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ORIGINAL PAPER

What Are You Hungry for? The 9 Hunger Mindful Eating Online Randomized Controlled Trial

Diana Peitz[1] · **Petra Warschburger**[1]

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Abstract

Objectives Mindful eating (ME) has been receiving increased attention in the treatment of eating and weight disorders. In this context, the ME approach is assumed to help modify maladaptive eating behaviors. This work investigated the effects of a brief ME intervention that focused on the non-judgmental awareness of different motivations to eat in order to study this mechanism.

Method Using a randomized controlled trial design, participants were allocated to an intervention group (IG; $n = 87$) or waitlist control group (W-CG; $n = 137$). For a 2-week training phase, participants of the IG were instructed to take a mindful moment to rate their different motivations to eat once per day. Self-report data on emotional eating, external eating, and loss of control eating (primary outcomes) and intuitive eating, ME, mental well-being, and self-compassion (secondary outcomes) were gathered online pre, post, and 3 months after the training. Latent change score (LCS) models were used to estimate shorter and longer term effects of the intervention.

Results LCS revealed significant shorter and longer term effects of the training when comparing data of the IG with those of the W-CG regarding all primary ($d = 0.38$–0.61) and most secondary outcomes ($d = 0.29$–1.16).

Conclusions The positive and sustainable effects of practicing this clearly outlined ME skill over a short period support the idea that ME might be a promising approach to enrich the current treatment of eating and weight disorders and aid in expanding our understanding of the underlying mechanisms on its application in the field.

Preregistration This study was preregistered at the German Clinical Trials Register (DRKS00012351).

Keywords Mindful eating · Eating and weight disorders · Online intervention · Mechanisms of action · Randomized control trial (RCT)

Eating is driven not only by the physiological need to eat but by several motives and triggers (Renner et al., 2012). Next to internal processes such as hunger and satiety, a variety of other cues trigger the initiation and termination of food intake. Therefore, the response to these cues is also assumed to influence the development of non-homeostatic eating (i.e., eating for other than physiological reasons), such as *emotional eating* (eating in response to emotions), *external eating* (eating in response to external cues), *loss of control eating* (LOC), or *binge eating* (Brewer et al., 2018). Since these eating behaviors can be considered non-adaptive in relation to physiological needs, they are often called *maladaptive eating behaviors*, especially when used extensively. These maladaptive eating behaviors were found to be involved in the development and maintenance of eating- and weight-related problems (Colles et al., 2008; Greeno et al., 2000; He et al., 2017; Patel & Schlundt, 2001; Ricca et al., 2012; Tanofsky-Kraff et al., 2011), revealing a promising starting point for their prevention and treatment.

The application of mindfulness (non-judgmentally paying attention to the present moment; Kabat-Zinn, 2013), i.e., mindfulness-based interventions (MBIs), has been found to improve maladaptive eating behaviors across persons with and without eating and weight disorders (Warren et al., 2017). For example, mindful awareness was found to be associated with lower craving (Sala et al., 2021). However, though several underlying mechanisms are assumed (e.g., self-regulation, emotion regulation), empirical research on

✉ Diana Peitz
dpeitz@uni-potsdam.de

[1] Department of Psychology, Counseling Psychology, University of Potsdam, Karl-Liebknecht-Str. 24-25, 14476 Potsdam, Germany

their direct investigation is scarce (Barney et al., 2019; Rogers et al., 2017; Tapper, 2017). Moreover, their investigation is hampered by the fact that mostly the effects of multi-component interventions are studied, making it difficult to clearly determine the specific effects of certain elements, such as mindfulness-immanent qualities and their unique importance relative to other components (Tapper, 2022).

One RCT provided first evidence that effects of a mindfulness-enhanced diet and exercise intervention might be mediated by the context-specific skill of *mindful eating* in terms of eating sweet foods and fasting glucose in adults with obesity (Mason et al., 2016). Another cross-sectional study showed that the relationship between generic mindfulness and the self-reported serving size of energy-dense food could be explained by mindful eating (Beshara et al., 2013). These recent findings show the context-specific approach of mindful eating as a potential pathway in explaining the effects of underlying mechanisms of mindfulness on modifying eating behavior. Like generic mindfulness (Baer et al., 2019), mindful eating comprises a set of different skills containing attention elements (so-called *what* of mindfulness) and attitude elements (so-called *how* of mindfulness) (Carrière et al., 2022; Mantzios, 2021). A seven-facet comprehensive operationalization of mindful eating describes the multidimensional construct as.

> … bringing an accepting and non-attached attitude to the experience of eating (1) while deliberately paying attention (2) to the present moment with all senses (3), being aware of not only motives and needs which trigger eating (4) without directly reacting to them (5) but also integrating this knowledge with the awareness of physiological hunger and satiety signals to guide one's own eating behavior consciously (6). Additionally, mindful eating includes the awareness of connectedness between the earth and all living beings setting the process of eating in a broader picture (7) (Peitz et al., 2021, p. 12).

Mindful eating has shown to be associated with reduced maladaptive eating behaviors such as emotional and external eating (Kerin et al., 2019), food preoccupation (Taylor et al., 2015), and grazing (Mantzios et al., 2018) in various correlational studies (with mostly moderate effect sizes) and experiments (Allirot et al., 2018; Arch et al., 2016). Positive associations with mindful eating were found for dietary quality such as the consumption of fruit and vegetables (Hutchinson et al., 2017; Keeler, 2014), reduced fat and/or sugar consumption (Mantzios, Egan, Hussain, et al., 2018a, 2018b), and reduced self-reported serving size of energy-dense food (Beshara et al., 2013) as well as with higher mental well-being (Khan & Zadeh, 2014; Peitz et al., 2021) and enhanced *self-compassion* (Mantzios & Egan, 2018; Taylor et al., 2015), another Buddhist concept describing an attitude of mindful kindness towards oneself in the face of difficulties (Neff, 2003).

Explicit mindful eating–specific MBIs such as those based on the program "Mindfulness-Based Eating Awareness Training" (MB-EAT; Kristeller, et al., 2013) have shown positive effects on maladaptive eating behaviors and related outcomes in a series of NIH-funded RCTs (e.g., most recent: Hooker et al., 2022) as well. Positive effects have also been found in different subgroups, such as in persons with diabetes (Miller et al., 2014), and low-income overweight women in primary health care (Salvo et al., 2022). However, studies on specific mindful eating–specific MBIs are still scarce (only one direct intervention study published in *Mindfulness* between 2022 and 2023; Hooker et al., 2022).

In approaching mechanisms of action regarding MBIs on maladaptive eating behaviors, there is preliminary evidence that certain facets of mindful eating differ in their relevance depending on the intervention goal or the considered outcome (Hutchinson et al., 2017; Mantzios et al., 2018; Moor et al., 2013). Consequently, these facets should be stressed in particular when treating maladaptive eating behaviors as significant characteristics in the development and maintenance of eating- and weight-related problems. In a recent study, Peitz and Warschburger (2022) identified four facets of mindful eating possessing predictive power to explain variance in both emotional and uncontrolled eating (i.e., LOC). One of these facets or mindful eating skills was the *awareness of eating triggers and motives* (ATM). ATM describes the ability to non-judgmentally notice and identify different needs which influence the initiation and termination of food intake and to distinguish them accordingly (i.e., distinguishing emotional triggers and external cues from physiological body needs). This requires awareness of emotional and physical sensations as well as external cues and personal eating habits in the present moment.

Teaching the mindful eating skill of ATM displays an important part in mindful eating–based interventions (Bays & Wilkins, 2017; Kristeller et al., 2014). In particular, the key "9 Hunger" exercise of the program "Mindful Eating – Conscious Living" (ME-CL) trains the awareness of so-called different *kinds* or *experiences of hunger* by pausing before a meal and mindfully asking "Who in there is hungry?" Then, nine kinds or aspects of hunger (Table 1) related to different eating triggers and motives should be non-judgmentally assessed on a 10-point scale (Bays, 2017; Bays & Wilkins, 2017).

Since different eating motives or needs come with similar experiences in the body (e.g., stomach growling as a sign of both physiological hunger and anxiety), they are difficult to distinguish, increasing the probability of non-homeostatic maladaptive eating (Bays, 2017; Brewer et al., 2018). Training ATM, i.e., practicing non-judgmental awareness of these different kinds of hunger or needs before and/or after a meal,

Table 1 Illustration of the nine different kinds of hunger (adapted from Bays, 2017)

Kind of hunger	Illustration
Eye hunger	What do I **see**? How much (more) of this food do my eyes want me to eat? Eyes' need for individual beauty/aesthetics (related to colors, shapes, surface textures, etc.); relates to delicious looking or just available food
Nose hunger	What do I **smell**? How much (more) of this food does my nose want me to eat? Need of the nose for individually fragrant impressions, smells, and aromas; strong effect on subconscious: smells activate memories and associated ideas
Mouth hunger	What can **I perceive in the mouth**? How much (more) of this food does my mouth want me to eat? The mouth's need for diverse and varied experiences and sensations (e.g., tastes, consistencies, and temperatures), so-called sensation seeker: looking for ever new, exciting sensations and experiences; endangers inattentive eating and rapid change related to consistency and taste
Ear hunger	What can I **hear**? How much (more) of this food do my ears want me to eat? Related to sounds or others' descriptions of food; strong effect on subconscious: sounds activate memories and associated ideas
Touch hunger	What do I **feel on my skin**? How much (more) of this food does my sense of touch want me to eat? Related to (surface) structures, temperature, changes in structures; making contact while shopping as well as preparing and eating food (e.g., finger food)
Mind hunger	What does my **mind say**? How much (more) of this food does my mind want me to eat? Interplay of all voices within that have something to say about the topic of food; arises through information from the outside, e.g., social environment and media; often anxious, critical (e.g., should/shouldn't); contains important information as well that can be used wisely in combination with information coming from the body
Heart hunger	What **emotion** do I associate with the food? Does it trigger memories, preferences or expectations in me? How much (more of) this food does my heart want me to eat? Describes feelings/memories associated with food (e.g., favorite childhood food); hope and expectation that the food will make me feel better (e.g., comfort, reassurance); mostly subconscious
Cell hunger	What does my **body need** right now? How interested are my cells in having this food come to them? "Intuitive eating" within the ME approach = perceiving instead of thinking what the body needs (listening to the body); recog nizing intuitive bodily signals (compare thirst; reactions during illness): buried quality that can be relearned step by step
Stomach hunger	How much food does my **stomach need** right now? How much of this food does my stomach want? Perceiving instead of thinking (how does my stomach communicate with me through e.g., growling, rumbling, emptiness, something completely different?); fullness level of the stomach (volume receptors); confusion with other types of hunger (needs) endangers risk of overeating

is assumed to facilitate untangling these various experiences of perceived hunger and might consequently support regaining interoceptive awareness of hunger and satiety signals as well as their differentiation from other cues (such as emotional triggers and external cues). In the long run, gaining awareness of one's own eating motives and triggers (i.e., mindful eating skill ATM) is supposed to increase conscious and informed decision-making about when and what to eat in line with physiological needs, thus reducing maladaptive eating behaviors (Bays, 2017). Moreover, it should enable a person to respond to those needs not directly related to nutrition uptake (e.g., emotional needs) in a more appropriate and wholesome way (Kristeller & Epel, 2014). In this way, ATM exercises, as well as mindful eating–based interventions in general, not only possess the potential to modify maladaptive eating but may also increase adaptive eating (Kristeller & Wolever, 2011; Warren et al., 2017), such as *intuitive eating*. Intuitive eating describes another well-studied approach relating to an adaptive eating style, which mainly involves eating more in line with physiological hunger and satiety cues, but also includes body-congruent food choices and an attitude of rejecting the diet mentality (Ruzanska & Warschburger, 2017; Tribole & Resch, 2020). Following a model of Brewer et al. (2018), ATM can be seen as the first step in disrupting neuronal habit loops of maladaptive or reward-related eating to establish more pronounced adaptive eating patterns.

The objective of the current study was to examine a clearly outlined mindful eating skill, which stems from a multi-component MBI (ME-CL), to approach the underlying mechanisms of mindfulness in the context of eating and weight disorders more closely. The mindful eating skill of *awareness of eating triggers and motives* (ATM) has been shown to be relevant in predicting maladaptive eating behavior in a recent study (Peitz & Warschburger, 2021).

Consequently, the current RCT aimed to explore if a short intervention, that was carried out online and in which the participants were asked to tune in and become non-judgmentally aware of their nine different kinds of hunger once a day before and after a self-chosen meal for 2 weeks, had short- and long-term effects on the reduction of maladaptive eating behaviors (emotional eating, external eating, and

LOC). Maladaptive eating behaviors serve as the primary outcomes since the overall evidence on the effectiveness of mindful eating was strongest and thus offers a reliable starting point to explore underlying mechanisms at a deeper level. Since the evidence on the following constructs was not as strong as on maladaptive eating behaviors, we investigated on an exploratory level (secondary outcomes) if the training had an effect on enhancing adaptive eating behaviors (intuitive eating and mindful eating) and more distant outcomes associated with mindful eating (self-compassion and mental well-being).

Method

Participants

In total, $n = 762$ participants requested the study link. Of those, $n = 392$ completed the first questionnaire battery (T0) and were therefore included in the intention-to-treat analyses (ITT). This initial sample consisted predominantly of females (92%) aged 18 to 82 years ($M = 37.04$, $SD = 13.82$; 23% between 18 and 24 years, 40% between 25 and 39 years, 24% between 40 and 54 years, 12% between 55 and 69 years, and 1% above 70 years). The average BMI (calculated from self-reported weight (kg) / height $(m)^2$; World Health Organization, 2000) was 25.21 ($SD = 5.43$) and ranged from 17.54 to 64.64. Following WHOs classification (World Health Organization, 2014), the initial sample included 3% individuals with underweight, 56% individuals with normal weight, 25% individuals with overweight, and 16% individuals with obesity. According to the Winkler Index score (Winkler & Stolzenberg, 1999), most of the participants belonged to the middle class (62%), 6% of the participants to the lower socioeconomic class, and 32% to the upper class. Sixty-eight percent had some experience with any form of mindfulness.

Data for post-measurement (T2) were provided by $n = 162$ participants of the waitlist control group (W-CG) and $n = 94$ members of the intervention group (IG). Reasons for drop out can be seen in the flow chart (Fig. 1). It can be assumed that most of the participants in the IG had not even started with the intervention. In total, $n = 87$ participants of the W-CG and $n = 137$ participants of the IG completed T2 and were therefore included in the completer analyses (per-protocol analyses, PPA). Due to a technical error, half of the follow-up results (T2) of the IG on the secondary outcomes (adaptive eating and broader health concepts) needed to be retraced, resulting in only $n = 53/87$ in the IG for completer analyses (PPA). The technical error did not concern the main outcomes on maladaptive eating behaviors.

Participants who dropped out between (a) T0 and T1 and (b) T1 and T2 did not differ from completers in terms of age (a: $t_{(392)} = 1.16$, $p = 0.246$; b: $t_{(262)} = 1.48$, $p = 0.140$), BMI (a: $t_{(392)} = 0.27$, $p = 0.786$; b: $t_{(262)} = 0.33$, $p = 0.740$), socioeconomic status (a: $t_{(392)} = 0.52$, $p = 0.603$; b: $t_{(392)} = 0.26$, $p = 0.796$), and gender distribution (a: $\chi^2_{(1)} = 3.69$, $p = 0.060$; b: $\chi^2_{(1)} = 0.48$, $p = 0.487$).

Procedure

The study utilized a randomized control design using a W-CG to compare their results on defined outcomes with an IG on three measurement points (before the intervention [T0], after the training [T1], and 3-month follow-up [T2]).

Participants were recruited online (social media, internet panels, blogs, mail distributors) and offline via flyers. A landing page informed participants about the broader scope of the training as well as its procedure and contained the informed consent. After providing their e-mail address, participants received an online link to the baseline survey (T0). Completion of this survey was mandatory for study inclusion. After its completion, participants were automatically randomized to one respective group by the used questionnaire platform (SoSci Survey) and informed whether they were allocated to the IG or W-CG. While the W-CG was informed that they would receive another questionnaire battery 2 weeks later, the IG received the study material for download.

The study material contained a 50-min training video. This video introduced ME and the nine kinds of hunger, led the participants through the exercise, and explained the procedure of the upcoming 2-week training (for content, see Supplementary Table 3). Participants were asked to pause mindfully to immerse into their experience and rate their nine kinds of hunger in a non-judgmental way once per day before and after a self-selected meal or snack. In the delivery, special attention was paid to introduce not only the *what* of mindfulness (i.e., paying attention) but also the *how* (i.e., getting aware of the "9 Hunger" in a non-judgmental way). Moreover, participants were instructed to pause and take a few mindful breaths before rating the "9 Hunger."

Additionally, two audio versions of the "9 Hunger" exercise (a 10-min version for the beginning and a 2-min short version for the time they would get used to it), a protocol sheet for the self-monitoring task, and a short explanation of the different kinds of hunger were provided.

During the 2-week training period, participants received three mails, which should remind them to adopt a self-compassionate attitude when performing the training task. Two weeks after the baseline survey as well as 3 months afterwards, participants of both the IG and the W-CG received a mail with a link to the post-survey (T1) and 3-month follow-up survey (T2). After the completion of the third questionnaire battery, participants of the W-CG received the link to the intervention materials. Both groups were offered an

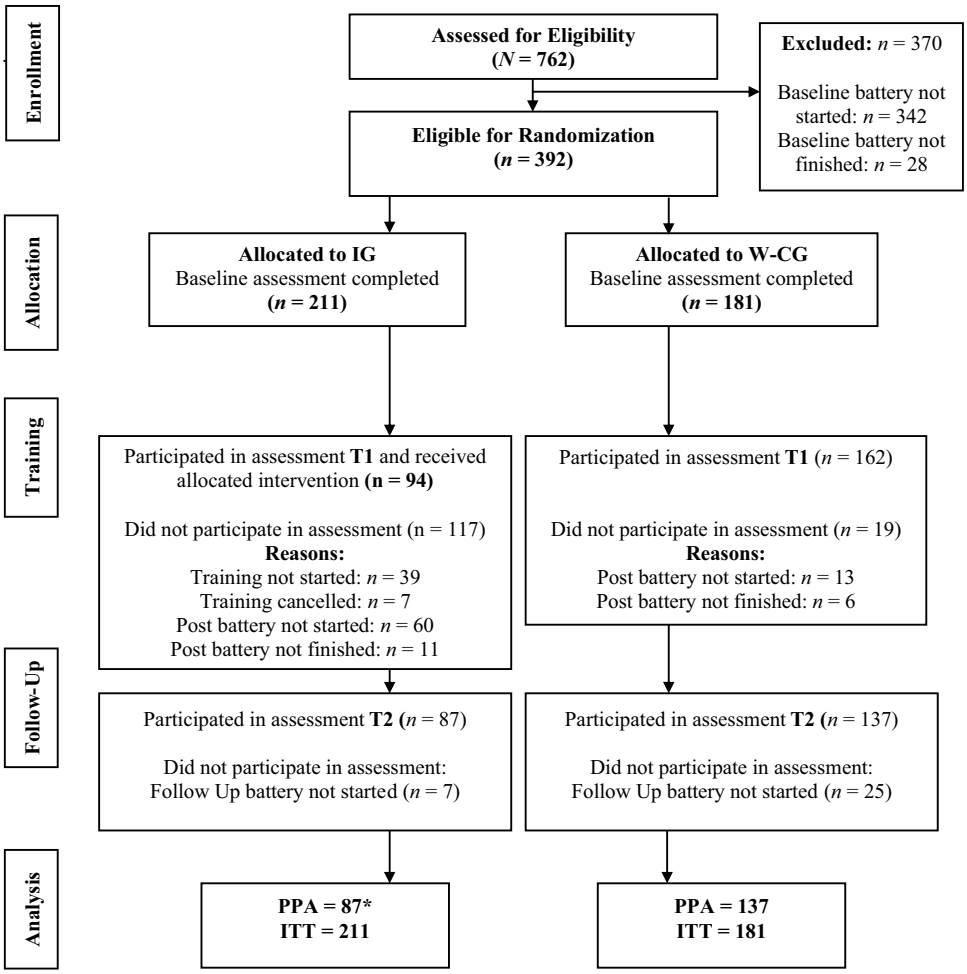

Fig. 1 Flowchart in accordance with CONSORT guidelines. IG intervention group, W-CG waitlist control group, ITT intention-to-treat analysis, PPA per-protocol analysis

*Due to a technical error in the follow-up battery, the questionnaire of the secondary outcomes was not forwarded to part of the IG; thus, only a reduced data set of $n = 53$ is available for these secondary outcomes at T2

incentive (information booklet on mindful eating or an evaluation of their mindful eating behavior).

Criteria for study inclusion were a minimum age of 18 years, informed consent, and completion of the baseline survey. Participation was voluntary.

Measures

To explore whether a training on the mindful eating exercise "9 Hunger" had an impact on maladaptive eating behaviors (primary outcomes) and additional secondary outcomes, these study outcomes were operationalized by the following measurement instruments, which have shown to be reliable and valid in various validation studies.

Primary Outcomes

Maladaptive eating behaviors (emotional eating, external eating, and LOC) served as primary outcomes of this study.

Emotional eating and *external eating* were measured by an adapted and established German version of the *Dutch Eating Behavior Questionnaire* (DEBQ; Grunert, 1989). The DEBQ measures—together with cognitive restraint—three domains of eating behaviors on a 4-point scale with alternating scale point descriptions. In the current sample, the averaged Cronbach alpha of all three measurement points reached $\alpha = 0.95$ for emotional eating (McDonald's omega $\omega = 0.95$) and $\alpha = 0.89$ for external eating ($\omega = 0.89$). Those were comparable with a representative German validation (emotional eating: $\alpha = 0.94$; external eating: $\alpha = 0.89$; Nagl et al., 2016). An example item for emotional eating is "I

want to eat when I am disappointed," and for external eating "I tend to eat more than usual when I see others eating."

The short version of the *Loss of Control over Eating Scale* (*LOCES*; Latner et al., 2014) with 7 items was used to assess *loss of control eating* (*LOC*). It screens for subjective binge episodes on a 5-point scale ranging from *never* to *always*. Averaged internal consistency in the current sample was $\alpha = 0.93$ ($\omega = 0.93$) which was comparable with the original validation ($\alpha = 0.93$; Latner et al., 2014). An example item is: "I felt helpless about controlling my eating."

Secondary Outcomes

Adaptive eating behaviors such as mindful eating and intuitive eating, as well as self-compassion and mental well-being, served as secondary outcomes for this study.

Mindful eating was assessed with the *Mindful Eating Inventory* (MEI; Peitz et al., 2021). It assesses the multidimensional construct of mindful eating with 30 items (e.g., "I taste every bite of food that I eat.") assigned to seven subfacets, which were answered on a 6-point scale ranging from *almost never* to *almost always.* For this study, the total score was used. Averaged internal consistency regarding this total score ranged from $\alpha = 0.92$ to $\alpha = 0.94$ ($\omega = 0.91$ to $\omega = 0.94$); comparable values were reported in the original validation ($\alpha = 0.91$; Peitz et al., 2021).

Intuitive eating as another adaptive eating style was captured by a German version of the *Intuitive Eating Scale-2* (IES-2; Ruzanska & Warschburger, 2017). The 23 items (e.g., "Most of the time, I desire to eat nutritious foods.") are assigned to four subscales ranging on a 5-point scale (*strongly disagree* to *strongly agree*). Averaged internal consistency for the total score was $\alpha = 0.86$ ($\omega = 0.83$) in the current sample and $\alpha = 0.89$ in the original validation (Ruzanska & Warschburger, 2017).

Mental well-being was assessed by the 5 items (e.g., "I have felt calm and relaxed.") of the German *Well-Being Index* (WHO-5; Bech, 2004; Bech et al., 2003) on a 6-point scale ranging from *not at all* to *all the time*. Averaged Cronbach's alpha was $\alpha = 0.86$ ($\omega = 0.90$) in the current study (original validation: $\alpha = 0.92$; Bech, 2004).

Self-compassion was measured with the German version of the 12 items *Self-Compassion Scale – Short Form* (SCS; Hupfeld & Ruffieux, 2011; Raes et al., 2011). On a 5-point rating scale (1 = *almost never* to 5 = *almost always*), participants rate how often they behave self-compassionately to themselves (e.g., "I try to see my failings as part of the human condition."). Averaged Cronbach's alpha for the total score was $\alpha = 0.91$ ($\omega = 0.88$) in the current sample (original validation: $\alpha = 0.87$; Raes et al., 2011).

Data Analyses

To examine intervention effects, we calculated latent change score (LCS) models using M*Plus*. In this approach, change scores between two measurement points are computed on the level of latent variables. Using LCS to evaluate interventions is preferable to the computing of classical (manifest) repeated-measures multivariate analysis of variance (MANOVA) for several reasons: They do not contain their strict and frequently unfulfilled prerequisites (e.g., homogeneity of variances), account for measurement error in the repeated measurements, consider interindividual differences, and have a higher statistical power, which increases the chance of detecting a treatment effect that is actually present (Mun et al., 2009). Significant deviations of mean differences in the change scores between IG and W-CG were interpreted as short-term effects of the intervention (difference between T1 and T0) and long-term effects of the intervention (difference between T2 and T0). Saturated models with freely estimated change scores for both groups were compared to two models that restricted the change scores for IG and W-CG to equality (the short-term and the long-term effect, respectively). Cohen's d was used as an effect size estimator for the intervention effect ($d = 0.20$ small, $d = 0.50$ moderate, $d = 0.80$ large effect sizes) (Cohen, 1988). Analyses were run for each outcome variable separately.

Missing data were handled with full information maximum likelihood (FIML) to include all available data (Schafer & Graham, 2002), even those of persons who just intended to take part in the intervention but dropped out later (intention-to-treat analyses, ITT). All analyses were run again without FIML to compare the result of this per-protocol analyses (PPA; main analyses) as a completer analysis with those of ITT (secondary analyses).

Results

Use of the Training

Most of those attending the IG practiced the "9 Hunger" exercise every day (modus value). However, on average participants trained tuning in and assessing the nine different kinds of hunger 4–5 times per week during the training period (8–10 times/2 weeks).

Effects of the Training

In studying short- und long-term effects of the 9 Hunger intervention in modifying maladaptive eating behaviors (primary outcomes) and further associated secondary outcomes,

the findings showed improvements regarding all focused outcomes.

Primary Outcomes

Regarding emotional eating and loss of control eating (LOC), LCS indicate significant changes in both groups between T0 and T1 and between T1 and T2. These changes were significantly higher in the IG compared to the W-CG for both measurement points, indicating both short- and long-term effects of the "9 Hunger" intervention on reduced emotional eating and LOC with moderate sizes.

Regarding external eating, significant LCS were observed for both groups between T0 and T1, but only for the IG between T1 and T2. Again, changes for both measurement points were higher in the IG, suggesting moderate short- and long-term effects of the "9 Hunger" intervention on reduced external eating with moderate sizes.

Secondary Outcomes

Regarding mindful eating, LCS revealed significant changes in both groups, but they were significantly higher in the IG compared to the W-CG for both measurement periods, indicating both short- and long-term effects of the "9 Hunger" intervention on enhanced mindful eating with high effect size.

Concerning intuitive eating, only the IG showed significant LCS between T0 and T1 and T0 and T2. Thus, although test of differences revealed higher LCS for the IG for both measurement periods, they were only significant for the post-measurement point, indicating moderate-sized short-term but no long-term effects of the "9 Hunger" intervention on enhanced intuitive eating.

Looking at the effect on mindful eating–related but more distant constructs, LCS analysis showed significant changes in both groups regarding self-compassion between T0 and T1 and between T1 and T2. In the IG, this change was significantly higher compared to the W-CG for the post and the follow-up measurement points, indicating large-sized short-term and moderate long-term effects of the "9 Hunger" intervention on enhanced self-compassion.

Considering well-being, only the IG showed a significant change between T0 and T1, but not between T1 and T2. The change between T0 and T1 was significantly higher compared to the W-CG suggesting a moderate-sized short-term effect of the "9 Hunger" intervention on general mental well-being.

PPA (Table 2; main analyses) and ITT analyses (Supplementary Table 4) led to similar results with a tendency to stronger effects for the IG in the PPA.

Discussion

The objective of the present work was to test the effects of a short 2-week mindful eating intervention, which focused on the differentiation of several motivations to eat, on eating behaviors, and on related but more distant constructs (generic self-compassion and mental well-being). Findings suggest both short- and long-term effects of the "9 Hunger" intervention on all of the addressed outcomes, particularly on eating behaviors. Moreover, participants' adherence to training the "9 Hunger" exercise almost every day showed a high acceptance of the training.

In line with findings of meta-analyses and systematic reviews on the effects of MBI on maladaptive eating (Grohmann & Laws, 2021; Mercado et al., 2021), the results of this study showed moderate effect sizes for the "9 Hunger" intervention on decreased maladaptive eating behaviors (emotional eating, external eating, and loss of control eating [LOC]) directly after and yet at the 3-month follow-up. In approaching mechanisms of action regarding MBIs on eating- and weight-related issues, our findings suggest that repeatedly training an isolated and clearly outlined ME skill ("*awareness of eating triggers and motives*"; ATM), in particular the non-judgmental awareness of several motivations to eat and their differentiation (i.e., distinguishing emotional triggers and external cues from physiological body needs), has the potential to influence maladaptive eating behaviors in the short and longer term.

Furthermore, ME techniques not only intend to decrease maladaptive eating behaviors (via awareness of different eating motivations) but develop more adaptive ways of eating (Kristeller & Epel, 2014). Compared to the strong findings on the effects of ME on maladaptive eating behaviors, there are fewer studies on the influence of ME on increasing adaptive eating behaviors. Findings of our study indicate that the "9 Hunger" exercise is suitable for this goal by showing more pronounced intuitive eating and ME in the IG compared to the W-CG directly after the training. At the 3-month follow-up, changes reached only significance for mindful eating but not for intuitive eating and should be considered preliminary due to the limited data. As it could be assumed, training a specific single ME skill had a particular high impact on the overall construct of mindful eating: Regarding this outcome, we found the highest effect sizes.

Lastly, the "9 Hunger" training showed even effects on more distant outcomes, which were in line with results on the positive relationship of ME with those constructs, namely mental well-being (Khan & Zadeh, 2014; Peitz et al., 2021) and self-compassion (Mantzios & Egan, 2018; Taylor et al., 2015): In comparison to the W-CG, the IG showed significantly increased self-compassion directly and 3 months after the training. Again, longer term effects should be interpreted

Table 2 Per-protocol analysis: primary outcomes/secondary outcomes

	T0	T1	Post (short-term effects) (change T1–T0)		T2	Follow-up (long-term effects) (change T2–T0)	
	M (*SD*)	*M*	Within-group	Between-group	*M*	Within-group	Between-group
Primary outcomes							
Emotional eating (DEBQ)							
IG[1]	3.22 (1.22)	2.46	−0.76 (0.98) $p < 0.001$*	−0.43 $p < 0.001$* $d = 0.47$	2.68	−0.54 (0.76) $p < 0.001$*	−0.39 $p < 0.001$* $d = 0.53$
W-CG[2]	3.24 (1.06)	3.00	−0.33 (0.82) $p < 0.001$*		3.17	−0.15 (0.70) $p = 0.011$	
External eating (DEBQ)							
IG[1]	3.41 (0.75)	2.67	−0.73 (0.77) $p < 0.001$*	−0.42 $p < 0.001$* $d = 0.58$	2.94	−0.43 (0.57) $p < 0.001$*	−0.36 $p < 0.001$* $d = 0.60$
W-CG[2]	3.63 (0.74)	3.32	−0.32 (0.67) $p < 0.001$*		3.53	−0.10 (0.64) $p = 0.065$	
Loss of control eating (LOCES)							
IG[1]	2.45 (0.93)	1.89	−0.56 (0.73) $p < 0.001$*	−0.43 $p < 0.001$* $d = 0.63$	1.99	−0.46 (.73) $p < 0.001$*	−0.27 $p = 0.005$* $d = 0.38$
W-CG[2]	2.67 (0.90)	2.54	−0.13 (0.61) $p = 0.002$*		2.49	−0.18 (.70) $p = 0.002$*	
Secondary outcomes							
Mindful eating (MEI)							
IG[1]	3.23 (0.72)	3.91	0.68 (0.64) $p < 0.001$*	−0.62 $p < 0.001$ $d = 1.19$	3.71	0.48 (0.57) $p < 0.001$*	−0.33 $p < 0.001$ $d = 0.66$
W-CG[3]	3.20 (0.73)	3.25	0.05 (0.37) $p = 0.087$		3.34	0.15 (0.43) $p < 0.001$*	
Intuitive eating (IES-2)							
IG[1]	3.28 (0.62)	3.53	0.25 (0.49) $p < 0.001$*	−0.25 $p < 0.001$ $d = 0.57$	3.48	0.20 (0.45) $p < 0.001$*	−0.11 $p = 0.483$ $d = \mathbf{0.11}$
W-CG[3]	3.17 (0.61)	3.17	0.00 (.41) $p = 0.654$		3.23	0.08 (0.40) $p = 0.014$	
Mental well-being (WHO-5)							
IG[1]	3.50 (1.06)	3.81	0.31 (0.74) $p < 0.001$*	−0.31 $p = 0.011$* $d = 0.42$	3.74	0.24 (0.97) $p = 0.069$	−0.06 $p = 0.656$ $d = \mathbf{0.07}$
W-CG[3]	3.46 (1.02)	3.46	0.00 (0.78) $p = 1.000$		3.59	0.13 (0.97) $p = .118$	
Self-compassion (SCS)							

Table 2 (continued)

	T0	T1	Post (short-term effects) (change T1–T0)		T2	Follow-up (long-term effects) (change T2–T0)	
	M (*SD*)	*M*	Within-group	Between-group	*M*	Within-group	Between-group
IG[1]	2.98 (0.75)	3.64	0.67 (0.69) $p<.001$*	−0.51 $p<0.001$* $d=0.92$	3.31	0.34 (0.49) $p<0.001$*	−0.23 $p=0.002$* $d=0.47$
W-CG[3]	3.06 (0.83)	3.21	0.15 (0.45) $p<.001$*		3.17	0.11 (0.47) $p<0.001$*	

[1]$n=137$. [2]$n=87$. [3]$n=53$. *IG* intervention group, *W-CG* waitlist control group, *M* mean, *SD* standard deviation, *p* *p*-values, *d* Cohen's *d* effect size (in bold for non-significant results)

with caution. PPA revealed significant results here, which can be interpreted as a preliminary indication for possible sustainable effects. Moreover, since participants were reminded to do the training compassionately, this could have also had an effect on the increased self-compassion scores. Regarding mental well-being, results provide first indications that training mindful eating for 2 weeks might lead to a more general feeling of comfort. This effect did not sustain until the 3-month follow-up. Due to the missing data on this outcome, findings should be considered preliminary and need to be replicated in future studies.

According to a recent literature review by Tapper (2022), it was noted that comprehensive and labor-intense MBIs such as *Mindfulness-Based Stress Reduction* (MBSR) or ME-CL might lead to greater benefits but could promote health inequalities because of restricted physical and psychological resources of those with greater health needs. Briefer, low-threshold applications of mindfulness might be suitable to reach larger numbers of people and thus might have the potential to achieve benefits for health and well-being at population level (Tapper, 2022). Findings of the current study support the idea that it might not always need a comprehensive intervention program to reach sustainable effects. Moreover, our study gives a preliminary indication that these effects can even be reached by brief but context-specific interventions. Results showed that, on average, a 5-min training per day for around eight–ten times during a 2-week period might be sufficient to effect this change. The "9 Hunger" exercise displays an informal mindfulness practice. It can be applied without introducing the theory of Buddhism or a broader spiritual background and be integrated in a time-saving economical manner as a cost-effective self-help intervention as well as a tool in therapy. Using it in these settings, the exercise might help to investigate and establish other ways to nourish different kinds of hunger. Following scientific research on different eating triggers and motives, Bays (2017) suggests that we do not always hunger for food but for various other reasons such as comfort and social interaction. Bringing awareness to one's own true needs might thus not only facilitate our ability to distinguish between them, resulting in pronounced eating in line with physiological needs. Moreover, it might help to respond to one's own true needs in a more appropriate and wholesome way.

Lastly, in our self-selected study sample with an interest in eating behavior, we found increases in almost all outcomes in the W-CG as well, though smaller and less stable than in the IG. This suggests that even filling in questionnaires related to the topic of eating behaviors, explicitly mindful eating, might evoke first reflections leading to initial behavior changes. This side result might be beneficial to further investigation and even development of an own

intervention in treating eating- and weight-related problems to support improvements of eating habits.

Limitations and Future Research

When interpreting the results of the current study, its limitations and strengths should be considered to arrive at suggestions for future research. Several limitations concern the following:

First, as often found in studies on eating behavior, particularly on mindful eating (O'Reilly et al., 2014; Ouwens et al., 2015; Rogers et al., 2017), our study included mainly females. This, as well as the overrepresentation of participants in the middle class, hampers the transferability of the results to the general population. Future studies should find ways to include more men and participants from lower socioeconomic classes to improve research on mindful eating regarding its generalizability. Furthermore, a next step in researching effects of mindful eating might be the inclusion of not only self-selected samples but of samples in broader health settings to test the approach's feasibility for universal prevention of eating and weight disorders.

Second, our study suffers from the well-known problem of high dropout in self-guided web-based interventions (Karyotaki et al., 2015). Although we retrospectively tried to assess reasons for dropout via mail, we were not able to fully explain this phenomenon. Future studies might address this problem by including an assessment of treatment fidelity or investigating the "9 Hunger" exercise or other mindful eating interventions via apps, which are able to assess if the training has even been started (e.g., via protocols). Moreover, targeted recruiting and/or advertising might be a promising way to address dropout in online interventions as well as guidance within a structured program or self-help (Zagorscak et al., 2019).

Third, due to a technical error, follow-up results (T2) on adaptive eating and broader health concepts (secondary outcomes) need to be interpreted with caution. Half of the IG sample needed to be retraced regarding these outcomes, so that only 60% of participants who finished the training offered data for T2. However, the results of the primary outcomes (maladaptive eating behaviors) were not affected by this problem.

Fourth, we did not intentionally include clinical groups with eating and weight disorders since this study served as a first step in approaching the influence of ATM on maladaptive eating behaviors directly. In a next step, future studies using online and face-to-face designs should include clinical samples in particular to investigate the effect of the "9 Hunger" exercise in these groups more closely. In addition to persons with a range of different eating disorders, this step should also include persons with obesity in weight loss programs who actually perceive health detriments because of their weight, ideally in comparison with *treatment as usual* (TAU) with and without the "9 Hunger" exercise (i.e., dismantling studies). To evaluate such interventions, questionnaire data should be supplemented with observation of direct behavior and the assessment of possible health detriments (e.g., high blood pressure).

Besides these limitations, there are different strengths to be mentioned. Firstly, isolating a single exercise of a multicomponent intervention allows for a targeted evaluation of mechanisms of action. The lack of research in this area in relation to the simultaneously increased use of MBIs in the field of eating- and weight-related issues has been criticized intensively (Tapper, 2017, 2022). Evaluating multi-component interventions as a whole may hamper statements about whether and which of the mindfulness-immanent qualities have an influence on a particular outcome. Instead, our approach allows for the first implication that promoting *awareness of eating triggers and motives* (ATM) might be one direct pathway in explaining the effects of MBIs on changing eating habits reported in systematic reviews and meta-analyses (Grohmann & Laws, 2021; Mercado et al., 2021; Tapper, 2022). Secondly, both the calculation of LCS and the additional use of an ITT evaluation strategy allowed for the inclusion of all possible data (Graham, 2009). Similar results of ITT and PPA support the use of the chosen methodology. Findings are additionally supported by the high number of participants who could be included. Finally, it is the first study showing change sensitivity of the MEI, a comprehensive and multifaceted mindful eating questionnaire, which was missing so far (Peitz et al., 2021; Tapper, 2022).

In sum, an economical 2-week mindful eating intervention with solely 5 min of training per day revealed not only short-term effects in decreasing maladaptive eating behaviors that foster the development and maintenance of eating- and weight-related disorders. Furthermore, it seems to hold the potential to change these behaviors in the longer term, as shown by effects 3 months after the short training period.

In approaching the mechanism of action, the results of the current study facilitate our understanding of mindfulness in the context of eating: By isolating a single exercise from a multi-component mindful eating intervention (ME-CL) and focusing solely on its specific effects, a first indication can be deduced that the mindful eating facet *awareness of eating triggers and motives* (ATM) leads to a change in eating patterns. Thus, training this particular skill might aid the current treatment of eating- and weight-related disorders.

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Author Contribution DP: conceptualization, methodology, formal analyses, investigation, writing—original draft, writing—review and editing, project administration. PW: writing—review and editing, supervision. Both authors approved the final version of the submitted manuscript.

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Data Availability The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Conflicts of interest/competing interest The authors have no relevant financial or non-financial interests to disclose.

Ethics Approval This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the local Ethic Committee of the University of Potsdam (88/2016). This study was preregistered at the German Clinical Trials Register (DRKS00012351).

Consent to Participate Informed consent was obtained from all individual participants included in the study.

Consent for Publication Participants signed informed consent regarding publishing their data on mean level.

Use of Artificial Intelligence Statement AI was not used.

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