

A Pilot Open Trial of a Digital Mindfulness-Based Intervention for Anorexia Nervosa

Margaret Sala

Ferkauf Graduate School of Psychology, Yeshiva University

Cheri A. Levinson

University of Louisville

Hedy Kober

Corey R. Roos

Yale University

Anorexia nervosa (AN) is a chronic and debilitating psychiatric disorder. Unfortunately, current treatments are lacking, with only 30–50% of individuals with AN recovering after treatment. We developed a beta-version of a digital mindfulness-based intervention for AN called *Mindful Courage-Beta*, which includes: (a) one foundational multimedia module; (b) 10 daily meditation mini-modules; (c) emphasis on a core skill set called the BOAT (Breathe, Observe, Accept, Take a Moment); and (d) brief phone coaching for both technical and motivational support. In this open trial, we aimed to evaluate (1) acceptability and feasibility; (2) intervention skill use and its association with state mindfulness in daily life; and (3) pre-to-post changes in target mechanisms and outcomes. Eighteen individuals with past-year AN or past-year atypical AN completed *Mindful Courage-Beta* over 2 weeks. Participants completed measures of acceptability, trait mindfulness, emotion regulation, eating disorder symptoms, and body dissatisfaction. Participants also completed ecological momentary assessment of skill use and state mindfulness. Acceptability ratings were good (ease-of-use: 8.2/10, helpfulness: 7.6/10). Adherence was excellent (100% completion for foundational module and 96% for mini-modules). Use of the BOAT in daily life was high (1.8

times/day) and was significantly associated with higher state mindfulness at the within-person level. We also found significant, large improvements in the target mechanisms of trait mindfulness ($d = .96$) and emotion regulation ($d = .76$), as well as significant, small-medium to medium-large reductions in eating disorder symptoms ($ds = .36-.67$) and body dissatisfaction ($d = .60$). Changes in trait mindfulness and emotion regulation had medium-large size correlations with changes in global ED symptoms and body dissatisfaction ($rs = .43-.56$). *Mindful Courage-Beta* appears to be promising and further research on a longer, refined version is warranted.

Keywords: anorexia nervosa; mindfulness-based intervention; eating disorder; digital

ANOREXIA NERVOSA (AN) is a chronic and disabling psychiatric disorder (Bohn et al., 2008; Fichter & Quadflieg, 2016; Hudson et al., 2007; Mitchell & Crow, 2006). AN is characterized by restricted food intake, intense fear of weight gain, disturbance in perceived weight or size, as well as low body weight. Two subtypes of AN have been distinguished: restricting (AN-R) and binge-eating/purging (AN-BP), with only the AN-BP subtype being characterized by binge eating and purging. Atypical AN is defined by AN features without low body weight (American Psychiatric Association, 2013). Unfortunately, efficacious treatments for AN are lacking. While cognitive behavioral therapy (CBT; Fairburn et al., 2003; Fairburn, 2008) has garnered much empirical sup-

The authors declare no conflicts of interest.
Address correspondence to Margaret Sala, Ph.D., Yeshiva University, Ferkauf Graduate School of Psychology, 1165 Morris Park Ave, Bronx, NY. e-mail: margarita.sala@yu.edu.

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port as a treatment for AN, outcomes are still sub-optimal for many patients, with only 30–50% of individuals recovering after treatment (Atwood & Friedman, 2020; Bulik et al., 2007). There is an urgent need to develop effective and accessible interventions for AN.

Mindfulness-based interventions (MBIs) involve systematic meditation training to enhance one's ability to intentionally pay attention to present-moment experiences (e.g., sensations, emotions, thoughts, external stimuli) with openness and acceptance (Chawla et al., 2010; Kabat-Zinn, 2003; Segal et al., 2002). MBIs may be promising for treating AN for several reasons. First, several decades of research have shown that MBIs are efficacious across many psychiatric disorders, such as depression (Kuyken et al., 2008; Williams et al., 2014), anxiety disorders (Goldberg et al., 2018), chronic pain (Goldberg et al., 2018; Hilton et al., 2017), substance use disorders (Goldberg et al., 2018; Grant et al., 2017), and attention-deficit/hyperactivity disorder (Cairncross & Miller, 2020). Furthermore, a recent meta-analysis indicates that MBIs are of similar potency to other evidence-based treatments (e.g., CBT, medications), and in some cases outperform other evidence-based treatments (Goldberg et al., 2018). Notably, research shows that MBIs are most effective for individuals with more severe psychopathology (i.e., higher primary disorder severity and/or co-occurring disorders; Piet & Hougaard, 2011; Roos et al., 2017). Therefore, MBIs may be particularly helpful for individuals with AN, who often present with severe psychopathology and co-occurring disorders (Braun et al., 1994).

Second, MBIs are designed to address deficits in emotion regulation and mindfulness (Lindsay & Creswell, 2017; Shapiro et al., 2006), and research has shown that both of these constructs play an important role in maintaining AN (Oldershaw et al., 2011, 2015; Westwood et al., 2017). Emotion regulation has been conceptualized as the ability to modulate the frequency, intensity, duration, and expression of emotional experiences (Gross, 2014). Meta-analytic research shows that individuals with AN exhibit greater deficits in emotion regulation than healthy controls (Oldershaw et al., 2011, 2015; Westwood et al.) and that greater deficits in emotion regulation are associated with more severe ED symptoms among individuals with AN (Prefit et al., 2019). Mindfulness overlaps with emotion regulation to some extent (Hayes & Feldman, 2004); it is a two-component construct that involves (1) attention towards a range of experiences in the present

moment (including external stimuli and situations that do not necessarily elicit salient emotions), including the ability to observe and describe present-moment experiences, coupled with (2) an open and accepting attitude towards the present moment, including a capacity to be nonreactive, nonjudgmental, and act with awareness (Baer et al., 2006; Bergomi et al., 2013; Bishop et al., 2004). Notably, it has been suggested that mindfulness might enhance emotion regulation by promoting emotion awareness and acceptance (Teper et al., 2013), and research has shown strong correlations between mindfulness and emotion regulation (Goodall et al., 2012). Meta-analytic research shows that deficits in mindfulness are associated with more severe ED symptoms (Sala et al., 2020). Together, deficits in mindfulness and emotion regulation may maintain AN because they enhance the likelihood that individuals engage in ED behaviors (e.g., restriction, vomiting, excessive exercise, body checking, self-weighing, etc.) in an *automatic, reflexive manner* in the presence of key internal and external triggers (e.g., difficult emotions, intrusive ED thoughts, meals). Current AN treatments (e.g., CBT) do not adequately address emotion regulation difficulties. Therefore, it is imperative to target mindfulness and emotion regulation in interventions for AN.

Third, MBIs have been shown to be efficacious for other EDs. Specifically, MBIs have been developed and evaluated for binge eating disorder (BED), with several meta-analyses supporting the efficacy of these MTs for BED (Godfrey et al., 2015; Turgon et al., 2019). For example, one study found that an MBI was as efficacious as CBT for the treatment of BED (Kristeller et al., 2014). Thus, there is precedence for applying MBIs for individuals with EDs. However, despite the promising potential of MBIs for targeting mindfulness and emotion regulation in AN, there is scant research on MBIs among individuals with AN. Two nonrandomized open trials evaluated multimodal treatments with mindfulness training as a component, and found evidence for feasibility and reductions in ED symptoms over time (e.g., body checking, body avoidance and anxiety, global ED symptoms; Morgan et al., 2014; Wildes et al., 2014). Additionally, preliminary randomized trials of third-wave behavioral therapies that include mindfulness training as one component (e.g., acceptance and commitment therapy and dialectical behavioral therapy) have demonstrated efficacy among heterogeneous samples of individuals with EDs, including some with AN (Linardon et al., 2017). Hence, although the body of research is nascent, extant empirical research suggests that

mindfulness training is acceptable and feasible, and may be efficacious among individuals with AN.

Although MBIs have been traditionally delivered via in-person format, more recent research has begun evaluating the delivery of MBIs via digital platforms, such as via self-guided web- and app-based multimedia programs (Spijkerman et al., 2016). For example, web-based MBCT has demonstrated efficacy for reducing relapse for depression (Segal et al., 2020). Notably, MBIs are particularly suitable for digital delivery because their primary component is guided mindfulness meditation, which can be provided via audio/video recordings. Digital MBIs thus have the potential for widespread scalability and may be particularly valuable to offer as adjunctive treatment, during critical transition periods in clinical care when provider contact is reduced (e.g., stepping down acute care to aftercare), or as a stand-alone intervention for patients who are unable to access in-person care.

Currently, to our knowledge, there are no digital MBIs designed for individuals with AN. Yet, researchers have begun to develop and evaluate other types of digital interventions for AN (Fairburn & Patel, 2017; Neumayr et al., 2019). For example, a smartphone application called *Recovery Record* has been applied as an AN intervention tool. *Recovery Record* primarily includes cognitive-behavioral treatment components, such as self-monitoring, meal planning, and goal setting (Tregarthen et al., 2015). The application is also integrated into in-person clinical care, with one version of the app for patients and another for therapists (to monitor patient's activity in the app and provide feedback). In a small, randomized trial among individuals with AN who were recently discharged from inpatient treatment, *Recovery Record* led to small-to-moderate yet nonsignificant improvements in body mass index and ED symptoms relative to treatment-as-usual (Neumayr et al., 2019). A larger scale randomized trial of *Recovery Record* is currently under way (Schlegl et al., 2020). Overall, existing digital interventions for AN, such as *Recovery Record*, show promise. However, there remains a critical need for further research on the application of digital interventions for AN, especially MBIs.

CURRENT STUDY

Our team developed a beta-version of a digital MBI for AN, called *Mindful Courage-Beta*, which includes one foundational multimedia module and 10 daily meditation mini-modules. *Mindful*

Courage-Beta focuses on formal mindfulness meditation training and teaches a core mindfulness skill set called the BOAT—an acronym for Breathe, Observe, Accept, Take a Moment. We conducted a 2-week open pilot trial of *Mindful Courage-Beta* among individuals with past-year AN or atypical AN. Our first aim was to evaluate acceptability and feasibility. Our second aim was to evaluate use of the BOAT and its association with state mindfulness in daily life [assessed via ecological momentary assessment (EMA); 4 surveys per day]. This second aim was included to investigate whether use of this set of skills taught in the intervention was effective in mobilizing changes in a target treatment mechanism. Moreover, EMA data enables investigation of putative causal links among skill use and treatment mechanisms at the intra-individual level, even with small samples. For this study, we opted to focus on mindfulness as the key momentary mechanism in daily life because we expected it to change in a variety of daily situational contexts when using the BOAT. Our third aim was to evaluate pre-to-post changes in target mechanisms (emotion regulation and mindfulness) and outcomes (ED symptoms and body dissatisfaction).

Method

PARTICIPANTS

Data collection occurred from March 2021 until September 2021. We nationally recruited 18 individuals with current or recent (within the past year) DSM-5 (APA, 2013) AN or atypical AN. Eligible participants were those who: (1) met DSM-5 criteria for AN or atypical AN within the last year; (2) were 18 years or older; (3) had the ability to read and write in English; (4) owned a smartphone; (5) had a private space or headphones to complete digital modules; and (6) were willing to commit to a 2-week intervention period. Exclusion criteria were: (1) current or recent substance use disorder; (2) current or recent untreated bipolar or psychotic disorder; (3) current suicidal intent; (4) medical instability, including BMI < 15; or (5) significant cognitive impairment that limited effective participation in the intervention. All potential participants were recruited via email (e.g., ED treatment center alumni network emails), social media (e.g., Twitter, Facebook, Reddit), and the investigators' lab websites. Participants were compensated up to \$120. All eligible participants provided informed consent and all study procedures were approved by the Yeshiva University Institutional Review Board.

PROCEDURE

Participants who were interested were directed to a brief survey on Qualtrics to determine preliminary eligibility. Questions included whether the participant had a recent AN or atypical AN diagnosis, height, weight, smartphone ownership, and access to a private space or headphones. We screened responses and contacted potentially eligible participants, inviting them for a Zoom-based screening interview. Please see Figure 1 for the CONSORT flow diagram.

At the beginning of the Zoom-based screening interview, a research coordinator obtained electronic informed consent, and then asked about current height and weight, current enrollment in AN treatment, medical problems, past 3 months

substance use, past 3 months bipolar or psychotic disorder, suicidal ideation/intent/plan (measured via the Columbia Suicide Severity Rating Scale; Posner et al., 2008), cognitive impairment, and recent AN diagnosis (measured via the Structured Clinical Interview for DSM V AN module; First, 2015). Participants who were deemed eligible were invited to enroll in the study and proceed to the first study session (also conducted over Zoom). This first session involved completing a battery of self-report measures via an online questionnaire (see Measures section below), completing the foundational web module of Mindful Courage (see Intervention section), and receiving instructions on how to access the rest of the intervention (i.e., the mini-modules) and how to complete EMA

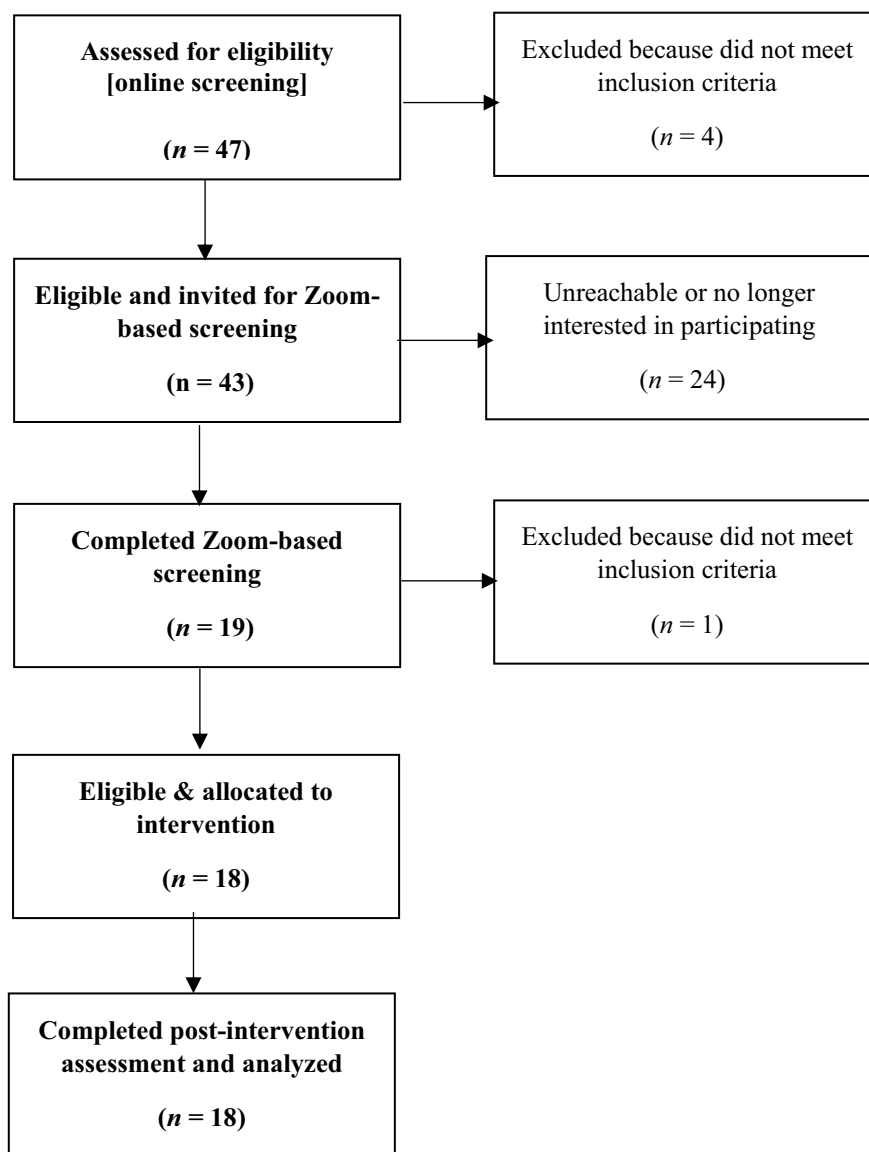


FIGURE 1 CONSORT Participant Flow Chart.

surveys during the upcoming 2 weeks. EMA was conducted via the Ethica smartphone app and included four surveys randomly administered within evenly spaced 90-minute time-blocks occurring between 8 a.m. – 8:30 p.m. each day for the duration of the 2-week intervention period. After the initial prompt was sent, the survey was available for 1 hour, and participants received one reminder notification after 30 minutes. As part of the \$120 study compensation, participants received \$1 for each completed EMA survey and received an additional \$10 bonus if they completed at least 75% of the EMA surveys. Upon completion of the 2-week intervention period, participants again completed several of the self-report measures that they completed at baseline via an online questionnaire (see Measures section below).

INTERVENTION

The treatment content of Mindful Courage-Beta is based on existing MBIs that center on formal mindfulness meditation training, including MBRP, MBCT, and Mindfulness-Based Stress Reduction (MBSR). Our team selectively drew from and adapted the content from these existing MBIs to create treatment content that is accessible and relevant to individuals with AN. We chose to create our own intervention rather than adapt an existing MBI for EDs into digital format because, to our knowledge, none of the existing MBIs for EDs have a targeted focus on improving emotional regulation. Mindful Courage-Beta has a specific focus on enhancing emotion regulation. Furthermore, unlike existing MBIs for EDs, Mindful Courage-Beta includes extensive discussion of how mindfulness skills can be applied to reduce ED behaviors, facilitate regular eating patterns, cope with general stressors in daily life, pursue valued life goals, and savor pleasant experiences. Further, Mindful Courage-Beta includes content on how mindfulness skills can be specifically applied to pathology that is applicable to AN (e.g., skipping meals, restricting calories, overexercising, coping with ED thoughts). As noted previously, Mindful Courage-Beta has a strong emphasis on a set of core mindfulness skills represented by the acronym BOAT (Breathe, Observe, Accept, Take a Moment). The BOAT was created by our team and is similar to acronyms used in other MBIs, such as “SOBER” (Stop, Observe, Breath, Expand, Respond) in MBRP. We intentionally included the word “Accept” in our acronym to directly target acceptance of momentary experience. Notably, recent research shows that awareness skills without acceptance may not be effective and that the acceptance component of mindfulness accounts

for reduced cognitive and affective reactivity to aversive experiences (Kober et al., 2019; Lindsay et al., 2018; Lindsay & Creswell, 2017). Mindful Courage-Beta includes 1 foundational web module (approximately 50-minutes) and 10 mini-modules (each approximately 15 minutes). Details on the treatment components in each module are provided in Table 1.

The foundational module includes brief animated videos, audio-guided meditation practices, and interactive questions and activities. The mini-modules include only brief animated videos and audio-guided meditation practices. The animated videos were created with Powtoon, (an online animation builder tool; powtoon.com), and modules were built with Rise (an e-course builder; Rise.com). Participants accessed the modules by signing in with an individual username and password to a web-based user portal, which tracked module completion and allowed participants to continue the program where they previously left off. Within the program, participants were guided through the intervention modules by a narrator, a clinical psychologist (author MS) represented in the animated videos as an “avatar.”

Finally, similar to other digital MBIs (Segal et al., 2020), Mindful Courage-Beta also included brief phone coaching (~10 minute). The intention of the phone coaching was to provide a minimal and simple-yet-effective “dose” of live person-delivered support to provide accountability and facilitate engagement (Mohr et al., 2011). Specifically, once per week for 2 weeks, clinical graduate students at Yeshiva University provided these brief coaching calls that included general motivational support (e.g., encouraging participants to continue with the modules) and technical support (e.g., answering questions about technical features of the web program), but did not include therapeutic content.

MEASURES

Screening Measures

Height and weight were self-reported for the calculation of body mass index (BMI). Notably, self-reported BMI is very closely correlated (Pearson’s $r = 0.97$) and not significantly different from objectively measured BMI in individuals with AN (Ciarapica et al., 2010). To establish AN diagnoses, we used the *Structured Clinical Interview for DSM-5* (SCID) AN module (First, 2015). The SCID diagnostic interviews were conducted by the first author’s clinical psychology doctoral students, who were trained and supervised by the first author (MS), a licensed clinical psychologist. Other inclusion/exclusion criteria (e.g., ability to

Table 1
Details About the Components Within Each Module of Mindful Courage

Foundational Module	Key Components
Getting Started (~ 50 minutes)	<ul style="list-style-type: none"> • Introduction to the program • Sights, Sounds, and Breath Meditation followed by experiential reflection questions • Brief video of therapist and client discussing experiential observations that arose during the Sights, Sounds, and Breath Meditation • Didactic information on mindfulness and its role in anorexia nervosa (AN) recovery • Reflection questions to elicit participant ideas regarding how mindfulness could play a role in their own recovery • BOAT (Breathe, Observe, Accept, Take a Moment) Meditation followed by experiential reflection questions • Card sorting activity matching descriptions to steps of the BOAT • Brief video of therapist and client discussing experiential observations that arose during the BOAT meditation • “Check Your Understanding” questions about key concepts • Patient sharing a testimonial of her experience with the program • Discussion of the importance of regular practice
Mini Modules (each ~ 15 min)	
1. Using the BOAT	<ul style="list-style-type: none"> • Review of BOAT steps • BOAT meditation • Practice tips (e.g., normalizing challenges)
2. Self-Compassion	<ul style="list-style-type: none"> • Didactic discussion of self-compassion, including importance of being kind to oneself when challenges arise during meditation practice • BOAT meditation with emphasis on self-compassion in “Take a Moment” step of BOAT • Practice tips: Using the BOAT when experiencing difficult ED-related thoughts and feelings
3. Taking a mindful pause	<ul style="list-style-type: none"> • Didactic discussion about taking a “mindful pause” • BOAT meditation with emphasis on taking a mindful pause in “Breathe” and the “Take a Moment” steps of BOAT • Practice tips: Noticing automatic ED urges and pausing to use the BOAT
4. Stepping back from thoughts	<ul style="list-style-type: none"> • Didactic discussion about the nature of thoughts and mindfully observing thoughts • BOAT meditation with emphasis on mindfully relating to thoughts in the “Observe” and “Accept” steps of BOAT • Practice tips: Using the BOAT when ED thoughts arise
5. Seeing thoughts as thoughts	<ul style="list-style-type: none"> • Didactic discussion of seeing thoughts as thoughts, not facts or commands • Walking Down the Street Exercise (noticing thoughts arising in an imaginal scenario and seeing them as just thoughts, that may or may not be true) • Practice tips: Not automatically believing our own thoughts when they arise
6. Emotions as visitors	<ul style="list-style-type: none"> • Didactic discussion about the nature of emotions • Reading of the Guest House Poem paired with Mindfulness of Emotions Meditation • Practice tips: Labeling and accepting emotions when they visit
7. Riding out urges	<ul style="list-style-type: none"> • Didactic discussion about the nature of urges • Urge Surfing Meditation (imagining a situation eliciting an ED urge and practicing riding urges out with openness and acceptance) • Practice tips: Bringing curiosity to the experience of urges in daily life
8. Exploring our needs	<ul style="list-style-type: none"> • Didactic discussion about striving for thinness • Exploring our Needs Meditation (imagining a situation eliciting an ED urge and pausing to reflect on other potential underlying needs beyond desire to be thin) • Practice tips: Pausing to reflect on other potential needs/ways to take care of self when ED urges arise
9. Being curious	<ul style="list-style-type: none"> • Didactic discussion about the role of curiosity in mindfulness • Curiosity Meditation (noticing the 5 senses and exploring what one may appreciate) • Practice tips: Curiosity as a way to increase engagement in present moment activities • Didactic discussion about personal values
10. Reflecting on values	<ul style="list-style-type: none"> • Values Meditation (reflecting on values in various life domains and noticing momentary experiences arising) • Practice tips: Mindfully reflecting on values to increase motivation and committed action towards life goals and expand beyond preoccupation with weight/shape

write and write English, substance use disorder status, bipolar/psychotic disorder, suicide intent, medical instability, cognitive impairment) were assessed by single-item questions.

Acceptability

Guided by the Technology Acceptance Model (Marangunić & Granić, 2015), the acceptability measure included questions on ease-of-use (i.e., usability and understandability) and perceived helpfulness (i.e., extent to which participants believed Mindful Courage to be helpful). Specifically, we assessed ease-of-use of the navigation system and website, the visual appeal of the content, program quality, understandability of the program material, comfort in recommending to a friend, likelihood of using the program again, and program satisfaction. We also assessed the extent to which participants found components of the program helpful, including the foundational module, foundational module reflection questions, daily meditations, and phone coaching. Participants rated their responses on each of these questions from 0 (*not at all*) to 10 (*extremely*) and a mean score was calculated across participants. Internal consistency was good ($\alpha = .88$).

Additionally, during the follow-up visit, participants were asked to provide free responses to the following questions: (1) What were your overall thoughts after trying out this 2-week program? (2) What aspects of this program were most useful? (3) What aspects of this program were not useful or were in any way annoying? (4) What would you have liked added to this program? (5) What do you think of the overall “look” or “design” of the program? Did you find the design appealing? Why or why not? (6) What are your thoughts about the audio-guided mindfulness practices? (7) Overall, did you find the program “relatable” or “applicable” to you as a person, your life, and your current situation. Why or why not? (8) Was the program engaging enough? What would have helped you to engage in the program more? (9) Do you think that mindfulness can help people in the process of recovering from anorexia nervosa? If so, in what specific ways? (10) What did you learn from the program? Thematic analyses were conducted to derive themes from written feedback about the acceptability of the intervention.

Feasibility

Feasibility was assessed by tracking completion of the initial module and mini-modules as well as percent of participant retention in the final study assessment. Of note, the *Rise* program enabled the objective tracking of user activity while completing modules (e.g., percent of modules completed).

Eating Disorder Examination–Questionnaire (EDE-Q; Fairburn & Beglin, 1994)

ED symptoms were assessed with the EDE-Q at the baseline assessment and at 2-week follow-up. The EDE-Q is a 28-item self-report version of the EDE, and measures core features of EDs. It has four subscales: (1) restraint; (2) eating concern; (3) shape concern; and (4) weight concern. The EDE-Q asks participants about various ED cognitions and behaviors over the past 28 days. For the current study, we modified the EDE-Q instructions when we administered it at the post-intervention assessment to ask about ED cognitions and behaviors over the past 14 days in order to measure changes in ED symptoms while the intervention was being administered. The EDE-Q has good psychometric properties (Berg et al., 2012). In the current study, internal consistency was excellent (global baseline $\alpha = .92$; global follow-up $\alpha = .95$).

Body Shape Questionnaire (BSQ; Cooper et al., 1987)

Body dissatisfaction was assessed with the BSQ. The BSQ is a 34-item self-report scale with excellent psychometric properties (Cooper et al., 1987; Pook et al., 2008; Pook & Tuschen-Caffier, 2004; Rosen, 1996). In the current study, internal consistency was excellent (baseline $\alpha = .95$; follow-up $\alpha = .97$).

Difficulties in Emotion Regulation Scale Short Form (DERS-SF; Kaufman et al., 2016)

Emotion regulation was assessed via the DERS-SF at the baseline assessment and at 2-week follow-up. The DERS-SF is 16-item, short-form version of the DERS and has strong psychometric properties for the measurement of emotion regulation problems, demonstrating convergent validity with the original DERS measure (Kaufman et al., 2016). The DERS-SF has six subscales: (1) emotional nonacceptance; (2) difficulty with goal-oriented behavior when upset; (3) difficulty controlling impulses when upset; (4) lack of emotional awareness; (5) perceived lack of access to strategies for coping with emotions; and (6) lack of emotional clarity. The DERS-SF has excellent psychometric properties (Kaufman et al.). In the current study, internal consistency was excellent (baseline $\alpha = .93$; follow-up $\alpha = .93$).

Cognitive and Affective Mindfulness Scale-Revised (CAMS-R; Feldman et al., 2006)

Trait mindfulness was assessed with the CAMS-R at the baseline assessment and at post-intervention. The CAMS-R is a 12-item measure of trait mindfulness that conceptualizes mindfulness as consisting of the ability to regulate atten-

tion, orientation to present-moment experience, awareness of experience, and an attitude of acceptance and nonjudgment towards experience. The CAMS-R has excellent psychometric properties, demonstrating convergent validity with other trait mindfulness measures and divergent validity from constructs such as distress and well-being (Feldman et al., 2006). In the current study, internal consistency was adequate to excellent (baseline $\alpha = .73$; follow-up $\alpha = .90$).

EMA Measures

BOAT skill use was measured with the following EMA item: *Since the last survey, how much did you use the BOAT technique (Breathe, Observe, Accept, Take a Moment)?* This item (and all EMA items) was rated on a Visual Analogue Scale (VAS) from 0 (*not at all*) to 100 (*very frequently*). For the purposes of examining frequency of using the BOAT, we computed a dichotomous variable capturing use or nonuse of the BOAT at each time interval. That is, we computed a dichotomous variable in which “not at all” (VAS values of 0–20) were coded as not using the BOAT skills (0) and any responses greater than “not at all” (VAS values of 21–100) were coded as using the BOAT skills (1). For multilevel analyses examining the association of BOAT use with state mindfulness, BOAT use was included as a continuous predictor with values ranging from 0 to 100 at each EMA timepoint.

State Mindfulness

State mindfulness was measured with three EMA items from the CAMS-R (Feldman et al., 2006) and adapted by changing language to present tense and adding the stem *right now*. These items included: (1) *Right now, I am focused on the present moment*; (2) *Right now, I can notice my emotions without judging them*; and (3) *Right now, I can accept the thoughts and feelings I am having* and were rated on a VAS from 0 (*strongly disagree*) to 100 (*strongly agree*). We selected these items to assess both the present-moment awareness and acceptance components of mindfulness. Internal consistency was excellent ($\alpha = .90$).

DATA ANALYSIS

All data were analyzed in SPSS version 27.0. We used descriptive statistics to examine the acceptability and feasibility of the intervention. Paired sample *t*-tests were conducted to evaluate pre-to-post changes in trait mindfulness, emotion regulation, ED symptoms, and body dissatisfaction. Effect sizes were computed by transforming the *t*-statistic to a Cohen’s *d* effect size. Following standard convention, a 0.2 effect size was consid-

ered small, a 0.5 effect size was considered medium, and a 0.8 effect size was considered large. Thematic analyses were used to derive themes from written feedback about the acceptability of the intervention. After meaningful themes were identified, the first author and one of her graduate students grouped each statement into one or more meaningful themes. Any disagreements were discussed among the two coders and resolved.

To analyze whether BOAT skill use was associated with state mindfulness as measured via EMA, we used multilevel linear modeling (MLM) with an AR1 correlation structure, fixed predictors, and random intercepts. We employed restricted maximum likelihood estimation (REML) given the small sample size. We also disaggregated all time varying predictors into the participant’s average level across all EMA surveys (the between-person component) and deviations from the mean at each survey (the within-person component). We only report within-person effects, as they reflect the degree to which an individual’s momentary value of a variable differs from that individual’s average level across EMA surveys.

Results

DESCRIPTIVES

Please see Table 2 for descriptive information. The average age of AN onset was 16.1 ($SD = 5.4$). Most ($n = 11$; 61.1%) participants had a BMI over 17, 4 (22.2%) had a BMI of 16–16.99, and 3 (16.7%) had a BMI between 15 and 15.99. All participants were still engaging in ED behaviors and none reported being fully recovered, but 7 individuals with AN were in partial remission

Table 2
Patient Demographics ($n = 18$)

	<i>M (SD) or n (%)</i>
Age (<i>M, SD</i>)	30.7 (2.7)
BMI (<i>M, SD</i>)	18.6 (2.2)
Gender (<i>n, %</i>)	
Female	17 (94.4%)
Male	1 (5.6%)
Race/Ethnicity (<i>n, %</i>)	
Non-Hispanic White	14 (77.8%)
Black	1 (5.6%)
Asian	1 (5.6%)
Other	2 (11.1%)
Diagnosis	
AN-R	13 (72.2%)
AN-BP	3 (16.7%)
Atypical AN	2 (11.1%)

Notes: AN-R = Anorexia Nervosa – Restrictive Subtype; AN-BP = Anorexia Nervosa Binge Purge; Atypical AN = Atypical Anorexia Nervosa.

(i.e., current BMI > 18.5 and full criteria for AN where met in the past year). Within the past year, 7 participants reported receiving inpatient or residential treatment, 6 reported receiving outpatient treatment, and 5 reported receiving no treatment.

ACCEPTABILITY AND FEASIBILITY

Acceptability

The mean ease-of-use rating was 8.2/10 ($SD = 1.31$; Range = 5.11–9.44), the mean helpfulness ratings was 7.6/10 ($SD = 1.15$; Range = 5.50–10.00). The mean scores for each individual acceptability question were all above 7 (see Table 3).

Results from written responses to open-ended acceptability questions also indicated general acceptance of the intervention. Percentages in parentheses indicates the percent of responses containing that theme. Below, we report themes that emerged for at least 20% of participants. For a full description of all themes and examples, see Supplementary Table 1. Overall, extracted themes indicated that over a third of participants (38.9%) reported that the program was *pretty good overall*, a third (33.3%) reported that the program made them *more mindful*, and a third (33.33%) reported that the program helped them *cope with negative thoughts and/or emotions*. Two third of the participants (66.7%) stated that the *mini-sessions* were the most helpful part of the program, and over a third (38.9%) reported that *checking in with thoughts and emotions* was most helpful. Most participants (77.8%) reported that the program had an *appealing design*, but four participants (22.2%) reported that they *did not like the animations*. Almost all participants (94.4%) reported that the audio-guided mindfulness practices were *very good and/or helpful*, and

almost all participants (88.9%) reported that the program was *relatable and/or applicable* to their life and current situation. Most participants (55.6%) found the program to be *engaging*. Most participants (83.3%) reported that the program was *helpful in the process of recovering from AN*. In regards to skills learned, participants reported that they learned *the BOAT technique* (27.8%), *accepting their thoughts and emotions* (27.8%), *identifying their emotions/thoughts* (22.8%), *checking in with themselves* (22.2%), and *mindfulness meditation practice* (22.2%).

Feasibility

The completion rate for the foundational module was 100%. The completion rate for the mini-modules was 96%. Specifically, out of 18 participants, 16 completed all the mini-modules, 1 completed 90% of the mini-modules, and 1 completed 30% of the mini-modules. All participants completed the post-intervention assessment.

USE OF THE BOAT AND STATE MINDFULNESS IN DAILY LIFE

Participants completed an average of 74.6% of EMA prompts, which is consistent EMA completion among clinical populations (Jones et al., 2019; Vachon et al., 2019). On average, participants reported using the BOAT 25.2 times (Range = 2–50, $SD = 13.2$) during the 2-week intervention period, or an average of 1.8 times per day. At the within-person level, greater use of the BOAT was significantly associated with higher state mindfulness ($b = .09$, $SE = .03$, $p = .005$). In other words, using the BOAT more than usual during a given time interval in daily life (e.g., reporting on a 2-hour interval when completing an EMA survey at noon and the last EMA survey was at 10:00 a.m.) was associated with higher

Table 3
Acceptability Ratings

	M	SD	Range
Overall, how satisfied are you with the program you just received?	7.57	1.59	4–10
How easy was it to navigate through the web program?	8.94	1.26	6–10
Please rate the visual appeal of the content	7.28	1.93	4–10
How likely would you be to continue using this program?	7.11	2.37	1–10
Please rate the ease of use of the website	8.79	1.70	4–10
How comfortable would you be recommending this program to a friend who is recovering from anorexia nervosa?	8.50	1.69	6–10
How likely would you be to participate in this program again for further help?	8.06	2.51	1–10
How understandable was the learning material presented in the program?	9.33	.77	8–10
How helpful did you find the 40-minute web module at baseline?	7.79	1.77	3–10
How helpful did you find the reflection questions?	7.39	2.12	3–10
How helpful did you find the 10 mini-sessions?	8.17	1.69	4–10
How helpful did you find the weekly check-ins with the coach?	7.17	1.95	3–10

Note. Participants rated their responses on each of these questions from 0 to 10.

than usual state mindfulness for an individual (e.g., at noon).

PRE-TO-POST CHANGE IN TARGET MECHANISMS

Participants exhibited decreases in DERS-SF total scores from pre- to post-intervention ($M = 3.10$; $SD = .80$; $M = 2.56$, $SD = .73$, respectively), indicating improvement in emotion regulation. This difference reflects a large effect size ($d = .76$) that was also statistically significant ($t_{(17)} = 3.24$, $p = .005$). Further, participants exhibited medium-to-large size statistically significant decreases in the DERS-SF subscales of nonacceptance, difficulty with goal-directed behavior, lack of emotional awareness, and lack of emotional clarity (see Table 4). Decreases in the DERS-SF subscales of difficulty controlling impulses and perceived lack of access to strategies were small and medium in size, respectively, and were not statistically significant (see Table 4). Participants exhibited increases in CAMS-R scores from pre- to post-intervention ($M = 1.95$; $SD = .40$; $M = 2.46$, $SD = .54$), indicating an increase in self-reported trait mindfulness. This difference reflects a large effect size ($d = .96$) that was also statistically significant ($t_{(17)} = -4.05$, $p = .001$).

PRE-TO-POST CHANGES IN OUTCOMES: ED SYMPTOMS AND BODY DISSATISFACTION

Participants self-reported decreases in the EDE-Q Global score from pre- to post-intervention ($M = 3.94$; $SD = 1.12$; $M = 3.48$, $SD = 1.29$). This difference reflects a medium-to-large effect size ($d = 0.60$) that was also statistically significant ($t_{(17)} = 2.54$, $p = .02$). Regarding specific subscales, participants exhibited medium-large size statistically significant decreases in EDE-Q Eating Concern and Shape Concern scores (see Table 4). Decreases in the EDE-Q Restraint and Weight Concern scores were small-to-medium in size and were not statistically significant (see Table 4).

Participants also exhibited decreases in their BSQ score from pre- to post-intervention ($M = 132.3$; $SD = 31.1$; $M = 117.2$, $SD = 37.0$), indicating a decrease in body dissatisfaction. This difference reflects a medium-large effect size ($d = 0.60$) that was statistically significant ($t_{(17)} = 2.57$, $p = .02$).

CORRELATIONS AMONG TARGETED CHANGES MECHANISMS AND OUTCOMES

We present correlations among changes in target mechanisms and changes in outcomes in Supplementary Table 2. Changes in trait mindfulness

Table 4
Mean Scores (Standard Deviations) on Treatment Outcome Variables From Pre- to Post-Intervention, Test Statistics (Paired Sample t Tests, Effect Sizes)

Outcome	Pre M (SD)	Post M (SD)	Pre vs. post test Statistic, ES
Emotion Regulation			
DERS Nonacceptance	3.33 (.94)	2.72 (1.02)	$t = 2.16^*$; $d = .51$
DERS Goals difficulty	3.65 (1.01)	3.09 (1.21)	$t = 2.54^*$; $d = .60$
DERS Impulsivity	2.08 (1.21)	1.72 (1.04)	$t = 1.32$; $d = .31$
DERS Lack of awareness	3.26 (.71)	2.83 (.80)	$t = 2.36^*$; $d = .56$
DERS Access to strategies	2.86 (1.06)	2.37 (.93)	$t = 2.02$; $d = .48$
DERS Lack of clarity	3.02 (1.06)	2.57 (.89)	$t = 2.54^*$; $d = .60$
DERS Total	3.10 (.80)	2.56 (.73)	$t = 3.24^{**}$; $d = .76$
Trait Mindfulness			
CAMS-R	1.95 (.40)	2.46 (.54)	$t = -4.05^{***}$; $d = .96$
ED Symptoms			
EDE-Q Restraint	3.74 (1.44)	3.27 (1.33)	$t = 1.53$; $d = .36$
EDE-Q Eating Concern	3.50 (1.19)	3.01 (1.57)	$t = 2.44^*$; $d = .58$
EDE-Q Shape Concern	4.61 (1.21)	4.11 (1.41)	$t = 2.81^*$; $d = .67$
EDE-Q Weight Concern	3.91 (1.43)	3.54 (1.53)	$t = 1.49$; $d = .35$
EDE-Q Global	3.94 (1.12)	3.48 (1.29)	$t = 2.54^*$; $d = .60$
Body Dissatisfaction			
BSQ	132.3 (31.1)	117.2 (37.0)	$t = 2.57^*$; $d = .60$

Note. ED = Eating Disorder; DERS-SF = Difficulties in Emotion Regulation Scale Short Form; CAMS-R = Cognitive and Affective Mindfulness Scale-Revised; EDE-Q = Eating Disorder Examination – Questionnaire; BSQ = Body Shape Questionnaire.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

and emotion regulation had a medium-large size correlation with changes in global ED symptoms and body dissatisfaction ($r_s = .43-.56$).

Discussion

Results from this open pilot trial of Mindful Courage-Beta, a beta-version of a digital MBI for AN, are highly encouraging. Mindful Courage-Beta was feasible and highly acceptable to participants. In a relatively short period of time (2 weeks), we found significant, large improvements in the target mechanisms of trait mindfulness and emotion regulation, as well as significant, small-medium to medium-large reductions in ED symptoms and body dissatisfaction. Furthermore, EMA revealed that participants frequently used the core BOAT skills in daily life and that greater use of the BOAT was associated with higher state mindfulness at the within-person level.

Feasibility was demonstrated by excellent rates of treatment adherence. All participants completed the foundational module, and compliance with the daily meditation 10 mini-modules was 96%. This rate of engagement is much higher than that of other digital and smartphone-based interventions for EDs (Jacobi et al., 2017; Juarascio, Felonis, et al., 2021; Pretorius et al., 2009). Our rate of engagement may be higher than that of previous digital and smartphone-based interventions for EDs because we employed brief phone coaching, which may have played a key role in providing supportive accountability and facilitating intervention engagement (Mohr et al., 2011). Indeed, in written feedback, several participants noted that they found the phone coaching calls (in addition to other aspects of the intervention) to be helpful. It is also important to mention that no participant dropped out, and all participants completed the follow-up assessment. The high adherence stands in sharp contrast to in-person AN treatments, where dropout rates are 20%–46% (Dejong et al., 2012).

Acceptability was demonstrated by high ratings on ease-of-use and helpfulness. Overall, participants found Mindful Courage-Beta easy to navigate, visually appealing, easy to use, of high quality, and satisfactory. Participants reported that they would be likely to continue using the program, as well as recommend it to a friend. Participants also found the intervention to be helpful, rating the foundational module, reflection questions, mini-modules, and calls with the coach to be helpful. We also obtained qualitative written feedback about intervention acceptability and ideas for improvement. Themes that emerged from written feedback included overall satisfaction, per-

ception that the program was helpful for recovering from AN and engaging, finding the daily mini-modules particularly helpful, satisfaction with the design, learning to cope with unhelpful thoughts and emotions, and learning how to identify and accept emotions. This latter theme is in line with research that suggests that MBIs may be helpful by improving emotion regulation (Juarascio, Felonis, et al., 2021). Several themes for improving the program emerged, including wanting the program to be longer and to include more mindfulness techniques, higher-quality audio-recordings, more interactivity, and more detailed and diverse animations. These recommendations for improvement will be incorporated in the next phase of refining Mindful Courage.

We integrated EMA into this pilot study—4 surveys/day capturing approximately 2- to 4-hour time intervals—to delve deeper into skill utilization in daily life and its link with a target treatment mechanism. Skill utilization in this study was high. Participants reported use of the BOAT skills an average of 1.8 times per day across the 2-week period—or nearly 50% of EMA assessments. Moreover, greater use of the BOAT was significantly associated with higher state mindfulness at the within-person level, suggesting that, intra-individually, greater use of the BOAT (compared to usual) was associated with higher than usual state mindfulness. This finding is important because it links specific intervention skills with a putative mechanism, thereby supporting the theorized causal chain of events that facilitate therapeutic change in MBIs such as Mindful Courage-Beta.

The significant and large-sized improvement in emotion regulation and mindfulness, in only a 2-week period, is encouraging and suggests that the intervention is mobilizing changes in the target mechanisms. Furthermore, changes in emotion regulation and mindfulness had medium-large size correlations with changes in global ED symptoms and body dissatisfaction. Regarding specific dimensions of emotion regulation as measured by the DERS-SF, we found significant improvements in emotional nonacceptance, lack of emotional awareness and clarity, and difficulty with goal-oriented behavior when upset. Altogether, our findings provide preliminary evidence that the intervention may improve individuals' abilities to regulate attention, orient themselves to the present-moment, recognize emotional experiences in the moment, relate to momentary experiences with acceptance and non-judgment, and engage in goal-oriented behavior when distressed. These findings are in line with other research that shows

that MBIs for EDs improve trait mindfulness (Barney et al., 2019) and emotion regulation (Juarascio, Michael, et al., 2021). Future research with a randomized design and longer assessment period is needed to further elucidate how the intervention works and the extent to which it may mobilize changes in these mechanisms to a greater degree than comparison treatments.

The significant and small-medium to medium-large sized reductions in ED symptoms and body dissatisfaction during a 2-week period is promising and suggests that the intervention may be effective, at least in the short-term. Regarding specific types of ED symptoms as measured by the EDE-Q, we found significant reductions in eating concern and shape concern. Although decreases in restraint and weight concern were not significant, the effect sizes were small-to-medium size with participant averaging a decrease of half a point in EDE-Q subscale scores. Again, future work with a randomized design and longer assessment period will clarify the extent to which the intervention is efficacious. Further, a longer version of the intervention may be needed to enact more significant change in such symptoms. Notably, in this study we did not assess changes in BMI as an outcome because we did not expect BMI to change over such a short treatment period, but it will be important to assess BMI in future studies to see if this intervention results in objective changes in key AN outcomes.

Notably, it is rare for pilot intervention studies to employ intensive longitudinal designs to examine skill utilization and mechanisms at the within-person level. Hence, this feature of our study is a unique strength and demonstrates the value of integrating EMA into pilot intervention research. In future research on Mindful Courage, we plan to integrate EMA to further investigate treatment mechanisms of change in daily life—including an investigation of how this intervention, relative to a comparison treatments, may weaken the within-person momentary link between emotions and ED behaviors.

After this promising pilot study, key next steps include refining and lengthening Mindful Courage, and conducting a randomized controlled trial comparing it against a control intervention among individuals with AN and other EDs. Our long-term goal is to develop a full-length (i.e., that matches the length of MBIs for other disorders, 12–20 sessions, over 8–12 weeks) digital MBI for AN that is both accessible and effective. This type of intervention may be integrated into existing treatment programs and/or may reach patients who cannot access other treatment. As a digital

tool, Mindful Courage may also be useful in the long-term, to be used for many years in order to maintain ongoing skills.

Limitations of this study must be considered. First, this study was conducted with a very small sample size, and findings are therefore tentative, as small sample sizes provide less precise estimates of population effect sizes (Leon et al., 2011). Given the very small sample size, subscale findings should be interpreted with particular caution. Second, given that this was a pilot feasibility and acceptability study, participants were not randomized to Mindful Courage, and we did not employ a control condition. Thus, we cannot confidently attribute improvements to Mindful Courage-Beta. Third, our sample may not have reflected the general AN population due to self-selection to participate. For example, it is possible that participants who self-referred to the study based on our advertisements had higher levels of motivation to recover than the general clinical AN population. Fourth, the high compensation of the study, which was necessary to incentivize EMA completion, may have artificially increased acceptability. However, it is important to note that we did not incentivize module completion. Finally, there was a lack of diversity in the sample studied. Specifically, most of the sample consisted of White women with mild AN-R. It is unclear whether findings would generalize to men, individuals of other races and ethnicities, individuals with AN-BP, and individuals with more severe AN.

Despite these limitations, this study was innovative and the results suggest that Mindful Courage-Beta is acceptable, feasible, and may promote improvements in trait mindfulness, emotion regulation, ED symptoms, and body dissatisfaction. This pilot trial provides groundwork for future research on digital MBIs for AN and other EDs.

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