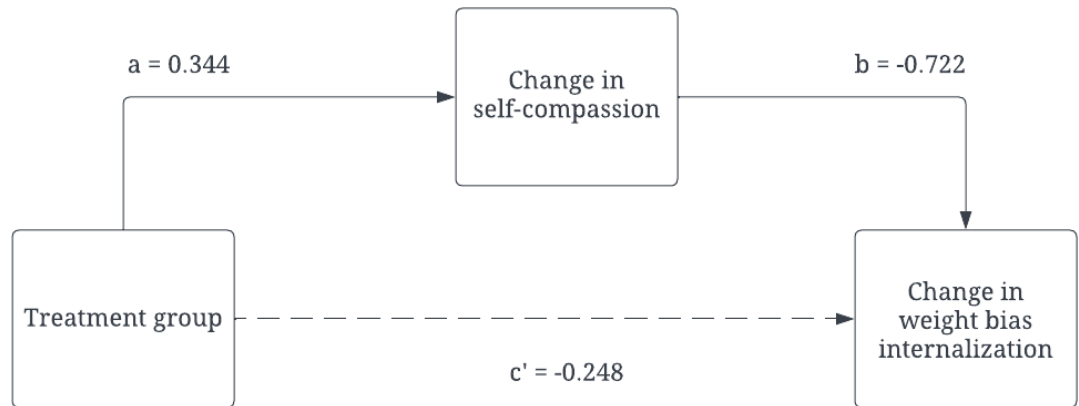


Figure 6: Summary of direct and indirect path coefficients in mediation analysis

4.2.4 Engagement

At end of treatment, participants retrospectively reported engaging in 47% of Ruby tasks overall (i.e., reading psychoeducation materials, completing daily mindfulness practices). When examining weekly responses to our engagement survey, we observed a significant amount of missing data. Figure 7 displays the percentage of participants in the intervention group ($n = 61$) who reported each level of engagement per week or did not respond to the survey. In weeks 1, 2, and 4, the majority of participants who completed the weekly survey were reporting completion of their intervention tasks 4-6 days per week. When reporting engagement retrospectively at the end of the trial, participants' median (SD) number of days completed was 4.0 (2.2) days. When examining the distribution of responses in Figure 8, we observed a U-shaped

distribution such that the majority of participants were reporting task completion on either 1 day per week (14.8%) or 5 days per week (16.4%).

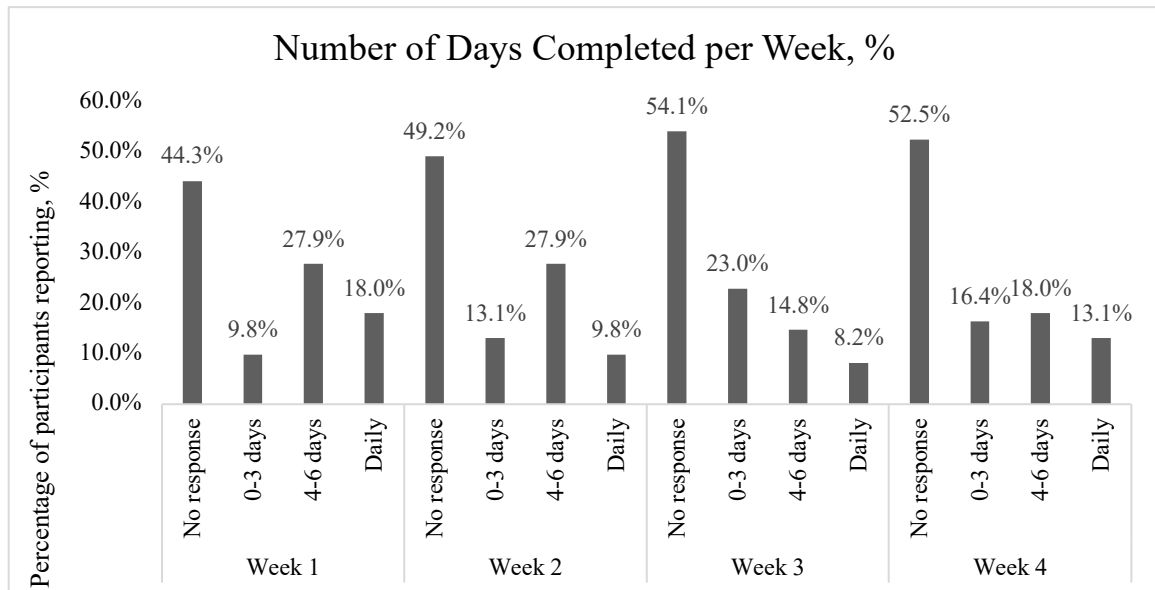


Figure 7: Percentage of participants reporting each level of engagement

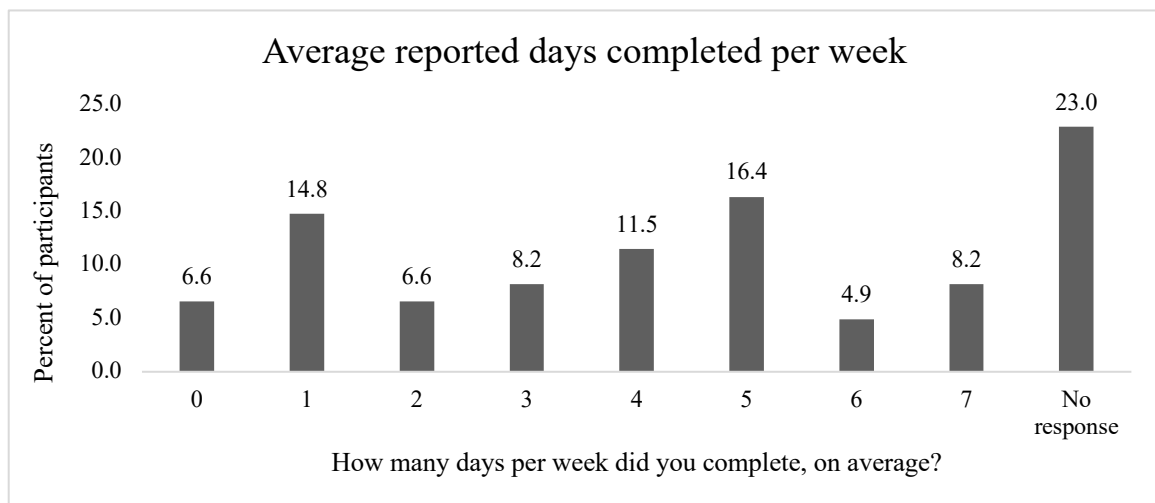


Figure 8: Average reported days completed per week

Based on this bimodal distribution, participants were coded as high engagers (i.e., reported engaging on 4 or more days each week) or low engagers (i.e., 3 days or fewer). In the intervention group ($n = 61$), 41% ($n = 25$) of participants were high engagers, while 59% ($n = 36$) were low engagers. We conducted an independent samples t-test to identify differences in change in weight bias internalization, weight self-stigma, and self-compassion based on engagement. For all three constructs, no significant group differences were identified ($p > .05$).

4.2.5 Participant Feedback

In the intervention group, 62% ($n = 38$) of respondents indicated they would recommend Ruby to a friend, while 11.5% ($n = 7$) participants indicated they would not recommend Ruby, and 26.2% ($n = 16$) did not complete the feedback survey. When exploring responses to open-ended feedback questions, most individuals who indicated they would not recommend Ruby explained that this was because their friends did not struggle with internalized weight bias.

Several themes emerged in our exploration of qualitative feedback. Almost all participants who provided feedback described Ruby as easy to use, helpful, and something they looked forward to engaging with. Several participants indicated that they planned to restart Ruby by revisiting links they had been sent in an effort to get more out of the program and build on their practice. Common themes that emerged were: (1) ease of use and accessibility of Ruby, (2) self-compassion as a transformative

concept, (3) common barriers and logistical issues, and (4) constructive feedback about how to improve integration of Ruby's various components.

Most participants expressed that they found Ruby to be highly accessible as a beginner meditator and found the program very easy to use. Several participants shared that they found the psychoeducation materials were delivered in a simple, digestible, and calm manner that made the subject matter feel approachable and easy to understand. They also expressed that part of Ruby's ease of use and accessibility was attributable to its standalone nature, sharing thoughts such as "It's like AI therapy in your pocket!" Further, a handful of participants expressed that they appreciated the level of privacy Ruby afforded them, expressing, "I can consider it somewhat being therapy but with yourself and that way you can keep some things to yourself but still getting it out or expressing them." See Figure 9 for quantitative ratings of ease of use on various metrics.

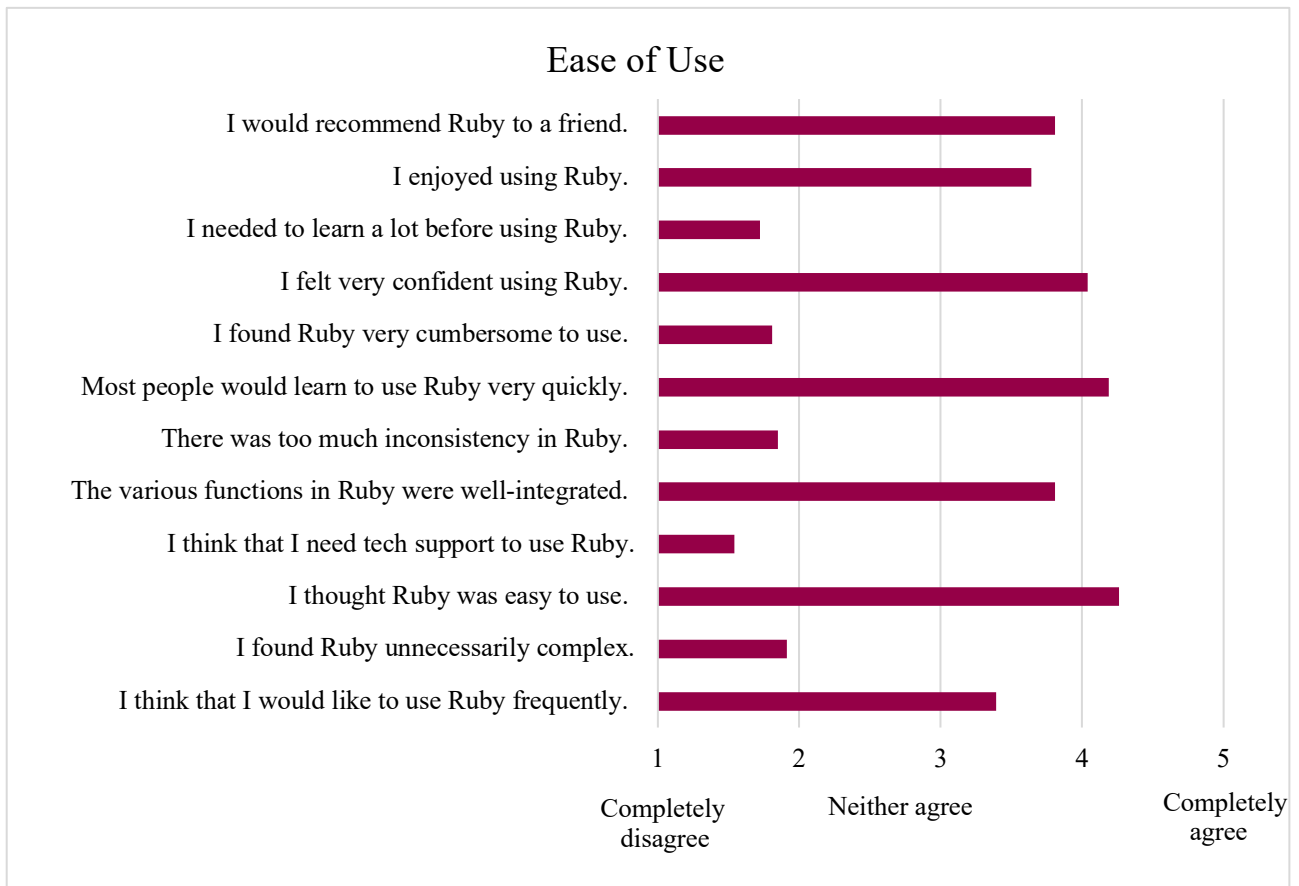


Figure 9: Ease of use

Most participants identified that self-compassion was a transformational concept for them and expressed that they think about their thoughts in a new and different way as part of their participation in Ruby. When queried about what they would identify as the best part of Ruby, participants expressed thoughts such as “Just the idea of self-compassion and the practice of it. It was validating that it there was a resource built for this, and I didn't have to feel shame about disliking myself. It showed me other people feel this way, and there are resources to help.” Participants also noted that they found they were able to use self-compassion beyond the time assigned to mindfulness

practices, expressing, “Even if I didn't get to take the whole amount of time for the exercise, I found myself taking mini breaks or short moments to use the techniques. The whole experience has taught me to be compassionate towards myself.”

Participants identified that the most difficult part of Ruby was making time in their schedule to complete their daily practice. Some participants attributed this to feeling they needed individual support to stay motivated to form a new habit. Most, however, identified this as a common theme in their life and not specific to Ruby, attributing lack of time to common barriers such as work, children, medical appointments, and other tasks that took precedence. One participant stated, “I initially attributed missing a day to ‘lack of time’ but came to see my missing days as not giving myself priority in my day.” Some participants expressed a sense of guilt when they missed a practice, though several expressed that they found the tone of the reminder texts motivating, warm, and supportive which helped to reduce a sense of guilt. Some participants shared that they felt they would have been able to engage more consistently if they had been able to receive reminders at a time of their choosing.

Ruby participants also shared valuable, constructive feedback about improving integration of digital tools. Participants felt that Soundcloud was not an ideal platform for hosting mindfulness audio files, as it automatically played random music at the completion of the audio file which some felt was disruptive. Further, they suggested a central database for tasks and recordings to prevent having to scroll through text

messages to find their last text from Ruby. Some participants found the mindfulness recordings repetitious, and suggested that more variety, flexibility, and options to personalize Ruby (i.e., selecting time of day or when to move on to the next practice) would have improved their experience.

4.2.6 Cost of Intervention

Due to its entirely digital and standalone design, Ruby was a relatively low-cost intervention. Table 9 outlines the itemized costs of intervention delivery, excluding labor costs. Given that labor costs were primarily related to the research, development, and testing phase (rather than intervention delivery), these costs are not related to potential reach and scalability of the intervention. Primary costs related to intervention delivery were cost of text message delivery (i.e., \$0.0075 per SMS), cost of Twilio phone number (i.e., \$1/month), and cost of website for recruitment and intervention materials (i.e., \$16/month). Altogether, the intervention delivery totaled \$281 or approximately \$2.30 per enrolled participant. The monthly costs of Twilio and website hosting were not dependent on the number of users, thus have less of an impact on scalability of this program. If we isolate costs of text messages alone, intervention delivery cost just under \$1 per participant.

Table 9: Intervention cost per participant

Month	Phase of Trial	Number of SMS sent	Twilio Cost	Website Cost
Aug	Development and Testing	428	\$3.41	\$16.00

Sept	Development and Testing	52	\$1.40	\$16.00
Oct	Development and Testing	920	\$6.52	\$16.00
Nov	Development and Testing	809	\$5.88	\$16.00
Dec	Development and Testing	235	\$2.54	\$16.00
Jan	Intervention Delivery	1401	\$11.48	\$16.00
Feb	Intervention Delivery	3746	\$25.76	\$16.00
Mar	Intervention Delivery	7286	\$42.65	\$16.00
Apr	Intervention Delivery	3033	\$18.46	\$16.00
May	Intervention Delivery	289	\$3.77	\$16.00
			\$121.87	\$160.00
			Total cost per participant:	\$2.33

5. Discussion

Ruby is the first study of its kind to demonstrate significant results. The results of this trial suggest that internalized weight bias can be reduced by a statistically significant amount after only 4 weeks, with minimal setup, and with no human interaction, support, or guidance. If the results of this initial trial hold in more robust testing environments – e.g., with a more treatment-focused comparator group rather than a wait list control, in a larger or more varied population – Ruby may be a key to reducing the psychological and physiological impacts of chronic weight-related discriminatory stressors.

5.1 Principal Results

As hypothesized, participants in the intervention group demonstrated statistically significant reductions in their internalized weight bias when compared to wait list control. These results suggest preliminary efficacy of a brief standalone mindful self-compassion intervention. Reductions observed in the intervention group of this trial are comparable to those in other randomized controlled trials.²³ Though these results are statistically significant, it is difficult to discern whether reductions were clinically meaningful. Notably, the end-of-treatment weight bias internalization score in the intervention group was 4.42 on average, which remains above the cutoff of 4.0 used to determine whether an individual has high internalized weight bias. This suggests that, though the intervention was able to reduce weight bias internalization somewhat, the intervention may need to be more potent (e.g., more engaging, longer in duration) in order to reduce weight bias internalization below the cutoff. Interestingly, within group changes in weight bias internalization did not appear to differ by level of engagement with Ruby. This may support qualitative feedback provided by participants: that the skill of self-compassion created a paradigm shift in their way of thinking and was usable beyond the time assigned to mindfulness practice, such that even those who engaged minimally were able to change their pattern of responding to self-critical thoughts. On the contrary, it could also indicate that more engagement did not actually increase the dose of self-compassion.

5.2 Secondary Outcomes

5.2.1 Weight Bias

Similar reductions in internalized weight bias were observed in a secondary measure of internalized weight bias. We included this measure for two reasons: to compare these measures to each other in their responsiveness to mindful self-compassion, and to explore the subconstructs assessed in the Weight Self-Stigma Questionnaire. Of the two subconstructs of weight self-stigma, we observed more reduction on the Self-devaluation scale than on the Fear of Enacted Stigma Scale. While these differences were minimal, it may suggest that shifts occur internally in self-talk and self-concept, rather than in fears of external experiences and the emotional reaction to experiences of stigma. Conceptually, this makes sense given the theoretical framework upon which Ruby was designed, in that treatment targets emphasized changes to internal self-talk rather than emphasizing changes in the emotional reaction or fear of stigma generally speaking.

5.2.2 Self-compassion and Mindfulness

As hypothesized, we observed overall improvements in self-compassion, mindfulness, and fear of self-compassion. Reductions in fear of self-compassion suggest that participants demonstrated more receptivity to the concepts of self-compassion broadly over the course of treatment, in addition to the shifts in compassionate self-talk. When we explored differences between subscales on measures of self-compassion and

mindfulness, we observed improvements in some subscales with little to no improvements on others. While these differences are small and may not signify clinically meaningful differences, they may also indicate mechanisms by which Ruby was efficacious and are worthy of curiosity.

When exploring subconstructs of self-compassion, we observed improvements (i.e., reductions in scores on negative scales, increases in scores on positive scales) on all subscales with the exception of mindfulness. This was surprising to us, especially given overall improvements in mindfulness on the dedicated inventory of mindfulness included in this trial. Improvements on self-compassion but mixed results with respect to mindfulness skills broadly suggest that while we may be able to improve the content and tone of self-talk by increasing self-compassionate responding with a brief standalone trial, more consistent improvement of mindfulness skills broadly construed may require more intensive treatment such as a longer intervention, group meetings more aligned with the Buddhist tradition or MBCT/MBSR, increased accountability and guidance from a live teacher, and so on.

5.2.3 Weight and Eating Constructs

Of great interest to us was the improvement in cognitive flexibility with respect to weight. Cognitive flexibility suggests that an individual can practice cognitive defusion, accept the reality of their present experience as it is (i.e., the emotions, thoughts, and physical sensations), and persist in the direction of their values. Cognitive

flexibility is the core process of Acceptance and Commitment Therapy and is often identified as the key mechanism of action in Acceptance and Commitment Therapy trials. Clinically-speaking, improvements in this area are likely to manifest in several important changes that may improve an individual's well-being. Primarily, individuals with weight-related cognitive flexibility may be more likely to engage in values-consistent healthcare *even when it is distressing or uncomfortable* due to the reduction in fusion with painful thoughts and increased emotional acceptance. This is critical for individuals with high internalized weight bias, as we typically observe increased avoidance of healthful activities due to fear of stigmatizing situations or avoidance of thoughts or memories related to past stigmatization. In this trial, we observed increases in cognitive flexibility which could lead to increased self-care, decreased avoidance of physical activity, and more values-consistent eating behaviors that could potentially improve health outcomes. Further, we observed increases in body appreciation, signifying a greater sense of gratitude for one's body, which could additionally translate into increased healthy behaviors. Notably, we observed increases in amount of physical activity as well. This is an exciting finding that may indicate the beginning of a shift in behavior in addition to shifts in cognitions and internalization.

Along these lines, scores on intuitive eating increased. While we did not observe improvements in participants' unconditional permission to eat, we did find improvements in the three body-related subconstructs, i.e., eating for physical rather

than emotional reasons, increased reliance on hunger and satiety cues, and body-food choice congruence. These improvements indicate participants' increased self-compassion and mindfulness skills might allow for an increased capacity for an individual to tune into their body, notice physical cues of hunger, fullness, and satisfaction, and additionally have greater commitment to choosing foods that feel good in their body and meet a direct need. Improvement in intuitive eating skills is essential as the human body is dynamic and dietary needs are not universal. If we are to begin to shift away from rigid food rules and one-size-fits-all dietary interventions, intuitive eating skills are likely to be an essential component of future treatments.

5.2.4 Moderating and Mediating Constructs

Contrary to our hypotheses, childhood trauma, depression, and fear of self-compassion did not moderate the intervention effects. While it is possible that this might indicate that these constructs are *not* barriers to development of self-compassion as we expected, it is also possible that our sample size was not sufficient to detect differences based on these factors. Overall, it does appear that these constructs had some meaningful impact on change in weight bias internalization over time, though the effects were quite small. As hypothesized, treatment effects of the intervention were partially mediated by change in self-compassion. This may indicate the key mechanism of action in this trial and supports our theoretical framework.

5.3 Comparison to Other Trials

Extant literature in this field is minimal. A handful of randomized controlled trials have tested the efficacy of various psychological interventions treating internalized weight bias or have measured changes in internalized weight bias as secondary outcomes. These trials have largely been testing more traditional treatment approaches, such as cognitive behavioral therapy skills in a group format over several weeks. These investigations have occurred both in the context of weight loss treatment^{23,24,78} and independent of weight loss intervention⁷⁹ with mixed results. Pearl et al. developed a group-based cognitive-behavioral treatment for internalized weight bias that included modules such as psychoeducation, cognitive restructuring about cognitive distortions related to anti-fat attitudes, and tips to promote body acceptance. After 8 weeks of treatment, those in the intervention group experienced decreases in self-reported internalized weight bias and increases in weight-related quality of life when compared to participants in a quasi-control group. Pearl and colleagues later tested a similar intervention with longer duration (i.e., 12 weeks of weekly treatment, with subsequent bi-weekly and monthly meetings for a total of 26 weeks of treatment) and follow up data six months after completion of the intervention. In this trial, cognitive behavioral treatment designed to reduce internalized weight bias was tested alone versus in tandem with a traditional behavioral weight loss intervention. Participants in this trial ($N = 72$) showed reductions in internalized weight bias in both groups, with no

significant difference between groups at end-of-treatment nor at follow up on the primary measure of weight bias internalization. Within-group reductions were similar to those observed in our intervention; over 26 weeks, participants in the behavioral weight loss group reported a mean reduction of 1.3 units on the Weight Bias Internalization Scale, while those in the behavioral weight loss plus weight bias intervention group reported a mean reduction of 1.5 units. These reductions remained at follow up (week 52). Similarly, small within-group improvements were observed on secondary outcomes (i.e., depression, body appreciation, maladaptive eating patterns) with no between-group differences. This suggests that, in this sample, some benefit may have been conferred by weight loss alone and no additional benefit was gained by adding cognitive behavioral treatment for internalized weight bias. While there is not yet a trial directly comparing mindfulness- or acceptance-based versus cognitive-behavioral therapy approaches for internalized weight bias, it is possible that the lack of additional improvement in the CBT intervention is indicative of a mismatch between the components of a CBT approach (e.g., cognitive restructuring) and the treatment target of internalized weight bias. This may lend support toward Ruby's approach.

Another trial has tested the efficacy of gratitude-based expressive journaling to reduce internalized weight bias, known as the Expand Your Horizon intervention.⁸⁰ The purpose of these writing exercises was to elicit a sense of gratitude and appreciation for the *functionality* of one's body, rather than appearance. Theoretically, the investigators

posited that increases in body functionality appreciation would allow for a more holistic view of the body and reduce body-related shame. Participants in this study ($N = 135$) were randomized to the body-focused gratitude journaling arm or an accomplishment-focused gratitude journaling arm. Participants in the body-focused journaling arm demonstrated significantly greater reductions in weight bias internalization as measured by the Weight Bias Internalization Scale, with mean reductions of approximately 0.3 units on this scale. Similarly, they observed increases in self-compassion as measured by the Self-compassion Scale, which could suggest that self-compassion is a key mechanism of change when aiming to reduce internalized weight bias. These outcomes, combined with findings from our trial, highlight the unique impact of self-compassion for internalized weight bias.

Others have also begun to design and test interventions to reduce internalized weight bias.⁸¹ Olson and colleagues tested a 4 week pilot study that compared a standard weight loss intervention to weight loss intervention plus content related to body dissatisfaction that was publicly available through The Body Project (www.bodyprojectsupport.com). Similar to the results of the trials described above from Pearl and colleagues, both the weight loss and weight loss plus weight bias intervention groups demonstrated within-group reductions in weight bias internalization, with no significant between-group difference.

Similarly, Mensinger et al.⁷⁸ investigated the moderating effect of internalized weight bias on eating behavior outcomes, and examined this association in both weight-neutral and weight-loss treatment arms. While the investigators state that intervention content did not specifically target internalized weight stigma, the weight-neutral arm included a Health At Every Size® approach that incorporated intervention content such as body appreciation and education about body size diversity.⁸² The weight loss arm was based on Brownell et al.'s LEARN Manual, a gold-standard behavioral weight loss treatment that does not include curriculum concerning body acceptance.⁸³ Mensinger et al. reported no differences in effect of the intervention on internalized weight bias; internalized weight bias was reduced in both groups over six months of treatment.

Though preliminary, results from Pearl et al., Olson et al., and Mensinger et al. suggest that interventions designed to reduce internalized weight bias and body dissatisfaction broadly can result in some improvements in internalized weight bias, obesity-related quality of life⁷⁹ and body appreciation,⁸¹ though these improvements may or may not be related to weight changes observed in those trials. Without clarity about which drives outcomes (i.e., weight loss versus cognitive change), it is difficult to discern the impact of these cognitive approaches. Ruby suggests that the changes in thinking alone can reduce weight bias internalization, suggesting there is no need to lose weight in order to improve outcomes. Further, in a sample where weight bias internalization is reduced via weight loss, it is not known whether weight regain will

contribute to resurgence of internalized weight bias. One could posit that if weight bias internalization reductions are driven by weight change rather than a shift in thinking, these results are unlikely to be durable given known patterns of weight regain in the majority of individuals who lose weight in clinical trials.

Notably, all extant trials designed to reduce internalized weight bias are time- and labor-intensive. Interventions ranged from 4-26 weeks, and all required in person instruction at a minimum, or continuous counseling from study staff, doctoral level clinicians, and other professionals. The need for more flexible, low-cost, accessible intervention is evident. As a standalone digital intervention delivered entirely via smartphone, Ruby is poised to potentially fill this critical need.

Our trial differs from existing treatments in its theoretical framework. As the first intervention to develop a mindfulness-based approach for weight bias internalization specifically, our treatment was developed using fundamentally different principles than those developed from a foundation of second wave cognitive behavioral theory. The theoretical underpinnings of our treatment do not require an individual to change their thoughts; rather, individuals learned to use mindful self-compassion to practice non-judging observation of thoughts, learn to distance from thoughts, and to cultivate a sense of self-compassion that may have contributed to greater connection to self-worth. This approach allows for less friction between the intervention and a participants' lived experience of frequent discrimination. Importantly, thoughts related to discrimination

and oppression are unlikely to be true “cognitive distortions” as some second wave CBT approaches might inadvertently convey. While certain maladaptive thinking patterns might exacerbate the experience of discrimination, such as all or nothing thinking, it is also possible that these thoughts are less able to be modified by evidence given the truth of weight-based stigmatization and discrimination in our society. Certainly, cognitive restructuring can be helpful in allowing a person to have a more balanced view of how they are perceived by the world, though it is likely that some level of cognitive defusion will be necessary.

Further, our trial differs from many existing interventions in that it does not require, or even mention, weight loss. While some have achieved meaningful and life-changing weight losses through behavioral, pharmacological, and surgical approaches, it is well-known that most individuals in weight loss clinical trials regain the majority of weight that they have lost. Additionally, many individuals do not seek to lose weight or are not able to lose weight for a variety of reasons. It is essential that we develop weight-neutral interventions for these individuals. It is possible that our conscious choice to not include weight loss as part of this intervention made the intervention more accessible to many individuals who are not seeking to or cannot change their weight.

5.4 Novelty of the Present Trial

Ruby is novel and innovative in several key ways: the use of digital tools, the standalone design, and the application of mindful self-compassion to internalized

weight bias to name a few. While the field of digital health has been in existence for several decades, we continue to struggle with low usership, worse engagement, and higher dropout rates when comparing standalone digital approaches to traditional in-person interventions. Ruby stands out in this regard. Based on extant literature in the mindfulness digital health field, we expected a retention rate of 70% or lower. Ruby retained over 80% of its participants, despite its standalone design wherein participants received no live feedback or encouragement from human clinicians and no guarantee of reward (e.g., symptom improvement, monetary compensation).

Our relatively high retention rate suggests that either the format or content of Ruby may have been compelling and reinforcing enough to keep participants engaged to some degree. It is possible that the design alone was structured with enough intention to maintain engagement at this rate. For instance, timing of text messages was selected specifically to maximize probability that a participant would interact with content at a time of day that was most convenient based on clinical expertise in application of mindfulness tools. Further, though available evidence was limited, there is existing literature about participants feeling more receptive to instructive messages sent during daytime hours and encouraging messages sent during evening hours. As such, the combination of clinical experience of the study team and extant literature in this area dictated the times and types of messages that were sent to maximize receptivity to the content.

It is also possible that retention was high simply due to the low user requirements of our program. Participants did not have to demonstrate engagement daily; practices were completed privately, and we did not assess ongoing adherence in a way that might bolster accountability and thus engagement. Participants who engaged with content very minimally still completed end-of-treatment surveys, which further enhanced retention. Potentially, if we had demanded more from our participants over the course of the intervention, engagement and retention would have been more comparable to other standalone trials.

Additionally, it is possible that the content alone was compelling or novel enough to participants to keep participants engaged. Participants selected to enroll in Ruby were new to mindfulness and, by design, had a lot to learn in this area. Additionally, self-compassion may have been a novel concept for many participants and, for some, may have presented a paradigm shift in their way of thinking about their thoughts, emotions, and experiences related to their weight. Based on qualitative participant feedback, it appears that this was transformative for many and may have contributed to ongoing motivation.

Qualitative feedback also suggested that the careful design of the delivery and progression of the intervention made the program feel approachable and easy to use which likely was a contributor to our high retention rate. The curriculum of Ruby was structured in a way that built incrementally over the course of 4 weeks. Participants

were exposed to one new concept each day and given a chance to reflect on how it might be integrated into their life and gain some mastery over that concept in their reflections. Each new lesson built on the last, allowing for synthesis of ideas. Mindfulness practices began short and simple (i.e., a four-minute breath practice) which allowed for additional avenues of self-efficacy building along the way. It is possible that beginning with a 20-minute mindfulness practice focused on weight concerns would have been too difficult or aversive for some participants, particularly those with very high fear of self-compassion or especially high internalized weight bias scores, and those participants would have dropped out early in treatment. Future studies should include more nuanced momentary assessment of the effects of these intervention components to strengthen the overall intervention package or tailor delivery of these components for those with increased vulnerability to disengagement.

The standalone nature of Ruby suggests it may hold significant scalability potential. While this intervention was delivered to only 121 individuals, the study sample could have easily grown exponentially with minimal additional costs incurred. As described above, the overall intervention delivery cost was approximately \$2.30 per participant, excluding labor costs. While labor costs are potentially significant, it is important to note that this intervention was designed and built by a single doctoral level psychology student with little to no assistance from high-cost computer programmers. Further, labor hours were almost entirely dedicated to research, development, and

testing of the intervention and were minimally necessary during the intervention delivery phase. As such, the labor costs for design and build of this intervention remain static as the intervention is preprogrammed, which would not inhibit scalability of the intervention.

Additionally, it is possible that the standalone design was a contributor to the reductions in internalized weight bias. As summarized by feedback from participants described above, the standalone digital approach allowed for increased privacy in treatment and did not require participants to talk to anyone else about their thoughts or emotions related to their weight. For some, group treatment on this subject may reduce shame and foster a sense of collective humanity. However, if a participant is likely to experience increased comparison and shame while engaged in group conversations or speaking with a clinician, the privacy inherent in our treatment format may have allowed for increased engagement with intervention content and thus, greater reductions of internalized weight bias.

5.5 Limitations

This trial has several limitations. First and foremost, all measures used in this trial rely on self-report, which has inherent weakness. Self-report assessment is subject to numerous types of bias, and it is possible that participant responses could be swayed by beliefs that the intervention would have an effect. Further, participants may have had beliefs about the expectations of researchers and give responses based on a desire to

satisfy the trial aims, e.g., inflate their sense of self-compassion due to knowledge that Ruby was a self-compassion focused intervention.

The reliance on self-report data also led to a lack of precision in measurement of engagement. Because we did not measure unique website visits, clicks through to mindfulness practices, plays/listens of YouTube lessons or mindfulness tracks, and other objective strategies to assess engagement, it is impossible to assess the dose of treatment each participant received. While we attempted to collect engagement data through self-report strategies, we have little idea what a user's daily experience in Ruby amounted to and how often they used self-compassion skills. Future work must use more advanced tools to measure engagement and behavior more objectively to build on our findings and bring more clarity to why this treatment may have been efficacious and how to build on it in the future.

In addition to weaknesses inherent in self-report studies, it is difficult to extrapolate clinical significance from our findings. Though we can be confident that group differences are statistically significant, we should not assume that these reductions in weight bias internalization are meaningful enough to translate to improvements in nervous system regulation, eating behavior, avoidance of healthy activities, and so on. Our within group reductions in internalized weight bias were exciting, though small. Because the end-of-treatment level of weight bias internalization ultimately remained above the cutoff for inclusion into our trial, it stands to reason that

this degree of improvement may not have translated to behavioral changes. Future investigations should include behavioral measurements over longer periods of time to begin to understand what constitutes clinically meaningful reduction of internalized weight bias.

Further, a wait list control group is not sufficient for robust testing of an intervention. Additionally, the short duration of this trial and lack of follow up assessment limit our ability to explore long-term effects of this intervention. Though the initial results are promising, there is no way to know how long the effects will last without intervention, or if participants will be able to use self-compassion skills on their own without daily prompts and reminders. In one long-term investigation, Pearl and colleagues found that weight bias internalization scores did not change from end of treatment to follow up assessment six months later, though this may be thanks to her more intensive treatment design and may not be replicable in a standalone design.²⁴ Future studies should assess long-term outcomes and detailed information regarding whether or not participants are able to guide themselves through a mindfulness practice after termination of an intervention such as this.

Finally, there were several limitations of our digital tools that dictated certain design choices. For instance, we were not able to allow participants to choose a preferred time to receive text messages. For some, this meant that they would receive morning text messages while they were still asleep or while they were already at work. While we did

our best to estimate the most convenient time for the average participant, it would be preferable to allow participants to choose the most ideal time based on when they are likely to complete their daily mindfulness practice. Additionally, text messages were designed for one-way communication only. This means that if participants responded to text messages, their responses were not viewable by study staff. In an ideal situation, participants would have been able to respond to study staff or reach out for technical assistance (i.e., if they didn't receive a text message but were expecting one). Participants also were not offered a space to write their reflections during psychoeducation; in future iterations of this project, we may consider incorporating a space for participants to submit and track their observations over time (e.g., within the text message exchange, or on a separate but integrated digital platform). Participants offered valuable feedback about shortcoming of adjunctive digital platforms we used within Ruby, such as SoundCloud. Using SoundCloud was a wise choice when considering cost of intervention, as it is a free service that was easy to integrate with a smartphone-delivered intervention. However, quirks within SoundCloud that were outside of our control (e.g., music playing after completion of a mindfulness track) led to undesirable user experiences for some. We made a choice not to develop a standalone smartphone application consciously, as we wanted to ensure ease of use and not rely on a user remembering to open an app or the app being offloaded by a user's phone without their

knowledge. However, an app may have allowed for increased integration that would have improved the user experience for Ruby participants.

5.6 Strengths

Ruby is the first of its kind and, despite its limitations, has many strengths. This is the first investigation to assess the impact of mindful self-compassion on internalized weight bias in a randomized controlled trial. No other trial treating internalized weight bias has utilized novel digital tools and employed them in an entirely standalone fashion without human support. The impact this novel design will have on Ruby's reach is immeasurable, and the potential for population health improvement is not to be overlooked.

While our sample is not diverse on race and ethnicity metrics, we were able to recruit a large proportion of LGBTQIA+ individuals. This is a critical strength given the known health disparities in this community. This allowed us to examine patterns of weight bias internalization according to sexual and gender identity, which has only minimally been done in this field due to underrepresentation of this community in academic research. It is possible that our digital recruitment strategies (i.e., ResearchMatch) allowed us to reach a broader base of interested participants and enroll a sample of individuals who more accurately represent the United States on this demographic variable.

Another key strength of Ruby was the ease of use reported by our participants. Overwhelmingly, participants provided both quantitative and qualitative feedback that Ruby was simple, approachable, easy to understand, and pleasant to use. Despite inclusion of new concepts to most participants (e.g., self-compassion, mindfulness, weight bias internalization, chronic stress response), they noted that psychoeducation lessons were easy to follow and integrate into their daily life. It is likely that our careful design of the progression of the intervention components, language used to describe scientific concepts to laypeople, and tone of our messages worked together to create an intervention that our participants found highly digestible, usable, and helpful.

Ruby was also very accessible. Participants were able to use Ruby content on their smartphone at any time of day in any location. They incurred no costs that might typically be associated with participation in a clinical trial, such as travel costs (e.g., public transit, gas, parking). It was also time efficient; participants were not expected to participate for more than 20 minutes per day at maximum which meant they did not have to take as much time away from their families, work responsibilities, or other common barriers to attendance of in-person treatments. Participants could access intervention content even when on vacation, when sick and unable to be in contact with other people, and regardless of how close they lived to our academic institution. Taken together, these qualities rendered Ruby highly portable, accessible, thus easier to engage with.

In addition to excellent accessibility for individual participants, the low cost of Ruby suggests it will be highly scalable and able to be accessed by greater numbers of individuals in need. Base monthly costs (i.e., Twilio and website fees) were \$17/per month and would remain static regardless of how many individuals were accessing Ruby. Cost per additional participant would be only \$1. It would be relatively easy to scale up this intervention and disseminate this program to many with little funding.

Finally, we believe a critical strength of this trial is that it is not tied to weight loss, nor was weight loss mentioned in any way. There is recent scientific evidence suggesting that the narratives around risks of obesity have historically been overblown or misattributed. First and foremost, we believe in an individual's right to bodily autonomy and connection with their agency in service of living a valued life. Should an adult seek to lose weight, there are many programs available to help them try to meet that goal. However, if an individual seeks to feel better about their weight and cope with weight-based stigma without changing their weight (whether by choice or because weight is not always easily modified by behavioral changes), they should have access to a high-quality, evidence-based program to ease suffering related to weight-based stigmatization. Weight loss is not mandatory, nor should it be the only avenue available for individuals seeking to exist with more peace in a world that is harsh and stigmatizing. We believe Ruby is the first step toward allowing individuals to cope with

weight-based stigma without weight loss and, potentially, free them up to engage in more health-promoting behaviors and valued living.

5.7 Future Directions

Though results were compelling, this work is preliminary and should be expanded upon to maximize benefit to individuals with weight bias internalization. First and foremost, Ruby should be expanded to measure more time points and with more frequency to assess how and when weight bias internalization shifts in response to use of mindful self-compassion. Additional digital assessment strategies could be used, such as ecological momentary assessment, to identify momentary shifts in self-compassion, weight bias internalization, and other adaptive and maladaptive coping behaviors. Future trials should include follow up data to examine durability of these results over longer periods of time and to examine whether weight bias internalization remains low even when an intervention ends.

Additionally, novel scientific approaches could be used to optimize treatment after identifying the most potent components of Ruby. A multiphase optimization trial approach would allow us to disentangle each distinct intervention component and calculate its unique effect on weight bias internalization. Novel approaches could be used to integrate new components to be tested, such as using machine learning to develop content of the intervention that is more responsive to a participant based on a certain set of variables (e.g., lapses in engagement).

Further, given our limited ability to assess clinical significance of our outcomes, it is essential that we understand the impact of mindful self-compassion on critical clinical targets. Future trials should include behavioral data such as adherence to diabetes self-care guidelines, objective measurements of physical activity, more robust assessments of intuitive eating patterns, and other measures of healthful behaviors. Future work should also include additional physiological measures, such as heart rate variability, cortisol reactivity, or galvanic skin response. By including these data, we could glean the effect of mindful self-compassion on nervous system regulation.

5.8 Conclusions

Ruby was a brief, low-cost, accessible intervention that reduced internalized weight bias to a statistically meaningful degree. Reductions in internalized weight bias were accompanied by reductions in fear of self-compassion and weight-related experiential avoidance. Further, Ruby allowed for increased body appreciation, intuitive eating, physical activity, and general mindfulness. Given its low cost and positive reception from participants, it is clear that Ruby is poised to improve health on a large scale. Though other interventions for reduction of internalized weight bias exist, many incorporate cognitive restructuring or weight loss; Ruby is unique in its novel mindfulness-based intervention approach and perhaps is more well-fitted to the clinical target of weight bias internalization. Individuals with obesity and internalized weight

bias should have access to simple, accessible, and low-cost treatments to improve their well-being independent of weight loss. For these individuals, Ruby may hold promise.

Appendix A

To view each psychoeducation module, please visit www.textruby.com/week-1.

Below are images of sample pages of the website that hosted psychoeducation readings and YouTube lessons, and an image of sample text messages received early in the intervention.

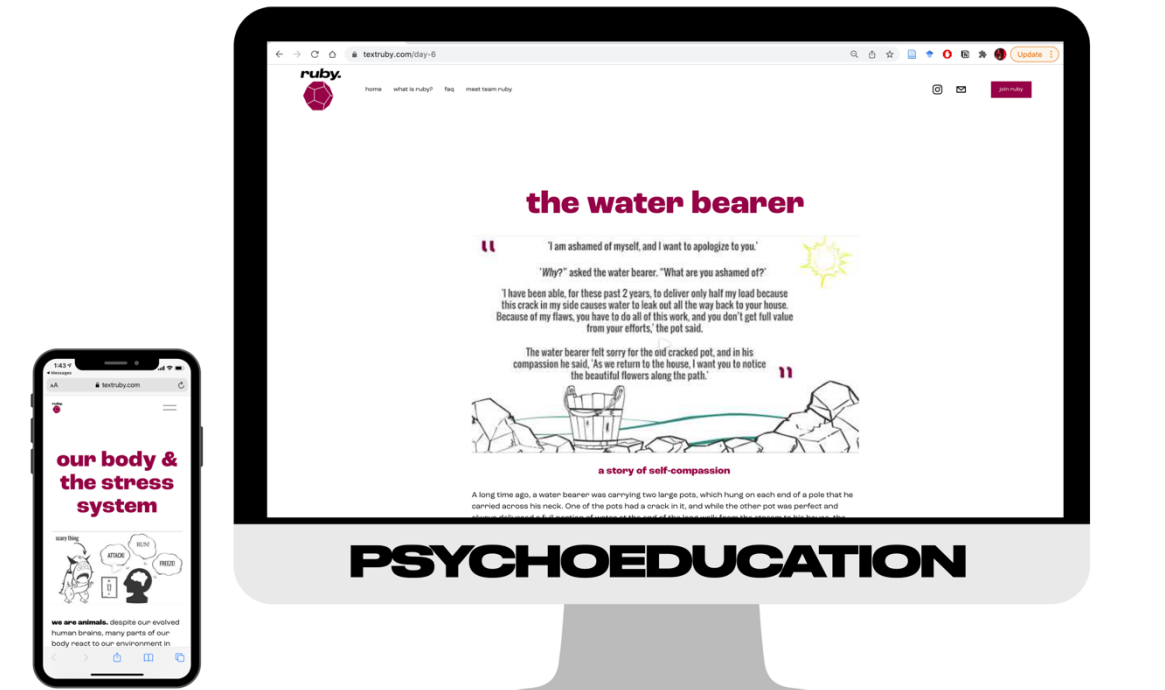


Figure A. 1: Sample of psychoeducation pages

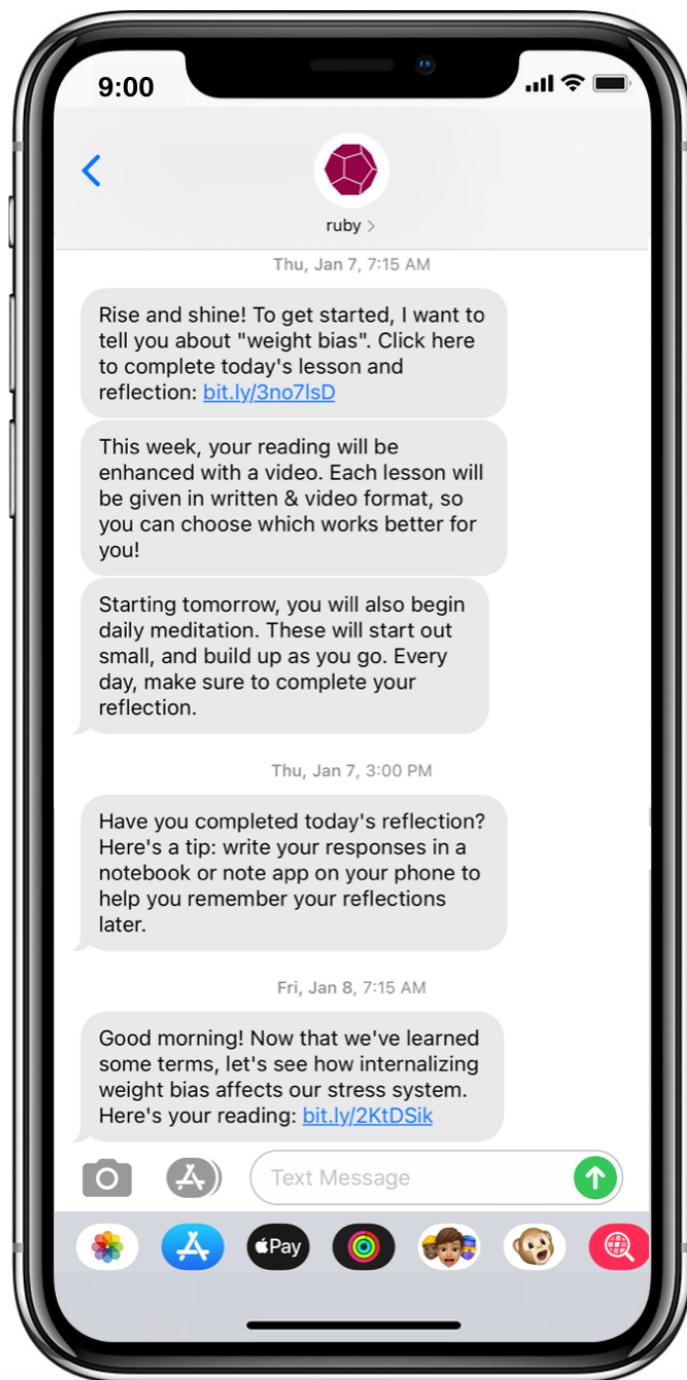


Figure A. 2: Sample of text messages

Appendix B

Table B. 1. Content of text messages for intervention group

Week	Day	Hour	Message Text
Week 1	0	immediate	Hey [first name], I'm Ruby. You've been assigned to Group A! This means we get to start working together right away. I'm delighted to be your guide for the next 4 weeks.
		immediate +1 min	Texts from me for the next 4 weeks will always come from this phone number. Go ahead & save this number in your phone as "ruby."
		immediate + 2 min	If you want, you can save a contact photo for me. I linked one here: bit.ly/35h3OEV Go ahead and save that photo and assign it to my contact!
		immediate +3min	Starting tomorrow, you'll receive one text every morning at 7:15am with a task for the day. For the first few days, you'll complete brief readings and reflections.
		immediate +4min	After you finish a lesson, complete your reflection & meditation. You should set aside about 20 min each day for Ruby & be sure to write down your reflections.
		immediate + 5min	You can read more about what to expect on the orientation page: bit.ly/2MwSdvv
		immediate +6min	Unfortunately, I'm just a pre-programmed bot, so I won't be able to help you when you're stuck. If you need help, email rubyteam@duke.edu or visit textruby.com .
		immediate +7min	You'll hear from me a lot in the next few days as you get up to speed, and then I'll text you about twice a day, so you know what to do. See you in the morning!
	1	0715h	Rise and shine! To get started, I want to tell you about "weight bias". Click here to complete today's lesson and reflection: bit.ly/3no7lsD
		0716h	This week, your reading will be enhanced with a video. Each lesson will be given in written & video format, so you can choose which works better for you!
		0717h	Starting tomorrow, you will also begin daily meditation. These will start out small and build up as you go. Every day, make sure to complete your reflection.
		1500h	Have you completed today's reflection? Here's a tip: write your responses in a notebook or note app on your phone to help you remember your reflections later.
	2	0715h	Good morning! Now that we've learned some terms, let's see how internalizing weight bias affects our stress system. Here's your reading: bit.ly/2KtDSik
		0716h	We'll also start meditating today! This 4 min practice will guide you through the basics & help you build a habit now. Click here to begin: bit.ly/2KaeaPH

		0717h	Today's short practice will get you started on the path of daily mindfulness. They'll get longer as Ruby progresses! Write down what you notice when you're done.
		1500h	For today's reflection, jot down a few words about how weight bias has affected you. What do you feel in your body when you experience weight bias?
	3	0715h	Over the next few weeks, you'll learn how to manage internalized weight bias. Let's read about a new coping skill: self-compassion. Click here: bit.ly/3gNX6eE
		0716h	Try observing your thoughts during today's meditation. Do you notice self-critique or self-compassion arising naturally? bit.ly/2KaeaPH
		1500h	Hey! Have you observed your thoughts today? If not, no worries, there's still time before tomorrow's reading. Remember to write down what you notice!
	4	0715h	Good morning, sunshine. Before we start practicing together, I want to help you set up a consistent mindfulness practice. Let's dig in: bit.ly/3r0iulS
		0716h	Try using some of the tips you learned when you practice today. Maybe experiment with a new time of day, new location, or new position! bit.ly/2KaeaPH
		1500h	Hiya, have you completed today's lesson & meditation? Can you feel the habit forming? Write down any barriers that may come up for you or have already.
	5	0715h	Rise and shine [first name]! Do you need some self-compassion? Today's the day. First, we'll learn how to adjust your mindfulness practice for your needs: bit.ly/3gRlXhD
		0716h	Today's meditation will be new & different. After today's lesson, settle in for a 5 min self-compassion break. bit.ly/3m5hMQq
		1500h	Tomorrow is already our last day of lessons before we dive deep into mindfulness! Revisit this week's lessons & make a plan for when you will meditate daily.
	6	0715h	Today, take time to set yourself up for Ruby. When will you meditate? Where? Why? Click here for a story of self-compassion & an action plan: bit.ly/3gPkf0e
		0716h	Here's our practice: bit.ly/3m5hMQq See if you can notice what it feels like to practice self-compassion. Do you feel warmth or peace in your body somewhere?
		1500h	Hi again, it's me, Ruby. Take a moment & revisit this week's lessons. If you haven't already, set up time tonight to make an action plan for the next 3 weeks.
		1900h	As we finish up our first week, I'd like to know how it's going for you. Please complete a quick survey telling me more about your experience.
	7	0715h	It's a good day for some self-compassion. Find a comfortable seat and click here to start today's meditation: bit.ly/3m5hMQq

Week 2		1500h	I'm excited for our next 3 weeks together! If you want to revisit any lessons from week 1, you can find them all here: bit.ly/3hJFfVY
	8	0715h	Good morning! Let's dive in. Today, see if you notice your mind wandering, then guide your mind back to the practice. Click here to start: bit.ly/3m5hMQq
		1500h	Hey, how's your habit going? Are you finding the day slipping away without meditation? Try scheduling your practice like an appointment. You're worth it.
	9	0715h	Hi friend. It's me, Ruby. Let's sit! Time to meditate. Click here to begin a new 10 min. practice: the RAIN of self-compassion bit.ly/3qAFcR8
		1500h	Just checking in - have you been able to meditate on most days? If you're stuck, revisit the problem-solving guide for adjustments: bit.ly/3gRIXhD
	10	0715h	Good morning! A meditation practice a day keeps the bad vibes at bay. Let's sit together. Click here to start today's practice: bit.ly/3qAFcR8
		1500h	Did you know you can use RAIN any time you need it? Try practicing the steps when you next have a painful moment - recognize, allow, investigate, nourish.
	11	0715h	Hey, friend. Let's get our daily dose of compassion today. Find a comfortable seat, with your head held high. Click here to start: bit.ly/3qAFcR8
		1500h	Sometimes we internalize stereotypes about weight, but that doesn't mean they're true! Notice if you're believing negative thoughts, then return to your breath.
	12	0715h	Good morning, [first name]! Here's today's practice: bit.ly/3qAFcR8 See if you notice anything new with a deeper, more curious investigation today.
		1500h	Hi, friend. I hope your day is going well. Don't forget to sit for 10 minutes of RAIN today! If you're falling behind, just jump right back in.
	13	0715h	Rise and shine! Find a comfortable seat and settle in for today's practice. Click here to begin: bit.ly/3qAFcR8
		1500h	Hi there. You're doing so well showing up for yourself. I'm really glad you're here. Tomorrow the sun will rise & we will try again.
		1900h	I'm so proud of your efforts this week. I'd like to know how this week went for you. Please complete this 2-minute survey tonight.
	14	0715h	Welcome to week 3! To begin, find a comfortable seat & settle into your new guided meditation practice for the week: a compassionate friend bit.ly/32K8YYD
		1500h	You're halfway through Ruby. Remember, if you miss a day, just pick right back up the next day.

Week 3	15	0715h	Ready to greet the day? Your compassionate friend is waiting for you. Click here to begin today's practice: bit.ly/32K8YYD
		1500h	As the practices get longer, you may notice more mind-wandering than usual. That's ok! The fact that you notice it means you're getting more mindful & aware.
	16	0715h	Hi there, it's good to sit with you again. Let's jump right in. Ready? Find a comfortable seat & click the link to begin: bit.ly/32K8YYD
		1500h	Just checking in - have you been able to meditate on most days? If you're stuck, be sure to revisit week 1 guides to adjust your practice: bit.ly/3hJFfVY
	17	0715h	Good morning! Now is a great time to sit and check in with yourself. Ready to begin? Click the link to get started: bit.ly/32K8YYD
		1500h	Hi there, just a friendly reminder to complete your practice today! Remember, it's ok to set boundaries for self-care. Prioritize yourself and Ruby today.
	18	0715h	The sun is up & a new day is starting. It's a new chance to treat yourself with some extra kindness. To begin today's practice, click here: bit.ly/32K8YYD
		1500h	A poem for you today: "This being human is a guest house. Every morning a new arrival... some momentary awareness comes As an unexpected visitor." -Rumi
	19	0715h	Hi, friend! It's time to settle in and reconnect with your compassion When you're ready, click here to begin today's practice: bit.ly/32K8YYD
		1500h	Hi there, [first name], it's Ruby checking in to say hi and gently remind you to complete today's practice. Take a minute now and decide when you will make time!
	20	0715h	Good morning! We've reached end of week 3. Enjoy your final visit with your compassionate friend. Click here to begin: bit.ly/32K8YYD
		1500h	You're doing great, my friend. You've completed week 3 & we're about to start our last week together. Tomorrow, you'll receive a new guided practice for week 4.
		1900h	I'm so proud of your efforts so far. I'd like to know how this week went for you. Please complete this 2-minute survey tonight.
	21	0715h	Welcome to week 4 of Ruby! This is our last week together, so let's make it count. This week we focus on compassion & the body. Click here begin: bit.ly/3hMJ0Ks
		1500h	You may notice body judgment thoughts when you practice. Don't fret, that's your mind playing the same old tape on a loop. Call it what it is: just a thought.

Week 4	22	0715h	Good morning! As we focus on body compassion, try experimenting with new body positions. Have you tried lying on the floor? Click here to begin: bit.ly/3hMJ0Ks
		1500h	A note for you: "Why do you run around looking for the truth? Be still, and there it is - in the mountain, in the pine, in yourself." - Lao Tzu
	23	0715h	Hi there. We all need a bit more self-kindness today, don't you think? Let's find a comfortable seat and begin: bit.ly/3hMJ0Ks
		1500h	Just checking in - have you been able to complete your practices? If you've missed many days, don't worry. Just jump right back in tomorrow. You deserve it, [first name].
	24	0715h	Another day, another opportunity to settle in and treat yourself with kindness & compassion. When you're ready, click here for today's practice: bit.ly/3hMJ0Ks
		1500h	Remember - sometimes we internalize stereotypes about our weight, but that doesn't mean they are true. Notice if you find yourself believing negative thoughts.
	25	0715h	Hi there, ready to settle in? Be gentle and kind to yourself today. Give yourself what you need. Click here to get started: bit.ly/3hMJ0Ks
		1500h	Are you getting the hang of self-compassion? If you find it difficult, remember the warmth of a compassionate wise friend.
	26	0715h	We're in the home stretch! If you've fallen off course, all it takes to get back on track is to click this little link. Let's sit together: bit.ly/3hMJ0Ks
		1500h	Only one more day of meditation. Let's finish strong, shall we? Make sure you complete today's practice and soak it all up.
	27	0715h	Rise and shine! It's time to get some self-compassion in. Today is our final practice session. Let's make the most of it. Click here to begin: bit.ly/3hMJ0Ks
		1500h	Hi, it's Ruby with your final gentle reminder to show up for yourself today. Find a quiet place & let's practice one more time.
		1900h	It's been an honor to sit with you for the past 4 weeks, [first name]. I'd like to know how this week was for you. Click here for the last weekly survey:
		1901h	Please complete the survey tonight. Tomorrow, I'll send you a link for the final assessments and where we go from here. Take care!
	28	0715h	It's hard to put into words how proud I am of you. For 4 weeks, you chose to take care of yourself & treat yourself with kindness, which is no small feat.

		0716h	We have one final task together, which is to complete the surveys required to finish Ruby. These will take 15-20 minutes, just like before you started Ruby. [survey-url]
		0717h	These are essential to help us learn how Ruby worked (or didn't work) for everyone. Even if you missed most of the practices, we really need your feedback.
		0718h	The survey link is also in your email. Please email rubyteam@duke.edu if you need help! Thanks in advance for your time, energy, and dedication.
End of treatment	29	0715h	Good morning, friend. Have you completed your surveys yet? Contact us if you have any questions [ruby@duke.edu]. Otherwise, please complete the surveys here:
		0716h	It's been a pleasure being your guide for the last 4 weeks. We are so grateful that you were a part of Ruby.
		0717h	If you'd like to continue your work on body acceptance and self-compassion, visit bit.ly/37lJswf for more information. Take good care of yourself, [first name]! Be well.

References

1. Bronfenbrenner U. Toward an experimental ecology of human development. *Am Psychol*. 1977;32(7):513-531. doi:10.1037/0003-066X.32.7.513
2. Cook JE, Purdie-Vaughns V, Meyer IH, Busch JTA. Intervening within and across levels: A multilevel approach to stigma and public health. *Soc Sci Med*. 2014;103:101-109. doi:10.1016/j.socscimed.2013.09.023
3. Andreyeva T, Puhl RM, Brownell KD. Changes in Perceived Weight Discrimination Among Americans, 1995–1996 Through 2004–2006. *Obesity*. 2008;16(5):1129-1134. doi:10.1038/oby.2008.35
4. Puhl RM, Himmelstein MS, Quinn DM. Internalizing Weight Stigma: Prevalence and Sociodemographic Considerations in US Adults. *Obes Silver Spring Md*. 2018;26(1):167-175. doi:10.1002/oby.22029
5. Callahan D. Obesity: Chasing an Elusive Epidemic. *Hastings Cent Rep*. 2013;43(1):34-40. doi:10.1002/hast.114
6. Puhl R, Suh Y. Health Consequences of Weight Stigma: Implications for Obesity Prevention and Treatment. *Curr Obes Rep*. 2015;4(2):182-190. doi:10.1007/s13679-015-0153-z
7. Lessard LM, Puhl RM, Himmelstein MS, Pearl RL, Foster GD. Eating and Exercise-Related Correlates of Weight Stigma: A Multinational Investigation. *Obes Silver Spring Md*. 2021;29(6):966-970. doi:10.1002/oby.23168
8. Tomiyama AJ. Weight stigma is stressful: A review of evidence for the Cyclic Obesity/Weight-Based Stigma model. *Appetite*. 2014;82:8-15.
9. Pearl RL, Puhl RM. The distinct effects of internalizing weight bias: An experimental study. *Body Image*. 2016;17:38-42.
10. Himmelstein MS, Puhl RM, Quinn DM. Weight stigma and health: The mediating role of coping responses. *Health Psychol*. 2018;37(2):139-147. doi:10.1037/hea0000575
11. Pearl RL, Puhl RM, Dovidio JF. Differential effects of weight bias experiences and internalization on exercise among women with overweight and obesity. *J Health Psychol*. 2015;20(12):1626-1632. doi:10.1177/1359105313520338

12. Pearl RL, Wadden TA, Hopkins CM, et al. Association between weight bias internalization and metabolic syndrome among treatment-seeking individuals with obesity. *Obes Silver Spring Md.* 2017;25(2):317-322. doi:10.1002/oby.21716
13. Potier F, Degryse JM, Bihin B, et al. Health and frailty among older spousal caregivers: an observational cohort study in Belgium. *BMC Geriatr.* 2018;18(1):291. doi:10.1186/s12877-018-0980-3
14. Penz KL, Kosteniuk JG, Stewart NJ, et al. Development and psychometric evaluation of the Job Demands in Nursing Scale and Job Resources in Nursing Scale: Results from a national study. *Nurs Open.* 2019;6(2):348-366. doi:10.1002/nop2.215
15. Ouellet-Morin I, Wong CCY, Danese A, et al. Increased serotonin transporter gene (SERT) DNA methylation is associated with bullying victimization and blunted cortisol response to stress in childhood: a longitudinal study of discordant monozygotic twins. *Psychol Med.* 2013;43(9):1813-1823. doi:10.1017/S0033291712002784
16. Richman LS, Jonassaint C. The Effects of Race-related Stress on Cortisol Reactivity in the Laboratory: Implications of the Duke Lacrosse Scandal. *Ann Behav Med.* 2008;35(1):105-110. doi:10.1007/s12160-007-9013-8
17. Bodhi B. What does mindfulness really mean? A canonical perspective. *Contemp Buddhism.* 2011;12(1):19-39. doi:10.1080/14639947.2011.564813
18. Segal ZV, Teasdale JD, Williams JM, Gemar MC. The mindfulness-based cognitive therapy adherence scale: inter-rater reliability, adherence to protocol and treatment distinctiveness. *Clin Psychol Psychother.* 2002;9(2):131-138. doi:10.1002/cpp.320
19. Kabat-Zinn J. *Full Catastrophe Living: The Program of the Stress Reduction Clinic at the University of Massachusetts Medical Cente.* Delta; 1990.
20. Piet J, Hougaard E, Hecksher MS, Rosenberg NK. A randomized pilot study of mindfulness-based cognitive therapy and group cognitive-behavioral therapy for young adults with social phobia. *Scand J Psychol.* 2010;51(5):403-410. doi:10.1111/j.1467-9450.2009.00801.x
21. Thompson BL, Waltz J. Mindfulness and experiential avoidance as predictors of posttraumatic stress disorder avoidance symptom severity. *J Anxiety Disord.* 2010;24(4):409-415. doi:10.1016/j.janxdis.2010.02.005

22. Greeson JM, Zarrin H, Smoski MJ, et al. Mindfulness Meditation Targets Transdiagnostic Symptoms Implicated in Stress-Related Disorders: Understanding Relationships between Changes in Mindfulness, Sleep Quality, and Physical Symptoms. *Evid Based Complement Alternat Med*. 2018;2018:e4505191. doi:10.1155/2018/4505191
23. Pearl RL, Wadden TA, Bach C, et al. Effects of a cognitive-behavioral intervention targeting weight stigma: A randomized controlled trial. *J Consult Clin Psychol*. 2020;88(5):470-480. doi:10.1037/ccp0000480
24. Pearl RL, Wadden TA, Bach C, Tronieri JS, Berkowitz RI. Six-Month Follow-up from a Randomized Controlled Trial of the Weight BIAS Program. *Obes Silver Spring Md*. 2020;28(10):1878-1888. doi:10.1002/oby.22931
25. Levin ME, Potts S, Haeger J, Lillis J. Delivering acceptance and commitment therapy for weight self-stigma through guided self-help: Results from an open pilot trial. *Cogn Behav Pract*. 2018;25(1):87-104. doi:10.1016/j.cbpra/2017.02.002
26. Lillis J, Hayes SC, Bunting K, Masuda A. Teaching acceptance and mindfulness to improve the lives of the obese: A preliminary test of a theoretical model. *Ann Behav Med*. 2009;37:58-69.
27. Palmeira L, Pinto-Gouveia J, Cunha M. Exploring the efficacy of an acceptance, mindfulness & compassionate-based group intervention for women struggling with their weight (Kg-Free): A randomized controlled trial. *Appetite*. 2017;112:107-116. doi:10.1016/j.appet.2017.01.027
28. Pinto-Gouveia J, Carvalho SA, Palmeira L, et al. Incorporating psychoeducation, mindfulness and self-compassion in a new programme for binge eating (BEfree): Exploring processes of change. *J Health Psychol*. 2019;24(4):466-479. doi:10.1177/1359105316676628
29. Potts SA. *Putting Weight in Context: Acceptance and Commitment Therapy (ACT) Guided Self-Help for Weight Self-Stigma*. Ph.D. Utah State University. Accessed May 17, 2022. <https://www.proquest.com/docview/2081200083/abstract/AD8D2268ED9A42A3PQ/1>
30. Strandkov SW, Ghaderi A, Andersson H, et al. Effects of Tailored and ACT-Influenced Internet-Based CBT for Eating Disorders and the Relation Between Knowledge Acquisition and Outcome: A Randomized Controlled Trial. *Behav Ther*. 2017;48(5):624-637. doi:10.1016/j.beth.2017.02.002

31. Weineland S, Arvidsson D, Kakoulidis TP, Dahl J. Acceptance and commitment therapy for bariatric surgery patients, a pilot RCT. *Obes Res Clin Pract.* 2012;6(1):e1-e90. doi:10.1016/j.orcp.2011.04.004
32. Alberts HJEM, Thewissen R, Raes L. Dealing with problematic eating behaviour. The effects of a mindfulness-based intervention on eating behaviour, food cravings, dichotomous thinking and body image concern. *Appetite.* 2012;58(3):847-851. doi:10.1016/j.appet.2012.01.009
33. Albertson ER, Neff KD, Dill-Shackleford KE. Self-Compassion and Body Dissatisfaction in Women: A Randomized Controlled Trial of a Brief Meditation Intervention. *Mindfulness.* 2015;6(3):444-454. doi:10.1007/s12671-014-0277-3
34. Duarte C, Gilbert P, Stalker C, et al. Effect of adding a compassion-focused intervention on emotion, eating and weight outcomes in a commercial weight management programme. *J Health Psychol.* Published online December 5, 2019. Accessed June 8, 2020. <http://eprints.whiterose.ac.uk/155106/>
35. McMahan A. *A Randomized, Controlled Trial of Mindfulness plus Exposure for Improving Body Image in Women.* Library and Archives Canada = Bibliothéque et Archives Canada; 2011.
36. Tsai A, Hughes EK, Fuller-Tyszkiewicz M, Buck K, Krug I. The Differential Effects of Mindfulness and Distraction on Affect and Body Satisfaction Following Food Consumption. *Front Psychol.* 2017;8:1696. doi:10.3389/fpsyg.2017.01696
37. Atkinson MJ, Wade TD. Impact of metacognitive acceptance on body dissatisfaction and negative affect: engagement and efficacy. *J Consult Clin Psychol.* 2012;80(3):416-425. doi:10.1037/a0028263
38. Svaldi J, Naumann E. Effects of rumination and acceptance on body dissatisfaction in binge eating disorder. *Eur Eat Disord Rev J Eat Disord Assoc.* 2014;22(5):338-345. doi:10.1002/erv.2312
39. Wade T, George WM, Atkinson M. A randomized controlled trial of brief interventions for body dissatisfaction. *J Consult Clin Psychol.* 2009;77(5):845-854. doi:10.1037/a0016879
40. Lillis J, Dahl J, Weineland SM. *The Diet Trap: Feed Your Psychological Needs and End the Weight Loss Struggle Using Acceptance and Commitment Therapy.* New Harbinger Publications Accessed May 17, 2022. <https://books.google.com/books?hl=en&lr=&id=4k5RAgAAQBAJ&oi=fnd&pg=PT6>

&dq=Lillis,+J.,+Dahl,+J.,+%26+Weineland,+S.+M.+(2014).+The+Diet+Trap:+Feed+Yo
ur+Psychological+Needs+and+End+the+Weight+Loss+Struggle+Using+Acceptance+
and+Commitment+Therapy.+New+Harbinger++Publications.&ots=bMill06nM5&si
g=Z1GbLz5wIMgMZd8Oddo0828ngXM#v=onepage&q&f=false

41. Hayes SC, Smith S. *Get out of Your Mind and into Your Life: The New Acceptance and Commitment Therapy*. New Harbinger Publications; 2005.
42. Teasdale JD, Segal ZV, Williams JMG, Ridgeway VA, Soulsby JM, Lau MA. Prevention of relapse/recurrence in major depression by mindfulness-based cognitive therapy. *J Consult Clin Psychol*. 2000;68(4):615-623. doi:10.1037/0022-006X.68.4.615
43. Puhl RM, Telke S, Larson N, Eisenberg ME, Neumark-Stzainer D. Experiences of weight stigma and links with self-compassion among a population-based sample of young adults from diverse ethnic/racial and socio-economic backgrounds. *J Psychosom Res*. Published online May 7, 2020:110134. doi:10.1016/j.jpsychores.2020.110134
44. Neff K. Self-Compassion: An Alternative Conceptualization of a Healthy Attitude Toward Oneself. *Self Identity*. 2003;2(2):85-101. doi:10.1080/15298860309032
45. MacBeth A, Gumley A. Exploring compassion: A meta-analysis of the association between self-compassion and psychopathology. *Clin Psychol Rev*. 2012;32(6):545-552. doi:10.1016/j.cpr.2012.06.003
46. Braun TD, Park CL, Gorin A. Self-compassion, body image, and disordered eating: A review of the literature. *Body Image*. 2016;17:117-131. doi:10.1016/j.bodyim.2016.03.003
47. Pearl RL, Puhl RM. Measuring internalized weight attitudes across body weight categories: Validation of the Modified Weight Bias Internalization Scale. *Body Image*. 2014;11(1):89-92. doi:10.1016/j.bodyim.2013.09.005
48. Neff K. The Development and Validation of a Scale to Measure Self-Compassion. *Self Identity*. 2003;2(3):223-250. doi:10.1080/15298860309027
49. Lillis J, Luoma JB, Levin ME, Hayes SC. Measuring Weight Self-stigma: The Weight Self-stigma Questionnaire. *Obesity*. 2010;18(5):971-976. doi:10.1038/oby.2009.353

50. Gilbert P, McEwan K, Matos M, Ravis A. Fears of compassion: Development of three self-report measures. *Psychol Psychother Theory Res Pract*. 2011;84(3):239-255. doi:10.1348/147608310X526511
51. Kroenke K, Spitzer RL, Williams JBW. The Patient Health Questionnaire-2: Validity of a Two-Item Depression Screener. *Med Care*. 2003;41(11):1284-1292. Accessed June 10, 2020. <https://www.jstor.org/stable/3768417>
52. Tylka TL, Kroon Van Diest AM. The Intuitive Eating Scale-2: Item refinement and psychometric evaluation with college women and men. *J Couns Psychol*. 2013;60(1):137-153. doi:10.1037/a0030893
53. Craig CL, Marshall AL, Sjöström M, et al. International Physical Activity Questionnaire: 12-Country Reliability and Validity. *Med Sci Sports Exerc*. 2003;35(8):1381-1395. doi:10.1249/01.MSS.0000078924.61453.FB
54. Bohlmeijer E, ten Klooster PM, Fledderus M, Veehof M, Baer R. Psychometric properties of the five facet mindfulness questionnaire in depressed adults and development of a short form. *Assessment*. 2011;18(3):308-320. doi:10.1177/1073191111408231
55. Tylka TL, Wood-Barcalow NL. The Body Appreciation Scale-2: Item refinement and psychometric evaluation. *Body Image*. 2015;12:53-67. doi:10.1016/j.bodyim.2014.09.006
56. Palmeira L, Cunha M, Pinto-Gouveia J, Carvalho S, Lillis J. New developments in the assessment of weight-related experiential avoidance (AAQW-Revised). *J Context Behav Sci*. 2016;5(3):193-200. doi:10.1016/j.jcbs.2016.06.001
57. Bernstein DP, Stein JA, Newcomb MD, et al. Development and validation of a brief screening version of the Childhood Trauma Questionnaire. *Child Abuse Negl*. 2003;27(2):169-190. doi:10.1016/S0145-2134(02)00541-0
58. Guided Meditations. Tara Brach. Accessed August 21, 2021. <https://www.tarabrach.com/guided-meditations/>
59. Self-Compassion Exercises by Dr. Kristin Neff. Self-Compassion. Accessed August 21, 2021. <https://self-compassion.org/category/exercises/>
60. Mohr DC, Cuijpers P, Lehman K. Supportive accountability: a model for providing human support to enhance adherence to eHealth interventions. *J Med Internet Res*. 2011;13(1):e30. doi:http://dx.doi.org.proxy.lib.duke.edu/10.2196/jmir.1602

61. Durso LE, Latner JD. Understanding Self-directed Stigma: Development of the Weight Bias Internalization Scale. *Obesity*. 2008;16(S2):S80-S86. doi:10.1038/oby.2008.448
62. Lee MS, Dedrick RF. Weight Bias Internalization Scale: Psychometric properties using alternative weight status classification approaches. *Body Image*. 2016;17:25-29. doi:10.1016/j.bodyim.2016.01.008
63. Hübner C, Schmidt R, Selle J, et al. Comparing Self-Report Measures of Internalized Weight Stigma: The Weight Self-Stigma Questionnaire versus the Weight Bias Internalization Scale. *PloS One*. 2016;11(10):e0165566. doi:10.1371/journal.pone.0165566
64. Neff KD. The Self-Compassion Scale is a Valid and Theoretically Coherent Measure of Self-Compassion. *Mindfulness*. 2016;7(1):264-274. doi:10.1007/s12671-015-0479-3
65. Wadden TA, Foster GD. Weight and Lifestyle Inventory (WALI). *Obesity*. 2006;14(S2):99S-118S.
66. Stevens VL, Jacobs EJ, Sun J, et al. Weight Cycling and Mortality in a Large Prospective US Study. *Am J Epidemiol*. 2012;175(8):785-792. doi:10.1093/aje/kwr378
67. Thombs BD, Benedetti A, Kłoda LA, et al. The diagnostic accuracy of the Patient Health Questionnaire-2 (PHQ-2), Patient Health Questionnaire-8 (PHQ-8), and Patient Health Questionnaire-9 (PHQ-9) for detecting major depression: protocol for a systematic review and individual patient data meta-analyses. *Syst Rev*. 2014;3(1):124. doi:10.1186/2046-4053-3-124
68. Paine EA. "Fat broken arm syndrome": Negotiating risk, stigma, and weight bias in LGBTQ healthcare. *Soc Sci Med* 1982. 2021;270:113609. doi:10.1016/j.socscimed.2020.113609
69. Austen E, Griffiths S. Weight stigma predicts reduced psychological wellbeing and weight gain among sexual minority men: A 12-month longitudinal cohort study using random intercept cross-lagged panel models. *Body Image*. 2022;40:19-29. doi:10.1016/j.bodyim.2021.10.006
70. Puhl RM, Himmelstein MS, Pearl RL, Wojtanowski AC, Foster GD. Weight Stigma Among Sexual Minority Adults: Findings from a Matched Sample of Adults Engaged in Weight Management. *Obes Silver Spring Md*. 2019;27(11):1906-1915. doi:10.1002/oby.22633

71. Muris P, Petrocchi N. Protection or Vulnerability? A Meta-Analysis of the Relations Between the Positive and Negative Components of Self-Compassion and Psychopathology. *Clin Psychol Psychother.* 2017;24(2):373-383. doi:10.1002/cpp.2005
72. Døssing M, Nilsson KK, Svejstrup SR, Sørensen VV, Straarup KN, Hansen TB. Low self-compassion in patients with bipolar disorder. *Compr Psychiatry.* 2015;60:53-58. doi:10.1016/j.comppsy.2015.03.010
73. Krieger T, Altenstein D, Baettig I, Doerig N, Holtforth MG. Self-Compassion in Depression: Associations With Depressive Symptoms, Rumination, and Avoidance in Depressed Outpatients. *Behav Ther.* 2013;44(3):501-513. doi:10.1016/j.beth.2013.04.004
74. Pearl RL, Puhl RM, Himmelstein MS, Pinto AM, Foster GD. Weight Stigma and Weight-Related Health: Associations of Self-Report Measures Among Adults in Weight Management. *Ann Behav Med.* Published online April 25, 2020:kaaa026. doi:10.1093/abm/kaaa026
75. Zou H, Yin P, Liu L, et al. Association between weight cycling and risk of developing diabetes in adults: A systematic review and meta-analysis. *J Diabetes Investig.* 2021;12(4):625-632. doi:10.1111/jdi.13380
76. Piercy KL, Troiano RP. Physical Activity Guidelines for Americans From the US Department of Health and Human Services. *Circ Cardiovasc Qual Outcomes.* 2018;11(11):e005263. doi:10.1161/CIRCOUTCOMES.118.005263
77. Himmelstein MS, Puhl RM, Quinn DM. Intersectionality: An understudied framework for addressive weight stigma. *Am J Prev Med.* 2017;53(4):421-431.
78. Mensinger JL, Calogero RM, Tylka TL. Internalized weight stigma moderates eating behavior outcomes in women with high BMI participating in a healthy living program. *Appetite.* 2016;102:32-43.
79. Pearl RL, Hopkins CH, Berkowitz RI, Wadden TA. Group cognitive-behavioral treatment for internalized weight stigma: a pilot study. *Eat Weight Disord EWD.* 2018;23(3):357-362. doi:10.1007/s40519-016-0336-y
80. Davies AE, Burnette CB, Ravyts SG, Mazzeo SE. A randomized control trial of Expand Your Horizon: An intervention for women with weight bias internalization. *Body Image.* 2022;40:138-145. doi:10.1016/j.bodyim.2021.12.006

81. Olson KL, Thaxton TT, Emery CF. Targeting body dissatisfaction among women with overweight or obesity: A proof-of-concept pilot study. *Int J Eat Disord*. 2018;51(8):973-977. doi:10.1002/eat.22874
82. Bacon L. *Health at Every Size: The Surprising Truth about Your Weight*. BenBella Books, Inc; 2010.
83. Brownell KD. *The LEARN Program for Weight Management*. 10th Edition. American Health Publishing Company; 2004.