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Can Mindfulness Influence Weight Management Related Eating Behaviors? If So, How?

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Abstract

Mindfulness is increasingly being used for weight management. However, the strength of the evidence for such an approach is unclear; although mindfulness-based weight management programs have had some success, it is difficult to conclude that the mindfulness components were responsible. Research in this area is further complicated by the fact that the term 'mindfulness' is used to refer to a range of different practices. Additionally, we have little understanding of the mechanisms by which mindfulness might exert its effects. This review addresses these issues by examining research that has looked at the independent effects of mindfulness and mindfulness-related strategies on weight loss and weight management related eating behaviors. As well as looking at evidence for effects, the review also considers whether effects may vary with different types of strategy, and the kinds of mechanisms that may be responsible for any change. It is concluded that there is some evidence to support the effects of (a) present moment awareness, when applied to the sensory properties of food, and (b) decentering. However, research in these areas has yet to be examined in a controlled manner in relation to weight management.

Keywords

mindfulness; acceptance; decentering; weight loss; eating; calories

Can Mindfulness Influence Weight Management Related Eating Behaviors? If So, How?

Levels of overweight and obesity have increased dramatically over the last three decades; globally, 1 in 3 adults are now overweight or obese and more than 3 million deaths are attributed to the condition every year (Ng et al., 2014). As well as being associated with increased mortality (Whitlock et al., 2009), being overweight or obese is linked to a wide range of chronic health conditions such as type 2 diabetes, hypertension, coronary heart disease, stroke, cancer, metabolic syndrome and osteoarthritis (Kopelman, 2007). As such, it impacts, not only upon quality of life, but also upon the wider economy. For example, overweight and obesity are estimated to have a global cost of $2.0 trillion a year; equivalent to the cost of armed war, violence, and terrorism (Dobbs et al., 2014). For these reasons, tackling obesity has become a priority for many governments.

An important part of government strategy is the development of weight management interventions. Such interventions may be aimed at helping individuals lose weight, maintain weight losses, or prevent weight gain. These may be achieved by targeting either energy expenditure or energy intake. However, a wide range of different eating behaviors can influence energy intake including reduced portion sizes, reduced frequency of overeating, and a switch from higher to lower calorie foods. Thus weight management may be achieved via multiple pathways.

One approach to weight management that is becoming increasingly popular is the use of mindfulness-based interventions. These are currently being employed by a number of healthcare organizations, as well as being promoted as a strategy for weight management and eating regulation among the general public. However, the strength of the evidence for such an approach is unclear. For example, Olson and Emery (2015)

conducted a systematic review of 19 mindfulness-based interventions for weight loss. Whilst 13 of these showed significant reductions in weight, it was not certain that these changes were brought about by increases in mindfulness; the authors concluded that there was a need for further research to isolate mindfulness as an active component of treatment, for example by measuring changes in mindfulness.

However, assessing change in mindfulness is not as straightforward as it sounds. In particular, questionnaires designed to assess mindfulness tend to show poor convergent validity and their items may be interpreted in different ways by those with and without experience of mindfulness. They may also be subject to significant desirability bias especially where one group has received training in mindfulness practice and thus subsequently becomes aware of what they are 'meant' to be answering (Grossman, 2011).

An alternative means of identifying a relationship between mindfulness and a particular outcome is simply to restrict the experimental manipulation to mindfulness techniques only. This means that any change in the outcome variable can be more confidently attributed to the mindfulness component. However, because weight loss is difficult to achieve, and because experts recommend that interventions contain multiple elements (National Institute for Health and Clinical Excellence, 2006), in practice such an approach is rare in research examining the effects of mindfulness on weight loss. Nevertheless, there are studies that have examined the independent effects of mindfulness, or mindfulness-related strategies, on what can be regarded as surrogate measures of weight loss, for example calorie intake or food choice. Such outcomes are also relevant for weight maintenance. Whilst there is no guarantee that changes in such outcomes will necessarily translate into weight loss or weight maintenance, they enable

us to more confidently conclude that the change was, indeed, due to the mindfulness-related strategy or strategies employed.

These types of more carefully controlled experimental studies also have two other important advantages over those that examine multi-component mindfulness-based interventions. First, they provide more opportunity to explore whether certain types of mindfulness strategy are more or less effective than others. This is important as mindfulness intervention generally comprises a range of different practices and strategies and it is not always clear whether all components are responsible for the benefits or whether some may be redundant. Indeed, a number of researchers have highlighted the need for dismantling studies (Cavanagh, Vartanian, Herman & Polivy, 2014; Shapiro, Carlson, Astin & Freedman, 2006). These issues are particularly important given that overburdening participants with strategies and rules may dilute effects and reduce adherence (Mata, Todd & Lippke, 2010; Verhoeven, Adriannse, de Ridder, de Vet & Fennis, 2013).

And second, studies assessing the independent effects of mindfulness typically allow for a more detailed examination of mechanisms. We still know very little about the ways in which different mindfulness strategies bring about their effects (Holzel et al., 2011; Sedlmeier et al., 2012); understanding how mindfulness strategies work will increase the confidence with which we can effectively modify these techniques and apply them in new settings and to different populations. This is essential for the development of effective evidence-based interventions that have a sound theoretical basis (Michie & Abraham, 2004).

In light of the above, the current review examines studies that look at the independent effects of mindfulness-related strategies on weight management and weight management related behavioral outcomes. The review explores (a) evidence for

effects, (b) differences in effects across different types of mindfulness-related strategies, and (c) the ways in which such strategies may exert their effects. This should help identify future directions for more experimental work in this area as well as inform the development of evidence-based mindfulness weight management interventions. The review begins with a brief examination of the concept and practice of mindfulness.

Mindfulness: Definitions and Variations in Practice

As noted above, the term 'mindfulness' can be used to refer to a range of different practices. Different authors have also conceptualized mindfulness in slightly different ways. The current review draws on definitions of mindfulness put forward by Kabat-Zinn (2003), Bishop et al. (2004), and Shapiro et al. (2006) in order to distinguish between three main types of practice.

Kabat-Zinn (2003), defines mindfulness as 'awareness that emerges through paying attention on purpose, in the present moment, and non-judgmentally to the unfolding of experience moment by moment'. This definition arguably encompasses two key ideas; that of paying attention to present moment experience, and also of taking a non-judgmental attitude toward this experience.

Paying attention to present moment experience requires attention regulation, and this is highlighted in most definitions of mindfulness (e.g. Bishop et al., 2004; Shapiro et al., 2006). Indeed, most mindfulness practice includes exercises in which the individual attempts to maintain their attention on a particular aspect of their present experience. For example, they may attend to their breath, shifting attention back to the breath whenever it wanders. This practice involves several different attentional processes; monitoring the focus of attention, disengaging from distractions, and re-orienting attention back to the original focus (Lutz, Slagter, Dunne & Davidson, 2008).

However, an additional important feature of mindful attention regulation, is that it is focused on present moment experience. So for example, whilst one might also engage the above attentional processes during other effortful tasks, such as following a complicated film plot or performing a difficult calculation, these would not be considered mindfulness practice since ones attention is being used to achieve a particular outcome (understanding the film plot, getting the right answer), rather than to simply observe what is happening in the present moment. Hence this component of mindfulness practice is often labeled 'observing' or 'present moment awareness' (e.g. Baer, Smith, Hopkins, Krietemeyer & Toney, 2006).

The second key idea contained in Kabat-Zinn's (2003) definition, is that of taking a non-judgmental attitude towards ones experience (i.e. feelings, thoughts and bodily sensations). This component relates to what others have termed 'acceptance', and entails a willingness to simply experience (rather than avoid or control) these feelings, thoughts and sensations, even where they are negatively valenced. Whilst some have argued that acceptance arises naturally from paying attention to the present moment (Brown & Ryan, 2004), most definitions of mindfulness refer to this idea (e.g. Bishop et al., 2004; Shapiro et al., 2006), and many interventions include strategies specifically designed to increase acceptance. For example, a person may be encouraged to accept whatever thoughts come to mind, without judgment (e.g. Alberts, Mulkens, Smeets & Thewissen, 2010), or asked to think of themselves as 'surfing' their feelings, 'riding the wave' of them, rather than 'sinking' or giving into them (Jenkins & Tapper, 2014; Marlatt, 1994).

These two concepts of attention regulation and acceptance form the basis of the two-component model of mindfulness put forward by Bishop et al. (2004). This model comprises (1) self-regulation of attention so that it is maintained on immediate

experience, and (2) an orientation of curiosity, openness and acceptance towards one's experiences in the present moment. Shapiro et al. (2006) also identified attention and acceptance ('attitude') as features of their model of mindfulness, alongside a third component of 'intention', included to capture the idea that mindfulness is practiced for a particular reason (e.g., stress management, self-exploration).

Both Bishop et al. and Shapiro et al. proposed that repeated practice of these key components results in the emergence of an additional important feature of mindfulness, that of 'decentering' or 're-perceiving' (also termed 'deautomatization', 'detachment', or 'cognitive defusion'; Deikman, 1982; Hayes, Strosahl & Wilson, 1999; Safran & Segal, 1990). Decentering refers to the practice of viewing ones thoughts and feelings as temporary events that are separate from oneself and not necessarily a true reflection of reality. Again, although Bishop et al. and Shapiro et al. propose that decentering emerges spontaneously, it is also possible to specifically target decentering. This might be achieved by asking the individual to visualize their thoughts and feelings as separate entities (e.g. Jenkins & Tapper, 2014), or via instructions that simply ask the individual to view their mental events in this way (e.g. Papies, Pronk, Keesman & Barsalou, 2015).

It seems likely that these three strategies of present moment awareness, acceptance, and decentering facilitate one another (Holzel et al., 2011). This in turn may mean that they are most effective when used in combination. In particular, in order to practice both acceptance and decentering, a degree of present moment awareness is needed since one cannot accept or decenter from ones experience if one is not aware of it. As noted above, the use of one strategy may also naturally give rise to another. For example, acceptance and decentering may arise spontaneously from repeated practice at present moment awareness (Bishop et al., 2004; Brown & Ryan, 2004; Shapiro et al., 2006). However, it is possible to target these strategies independently and different

interventions vary in the emphasis they place on each type of strategy. Indeed, some interventions may draw on just one strategy. As such, it is important to establish the evidence for each technique, when used in both isolation and in combination. For this reason the current review is informed by the emphasis each study places on each of the three techniques detailed above: present moment awareness, acceptance, and decentering.

The review also takes account of the specific stimuli targeted by these techniques. For example, present moment awareness may be directed at a diverse range of stimuli. These could include environmental stimuli such as the sight of food in a shop window, the sensory qualities of food as it is eaten (e.g. its smell, taste and texture) or internal stimuli such as feelings of hunger, craving or fullness. Attention towards these different types of stimuli could have quite different effects, especially for an individual with limited experience of mindfulness practice. For example, it is possible that increased attention towards environmental food cues could elicit overeating (Doolan, Breslin, Hanna & Gallagher, 2015; Hendrikse et al., 2015). Conversely, overeating might also be the result of a lack of attention toward feelings of fullness (van de Veer, van Herpen & van Trijp, 2015). The effects of increased attention towards these different types of stimuli may also differ in different circumstances. For example, paying attention to ones surroundings may have very different effects if one is walking down a country path or through a high street filled with fast food outlets, potentially eliciting a desire for food in the latter but not the former.

In a similar manner, strategies of acceptance and decentering may also be directed at different types of events; they may target bodily sensations (e.g. sensations associated with hunger), emotions (e.g. feelings of desire for a particular food) or cognitive content (e.g. verbalizations relating to food or weight loss). It would be a

mistake to assume that these necessarily have equivalent effects. As such, when examining the evidence for mindfulness-based interventions, it is important to be clear about exactly what individuals have been asked to do.

Effects of Mindfulness on Weight Management and Weight Management Related Behavioral Outcomes

Literature search and study selection. The literature search was aimed at identifying all studies that examined the independent effects of mindfulness (or a mindfulness-related strategy) on either weight loss, or a behavioral outcome closely associated with weight management, namely quantity or type of food consumed. A literature search of English language publications was conducted during April 2016 using Web of Science and the search term 'mindful*' together with each of the following: 'weight loss', 'calorie*', 'energy intake', 'food consumption', 'weight consumed', 'eat*', 'diet*', 'food choice', 'body mass index', 'obesity', 'weight management'. The terms 'attentive eating' and 'intuitive eating' were also searched in isolation. This led to the identification of 524 publications. The titles and abstracts of these were reviewed and 470 were excluded for at least one of the following reasons: (a) no mindfulness manipulation, (b) no control or comparison group, (c) no weight management related behavioral outcome. The remaining 54 publications were examined in full. Of these a large number employed, or were informed by, Mindfulness-Based Cognitive Therapy (MBCT; Segal, Williams, Teasdale & Kabat-Zinn, 2012), Mindfulness-Based Stress Reduction (MBSR; Kabat-Zinn, 2013), intuitive eating (IE; Tribole & Resch, 2012), Health at Every Size (HAES; Bacon, 2010), Mindfulness-Based Eating Awareness Training (MB-EAT; Kristeller & Wolever, 2011) or Acceptance and Commitment Therapy (ACT; Hayes, Strosahl & Wilson, 1999). These programs all include elements that could potentially bring about change in the absence of any change in mindfulness.

For example, MBCT includes action planning, MBSR and MB-EAT use physical activity (yoga), IE encourages participants to 'reject the diet mentality', HAES employs nutrition education and social support, and ACT asks individuals to think about their values. Because the aim of the current review is to try to establish the independent effects of mindfulness-related strategies, where studies employed standard or adapted versions of these programs they were excluded. Studies were not excluded if they simply used mindfulness-based exercises drawn from these programs.

A total of 25 records were excluded because they included these types of non mindfulness-based components. A further 15 records were excluded because there was (a) no control or comparison group, and/or (b) no weight management related behavioral outcome. This left 14 studies. An additional five studies were identified on the basis of author knowledge, resulting in a total of 19 studies. The key features of these studies are summarized in Appendix A. They are grouped according to study outcome and within each group are ordered, as far as possible, according to the time period over which the outcome was assessed.

Weight loss. As noted previously, most studies that have examined the use of mindfulness for weight loss have employed a combination of mindfulness and non-mindfulness techniques, making it difficult to establish the independent effects of the mindfulness components. However, as shown in Appendix A, there are three studies that have looked at the effects of mindfulness only components on weight loss.

Mantzios and Wilson (2014) examined the effects of increasing present moment awareness of the sensory properties of food. They did this by asking undergraduate students to answer a series of questions every time they ate for a 5-week period. These questions were provided in the form of a diary that participants were asked to complete either whilst they were eating or immediately afterwards. In the mindfulness condition

the diary included questions relating to how the meal tasted and smelled as well as its color and texture. Participants were encouraged to answer these in as much detail as they could and to revisit the questions every 2 to 3 minutes. In this way they were prompted to repeatedly return their attention toward their present moment experience of eating. In the control condition the diary consisted of questions that encouraged them to think about their meal in a way that was not related to their present moment experience, for example about why it might be important to eat less. Although this study suffered from a high level of attrition (64 of the 136 participants failed to return for follow up measures and/or did not adhere to instructions), the results showed that those in the mindfulness condition lost significantly more weight than those in the control condition.

Alberts et al. (2010) examined the effects of present moment awareness and acceptance among overweight and obese adults. Although this study was primarily aimed at reducing food cravings, it also assessed weight loss. All participants attended a series of 10 weekly meetings that consisted of information on healthy food choices and a 1-hour session of physical activity. Those assigned to the mindfulness group received an additional instruction manual designed to develop present moment awareness and acceptance skills, together with audio instructions on an MP3 player and daily emails containing quotes about acceptance-based craving regulation. The manual contained eight chapters that were designed to be read over seven weeks and included exercises aimed at developing present moment awareness of bodily sensations, eating behaviors, and craving related thoughts, as well as acceptance of craving related bodily sensations and thoughts. Although those in the mindfulness group lost more weight than those in the control group, with just 19 participants in total the study was likely underpowered and this difference was not significant.

Finally, Mantzios & Wilson (2015) examined the effects of two different types of mindfulness interventions on weight loss over a 12-month period with military employees. All participants initially attended a presentation of information relating to eating behaviors and weight loss and received corresponding written materials. Participants assigned to the control group were then simply asked to watch their weight and food consumption with the help of these materials. By contrast, those assigned to the two mindfulness conditions (mindfulness meditation versus mindful self-compassion) attended a 2-day workshop on mindfulness meditation and were asked to practice three times a day with a meditation teacher, for a period of 5 weeks. The workshops included exercises that promoted present moment awareness of bodily sensations, thoughts, emotions, environmental cues and the sensory properties of food. Those assigned to the mindfulness with self-compassion condition attended an additional day's workshop that included exercises that emphasized kindness to the self. Two of their three daily practice sessions were also devoted to meditation practice that was designed to promote kindness to the self. Weight was assessed 5 weeks post-baseline (i.e. immediately following the end of the intervention period), at 6 months and at 12 months. The results showed significantly greater weight loss in the two mindfulness groups compared to the control group at 5 weeks and 6 months, but no difference between groups at 12 months. However, attrition in this study was both high and biased. Of the 88 individuals who were randomized, 25 dropped out and all of these were from the two mindfulness conditions. In other words, in the mindfulness meditation and mindfulness self-compassion groups there were attrition rates of 34 and 52% respectively whereas there was no attrition in the control group. This means that participants remaining in the mindfulness groups at follow-up were likely to have been relatively more motivated to lose weight and/or have higher self-regulatory skills. As

such it is difficult to attribute the differences in weight loss to the mindfulness interventions.

Thus whilst average levels of weight loss in the above studies were all higher in the mindfulness conditions, methodological weaknesses (high attrition and a small sample size) limit the conclusions that can be drawn from these studies regarding the use of mindfulness for weight loss.

Calories/weight consumed. Since weight loss is ultimately brought about by reductions in energy intake relative to energy expenditure, provided that energy expenditure remains constant, a reduction in energy intake will inevitably lead to either weight loss, or a decline in weight gain. Similarly, avoiding excess calorie intake will help prevent weight gain.

A total of ten studies have looked at effects on amount of food consumed, either in terms of energy content or food weight (see Appendix A). These studies have generally examined immediate effects on intake, or effects on intake 2-3 hours later. The longest duration for which intake has been assessed in these studies is 24 hours (Bellise & Dalix, 2001). In terms of the type of strategy employed, with just one exception (Marchiori & Papies, 2014), all of the manipulations have attempted to increase present moment awareness. Fisher, Lattimore and Malinowski (2016) looked at awareness of bodily sensations, thoughts and emotions, whilst the remaining studies have either targeted the sensory properties of the food, or the person's internal bodily sensations.

Thus these studies are relatively homogenous in terms of outcomes measures, and also employ a more limited range of strategies, both within and across studies. This makes it easier attribute particular effects to specific techniques. As such the studies will be considered in relation to the type of strategy they employ.

In terms of studies employing present moment awareness, six have focussed exclusively on increasing awareness of the sensory properties of food whilst eating (Arch et al., 2016; Bellisle & Dalix, 2001; Cavanagh, Vartanian, Herman & Polivy, 2014; Higgs & Donohoe, 2011; Long, Meyer, Leung & Wallis, 2011; Robinson, Kersbergen & Higgs, 2014). This has been achieved by asking individuals to attend to the appearance, smell, taste and/or texture of the food they are eating. Although some authors have not explicitly identified this manipulation as a mindfulness-based strategy (Bellisle & Dalix; Long et al.; Robinson et al.), participants are encouraged to repeatedly return their attention to their experience of eating. As such it can be viewed as a practice that promotes present moment awareness. Whilst one might argue that promoting present moment awareness in isolation (i.e. in the absence of an attitude of acceptance) does not constitute mindfulness, it can still be seen to be a key component of mindfulness practice. As such, the results of these studies are important for helping us understand the ways in which mindfulness may exert its effects on behavior.

Three of these studies looked at the effects of this present moment awareness strategy on the amount of food consumed whilst the strategy was being applied. Using a within subjects design, Long et al. (2011) failed to find any difference in intake of pasta and sauce (using servings of 750 g and 500 g respectively) when participants were asked to focus on the sensory properties of their lunch compared to when no instructions were given. Using a similar within subjects design, Bellisle and Dalix (2001) likewise failed to find any difference in lunch intake (using 1 kg beef casserole and 150 g fruit sherbert), between the present moment awareness and control conditions. However, Arch et al. (2016), using a between subjects design, asked participants to attend to, taste and rate six different snack foods. They found that those who had previously practiced a present moment awareness strategy (whilst eating five raisins)

and were then asked to apply it whilst tasting and rating the foods, consumed fewer calories compared to those who had eaten the raisins and snack foods either whilst solving word puzzles or in the absence of any strategy. This difference in calorie consumption was driven by a reduction in consumption of 'unhealthy' as opposed to 'healthy' foods (i.e. participants in the mindfulness condition reduced their consumption of foods such as chocolate and crisps but not their consumption of unsalted almonds and carrot sticks).

Thus it is unclear whether attending to the sensory properties of food whilst eating, reduces the amount eaten at that point in time. It is possible that the use of a within subjects design in two of these studies resulted in contamination across conditions which may in turn have masked effects. It is also possible that effects are moderated by the range of foods available; the two studies that showed no effect provided participants with just one or two types of food. By contrast, the study that did find an effect provided participants with a range of six different snack foods. However, this was also the only study in which participants had previously practiced the technique whilst eating raisins, hence the significant effects could also be a result of practice effects, or may have occurred as a result of this prior manipulation. Given the current popularity of 'mindful eating' in which individuals are encouraged to focus on the sensory properties of food as they eat, and the fact that people often consume a variety of different foods at mealtimes, these possibilities would be worth exploring in future research.

Two studies taught participants to attend to the sensory properties of food and then looked at the amount they consumed immediately following this instruction, in the absence of any explicit instructions to continue using the technique. Arch et al. (2016), in addition to the measure described above, also included a free eating period

immediately after asking participants to taste and rate raisins whilst attending to their sensory properties (or solving word puzzles / receiving no instruction). During this free eating period participants were presented with six different snack foods and instructed to 'please try to eat something so that you're not starving' (p. 29). They found no difference in consumption between the three conditions. Cavanagh et al. (2014) asked participants to read an information brochure on mindful eating and to spend 6 minutes attending to the sensory properties of a raisin. They were then served either a large (750 kcal) or small (440 kcal) portion of pasta and 'were told they could eat as much as they wanted of the meal' (p. 734). They also had access to additional pasta. Those in an education condition were asked to read information on external influences on food intake and to spend 6 minutes reflecting on these, whilst those in a control condition were given an equivalent brochure and task relating to sleep habits. The results showed that although participants in the mindfulness condition ate less compared to those in the combined education and control conditions, this difference was not statistically significant. Thus again the findings are inconclusive; although participants were not explicitly asked to apply the strategy in the Cavanagh study, it seems reasonable to assume that many of them did, and that it was this application of the strategy that was responsible for the trend toward a significant difference.

Three studies have looked at the effects of attending to the sensory properties of food on subsequent intake. After asking participants to apply this strategy whilst consuming lunch, Bellise and Dalix (2001) also asked them to keep a food diary over the subsequent 24-hour period in order to estimate total calorie intake. Estimated 24-hour intake (including the lunch consumed in the laboratory) was 1,794 kcal when participants were asked to attend to the sensory properties of their food and 1,850 kcal

when they were in the control condition. However, this difference was not statistically significant.

Two further studies have specifically examined effects on subsequent intake, assessed in the laboratory. Higgs and Donohoe (2011) found that undergraduate students who had been asked to focus on the sensory characteristics of their lunch ate fewer cookies approximately 2 to 3 hours later. The authors suggest that the food focus manipulation enhanced participants' memory for their lunch, which in turn helped them appropriately label physiological signals in the afternoon and adjust their consumption of cookies accordingly. This interpretation is supported by the fact that participants in the food focus condition also rated their memory of lunch as more vivid. It is also consistent with other work showing how memory for what has been eaten influences subsequent intake (Higgs, 2008). This finding has since been replicated with overweight and obese females who, compared to a control group, showed a 30% reduction in consumption of an afternoon snack (equivalent to 93kcal) when instructed to focus their attention on the food they were eating at lunchtime (Robinson et al., 2014). Neither of these studies found differences in amount of food consumed at lunchtime in the experimental versus control conditions, though lunch consumption was not the aim of the investigations and the relatively small portions provided at lunch (a sandwich and crisps, containing approximately 500 kcals) are likely to have resulted in ceiling effects.

Thus the studies by Higgs and Donohoe (2011) and Robinson et al. (2014) suggest that if individuals are encouraged to attend to the food they are eating, this may reduce the amount they consume later in the day. This effect seems to hold for both normal weight and overweight/obese populations, though has yet to be examined with men. However, since food consumption in these studies was only measured in the

laboratory, and over a limited time frame (2 to 3 hours) it is unclear whether such effects would translate into weight loss. For example, individuals may compensate for their reduced intake by eating more on other occasions, or the effects of this strategy may dissipate with repeated use. Nevertheless, the results of research by Mantzios and Wilson (2014), described in the previous section, are consistent with these findings, and support the possibility that attending to the sensory properties of food as one eats may aid weight management.

Three studies have looked at the effect of attending to internal bodily sensations on quantity of food consumed. Van de Veer, van Herpen & van Trijp (2012) found that those who spent 4 minutes being instructed to attend to bodily sensations ate fewer cookies when they had previously eaten a large (rather than small) chocolate bar. In other words, they were more likely to compensate for previous consumption by eating less, presumably because they had been made more aware of internal satiety cues. Conversely, Marchiori and Papies (2014) found that students who completed a 14-minute body scan ate fewer cookies relative to a control group when hungry, but the same amount when not hungry; hungry participants increased their intake by an average of 1 kcal in the mindfulness condition but 67 kcal in the control condition. However, the authors report that the body scan also instructed participants to observe their thoughts and sensations in an open, non-judgmental manner. Thus the manipulation included elements of acceptance as well as present moment awareness, and it was this acceptance component that the authors believed were responsible for the effects. Jordan, Wang, Donatoni and Meier (2014) also found that male and female undergraduates who completed a 15-minute body scan consumed fewer calories of snacks compared to those that completed a relaxation task (149 kcal versus 198 kcal respectively). Although the authors did not measure hunger or report any moderating

effects of time of last eating, the fact that on average participants had last eaten over 5 hours ago suggests that they may have been hungry.

Thus there is also some evidence to suggest that it may be beneficial to encourage individuals to attend to internal bodily cues. This is consistent with other research that has shown that, when it comes to meal cessation, normal-weight individuals are more influenced by internal cues whereas overweight individuals are more influenced by external cues (Wansink, Payne & Chandon, 2007). However, the evidence in this area is more mixed, with results suggesting that such an effect may be moderated by hunger (Marchiori & Papies, 2014; Van de Veer et al., 2012). More research is needed to establish this. It would also be important to determine whether such an effect is moderated by individual differences in ability to perceive gastric sensations (Herbert, Blechert, Hautzinger, Matthias & Herbert, 2013; Herbert, Muth, Pollatos & Herbert, 2012; see also Carnell & Wardle, 2008; Carnell, Haworth, Plomin & Wardle, 2008; Wardle et al., 2008). For example, encouraging an individual to attend to feelings of satiety during a meal may be less effective for a person who has difficulty perceiving such sensations.

Finally, Fisher et al. (2016) spent 10 minutes training individuals to attend to their breath and to notice thoughts, emotions and physical sensations without reaction or judgment. A control group listened to an audio description of a rainforest. Both groups then completed a food cue exposure task in which they spent 10 minutes smelling, touching and looking at (but not eating) four high calorie foods, before completing a series of questionnaires. They were subsequently left for 10 minutes in the presence of four high calorie foods and asked to practice the mindful breathing meditation (intervention group) or to reflect on their experience up to that point (control group). Following an additional 10 minutes spent completing further

questionnaires they were given a plate of 12 cookies 'as a token of appreciation' (p. 13). Participants who had been allocated to the mindfulness condition ate significantly fewer of these cookies.

This study is more difficult to interpret as it draws on several different mindfulness-related components (awareness not just of bodily sensations but also of thoughts and emotions) that were applied on two separate occasions. Thus it is difficult to establish which components of the procedure were responsible for the effects. For example, it is possible that the instruction influenced the way in which participants engaged with the subsequent food cue exposure task; those in the mindfulness condition may have been better able to attend to the sensory properties of the food in this task. Like the studies conducted by Higgs and Donohoe (2011) and Robinson et al. (2014), this may have influenced later consumption. Alternatively, having undergone the training and practice, (that was more extensive than that employed by Higgs and Donohoe, and by Robinson et al.), participants may have been more inclined to continue applying the strategy whilst eating the cookies. Additionally, since the training involved increased awareness of thoughts and emotions, as well as bodily sensations, it may have elicited decentering and it may be this element that was primarily responsible for the reduced consumption.

Consumption of high calorie foods. Five studies have looked at whether mindfulness-based strategies can reduce consumption of specific high calorie foods (i.e. foods that are high in fat and/or sugar, such as chocolate). Again, it is possible that such reductions will be compensated for by increased consumption of other foods, and thus will not necessarily lead to reductions in total calorie intake and to weight loss or better weight management. Nevertheless, there is evidence that sustained reductions in intake

of high calorie foods does lead to weight loss (Grafenauer, Tapsel, Beck & Batterham, 2013; Huseinovic, Winkvist, Bertz & Brekke, 2014).

Forman, Hoffman, Juarascio, Butryn & Herbert (2013) examined intake of sweets amongst overweight and obese women following a 2-hour intervention. In the mindfulness condition this intervention focused on both acceptance of cravings (i.e. a willingness to experience cravings rather than attempt to avoid or control them) and decentering from cravings (i.e. seeing oneself as separate from ones cravings). In the comparison condition it focused on distraction and cognitive restructuring. Participants were then given a bag of chocolates to carry with them for the following 72 hours and consumption of these chocolates was assessed together with self-reported consumption of other sweet foods and drinks. The results showed no significant difference between groups for either self-reported consumption or observed consumption.

Jenkins and Tapper (2014) recruited university students who expressed an interest in reducing the amount of chocolate they consumed. They spent 5 minutes in the laboratory practicing one of three different types of strategy; acceptance of cravings, decentering from food-related thoughts, or a relaxation (control) strategy. They were then asked to employ the strategy every time they felt like eating chocolate over the next 5 days. They were also given a bag of chocolates to carry with them at all times during this period, and were asked to record all chocolate and chocolate-related products they ate in a food diary. The results showed no difference in chocolate consumption, either from the bag or according to the diary, between those who had been given the acceptance strategy and those who had been given the relaxation (control) strategy. However, those who had been given the decentering strategy ate significantly less chocolate from the bag compared to the control group. They also ate (non significantly, $p = .053$) less chocolate according to the diary measure. The total

difference in chocolate consumed between the decentering and control group was estimated at 30 grams, equivalent to approximately 165 kcals over the 5-day period.

Hooper, Sandoz, Ashton, Clarke and McHugh (2012) examined the effects of decentering when applied to both feelings of chocolate craving and thoughts about chocolate craving. They asked undergraduate students to abstain from chocolate for 6 days, but to record any instances of chocolate consumption in questionnaires completed at the end of each day. Participants were allocated to one of three groups. Those in the mindfulness group were given 5-10 minutes instruction in the decentering strategy and asked to apply it every time they experienced a chocolate craving. Those in an active control group were given 5-10 minutes instruction in a thought suppression strategy and also asked to apply it every time they experienced a chocolate craving. A third group was not given a strategy. The results showed no significant differences between the three groups in terms of the number of occasions they ate chocolate over the 6-day period.

Forman et al. (2016) examined the effects of both mindfulness and inhibitory control training on students' consumption of salty snack foods over a 7-day period. The mindfulness component involved a 60-minute group training session aimed at de-automatizating eating behavior using present moment awareness of the sensory, cognitive and emotional processes that influence eating. The effects of this training were examined with and without inhibitory control training, and also compared to a 60-minute educational session in which participants were taught how to read labels and provided with information on the effects of salt on health. The results showed a significant reduction in salty snack intake amongst those who had received the mindfulness training.

Finally, Moffitt, Brinkworth, Noakes and Mohr (2012) recruited chocolate cravers and allocated them to one of three conditions. Those allocated to the mindfulness condition were provided with 60 minutes of instruction in decentering from food related thoughts. Those allocated to the active control condition were provided with 60 minutes of instruction in cognitive restructuring. A third group acted as a wait list control. All participants were then asked to carry a bag of chocolates with them for a 7-day period. Those in the decentering condition were significantly more likely to report having eaten no chocolate over the 7-day period compared to those in the cognitive restructuring or control conditions. Participants who reported high (as opposed to medium or low) levels of 'cognitive distress', also ate less significantly less chocolate from the bag if they were in the decentering condition compared to the cognitive restructuring or control condition. (Cognitive distress was assessed via three standardized questionnaires measuring the frequency and believability of automatic negative thoughts, cognitive distortions and pervasive negative attitudes, and attempts to avoid or control negative emotional or cognitive content.)

Thus the results of these five studies appear inconsistent. They included a total of ten measures of consumption, five of which showed no significant difference between the mindfulness and non-mindfulness conditions (Forman et al., 2013; Hooper et al., 2012; Jenkins & Tapper, 2014;), one of which showed a trend towards a significant difference ($p = .053$; Jenkins & Tapper), one of which showed a significant effect within a sub-group of participants (Moffitt et al., 2012) and three of which showed significant main effects (Forman et al.; Jenkins & Tapper; Moffitt et al.). These discrepancies do not appear to be associated with the type of outcome measure employed; the three significant effects occurred for both observed and self-reported outcomes.

In terms of type of mindfulness strategy, of the four studies that employed decentering (Forman et al., 2013; Hooper et al., 2012; Jenkins & Tapper, 2014; Moffitt et al., 2012), two found significant effects (Jenkins & Tapper; Moffitt et al.). These focused on decentering from food related thoughts whilst the two that showed no significant effects included decentering from cravings or craving related thoughts. Of the two studies that looked at acceptance (Forman et al.; Jenkins & Tapper), neither showed significant effects. Thus it is possible that for these types of intervention, where participants receive limited instruction and practice, decentering from cognitive content has some benefits whilst acceptance strategies, and strategies relating to craving, do not. It is also possible that effects were moderated by participant motivation; of the five studies, the three that found significant effects employed participants who had expressed an interest in reducing their consumption of the target food (Forman et al.; Jenkins & Tapper; Moffitt et al.). Just one of these studies looked at the effects of present moment awareness (Forman et al. 2016) and this study showed a significant effect. In this study present moment awareness was directed at a wide range of experiences, including internal bodily sensations, external cues, thoughts and emotions. This makes it difficult to establish the extent to which any individual technique was responsible for the effects. However, the results are broadly in keeping with studies described above that have found significant reductions in food consumption following present moment awareness manipulations.

Food choice. Just one study has examined the effects of mindfulness on food choice. Whilst food choice is not equivalent to food consumption, research shows that there is an association between the two, with individuals showing a tendency to eat food that is in front of them (Wansink, 2005).

In this study, Papies et al. (2015) recruited undergraduate students as they were about to enter a university cafeteria and allocated them to one of three groups. Two of these groups were exposed to a 12-minute training procedure in which they were asked to view a series of pictures (including 'healthy' and 'unhealthy' foods), either in a relaxed manner (control condition) or whilst observing their reactions as passing mental events (mindfulness condition). The third group received no training. Participants then entered the cafeteria. After they had selected their food they were probed for suspicion and asked to complete an additional questionnaire that included a measure of hunger. The foods they had chosen from the cafeteria were also recorded.

The results showed that higher levels of hunger were associated with the selection of a higher calorie meal in the no training group, but not in the mindfulness group. The authors interpreted these results as showing that the mindfulness manipulation reduced the effect of motivational state (hunger) on behavior (food intake). Further analysis indicated that, compared to those in the no training condition, participants in the mindfulness condition were less likely to select an 'unhealthy' snack item and more likely to select a salad.

Those who had viewed the food pictures in a relaxed manner also showed a reduction in unhealthy snack selection compared to the no training condition. However, this effect only occurred among those with a chronic dieting goal; the authors suggested that viewing the food pictures activated this goal amongst dieters. By contrast, in the mindfulness condition, snack consumption was reduced amongst all participants.

Thus although only one study has examined effects on food choice, the results are consistent with previous work by Marchiori and Papies (2014) who found that a mindfulness strategy only exerted effects when participants were hungry. The findings

are also in line with other research showing beneficial effects of decentering strategies (Jenkins & Tapper, 2014; Moffitt et al., 2012).

Potential Mechanisms of Action

The studies summarized in Appendix A illustrate the wide range of strategies and interventions that are referred to as mindfulness. Since different techniques may work in different ways, our understanding of mindfulness is only likely to improve if we take account of these different approaches. As such, potential mechanisms of action will be considered in relation to the three broad categories of technique identified previously; present moment awareness, acceptance, and decentering.

Present moment awareness. Although there are a range of possible ways in which present moment awareness techniques may exert an effect on eating (and, indeed, effects may occur via a number of interacting pathways rather than a single mechanism), three processes for which there is currently most evidence will be considered here.

As described previously, there is some evidence to suggest that attending to the sensory properties of food enhances episodic memory for that eating episode, and that this memory is then used to help interpret physiological signals (that are then less likely to be interpreted as hunger) later in the day. This in turn reduces the likelihood of overeating. This pathway would explain the effects of present moment awareness interventions that encourage attention toward the sensory properties of food. Higgs and Donohoe (2011) found that memory vividness mediated the effects of such a manipulation on subsequent consumption, though Robinson et al. (2014) did not. Thus although there is some support for this pathway, further research is needed.

The second potential pathway for the effects of present moment awareness strategies is a reduction in eating automaticity. Automatic behaviors are characterized

by a lack of awareness (Bargh, 1994) and there is evidence to indicate that much of our eating is elicited by external cues and conducted in a relatively automatic (habitual) fashion (Adriaanse, de Ridder & Evers, 2011; Neal, Wood, Wu & Kurlander, 2011; Tuomisto, Tuomisto, Hetherington & Lappalainen, 1998; Verhoeven, Adriaanse, Evers & de Ridder, 2012; see also Hoffman & Van Dillen, 2012). As a result, we frequently eat even when we are not hungry or when the food does not taste good (Neal et al.). This may ultimately lead to overeating and weight gain (Wansink et al., 2007). Indeed, there is a large body of work showing how 'mindless' eating tends to increase food intake (Wansink, 2010). Encouraging present moment awareness may weaken this type of habitual eating by increasing awareness of the fact that the food is no longer pleasurable and/or that one is not hungry. This in turn may alert the individual to the fact that they need to exercise self-control in order to inhibit the automatic eating response (Teper, Segal & Inzlicht, 2013). This reduction in automaticity may be coupled with an increase in the accessibility of competing attitudes and goals (i.e. negative attitudes towards the food where the individual is not enjoying eating it; incompatible goals relating to healthy eating or weight loss) that may further reinforce intentions to inhibit automatic responses.

Although no studies have examined causal links between present moment awareness techniques and habitual eating, there is evidence to suggest that higher levels of present moment awareness are associated with healthier eating behaviors. For example, Tak et al. (2015) found that those who scored higher on a measure of 'acting with awareness' were less likely to report eating in response to food cues or particular emotions. Likewise Beshara, Hutchinson and Wilson (2013) found a significant negative correlation between acting with awareness and self-reported serving size of energy dense foods. The notion that mindfulness may increase the cognitive accessibility of

competing goals is also consistent with research showing that present moment awareness techniques can influence the type of foods eaten, increasing consumption of more healthy foods relative to less healthy ones (Arch et al., 2016).

Third, it is possible that attending to the sensory properties of food encourages individuals to eat in a way that maximizes the amount of pleasure obtained from food rather than degree of satiation. Research suggests that portion size selection is usually determined by the amount we think we need to eat in order to satiate hunger (Brunstrom 2014; Brunstrom & Rogers 2009). However, research on sensory-specific satiety shows that the pleasure we obtain from a particular food is highest with the first few mouthfuls and then declines as we eat more (Rolls, Rolls, Rowe & Sweeney, 1981). This means that in order to maximize the average pleasure experienced from a particular eating episode, we need to eat smaller rather than larger portions (Cornil & Chandon, 2016; Rode, Rozin, & Durlach 2007). Thus asking individuals to attend to the sensory properties of food as they eat may reduce consumption because they may be more aware of the pleasure they are experiencing and prioritize this over other considerations such as satiation. As such they may be more likely to stop eating once their enjoyment drops below a certain level, even if they are not completely satiated. They may also become more aware of the rapid decline in pleasure as one eats, which may prompt them to select smaller servings.

This interpretation is supported by a series of five studies carried out by Cornil and Chandon (2016). They asked individuals to vividly imagine the taste, smell and texture of three different palatable foods, before being asked to select a portion of a fourth palatable food. Compared to those in control conditions, participants chose smaller portions. However, they anticipated experiencing just as much enjoyment from these portions as those in control groups who, on average, had selected larger portions.

Additionally, participants who had taken part in the imagery manipulation were better at accurately predicting the enjoyment they would experience from eating different quantities of food. Cornil and Chandon suggested that these effects occurred because the imagery task helped people realize that overall pleasure is higher with smaller portions. It also increased the importance of pleasure compared to other concerns such as satiation. However, it is important to note that individuals who were not hungry, or who were dieting to lose weight, tended to select smaller portion sizes, and the imagery manipulation did not bring about further reductions in these portion sizes. Indeed, in some instances, encouraging such individuals to think about pleasure, rather than hunger or weight loss goals, actually increased the portion sizes they selected.

Interestingly, this type of approach to eating, i.e. explicitly promoting awareness of sensory-specific satiety and/or taste satisfaction, is something that is often incorporated into mindfulness-related eating interventions such as MB-EAT (Kristeller & Wolever, 2011), intuitive eating (Tribole & Resch, 2012) and Health and Every Size (Bacon, 2010).

Acceptance. Just four studies specifically examined the effects of acceptance strategies on weight loss related behavioral outcomes (see Appendix A). Of these four studies, only one, Marchiori and Papies (2014), found significant effects. However, in this study the acceptance strategy was combined with increased present moment awareness of bodily sensations, thus it is possible that it was the latter driving the reductions in intake.

As such, it is unclear whether acceptance strategies can be used to promote changes in eating behavior. Nevertheless, there is some evidence to suggest that, in principle, acceptance strategies could bring about such effects by increasing the availability of self-regulatory resources. Engaging in emotion regulation, such as

supressing feelings of hunger or cravings, is believed to use up self-regulatory resources (Muraven, Tice & Baumeister, 1998). Thus accepting these emotions may result in a relative increase in the availability of self-regulatory resources, which may in turn be used for resisting food. In support of this view, Alberts Schneider, and Martijn (2012) found that participants who accepted their emotions whilst viewing a sad video clip performed better on a subsequent self-regulation task. However, it is important to note that others have questioned the limited resource model of self-control (Inzlicht, Schmeichel & Macrae, 2014). As such, it is unclear whether acceptance strategies could bring about change in this way.

Decentering. The ways in which decentering might bring about changes to eating are varied, but can be seen to fall into two distinct categories. First, decentering might enable the individual to exercise greater self-control over their behavior. In other words, decentering might influence the way in which the person responds to a desire to eat, but may have no influence on the desire itself. Alternatively, decentering might act directly on desire to eat, meaning that less self-control is needed. There is evidence to support both interpretations, and it is possible that decentering elicits different processes depending on whether it is applied to cognitive or affective mental content.

Where decentering is applied to cognitive content, it may increase self-control by disrupting habits. For example, if a particular thought (e.g. 'I really need something sweet') is consistently followed by a particular behavior (e.g. reaching for the biscuit tin), this response may eventually become a habit, being carried out in an automatic fashion. Prompting the individual to view their thoughts as separate from themselves, may be sufficient to disrupt automatic links between thoughts and behavior, bringing the behavior under conscious control and enabling the individual to consider whether an alternative response (such as eating a banana) might be preferable. Jenkins and

Tapper (2014) found some evidence to support this view. They found that the extent to which chocolate eating was habitual (as assessed by questionnaire) declined to a greater degree following a decentering manipulation compared to a relaxation control. If decentering works in this way, it would mean that it may be particularly useful for targeting habitual behaviors.

As per present moment awareness techniques, a reduction in this type of habitual or automatic eating might also be coupled with an increased accessibility of competing goals (e.g. weight loss or healthy eating goals). This interpretation is partially supported by Papies et al. (2015) who found that hungry individuals exposed to a decentering manipulation made more healthy food choices in both a cafeteria and a hypothetical food choice task. The fact that these effects were not moderated by the individual's dieting motivation is not entirely consistent with this view, though may be because many individuals approach dieting by attempting to reduce all food intake regardless of whether it is considered healthy or unhealthy; it is possible that a measure of healthy eating goals would have moderated healthy food choice.

Where decentering is applied to affective content, it may work by dampening the desire to eat, or by inhibiting the development of cravings. Papies, Barsalou and Custers (2012) and Papies et al. (2015) draw on the theory of grounded cognition, which asserts that when we encounter a relevant stimuli we automatically draw on our previous experience with that stimuli to simulate interacting with it; this in turn contributes to appetitive behavior (Barsalou, 2008). They suggest that engaging in a mindfulness strategy, i.e. seeing such simulations as mere mental events, reduces the subjective realism of these simulations and in this way prevents feelings of desire from developing. They support this view with a series of studies that show that a decentering manipulation brings about a reduction in spontaneous approach reactions to attractive

food in an implicit approach-avoidance task (Papies et al., 2012). They also show how the effects of a decentering task on hypothetical food choice amongst hungry individuals are mediated by reductions in food attractiveness (Papies et al., 2015).

Similarly, the elaborated intrusion theory of desire (Kavanagh, Andrade & May, 2005; May, Andrade, Kavanagh & Hetherington, 2012) states that desires and cravings arise when we employ working memory to consciously elaborate on craving related cues. According to this theory, any task that interrupts this elaborative process (e.g. by drawing on working memory) will prevent the development of the craving. It is this disruption that could be responsible for results presented by Lacaille, Zacchia, Bourkas, Glaser & Knauper (2014) that showed reduced craving amongst those who had practiced a decentering technique. Such an explanation would suggest that other techniques that draw on working memory resources would be equally as effective as decentering at reducing cravings (e.g. Kemps & Tiggemann, 2013; Skorka-Brown, Andrade & May, 2014). Further research could usefully compare decentering with such techniques. This could help establish whether there is a reason to recommend decentering in preference to other such techniques, and also whether a grounded cognition or elaborated intrusion explanation best accounts for any effects.

Conclusions and Recommendations

As described previously, mindfulness-based weight management interventions tend to include a range of different components, some of which could potentially elicit change even in the absence of any change in mindfulness (Olson & Emery, 2015). This means that it is often unclear whether changes in weight or eating behaviors are brought about by increases in mindfulness. The current review sought to address this shortcoming by looking at findings from studies in which mindfulness-related practices

were examined in isolation. The results from these studies are equivocal and highlight a number of important issues.

The two areas that show the most promise are (a) present moment awareness of the sensory properties of food, and (b) decentering. However, there is relatively little research examining these techniques, and no rigorously conducted studies have examined their effects on weight loss or weight maintenance. Thus whether such techniques can actually help with weight management remains to be seen.

It is also clear that we have little understanding of how mindfulness might work with respect to eating and weight management. Given the myriad different ways in which a strategy may be applied, and its effects may be measured, simply comparing strategies in the absence of theory will do little to advance our understanding of what works and why. By contrast, where research is informed by a particular theory, this will lead to much more specific predictions about the circumstances in which a technique is likely to show an effect. These predictions can then be tested. This is likely to result in much more rapid progress in the science of both mindfulness and eating behavior. In the current review, theories that have been used to try to understand the effects of mindfulness-based strategies include theories of episodic memory (Higgs, 2008), automaticity (Bargh, 1994), grounded cognition (Barsalou, 2008) and the elaborated intrusion theory of desire (Kavanagh et al., 2005). Whilst this list is by no means exhaustive, it serves to illustrate the opportunities available for grounding research into mindfulness in existing theory.

The studies in this review also illustrate the range of different ways in which mindfulness has been operationalized, and how these differences may influence effects on eating behavior. In order to make sense of the literature on mindfulness, it is critical that researchers are clear about exactly what participants have been asked to do.

Likewise, those seeking to develop evidence-based mindfulness interventions should be wary of such differences and avoid assuming that any technique labeled as 'mindfulness' will have equivalent effects. Indeed, the term 'mindful eating' may be used to refer to, or include, practices not covered in the current review, for example practices relating to triggers for eating and social pressures to eat. It is quite possible that such practices can bring about changes in eating but in the absence of any rigorous evaluation we cannot be certain of their effects.

Relatedly, one might argue that some of the strategies examined in the present review are not mindfulness-based strategies. In particular, one might argue that, in the absence of an attitude of acceptance, simply directing ones attention toward the sensory properties of ones food does not represent a mindfulness strategy. Indeed, whilst some authors have labeled this strategy as mindfulness (e.g., Mantzios & Wilson, 2014), others have not (Bellisle & Dalix, 2001; Long et al. 2011; Robinson et al., 2014). However, irrespective of the way in which such studies are labeled, their results provide important insights into the ways in which mindfulness may exert its effects. For example, it may be that the effects of mindfulness on the amount of food eaten is driven only by increased attention toward the sensory properties of the food, in which case additional instruction in acceptance may be unnecessary. Alternatively, future studies may find that acceptance strategies enhance the effects of present moment awareness on eating. In which case we would be justified in promoting mindfulness-based strategies in preference to simple attentional ones. Only further carefully controlled experimental studies, like those included in the present review, will help us answer such questions.

Additionally, it is important to note that the majority of studies reported in this review employ primarily normal weight university students as participants. Whilst this

is often a convenient starting point for experimental work, we must keep in mind that results obtained with such populations will not necessarily generalize to those who would most benefit from weight management interventions. Given that mechanisms underlying overeating and weight gain may vary with BMI (Davis & Fox, 2008), we should be cautious about assuming that any benefits will apply to all individuals. Equally, null effects amongst normal weight individuals will not necessarily rule out effects amongst those who are overweight or obese. A similar argument applies to gender. Much of the work in this area has been conducted with women. Given gender differences in food-related attitudes and responses (e.g. Adriaanse et al. 2011; Cleobury & Tapper, 2014; Frank et al., 2010; Larsen, van Strien, Eisinga & Engels, 2006), there is a need to establish that effects generalise to both men and women.

Other moderators of effect should also be considered. A particularly fruitful area may be trait differences, especially given the increased opportunity for tailored intervention now afforded by digital technologies. Two areas are worthy of note. First, as mentioned previously, there is increasing evidence to indicate individual differences in sensitivity to satiety cues. These seem to be influential in relation to eating behaviours and obesity (Carnell et al. 2008; Carnell & Wardle, 2008; Wardle et al., 2008). To date there has been little research examining whether such differences moderate the effects of mindfulness interventions. Relatedly, other research indicates variation in the extent to which an individual is sensitive to reward (Corr, 2008). This seems to translate into a greater response to appetising food cues (e.g. Tapper, Pothos & Lawrence, 2010), an increased tendency to overeat (Davis et al., 2007), and a greater intake of dietary fat (Tapper, Baker, Jiga-Boy, Haddock & Maio, 2015). It also predicts differences in BMI (Davis & Fox, 2008; Davis et al., 2007). Given that decentering strategies may help dampen desire (Papies et al., 2015), it would be interesting to

explore whether decentering was equally effective amongst those with high versus low reward sensitivity.

To conclude, a diversity of practices have been labeled as mindfulness, and the effects of each of these on weight management related eating behaviors are far from established. As such it would seem wise to invest in more carefully controlled experimental studies before developing and promoting additional mindfulness-based weight management interventions.

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Appendix A

Characteristics of Studies Examining the Independent Effects of Mindfulness and Mindfulness-Related Strategies on Weight Loss and Weight Loss Related Behavioral Outcomes

Outcome type	Study	Sample size[1]	Sample details	Gender distribution (% female)	Primary mindfulness (-related) strategy(ies) / intervention	Control strategy(ies) / intervention	Dependent variable	Results[2]
Weight loss	Mantzios & Wilson (2014)	73 (136 were random-ized)	University students.	42%	Present moment awareness of the sensory properties of food.	Thinking about reasons for eating.	Weight loss over 5 weeks.	Greater weight loss in the mindfulness-related condition.
Weight loss	Alberts et al. (2010)	19	Community sample, overweight or obese.	89%	Present moment awareness of bodily sensations, eating behaviors and craving related thoughts. Acceptance of craving related bodily sensations and thoughts.	Information and physical activity.	Weight loss over 7 weeks.	No significant difference.

Appendix A (continued)

Weight loss	Mantzios & Wilson (2015)	63 (88 were randomized)	Military employees.	33%	Present moment awareness of bodily sensations, thoughts, emotions, environmental cues and the sensory properties of food.	1. Asked to watch their weight with the help of psycho-educational materials. 2. Mindfulness and self-compassion.	Weight loss at 5 weeks.	Greater weight loss in both mindfulness conditions compared to the control condition. No significant difference between the two mindfulness conditions.
							Weight loss at 6 months.	Greater weight loss in both mindfulness conditions compared to the control condition. Greater weight loss among the mindfulness with self-compassion condition compared to the mindfulness condition.
							Weight loss at 12 months.	No significant differences.

Appendix A (continued)

Calories / weight consumed	Long et al. (2011)	27 (Within groups design)	University students.	100%	Present moment awareness of the sensory properties of food.	No strategy.	Weight of pasta consumed whilst applying the strategy.	No significant difference.
Calories / weight consumed	Arch et al. (2016)	102	University students, abstained from eating for at least 2 hours.	42%	Present moment awareness of the sensory properties of food.	1. Word puzzles. 2. No strategy.	Calories of 'healthy' and 'unhealthy' snacks consumed immediately after applying the strategy.	No significant differences.

Appendix A (continued)

							Calories of 'healthy' and 'unhealthy' snacks consumed whilst applying the strategy for a second time.	Lower total calorie consumption in the mindfulness-related condition compared to the control conditions. Lower total consumption of 'unhealthy' foods in the mindfulness-related condition compared to the control conditions. No significant difference in total consumption of 'healthy' foods between conditions.
Calories / weight consumed	Bellisle & Dalix (2001)	41 (Within groups design)	Community sample.	100%	Present moment awareness of the sensory properties of food.	No strategy.	Calories of casserole and fruit sherbet consumed whilst applying the strategy.	No significant difference.

Appendix A (continued)

							Calories consumed during 24-hour period including and following strategy use (includes self-reported intake).	No significant difference.
Calories / weight consumed	Cavanagh et al. (2014)	96	University students.	100%	Present moment awareness of the sensory properties of food.	1. Reflection on external influences on food intake. 2. Reflection on sleep habits.	Calories of pasta consumed immediately after being taught the strategy.	A trend toward lower consumption in the mindfulness-related condition compared to the combined control conditions; p = .07.

Appendix A (continued)

Calories / weight consumed	Van de Veer et al (2012)	Not reported.	Not reported.	Not reported.	Present moment awareness of bodily sensations.	Present moment awareness of the environment.	Weight of cookies consumed immediately following consumption of either a large or small chocolate bar. Strategy was delivered prior to consumption of the chocolate bar.	Lower consumption in the mindfulness-related condition following consumption of the large chocolate bar.
Calories / weight consumed	Marchiori & Papies (2014)	110	University students.	71%	Present moment awareness of bodily sensations. Acceptance of thoughts and sensations.	Audio book.	Calories of cookies consumed immediately following the manipulation.	No significant difference in overall intake. Lower consumption in the mindfulness-related condition among hungry participants.
Calories / weight consumed	Jordan et al. (2014)	60	University students.	50%	Present moment awareness of bodily sensations.	Audio guided relaxation.	Calories of snack foods consumed immediately following the manipulation.	Lower consumption in the mindfulness-related condition.

Appendix A (continued)

Calories / weight consumed	Fisher et al. (2016)	40	University staff and students.	100%	Present moment awareness of bodily sensations, thoughts and emotions.	Audio description of a rainforest.	Number of cookies eaten 10 minutes after practicing the strategy in the presence of food.	Lower consumption in the mindfulness-related condition.
Calories / weight consumed	Higgs & Donohoe (2011)	29	University students.	100%	Present moment awareness of the sensory properties of food.	No strategy.	Weight of cookies consumed 2-3 hours after using the strategy.	Lower consumption in the mindfulness-related condition.
Calories / weight consumed	Robinson et al. (2014)	48	University and community participants, overweight or obese.	100%	Present moment awareness of the sensory properties of food.	No strategy.	Weight of cookies consumed 2-3 hours after using the strategy.	Lower consumption in the mindfulness-related condition.
Consumption of high calorie foods	Forman et al. (2013)	48	Community participants, overweight or obese.	100%	Acceptance of cravings. Decentering from cravings.	Distraction and cognitive restructuring.	Observed consumption from a container of sweets over 72 hours.	No significant difference.

Appendix A (continued)

							Self-reported consumption of sweet foods and drinks over 72 hours.	No significant difference.
Consumption of high calorie foods	Jenkins & Tapper (2014)	135	University students, interested in reducing chocolate consumption.	72%	Decentering from chocolate related thoughts.	Relaxation.	Observed consumption from a bag of chocolates over 5 days.	Fewer chocolates consumed in the mindfulness-related condition.
							Self-reported consumption of chocolate related products over 5 days.	A trend towards lower consumption in the mindfulness-related condition; p = .053.
					Acceptance of chocolate related feelings.		Observed consumption from a bag of chocolates over 5 days.	No significant difference.

Appendix A (continued)

							Self-reported consumption of chocolate related products over 5 days.	No significant difference.
Consumption of high calorie foods	Hooper et al. (2012)	54	University students, not dieting.	59%	Decentering from feelings of chocolate craving and thoughts about chocolate craving.	1. Thought suppression. 2. No strategy.	Self-reported number of times chocolate eaten over 6 days.	No significant differences.
Consumption of high calorie foods	Forman et al. (2016)	119	University students consuming salty snack foods at least four times a week and expressing a desire to cut back.	62%	Present moment awareness of bodily sensations, external cues to eat, thoughts and emotions.	1. Inhibitory control training. 2. Inhibitory control training + mindfulness. 3. Psycho-education.	Number of salty snack foods consumed over 7 days post intervention compared to 7 days pre intervention.	Reduction in consumption in conditions with the mindfulness component relative to the psycho-education condition. No independent effects of inhibitory control training.

Appendix A (continued)

Consumption of high calorie foods	Moffitt et al. (2012)	110	Community sample, individuals who regularly crave and eat chocolate and have a desire to better manage eating behaviors.	85%	Decentering from food related thoughts.	1. Cognitive restructuring of food related thoughts. 2. No strategy.	Observed consumption from a bag of chocolates over 7 days.	Lower levels in the mindfulness-related condition, compared to the cognitive restructuring and no strategy conditions, among those with high (rather than medium or low) levels of cognitive distress.
							Self-reported chocolate abstinence over 7 days.	More participants in the mindfulness-related condition abstained from chocolate compared to those in the cognitive restructuring group or no strategy group.

Appendix A (continued)

Food choice	Papies et al. (2015)	114	University students.	Not reported.	Decentering from reactions to pictures of food.	1. Viewing pictures of food in a relaxed manner. 2 No strategy.	Calories in foods selected in a cafeteria.	Fewer calories selected in the mindfulness-related condition compared to the no strategy condition. Hunger increased calorie selection in the no strategy condition but not in the mindfulness-related condition.

[1] Restricted to participants included in the analyses of interest.

[2] Differences are statistically significant, unless otherwise stated.