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Mindfulness-Based Interventions for Weight Loss and CVD Risk Management

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Abstract Obesity affects more than one third of US adults and is a major cause of preventable morbidity and mortality, primarily from cardiovascular disease. Traditional behavioral interventions for weight loss typically focus on diet and exercise habits and often give little attention to the role of stress and emotions in the initiation and maintenance of unhealthy behaviors, which may account for their modest results and considerable variability in outcomes. Stress eating and emotional eating are increasingly recognized as important targets of weight loss interventions. Mindfulness-based interventions were specifically developed to promote greater self-efficacy in coping with stress and negative emotions and appear to be effective for a variety of conditions. In recent years, researchers have begun to study mindfulness interventions for weight loss and CVD risk management. This review describes the rationale for the use of mindfulness in interventions for weight loss and CVD risk management, summarizes the research to date, and suggests priorities for future research.

This article is part of the Topical Collection on *Novel + Emerging Risk Factors*

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Introduction

Obesity is a major cause of preventable mortality, with the WHO estimating that they cause 2.9 million deaths annually worldwide. Obesity is an independent risk factor for cardiovascular disease [1, 2] and also increases the incidence of other risk factors like hypertension, dyslipidemia, and diabetes. With more than two thirds (68.5 %) of US adults considered overweight or obese [3], effective approaches to weight loss and prevention of weight gain are imperative. Intentional weight loss is associated with reduced CVD risk factors (e.g., hypertension, diabetes), cardiac events, and mortality [4, 5].

Despite growing awareness of the importance of weight loss, current efforts to achieve sustained long-term weight loss have not been particularly successful. Lifestyle interventions that rely on education and cognitive-behavioral strategies to facilitate change in diet and physical activity are the mainstay of treatment but produce modest results; the majority of lost weight is regained [6–9]. Moreover, there is marked variability in outcomes, with some participants losing 10 % of body weight and others losing much less, or even gaining weight. Success rates of bariatric surgery for obesity are higher, but surgery is not a practical or cost-effective solution to the epidemic of overweight and obesity [10].

One reason for the disappointing results of lifestyle interventions may be their failure to adequately address the effects of stress and emotions on the initiation and maintenance of unhealthy behaviors that contribute to energy imbalance. A growing body of evidence implicates stress in disordered eating and obesity [11, 12••, 13], while epidemiological [14–17]

and longitudinal studies have linked stress and weight gain [18]. Although the effects of acute stress on food intake are variable (on average about 40 % increase intake, 40 % decrease intake, and 20 % show no change [11], emotional eaters and obese individuals consistently increase intake in response to stress and negative emotion and tend to gain weight as a result [19, 20, 13]. Moreover, acute stress and negative emotions consistently affect food preference in both animals and humans, causing an increased preference for highly palatable foods, which are calorie-dense and high in fat, sugar, and/or salt [11, 12••]. These "comfort foods" are increasingly available in our obesogenic environment and are increasingly used to cope with stress and regulate mood.

The consumption of comfort foods, as the name implies, provides temporary relief from negative emotional states likely because of their effects on the brain's reward system: Individuals learn that eating these types of food makes them temporarily feel better [12••]. This negative reinforcement contributes to emotional learning – stress and negative emotion become associated with the rewarding effects of eating comfort foods, and with repetition, this response becomes habitual. Repeated consumption of highly palatable food increases sensitivity of reward pathways, influencing food preference and intake. Overlap between reward and emotion circuits contributes to emotional and reward-based eating and to lasting changes in appetite and craving for these foods [12••]. Emotional eating, defined as eating in response to emotional distress, is a better predictor of weight gain and regain than other eating behaviors and lifestyle factors [21] and also predicts weight loss and maintenance in clinical trials [22–24]. Stress eating and emotional eating are related; stress perceived as overwhelming one's ability to cope, has been shown to trigger negative emotions and emotional eating of highly palatable food [25, 26]. Evidence suggests that both stress eating and emotional eating increase risk for weight gain and eventual obesity [11, 27, 28]. Standard behavioral weight loss programs often include only two to three sessions on cognitive-behavioral strategies to address overeating in response to psychological factors. These strategies can be difficult to sustain over time for most people and may be particularly vulnerable to periods of emotional challenge and increased stress which is associated with diminished cognitive processing ability [29].

The objectives of this article are to (1) describe the rationale of why mindfulness-based interventions (MBIs) may be effective for weight loss and other cardiovascular risk factors, (2) discuss strategies for applying mindfulness to behavioral interventions for these conditions, (3) examine the state of the evidence for these interventions, and (4) suggest priorities for future directions. Note that there is evidence that MBIs may be effective for some obesity-related eating behaviors, specifically binge eating, emotional eating, and external eating, but studies that did not include weight as an outcome are beyond the scope of this review (see [30] for a recent review).

Origins and Rationale for Mindfulness-Based Interventions

Mindfulness has been defined as "the awareness that emerges through paying attention on purpose, in the present moment, and nonjudgmentally to the unfolding of experience moment by moment" [31]. Mindfulness meditation is a form of mental training that involves observation of the constantly changing patterns of internal and external experience moment to moment. Mindfulness training (MT) emphasizes cultivation of nonreactive, nonjudgmental awareness which promotes reduced reactivity to aversive experience [32, 33]. Emerging evidence suggests that MT reduces subjective, self-referential appraisal ("it's about me" [34]) and is believed to exert its effects through several components, including attention regulation, viscerosomatic awareness, emotion regulation, and self-perception, which together enhance self-regulation (see [35] for review and [36••] for a recent review of our current understanding of the neural mechanisms mediating these effects). In contrast to cognitive strategies that rely on "top-down" neural processes to alter cognitive elaboration (e.g., reappraisal), mindfulness limits cognitive elaboration and supports more sensory-based representations, and acceptance of negative thoughts and emotions. These support a more objective perspective, reducing the perceived threat to self ("it's not about me").

MBIs were first introduced to Western medical settings in 1979 by Jon Kabat-Zinn who developed Mindfulness-Based Stress Reduction (MBSR) [37]. MBSR is a multicomponent intervention that provides systematic training in formal mindfulness meditation practices as well as the informal application of mindfulness in daily life. It also includes gentle stretching and mindful yoga and psychoeducation about the effects of stress on health and the applications of mindfulness to support improved health and health-enhancing behaviors. Subsequent adaptations of MBSR have been developed for a variety of conditions such as preventing relapse of recurrent depression [38] and addiction [39]. MBIs have in common the formal teaching of mindfulness meditation practices, explicit encouragement to develop a daily practice, and the requirement that teachers have extensive formal training in mindfulness and their own daily practice. Mindfulness is also a core ingredient of other interventions such as Acceptance and Commitment Therapy (ACT) [40], without the emphasis on formal meditation practice.

A growing body of evidence supports the efficacy of MBIs for a variety of populations and conditions. Recent meta-analyses have found small to moderate effect sizes for promoting psychological well-being and reducing stress [41, 42] and for relieving symptoms of anxiety, depression, and chronic pain in clinical populations with both mental health and physical disorders [43, 44]. The largest meta-analysis of all research on meditation practices, commissioned by the

Agency for Healthcare Research and Quality, recently concluded that based on current evidence that mindfulness is effective for symptoms of anxiety, depression, and chronic pain and that physicians should be prepared to talk to their patients about the role that mindfulness meditation programs could have in addressing psychological distress [43]. The clinical changes produced by mindfulness are associated with lasting changes in brain structure and function subserving attentional processes, emotion regulation, and self-processing [35, 36••].

Mindfulness-Based Interventions for Weight Loss

The rationale for applying mindfulness to weight loss interventions derives from the intention of MT to cultivate a nonreactive and nonjudgmental form of awareness in the face of stressors and unpleasant thoughts, emotions, and sensations. Less reactivity and greater self-efficacy may, in turn, reduce impulsive eating and food craving and facilitate unlearning of unhealthy behaviors previously used to cope with stress and negative emotions. In addition, from the outset, the MBSR program emphasized self-care and a healthy lifestyle and incorporates instruction for mindful eating and healthy nutrition, physical activity, and adequate sleep. Based on the evidence that MBIs are effective for reducing relapse of recurrent depression [45] and substance abuse [46], continued practice may also support maintenance of weight loss by reducing sensitivity to stressors and negative emotions which otherwise may trigger relapse to unhealthy behaviors.

A limited number of studies have examined whether the original MBSR program promotes weight loss. To date, MBSR alone has not been found to lead to weight loss, but adequately powered randomized controlled trials of populations seeking to lose weight have yet to be done (see [47••] for review). Mindfulness-based eating awareness training or (MB-EAT) [48•] is an adaptation of MBSR that applies mindfulness meditation practices to eating and awareness of eating-related physical cues, such as hunger and satiety cues, thoughts, and emotions. It was designed to treat binge eating and does not focus on weight loss. The largest RCT of MB-EAT demonstrated a significant reduction in binge eating and weight, but results were not significantly different compared to a psychoeducational/cognitive-behavioral treatment known to be effective for binge eating [49]. This study did not report on whether results differed for obese participants. One RCT on stress eating in 47 overweight and obese women examined a novel mindfulness intervention based on components of MBSR, MB-EAT, and mindfulness-based cognitive therapy (MBCT) for stress eating [50]. Although not designed to produce weight loss, the investigators measured change in weight and abdominal adiposity in participants assigned to the intervention and a waitlist control group. No significant changes in weight or adiposity were observed in either group, but in an exploratory intent-to-treat analysis by obesity status, obese subjects in the treatment group maintained weight (−0.4± 3.5 kg, p=.70) while those in the control group gained weight (1.7±1.5 kg, p=.01). Another intervention that modified MBCT to include training in mindful eating and body awareness found a significant reduction in both emotional and external eating relative to a control group but no significant weight loss [51]. Thus, based on current evidence, MBIs without diet and/or exercise components tend not to be effective for weight loss. However, the focus of these studies has been primarily on the emotional determinants of eating and psychological distress rather than promoting weight loss, with only brief follow-up (3–4 months at most). The standard MBI approach may yet prove effective in the long-term as it promotes increasing awareness and long-term changes in automatic and habitual patterns. The vast majority of overweight and obese individuals have lost significant amounts of weight repeatedly, only to regain it after 1–2 years. It is possible that the effect of MBIs on weight would be gradual so longer follow-up is needed.

There is a larger literature on weight loss interventions that combine mindfulness training with a focus on mindful eating with elements of traditional weight management programs such as educational and/or behavioral skills training for improving diet and physical activity [52–54]. For example, an adaptation of MB-EAT that included medical nutrition therapy was developed for individuals with diabetes. In this RCT, overweight or obese type 2 individuals with diabetes (n=52) were randomized to the 12-week mindfulness intervention or a diabetes group self-management education program [55•]. Both interventions resulted in significant weight loss at post-intervention and 3-month follow-up (1.8 kg$\pm$0.5 and 1.5$\pm$0.5 (both p<.01), respectively, for MB-EAT-D and 3.2$\pm$6 and 2.9$\pm$5, respectively, for the control intervention). Weight loss was not significantly different between the two interventions, consistent with findings from the largest MB-EAT trial to date [49]. Another study focused specifically on mindful restaurant eating for individuals who eat out frequently to address the excess calories typically consumed at restaurants [54]. Mindful eating skills were taught in six weekly group sessions and included nutritional education and cognitive-behavioral components in addition to mindfulness skills training. Although the intention of the intervention was prevention of weight gain and the majority of participants were not dieting with the intent to lose weight at the start of the study, on average, the intervention group lost 1.7 kg at 6 weeks follow-up (p=.03).

Another application of mindfulness to weight loss interventions is the teaching of mindfulness skills for responding to specific external conditions or internal states. These interventions might best be characterized as mindfulness skills training rather than mindfulness-based because they do not involve training in formal meditation practices or the expectation to

develop a daily meditation practice. To date, most studies of this strategy for weight loss have been based on Acceptance and Commitment Therapy and other acceptance-based therapies shown to be effective for a variety of mental health conditions, with additional educational and behavioral skills components targeting eating and/or weight management (see [56] for a discussion of the rationale for teaching acceptance and mindfulness for weight management). Acceptance-based therapies aim to reduce avoidance behavior, increase psychological flexibility, and facilitate commitment to change. Although promising, the methodological shortcomings of most studies of acceptance-based treatments for weight loss limit the strength of conclusions about their efficacy. One exception is a recently published randomized controlled trial of 128 overweight and obese men and women who were randomized to an acceptance-based weight loss intervention or a standard behavioral program [57]. Treatment was group-based, consisting of 30 sessions over 40 weeks. Both groups demonstrated significant weight loss with the experimental group losing significantly more weight post-treatment (13.17 vs. 7.54 %) and 6-month follow-up (10.98 vs. 4.82 %). The acceptance-based treatment was particularly effective for participants with more depressive symptoms at baseline.

The long-term effects of mindfulness on weight loss are unknown. Research to date has only reported outcomes post-intervention or relatively short follow-up (3–4 months), and no study has yet been published on maintenance of weight loss.

Mindfulness-Based Interventions for Cardiovascular Disease Risk Management

To date, there is virtually no evidence on whether mindfulness is related to cardiovascular events. However, there is preliminary evidence that mindfulness is related to cardiovascular health [58] and that MBIs may impact CVD risk factors, reviewed below.

Smoking

There has been early exploration of MBIs on smoking cessation, using randomized controlled trials [59]. For example, in an intent-to-treat analysis, Brewer et al. found that participants enrolled in MT for smoking cessation vs. American Lung Association's *Freedom From Smoking* had significantly higher 4-month abstinence rates, demonstrating 31 vs. 5 % abstinence, respectively [60]. In this study, mindfulness practice was found to moderate the decoupling of the link between craving and smoking [61]. A recent study on a different intervention named "Mindfulness Training for Smokers" showed significant differences between treatment vs. control groups in a disadvantaged population, but no difference in a more generalizable population [62]. Finally, there have been a number of recent reports suggesting that app- and web-based delivery of mindfulness interventions have promise in smoking cessation [63–65]. Studies are moving forward in identifying active components of the mindfulness interventions and subgroups of people for whom the interventions may be most effective. Additional work, including replication studies, with larger sample sizes and longer follow-up periods is needed to evaluate intervention effectiveness.

Blood Pressure

A 2014 systematic review and meta-analysis of four MBIs randomized controlled trials showed significant but heterogeneous effects on blood pressure [66•]. Rigor of methods for several of the studies was limited, often including fairly high loss to follow-up and brief follow periods, with the exception of a study that used 1-year follow-up period [67]. There is some evidence of floor effects, where the greatest blood pressure effects were seen in the study that included participants with the highest baseline blood pressure (unmedicated stage 1 or 2 hypertension) [68], compared to other studies that included participants with unmedicated stage 1 hypertension [67], prehypertension [69], or did not have blood pressure level inclusion criteria [70]. Methodologically rigorous, randomized controlled trials with larger sample sizes and long-term follow-up will provide important information about whether MBIs have an impact on blood pressure, and if so, for whom.

Diabetes and Glucose Regulation

Five randomized controlled trials have investigated contributions of mindfulness interventions on glucose regulation in patients with diabetes. Of these, two showed significant improvements in glucose regulation measures (i.e., HbA1C, fasting glucose) [71, 72], and three demonstrated no effect [70, 73, 74]. Both of the interventions that significantly improved glucose regulation trained participants in mindfulness in addition to health behaviors that improve glucose regulation, including diet, physical activity, glucose monitoring, and use of diabetes medication [71, 72]. Studies not influencing glucose regulation tested standardized mindfulness-based interventions, specifically mindfulness-based stress reduction [70] and mindfulness-based cognitive therapy [73, 74]. Thus, mindfulness interventions that are customized toward improving mindfulness skills for glucose regulation may yield greater effects on diabetes management. To our knowledge, there have been no studies of MBIs targeting prevention of diabetes in at-risk populations. Overall, evidence suggests that mindfulness practices may help with glucose regulation, but additional research is needed to determine if standard vs. customized mindfulness interventions are more effective at lowering diabetes risk.

Physical Activity

To date, the interventions for physical activity that have included mindfulness have been based on Acceptance and Commitment Therapy [75–78]. Three of the four randomized controlled trials showed significant effects on physical activity outcomes including self-report physical activity (Brief Physical Assessment Tool assessing number of physical activity bouts per week [79], International Physical Activity Questionnaire [76]) and directly assessed physical activity (pedometer-assessed step count [76] and exercise tolerance time defined as duration of loaded pedaling [77]). The study showing null findings used self-report and accelerometer-based measures of physical activity [78]. It should be noted that the latter study found significant improvements in accelerometer-assessed physical activity for both the intervention (ACT + physical activity feedback) and active control (feedback only), and significant improvements in physical activity for intervention vs. control in post hoc analyses of the nondepressive sample [78]. Follow-up time of studies had a wide range and were approximately 1 h [77], 12 weeks [76], and 6 months [78, 79].

Mechanisms

A recent review by our group described mechanisms and a theoretical framework by which mindfulness interventions could influence CVD risk [80]. Mechanisms with evidence to date include three main areas, specifically (1) attention control, (2) emotional regulation, and (3) self-awareness. We refer readers to this review for further information on plausible mechanisms and a theoretical framework of how mindfulness interventions could influence obesity and CVD risk management.

Future Directions

Given the promising but inconclusive evidence that MBIs may be effective for promoting weight loss and reducing cardiovascular risk, the field is now ready for fully powered randomized controlled interventions employing appropriate comparison conditions and follow-up periods of 1–2 years. There is insufficient evidence to date that mindfulness interventions are superior to other evidence-based approaches for weight loss or CVD risk.

Additionally, before conclusions can be made about the need for customized programs to address weight loss and CVD risk factors, well-designed, fully powered studies of MBSR with long-term follow-up are needed. MBSR has been disseminated worldwide, is available in over 500 sites in the USA, and has formalized training and certification processes in place. Given these, it could be a cost-effective approach that is more easily generalized. The standard MBI approach may yet prove effective with adequate follow-up. For example, in a RCT of MBSR vs. a well-matched education control for patients with asthma, both groups improved on measures of asthma-related quality of life and perceived stress at 6 months with no significant between-group differences. But by 12 months, participants in the control group had returned to baseline while the MBSR group maintained their gains and the difference on both measures was significantly different between groups. [81]. Similarly, in a RCT of MBSR in people with type 2 diabetes, there were no significant differences post-intervention compared to treatment as usual, but at 1-year follow-up, the MBSR group showed significantly lower diastolic blood pressure and depression scores and improved health status [70]. Thus, comparative effectiveness studies will be needed, and it will be important to examine predictors of response in order to identify which patients are most likely to benefit from mindfulness interventions.

Future studies should also include data on adherence to establish the impact of dose on outcomes, and on the meditation training and practice of teachers as this has been shown to affect outcomes [44]. One challenge to this and other fields of mindfulness research will be understanding the mechanisms underlying positive outcomes given the limitations of the tools currently available for measuring mindfulness and the importance of elucidating mechanisms for producing maximally effective and implementable interventions in actual practice [82]. Until reliable biological or behavioral measures are available, it may prove more useful to examine the dose-response relationship using measures of mindfulness practice, although this approach has its own limitations as it relies on self-report.

It is critically important that future studies include more diverse populations given that obesity rates are higher among socioeconomically disadvantaged groups [83, 84] and existing weight loss interventions may be less effective in these groups [85, 86]. Future studies of MBIs for CVD risk factors will need to examine whether they can be maintained over time to lower cardiovascular morbidity and mortality.

Conclusions

Current evidence supports the efficacy of mindfulness-based interventions for improving mental health symptoms and psychological stress that can interfere with efforts to lose weight and improve CVD risk. Patients with obesity and other CVD risk factors may benefit from a mindfulness meditation program to address psychosocial stress, depression, and anxiety, which are independent risk factors for CVD [87, 88]. However, evidence to date that MBIs are effective for addressing obesity and CVD risk directly is mixed. The goal of

mindfulness practices is lasting changes in long-standing cognitive and emotional habits. The impact of these changes on weight and CVD risk are likely to be gradual and will require longer follow-up periods to demonstrate.

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Compliance with Ethics Guidelines

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