Mindfulness in Weight Management: Understanding Efficacy, Mechanisms of Action and Implementation

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Declaration

I submit this thesis to City, University of London for the degree of Doctor of Philosophy in Psychology. I confirm that the work contained within this thesis is my own, and that it has not been submitted in fulfilment of the award of any other degree or qualification.

Abstract

As rates of overweight and obesity continue to increase across the global population, addressing this major health crisis has become a primary concern for governments and public health officials. Several measures have been implemented to induce behaviour change and promote healthier lifestyles, such as development of dietary and physical activity interventions and introduction of policies to make healthier choices more accessible. In recent years, mindfulness has emerged as a novel approach that could potentially be beneficial in the context of weight management. Mindfulness is the practice of paying deliberate attention to the present moment, without judgment. It has been suggested that practicing mindfulness can help individuals to regulate their food consumption, for example, by increasing awareness of internal sensations of hunger and satiety which can prevent overeating and mindless snacking. However, findings are inconsistent across the literature with some studies failing to find any effect of mindfulness on food intake. Insights into the underlying mechanisms of action by which mindfulness influences food consumption may help to understand when mindfulness is and is not effective, however at present there is limited research in this area. Furthermore, even if mindfulness is an effective practice for helping curb food intake, research shows that individuals may struggle with adhering to the practice consistently enough to see its effects. It is therefore imperative to explore how adherence to mindfulness can be encouraged in order to facilitate implementation of mindfulness-based interventions in practice. This thesis aimed to address these knowledge gaps by examining the effects of mindfulness on food consumption, exploring a potential underlying mechanism, and investigating strategies which may enhance adherence to mindfulness-based weight management strategies.

Chapter Two presents a systematic review and meta-analysis which consolidated the available research exploring the effects of mindfulness on food intake and appetite. Mindfulness was significantly associated with a reduction in food intake with a small effect size. No associations were found between mindfulness and appetite. In Chapter Three, an empirical laboratory-based study investigated increased awareness of satiety signals as a potential mechanism of action for the effect of mindfulness on food intake. Individuals' food intake while they were distracted was measured following a mindfulness-based body scan or control visualisation meditation. Although the mindfulness-based body scan was associated with increased attention to the body, this did not subsequently diminish food intake as predicted, thus failing to provide evidence for this particular mechanism of action. Finally,

Chapter Four investigated whether adherence to mindfulness-based weight management strategies over a two-week period could be enhanced by manipulating the length of information given to participants about the strategy and promoting the formation of implementation intentions to support use of the strategy. Although shorter information was found to be associated with increased adherence with a small effect size, this effect was not statistically significant, potentially due to inadequate power. There was no significant effect of implementation intentions on adherence overall, however, there was a significant moderation effect by individuals' planning skill abilities. Individuals with poorer planning skills reported greater adherence when forming implementation intentions as opposed to when they were given simple tips on strategy use.

The thesis makes several key contributions to the literature on mindfulness and food intake, by establishing more conclusive results regarding the impact of mindfulness on food intake and expanding the limited literature available on potential underlying mechanisms for this effect. Despite the absence of evidence for increased awareness of satiety signals as an underlying mechanism, the research establishes a foundation for future work in this field. Finally, the thesis provides preliminary support for the use of shorter information and the personalisation of interventions based on traits such as planning ability to improve adherence to mindfulness-based weight management interventions. Overall, the findings of this thesis establish mindfulness as a valuable component of weight management approaches. While further investigations are necessary to corroborate these findings, they have important implications for the development of interventions and policies in the context of weight management to address the issues of overweight and obesity.

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Research Output

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Contribution Statements

Contribution statements for each chapter of this thesis are presented below. Contributions for Chapter Four follow the Contributor Roles Taxonomy (CRediT) format.

Key

KA: Khaleda Ahmadyar; **KT:** Katy Tapper; **AB:** Angeliki Bogosian; **ER:** Eric Robinson; **QZ:** Qing Zhang; **GC:** Ge Chen; **ECH:** Elanor C Hinton; **DF:** Danielle Ferriday; **AJ:** Andrew Jones; **JS:** Joanna Szypula

Chapter One

KA conceptualised and wrote the first draft of the chapter. KT reviewed it and KA further revised it.

Chapter Two

KT, ECH and DF conceptualised the study. KA, QZ, KT, AB, ER, ECH and DF contributed to the study design. KA carried out the database searches, article screening, data extraction, risk of bias assessment and data analysis. GC supported as second reviewer for article screening. QZ supported as second reviewer for article screening, data extraction and risk of bias assessment. ER and AJ supported with data analysis. KA wrote the first draft of the chapter. KT reviewed it and KA further revised it.

Chapter Three (Published)

The study was conceived by KT and KA. KA, KT and ER contributed to the design of the study and the analysis plan. KA carried out the data collection, analysed the data and wrote the initial draft of the manuscript. KT and ER reviewed and edited it and KA further revised it.

Chapter Four (Submitted for publication)

KA served as lead for project administration, investigation, data curation, formal analysis, writing – original draft and writing – review and editing, and contributed to methodology. JS contributed to project administration and writing – review and editing. AB contributed to formal analysis and writing – review and editing. KT served as lead for conceptualisation, methodology, and supervision, and contributed to writing – review and editing.

Chapter Five

KA conceptualised and wrote the first draft of the chapter. KT reviewed it and KA further revised it.

Chapter One – General Introduction

1.1 Overweight and Obesity

Definition and prevalence

The increased prevalence of global overweight and obesity in recent decades has become a major public health concern. The World Health Organization (WHO) defines overweight and obesity as conditions in which an individual develops excessive fat deposits in their body (WHO, 2024). Overweight and obesity are classified using body mass index (BMI) which is calculated using an individual's weight in kilograms and their height in metres (kg/m^2). Individuals with overweight have a BMI equal to or greater than 25 while individuals with obesity have a BMI equal to or greater than 30. In 1990, 25% of adults across the world were classified as overweight or obese (WHO, 2024). Fast forward to 2022, just 32 years later, and this figure has almost doubled to 43% of adults. This is equal to 2.5 billion adults living with overweight globally, of which 890 million have obesity. In England, the percentage of adults with overweight or obesity was estimated to be 64% in 2019; an increase from 53% in 1993 (Health Survey for England, 2021). If this trend continues, it is estimated that 71% of the adult population in England will be living with overweight or obesity by the year 2040 (Cancer Intelligence Team, 2022).

The rising trend in overweight and obesity is not limited to higher income countries. Although obesity prevalence is much greater in higher income countries such as the UK and US, data show that rates have risen comparably across lower income countries such as those in the African regions, with an increase from 3.8% in 1980 to 10.9% in 2019 (Boutari & Mantzoros, 2022). Global overweight and obesity rates are projected to rise to 51% in the year 2035 (World Obesity Federation, 2023).

Causes

The causes of overweight and obesity are complex, with both biological and environmental determinants. At the most basic level, excess weight is caused by an energy imbalance, in which the amount of energy consumed exceeds the amount of energy expended over a period of time (Mitchell et al., 2011). Therefore, the two key physiological factors that contribute to overweight and obesity are excess food consumption and reduced physical activity. The rising prevalence of overweight and obesity may be attributed in part to the stark environmental changes that have taken place over the past few decades, namely the increased availability and accessibility of highly processed calorie-dense foods resulting in an “obesogenic” environment (Swinburn et al., 2011). Fast food outlets and pre-packaged processed food have become more widespread, offering quick, low-cost meals and snacks that are often high in sugar, fat, and sodium (WHO, 2022). These foods are often cheaper than healthier options, making them particularly appealing to individuals on tight budgets. Moreover, portion sizes have dramatically increased, leading to greater calorie consumption per meal (Livingstone & Pourshahidi, 2014).

These dietary shifts have been exacerbated by aggressive marketing strategies that promote overconsumption of these unhealthy foods. In 2020, the food and soft drink industry invested over $33 billion in advertising globally (WHO, 2022). These advertisements frequently promote sugary drinks and unhealthy foods, particularly targeting children which contribute to poor dietary patterns from a young age (Taillie et al., 2019). Additionally, product placement in media and strategic positioning of unhealthy foods in supermarkets further encourage impulse purchases and consumption (McCarthy et al., 2022; Shaw et al., 2020). This constant exposure to unhealthy food options normalises their consumption and undermines efforts to promote healthy eating habits.

Simultaneously, changes in the physical environment have led to a decline in physical activity, further escalating the obesity epidemic (Caballero, 2007). Urbanisation and technological advancements have given rise to more sedentary lifestyles. Many people now work in jobs that require long hours of sitting; over the last 50 years there has been a sharp decline in occupations that require physical labour and an increase in occupations that are largely desk-based and sedentary (Church et al., 2011). Additionally, leisure activities have become more passive as individuals now rely on screen-based entertainment such as television, video games, and social media (Tutar & Turhan, 2023). The increased use of technologies such as elevators, escalators, and automated machinery in homes and workplaces also minimises physical exertion (Booth et al., 2001). Together, these environmental factors have created an “obesogenic” environment where a combination of high calorie intake and low energy expenditure has driven up obesity rates globally.

Although these environmental changes have certainly contributed to the rise in overweight and obesity, individual susceptibility to obesity can be influenced by genetic factors as there is evidence to suggest that some individuals may be genetically predisposed to obesity (Omer, 2020). Studies carried out in twins, families and adopted children have found that 40% to 70% of the variance in BMI may be attributed to genetic factors (Maes & Neale, 1997; Elks et al., 2012). The most influential gene associated with obesity is the fat-mass and obesity-associated gene (FTO), which is strongly correlated with higher BMI and greater fat mass, making individuals with certain FTO variants more prone to obesity (Golden & Kessler, 2020). Additionally, mutations in the leptin gene and its receptor genes, which regulate appetite and energy balance, have been shown to lead to severe, early-onset obesity (Mărginean et al., 2018). However, this type of monogenic obesity tends to be quite rare, whereas polygenic obesity, which results from the cumulative effect of variations in multiple genes, is more common (Loos & Yeo, 2022). Therefore, while lifestyle and environmental factors play a crucial role, biological and genetic factors also substantially contribute to the development and persistence of obesity. Nevertheless, it is evident that although the environment has massively changed over the past few decades, our genetics and biology has stayed the same; it is therefore reasonably clear that the sudden global prevalence of overweight and obesity has largely been driven by the environment.

Consequences

Regardless of the cause of overweight and obesity, emerging evidence has increasingly suggested that it has major negative health consequences (WHO, 2022). Excess body weight significantly increases the risk of developing cardiovascular diseases, including heart disease and stroke, which are among the leading causes of death globally (Koliaki et al., 2019; Vos et al., 2020). Individuals with overweight and obesity are also predisposed to type 2 diabetes as almost 90% of all individuals with type 2 diabetes have overweight or obesity (Maggio & Pi-Sunyer, 2003). Musculoskeletal disorders, such as osteoarthritis, are also more prevalent in individuals with obesity because of the increased stress on weight-bearing joints (Fortunato et al., 2021). Furthermore, obesity is linked to a higher risk of several types of cancers, including breast, colorectal, and endometrial cancers (Calle & Thun, 2004).

The impact of overweight and obesity extends beyond physical health to mental health and psychological wellbeing, with higher rates of depression and anxiety observed among those with excess weight (Fulton et al., 2022). Individuals with overweight or obesity have a 55% higher risk of developing depression over their lifetime (Blasco et al., 2020). A recent systematic review also found that the prevalence of overweight and obesity was higher in populations with severe mental illness, such as schizophrenia, than the general population (Afzal et al., 2021). The relationship between excess weight and mental health is unique in that there is evidence it may be bi-directional; excess weight may cause higher risk of mental health conditions, but having a mental health condition may also lead to weight gain. This may be because individuals with excess weight are subject to weight discrimination and stigmatisation and may suffer with body image dissatisfaction and other weight-related issues

(Sarwer & Polonsky, 2016). Given its impact on the various aspects of physical and mental health, obesity is a major risk factor for death; it is estimated that globally 4.72 million people die each year due to the consequences of obesity (The World Counts, n.d.).

Beyond the negative health consequences to the individual, the increasing prevalence of overweight and obesity also has major economic impacts and system level consequences. Overweight and obesity are estimated to have had a global economic impact of $1.96 trillion in 2020 (World Obesity Federation, 2023). This includes the healthcare costs of treating obesity and its consequences, as well as the impact of obesity on economic productivity as a high BMI is associated with reduced productivity at work and premature retirement or death (World Obesity Federation, 2023). If current trends continue, the global economic impact of overweight and obesity is expected to rise to $4.32 trillion annually by 2035. In the UK, the burden of obesity on the National Health Service (NHS) is estimated to be £6.5 billion per year and this is expected to rise to £10 billion by 2050 (Department of Health and Social Care, 2024).

As one of the factors contributing to excess weight is overconsumption of food, overweight and obesity also contribute negatively to climate change (Swinburn et al., 2022). The link between obesity and climate change is primarily driven by food production and consumption patterns. According to the report by Swinburn et al. (2022) diets that contribute to obesity often have a higher carbon footprint due to the energy-intensive processes involved in producing high-calorie, low-nutrient foods. For instance, individuals with obesity generally consume about 30% more calories than healthy-weight individuals, which translates into greater greenhouse gas emissions from food production (Pradhan et al., 2013). Meat consumption, particularly red meat, is a significant contributor to these emissions, with livestock farming accounting for substantial methane and nitrous oxide emissions, as well as extensive deforestation and soil degradation (Mulhern, 2020).

Solutions

As demonstrated above, the consequences of overweight and obesity are significant and extend beyond individual health issues to broader systemic impacts. These consequences have been widely acknowledged and countless initiatives have been implemented globally in efforts to address this health crisis (Seagle et al., 2013). Clinical approaches to treat excess weight include bariatric surgery and pharmacological treatments (Shekelle et al., 2004). Bariatric surgery includes procedures such as gastric bypass and sleeve gastrectomy, which involve reducing the size of the stomach or bypassing a portion of the intestines (Elder &

Wolfe, 2007). These procedures not only restrict food intake but also alter gut hormones involved in hunger and satiety regulation. Evidence suggests that bariatric surgery can lead to sustained weight loss of 20-30% of total body weight and significant reductions in obesity-related conditions such as type 2 diabetes and hypertension (Arterburn et al., 2020).

Pharmacological treatments include anti-obesity drugs such as Orlistat, which inhibits fat absorption from food (Drew et al., 2007), and the more recently approved semaglutide, which mimics the actions of the glucagon-like peptide-1 (GLP-1) hormone leading to better glucose control and enhanced satiety (Suran, 2023). However, these drugs cause several adverse side effects and given their relative novelty, research on their long-term effects is lacking (Krentz et al., 2016; Feier et al., 2024). Similarly, bariatric surgery carries several serious risks and is reserved for the most extreme cases of obesity (Arterburn et al., 2020).

In recent years there have also been numerous population-level approaches adopted worldwide, targeting the obesogenic environmental influences described above (Lobstein & Leach, 2007). These include policies attempting to reduce overconsumption, improve diet quality and promote physical activity. For example, in 2018, the UK introduced the Soft Drinks Industry Levy, also known as the "sugar tax", which imposed a charge on manufacturers based on the sugar concentration in their beverages; drinks with more than 8 grams of sugar per 100 millilitres were to be taxed at a higher rate (HM Revenue & Customs, 2016). Since its introduction, this initiative has removed the equivalent of over 45,000 tonnes of sugar from soft drinks (Department of Health and Social Care, 2024). More recently in 2022, the UK government mandated calorie labelling on menus and food labels for large food businesses, including restaurants, cafes and takeaways (Department of Health and Social Care, 2021). The initiative is grounded in the evidence suggesting that calorie transparency can help individuals reduce their calorie intake and encourage healthier eating behaviours.

While these population-level and system-level approaches may help address some of the factors that have contributed to the increased prevalence of overweight and obesity, it is also important to target dietary and physical activity behaviour at the individual level. Lifestyle interventions that promote dietary and/or physical activity modifications have been identified as an effective treatment for overweight and obesity at the individual level (Burke & Wang, 2011). A variety of different interventions exist. The overarching goal in dietary interventions is to restrict the overall calories consumed in order to create an energy deficit resulting in weight loss (Chao et al., 2021). Some approaches employed to achieve this include restricting overall daily caloric intake to 1000 – 1500 kcals, restricting intake of fats or carbohydrates, or increasing intake of fruits, vegetables, and lean proteins (Kim, 2020).

Dietary interventions may also incorporate approaches such as replacing meals with portion-controlled soups, shakes or bars, or restricting food intake to certain hours of the day (known as intermittent fasting). However, the methods by which dietary intake is modified does not seem to make a difference to weight loss outcomes as long as overall daily energy intake is reduced (Kim, 2020). Physical activity interventions typically consist of structured exercise programmes involving 200 – 300 minutes of moderate intensity exercise as recommended by the American College of Sports Medicine for long-term weight loss (Lee & Lee, 2021; Jakicic et al., 2001). Some interventions encourage individuals to expend more energy throughout the day, for example, by taking the stairs instead of a lift or aiming to walk 10,000 steps per day (Richardson et al., 2008).

Both dietary and physical activity interventions have been associated with clinically significant levels of weight loss (Kim, 2020; Lee & Lee, 2021), however, optimal weight loss outcomes are achieved with multi-component interventions that target both diet and physical activity (Hassan et al., 2016). The National Institute for Health and Care Excellence (NICE) recommends that in addition to addressing dietary intake and physical activity levels, weight management interventions should also include a behavioural component (NICE, 2014). Behavioural components are strategies incorporated into the intervention to facilitate dietary and physical activity changes (Olateju et al., 2021). Self-monitoring is a key behavioural component that involves recording of food intake and exercise activity in a diary to increase self-awareness of behaviours within the individual (Burke & Wang, 2011). This exercise is thought to help individuals understand how their daily choices influence their weight management and allows them to identify patterns and make more informed choices. Evidence shows that self-monitoring is consistently associated with weight loss (Burke et al., 2011; Patel et al., 2021).

Other effective behavioural components in weight loss interventions include strategies such as goal setting, problem-solving and cognitive restructuring (Olateju et al., 2021). Goal setting involves setting specific, reasonable and achievable goals related to dietary intake and physical activity, focusing the individual's attention on behaviour change (Pearson, 2012). Problem solving involves identifying specific barriers to behaviour change such as time constraints or lack of motivation and developing actionable solutions to overcome them (Murawski et al., 2009). Cognitive restructuring is grounded in cognitive behavioural therapy (CBT) and focuses on identifying and challenging irrational beliefs and cognitive distortions related to eating behaviours, body-image and other aspects of weight management (Fabricatore, 2007). A highly successful multi-component weight loss intervention which incorporates all these strategies is the Diabetes Prevention Program (DPP; Diabetes Prevention Program Research Group, 2002a). In this large randomised controlled trial of 3,234 nondiabetic individuals, weight loss achieved at the end of the 24-week study period was significantly greater in the intervention group compared to the control groups (DPP Research Group, 2002b).

One of the issues with many weight loss interventions, regardless of their components, is that despite their initial success they have less than optimal long-term effects. Sustaining weight loss over the long term remains a significant challenge for individuals, and evidence shows that following a lifestyle intervention, individuals tend to regain a third of the weight lost within 1 year and return to their original weight within 3-5 years (Avenell et al., 2004; Dansinger et al., 2007). Even the best examples of weight loss interventions, such as the DPP described above, have failed to produce clinically relevant (<5% of initial body weight) sustained weight loss outcomes; a 10-year follow up study showed that individuals on the DPP gradually regained almost all of the weight they had lost while on the program (DPP Research Group, 2009). A potential reason for this may be that traditional weight loss interventions focus primarily on the physical aspects of weight loss and may not be addressing the psychological aspects that significantly influence eating behaviour and weight management. For example, individuals with excess weight may have weaker emotion regulation skills, which is associated with increased food intake in response to negative emotions or stress, known as emotional eating (Ozier et al., 2008). Excess food intake is also associated with a lack of awareness of internal hunger and satiety cues (Robinson et al., 2021a). Additionally, changing dietary intake and physical activity may cause discomfort, such as feelings of hunger due to reduced caloric intake, and requires significant mental effort, making it difficult for individuals to maintain the changes (Greaves et al., 2017). In order to address these psychological challenges of sustaining long-term weight loss, the integration of mindfulness and mindful eating components into weight loss interventions has gained attention (Godsey, 2013). The following sections define mindfulness and mindful eating and discuss research exploring their effects on weight management.

1.2 Mindfulness

Definition

The practice of mindfulness originates from Buddhist traditions and was first adopted in Western psychology in the 1970s (Anālayo, 2003). Since then, there have been numerous efforts to define mindfulness and various definitions have emerged (Quaglia et al., 2015). Jon

Kabat-Zinn, who played a pivotal role in introducing and integrating mindfulness into modern clinical psychology, defines it as "the awareness that emerges through paying attention on purpose, in the present moment, and nonjudgmentally to the unfolding of experience moment to moment" (Kabat-Zinn, 2003, p. 145). This definition highlights the two key features of mindfulness that many other definitions also emphasise (e.g. Brown & Ryan, 2003; Bishop et al., 2004; Shapiro et al., 2006). The first is maintaining awareness of the present moment, which may involve paying attention to internal experiences such as current thoughts, feelings, or bodily sensations, or external stimuli such as the surrounding environment (Shapiro et al., 2006). This is as opposed to being distracted by past events or future concerns (Brown & Ryan, 2003). Bishop et al. (2004) propose that this step involves not only attending to present moment experiences, but also being able to sustain this attention so that one is able to bring their attention back to the present moment if their mind begins to wander, described as self-regulation of attention. This skill involves acknowledging additional arising thoughts and sensations but then redirecting the attention back to the present moment, without elaborating on them further. Since attention has a limited capacity (Shiffrin & Schneider, 1977), self-regulation allows individuals to focus their attention fully on the present moment and have more resources to process information related to the current experience that may have otherwise been overlooked (Bishop et al., 2004).

The second feature of mindfulness is adopting a non-judgemental attitude of acceptance towards one's experiences (Kabat-Zinn, 2003; Brown & Ryan, 2003; Bishop et al., 2004; Shapiro et al., 2006). This means taking note of thoughts, feelings and sensations but not judging them or reacting to them in any way, instead being open and curious about them. Bishop et al. (2004) argue that this is an important aspect of mindfulness, as an attitude of acceptance means painful thoughts or feelings can be perceived as less unpleasant or threatening. Shapiro et al. (2006) further posit that acceptance involves practicing kindness and compassion in response to internal and external experiences, regardless of how aversive they may be. This allows individuals to refrain from constantly seeking pleasant experiences or avoiding negative experiences. Shapiro et al. (2006) also propose a third core component of mindfulness which they refer to as intention. This component relates to the individual's motivations for practicing mindfulness. Shapiro et al. (2006) argue that it is crucial for individuals to intentionally make a conscious choice to shift their awareness away from automatic or habitual patterns of thinking and into a state of heightened attentiveness. This fosters a deeper engagement with the immediate here and now. Furthermore, the intention component of mindfulness underscores its active and purposeful nature.

Bishop et al. (2004) further argue that mindfulness involves a closely related concept known as decentering. Decentering also emerges as a feature of mindfulness in Shapiro et al.'s (2006) definition. Decentering involves observing thoughts and feelings as transient events and separate from the self, fostering a sense of detachment and perspective (Safran & Segal, 1990). This allows individuals to observe these mental events as passing phenomena rather than intrinsic truths, enabling them to remain present and balanced amidst the fluctuations of the mind (Teasdale et al., 1995). Both Bishop et al. (2004) and Shapiro et al. (2006) propose that decentering arises naturally via repeated practice of present moment awareness and acceptance, the two key features of mindfulness described above. However, it is also possible to prompt decentering directly by instructing individuals to observe their thoughts and feelings as separate entities that come and go (Tapper, 2017).

A common and well-known form of mindfulness practice is meditation (Siegel et al., 2009). Lutz et al. (2008) distinguish between two distinct types of mindfulness meditation: focused attention and open monitoring. Focused attention involves directing attention to a specific aspect of the present moment and continuously sustaining this attention (Lutz et al., 2008). For example, this may involve focusing attention on the breath, observing each inhale and exhale (Salzberg & Mipham, 2008). Alternatively, attention may be focused on bodily sensations, thoughts or emotions (Kristeller, 2007). For instance, the body scan exercise developed by Kabat-Zinn (2002) guides attention through different body parts in sequence starting from the feet to the head and encourages individuals to notice and accept any physical sensations they may be experiencing. Open monitoring, also known as open awareness meditation, involves maintaining a broad awareness of thoughts, feelings, and sensations as they come and go, remaining in a monitoring state and allowing the attention to rest on whatever arises in the present moment without attachment or judgment (Lutz et al., 2008). A key aspect of this type of meditation is to refrain from delving too deeply in arising thoughts or sensations, instead simply noting them and allowing the mind to move onto the next object of awareness (Kristeller, 2007). Mindfulness meditation is typically scripted, and a guide leads individuals through the meditation process, whether through recorded audio or live instruction (Moral, 2017).

Mindful eating

Mindful eating is the application of mindfulness concepts in the context of eating behaviour, i.e., maintaining non-judgemental present moment awareness of eating-related thoughts, emotions, sensations and behaviours (Framson et al., 2009). In a comprehensive review of the mindful eating literature, Tapper (2022) describes the six most common ways in which mindful eating has been operationalised. The first is present moment awareness of the sensory properties of food, which involves carefully attending to the various sensory aspects of one's food while eating, such as the smell, taste and texture. A common exercise which employs this technique is the raisin-eating exercise developed by Kabat-Zinn (2006), which guides individuals to engage all their senses in a deliberate and focused way while eating a single raisin.

The second mindful eating practice is present moment awareness of bodily sensations. This is commonly induced via a body scan exercise which guides individuals to focus their attention on internal feelings of hunger and satiety, or other bodily sensations associated with food consumption (e.g. Palascha et al., 2021).

The third practice is present moment awareness of cues that elicit eating or the urge to eat; a practice that comprises noticing internal and external cues that may prompt one to eat, such as the presence of food or low mood. This mindful eating practice may be prompted by daily self-monitoring where individuals are asked to notice cues which drive the urge to consume, and to practice present moment awareness rather than act on the urge (e.g. Martin et al., 2017).

The fourth practice is acceptance of cravings, which requires that instead of trying to alleviate or control cravings, individuals should practice observing them non-judgmentally. This is typically done by exercises such as urge surfing, which instructs individuals to approach the urge to eat with curiosity and non-judgmental awareness rather than act on it (e.g. Jenkins & Tapper, 2014).

The fifth practice is acceptance and/or decentering from food-related thoughts, which involves acknowledging and allowing food-related thoughts to arise without judgment or the need to act on them. A common exercise that fosters acceptance and decentering from food-related thoughts is the mind bus exercise, where individuals visualise themselves as a bus driver and their thoughts as passengers on the bus; regardless of what their thoughts are their job is to drive along the planned route (e.g. Tapper & Ahmed, 2018).

The final mindful eating practice is decentering from cravings, which similarly to the previous practice, involves viewing cravings from an objective perspective as separate from the self. An example exercise is the leaves on a stream exercise, in which individuals visualise sitting by a stream and placing their thoughts or feelings onto a leaf and watching it float down the stream (e.g. Wilson et al., 2021). This visualisation allows a non-attached and non-judgmental attitude towards the cravings, allowing them to come and go naturally without the urge to act on them.

1.3 Mindfulness and Weight Management

Mindfulness-based interventions for weight loss

Mindfulness and mindful eating practices have been proposed as potential tools to aid weight management, as the cultivation of non-judgmental present moment awareness may help individuals to better recognise internal and external stimuli that may influence their behaviours, and reduce reactivity, allowing them to alter their responses (Caldwell et al., 2012). The acceptance component of mindfulness may also help individuals to tolerate and cope better with the discomforts associated with weight loss behaviours such as calorie restrictions and increased physical activity (Carrière et al., 2018). Mindfulness and mindful eating practices are employed in weight loss interventions primarily in one of two ways. The first is through informal mindfulness-based exercises such as Kidd et al.'s (2013) mindful eating intervention which educated participants on several mindful eating principles (e.g. awareness and acceptance of bodily cues) that they were to then practice in their daily life. Alternatively, many weight loss interventions may incorporate formal structured meditation sessions. For example, Kristeller et al.'s (2014) Mindfulness-Based Eating Awareness Training (MB-EAT) intervention consisted of 9 1-1.5-hour weekly sessions and 3 monthly booster sessions where individuals received mindfulness training designed to enhance awareness of eating-related experiences and reduce mindless or habitual reactivity.

A number of structured interventions have also combined mindfulness principles with other components; these interventions have been termed third-wave cognitive behaviour therapies (Lawlor et al., 2020). One such example is Acceptance and Commitment Therapy (ACT) interventions, which encourage individuals to accept their thoughts and feelings without judgment while committing to behaviour changes aligned with their values (e.g. Richards et al., 2022). ACT interventions aim to enhance psychological flexibility, which is the ability to adapt to different situations, shift perspectives and maintain value-driven actions despite challenges or discomfort (Doorley et al., 2020). Mindfulness is integral to this process as it allows individuals to become more aware of their thoughts and feelings in the present moment without becoming overwhelmed or controlled by them.

The effects of mindfulness-based interventions (MBIs) on weight loss outcomes have been extensively explored and reported in several reviews. A systematic review by O'Reilley et al. (2014) found that 9 out of 10 MBI studies reported significant weight loss or weight maintenance, albeit with small overall effect sizes (average Cohen's $d = 0.19$). Likewise, Olson & Emery (2015) reported that 13 of the 19 studies they reviewed found a significant effect of MBIs on weight loss. Similarly, in Rogers et al.'s (2017) meta-analysis of 15 studies, MBIs were found to significantly reduce BMI with a small effect size (Hedge's $g = 0.47$) and an average weight loss of 4.2kg. Another meta-analysis of 19 studies by Carrière et al. (2018) found that MBIs resulted in a mean weight loss of 6.8lbs post intervention and 7.5lbs at follow up, with a moderate effect size (Cohen's $d = 0.42$). Importantly, Carrière et al. (2018) also found that while there was no significant difference in weight loss outcomes between MBIs and traditional lifestyle interventions (e.g. diet and exercise programmes) post-intervention, participants in MBIs continued to lose wight at follow up whereas those in traditional programmes had sightly gained weight. This finding supports the idea that MBIs may be more effective in promoting sustained weight loss. Moreover, a literature review by Dunn et al. (2018) concluded that incorporating mindfulness components in weight loss programmes shows promise for the treatment of overweight and obesity. More recently, a meta-analysis of 9 studies by Fuentes Artiles et al. (2019) found that overall MBIs resulted in significant weight loss, though weight loss was more significant when MBIs were compared with a no-diet control group as opposed to control diet interventions. Finally, a meta-analysis by Lawlor et al. (2020) focused specifically on third-wave cognitive behaviour therapies for weight management and found that these interventions resulted in significantly greater weight loss compared to standard behavioural interventions at post intervention and at follow-up 12 and 24 months later.

However, other reviews have reported contradicting findings. In a systematic review of 10 studies exploring the effects of MBIs on weight loss, Katterman et al. (2014) found mixed effects with only 4 studies reporting significant weight loss following an MBI, with small effect sizes with the exception of one study. Warren et al. (2017) also reported mixed findings in their literature review of 19 MBI studies, with only 5 studies found to report significant weight loss. Similarly, Ruffault et al.'s (2017) meta-analysis found no significant effects on BMI across 9 MBI studies. Mercado et al. (2021) meta-analysed 11 studies and found no significant effect of MBIs on body mass post intervention. A more recent meta-analysis of 6 studies by Sosa-Cordobés et al. (2022) found no significant effects of MBIs on weight or BMI either in the short term or the long term.

There are several reasons for the mixed effects of MBIs observed across the literature. Firstly, the characteristics of the MBIs vary hugely across different studies, and the systematic reviews and meta-analyses described above have often combined findings across different types of studies. For example, the specific mindfulness components used in interventions can vary from simple informal mindfulness exercises (e.g. Kidd et al., 2013) to more structured formal programmes (e.g. Kristeller et al., 2014). Interventions also vary greatly in terms of length, lasting anywhere from a day to several months or years. Follow-up periods also differ across studies; it can be the case that despite the intervention length changes in weight are assessed at different time points following the end of the intervention. There are also differences in the groups of participants that have been examined across the studies, with studies conducted in a combination of individuals with healthy weight, overweight or obesity. Many of the interventions also include non-mindfulness components or more than one mindfulness component, making it difficult to disentangle the effects of individual components. Additionally, some studies compare change in weight from pre-intervention to post-intervention, while others compare the effect of MBIs against non-mindfulness comparison arms. Combining these two types of effects in a meta-analysis without using appropriate statistical approaches may have contributed to the inconsistent findings reported across meta-analyses of MBIs.

Given that a key aim of MBIs is to facilitate changes in behaviour that result in weight loss, it may be more insightful to explore how MBIs influence weight-loss related behaviours rather than just focusing on weight-loss outcomes. The reviews described above all indicate that MBIs primarily focus on modifying individuals' eating behaviour which in turn influences food consumption and subsequently body weight. It is therefore important to examine the effects of MBIs on eating behaviour in order to understand the relationship between mindfulness and weight management. It is also necessary to explore the individual components of MBIs in greater depth to identify how specific mindfulness and mindful eating practices influence eating behaviour.

Mindfulness and eating behaviour

Binge eating, emotional eating and external eating are three eating behaviours that have been linked to weight gain (Stunkard & Costello Allison, 2003; Koenders & van Strien, 2012; Benbaibeche et al., 2023). Binge eating refers to eating a substantial amount of food within a short period of time, and is often accompanied by feelings of loss of control over eating (Stunkard & Costello Allison, 2003). Emotional eating is characterised by eating in response to emotions (Koenders & van Strien, 2012) while external eating describes eating in response to external cues or stimuli, such as the sight, smell or availability of food as opposed to internal stimuli such as feelings of hunger (Benbaibeche et al., 2023). Mindfulness practices are thought to reduce these types of eating behaviours by enhancing awareness and acceptance of emotions and internal cues such as hunger and satiety, as well as promoting self-regulation and impulse control (Kristeller & Wolever, 2014). Indeed, several reviews have synthesised findings across the literature and consistently found that MBIs effectively reduce binge eating (Katterman et al., 2014; O'Reilly et al., 2014; Godfrey et al, 2015; Warren et al., 2017; Carrière et al., 2018; Yu et al., 2020), emotional eating (Katterman et al., 2014; O'Reilly et al., 2014; Warren et al., 2017; Carrière et al., 2018; Yu et al., 2020) and external eating (O'Reilly et al., 2014; Warren et al., 2017, Yu et al., 2020).

Nevertheless, although the above reviews demonstrate improvements in maladaptive eating behaviours as a result of MBIs, they do not offer any insights on whether these improvements lead to tangible outcomes that affect weight management, such as reduced energy intake. Additionally, the studies reviewed typically measure eating behaviour via questionnaire measures as opposed to actual behaviour. In order to explore the efficacy of mindfulness and mindful eating practices in weight management, it is important to assess their effects on food consumption as it has been established that weight loss is achieved primarily by reducing energy intake.

Mindfulness and energy intake

There is a growing body of evidence exploring the effects of a variety of mindfulness and mindful eating practices on food intake, indicating that mindfulness may be effective in reducing food consumption. For example, Arch et al. (2016) randomised 120 undergraduate students to either a mindfulness group, a distraction group or a no-instruction control group. All groups first completed 5 tasting trials, each trial consisting of tasting a single raisin. During the trials, the mindfulness group listened to an audio recording guiding them to attend to the sensory properties of each raisin as they tasted it. The distraction group listened to an audio recording instructing them to focus on a word puzzle while eating the raisins. The control group listened to an excerpt from a cognitive psychology textbook. Participants were then provided with snack foods, disguised as a taste testing task, and their total food intake was measured. The study found that participants in the mindfulness condition consumed fewer overall calories ($M = 196.7$, $SD = 135.2$) compared to the distraction ($M = 251.2$, $SD = 142.3$) and no-instruction control conditions ($M = 259.7$, $SD = 159.2$).

The study by Arch et al. (2016) induced a present moment awareness of the sensory properties of food. Similar results on food intake have been found using other types of mindfulness practices. For example, Dutt et al. (2019) employed a 12-minute breath awareness guided meditation, inducing general present moment awareness. The study involved 90 students allocated to either the mindfulness condition or a control group who listened to a nature audiobook. Participants first completed a stress-inducing task which required them to solve an anagram, followed by listening to the allocated audio recording. They were then provided with chocolates and grapes as a token of appreciation for their participation in the study and left alone for 10 minutes. The results showed that the mindfulness group consumed significantly less chocolate (*M* = 2.2, *SD* = 3.7) and grapes (*M* = 3.1, *SD* = 5.1) than the control group (*M* = 5.3, *SD* = 6.82 and *M* = 6.1, *SD* = 7.1, respectively) with medium to large ($\eta_p^2 = .09$) and medium ($\eta_p^2 = .06$) effect sizes, respectively.

However, these positive effects of mindfulness and mindful eating practices on food consumption are not corroborated in other studies across the literature. Conflicting findings have been reported in several studies. For instance, Tapper and Seguias (2020) carried out a study with 60 women in which they randomised participants to either a mindful eating condition or a control condition. Participants were first provided with an ad libitum lunch along with written instructions to either pay attention to the sensory properties of the food while they ate (mindful eating group), or simply to eat as much as they like (control condition). Participants were left alone for 10 minutes to eat the lunch. Participants were then administered a 10-minute filler task followed by a bogus taste test of biscuits and cookies. Participants then left the laboratory and logged on to a website at the end of the day where they completed a surprise food recall measure outlining their food intake during the remainder of the day. There were no significant differences in total calories consumed during the taste test between the mindful eating group (*M* = 166, *SD* = 105) and control group (*M* = 144, *SD* = 96). There were also no significant differences in calorie intake during the half-day period between the mindful eating group (*M* = 839, *SD* = 496) and control group (*M* = 759, *SD* = 403).

Similar findings have been reported in studies employing more structured mindful eating interventions. For example, Whitelock et al. (2019) tested the effects of an 8-week smartphone-based mindful eating intervention among 107 individuals with overweight or obesity in a randomised controlled trial. Participants either received the mindful eating intervention along with dietary advice, or dietary advice only (control group). The mindful eating intervention consisted of encouraging participants to record their food and drink intake by taking photographs before consumption, followed by answering questions about the consumption experience such as whether they finished the whole meal and how they felt.

Participants were able to then review a gallery of their consumption experiences along with their answers to the questions prior to deciding what they would eat or drink. The smartphone application also included a 2.5-minute audio clip comprising a mindful eating meditation that instructed participants to pay attention to the sensory properties of their food and feelings of fullness while eating. To enhance motivation to use the application features, participants were rewarded 'stars' for taking photographs, logging their consumption experiences and listening to the audio recording. Food intake was measured at 4 and 8 weeks via self-reported 24-hour energy intake as well as an objective laboratory measure using a bogus taste test. No significant differences were detected in either self-reported or objectively measured food intake at either 4 weeks or 8 weeks.

As demonstrated above, research exploring the effects of mindfulness on food consumption is varied and has produced mixed findings. At present there are only a handful of reviews attempting to synthesise findings across the literature (Tapper, 2017, 2022; Warren et al., 2017; Grider et al., 2021). The outcomes and limitations of these reviews are discussed in Chapter Two. While there is some promising evidence, overall, the association between mindfulness and food consumption remains inconclusive, highlighting the necessity for further investigation to clarify this relationship.

Mindfulness and appetite

In addition to exploring the effects of mindfulness and mindful eating on food intake, researchers have increasingly become interested in their effects on appetite (e.g. Allirot et al., 2018). Appetite refers to hunger and satiety (or fullness) levels typically measured using a Visual Analogue Scale (VAS; Gibbons et al., 2019). Hunger is the physiological and psychological sensation that drives the urge to eat, characterised by feelings of light-headedness, weakness or emptiness in the stomach (Blundell et al., 2010). Satiety, on the other hand, is the state of fullness and satisfaction that follows the consumption of food, preventing further eating until hunger returns (Blundell et al., 2010). Hunger and satiety are fundamental concepts in the regulation of food intake and energy balance (Amin & Mercer, 2016). It is therefore imperative to explore whether appetite plays a mediating role in the relationship between mindfulness and food intake. However, few studies have investigated the impact of mindfulness and mindful eating on appetite ratings, yielding mixed results (discussed in Chapter Two). Hence, at present there is no conclusive evidence on the association between mindfulness and appetite, underscoring the need for further investigation to consolidate the existing findings.

1.4 Mechanisms of Action

Potential underlying mechanisms

Given that mindfulness practices exert some effects on food consumption as indicated above, researchers have become interested in exploring the underlying mechanisms of action for these effects. Understanding these mechanisms may help to shed light on when mindfulness is and is not effective in influencing food consumption. This line of enquiry aligns with the experimental medicine (EM) approach to health behaviour change (Sheeran et al., 2017). The EM approach places a strong emphasis on mechanisms of change and outlines a systematic process for researching and advancing intervention design for behaviour change (Sheeran et al., 2017). The approach proposes that researchers must first identify a target (i.e. a potential mechanism of action) that relates to the behaviour of interest (i.e. food intake). The second step is to develop measures of the target and assess their impact on the behavioural outcome. The third step involves assessing how the intervention (i.e. mindfulness) influences the target. The final step is investigations determining whether the intervention results in behaviour change via its effect on the proposed target. This approach differs from traditional efficacy trials which are primarily focused on determining whether an intervention is effective as opposed to how and why.

Since the practices of mindfulness and mindful eating are vast and diverse, their effects on eating behaviour may involve a range of different processes. As such, there have been a wide range of potential underlying mechanisms proposed. Tapper (2022) provides a comprehensive overview of potential mechanisms that may be underlying the effects of mindfulness and mindful eating on energy intake. For example, one of the key ways in which mindful eating may reduce food intake is by slowing down eating rate and increasing feelings of fullness. Specifically, the practice of paying attention to the sensory properties of food while eating may cause individuals to slow down the pace at which they are eating in order to fully experience the taste, texture and smell of their food. This is then thought to lead to reduced energy intake as evidence shows that eating at a slower pace is associated with reduced food consumption (Robinson et al., 2014). This effect may occur because slower eating enhances orosensory exposure, meaning the food remains in the mouth longer. This extended exposure stimulates the release of gut hormones that decrease appetite (Krop et al., 2018; Hawton et al., 2018).

Other potential mechanisms by which mindfulness influences food consumption include increasing autonomous motivation and self-regulation, increasing awareness and acceptance of internal emotional cues, improving working memory, and increasing attention toward hunger, satiation, and satiety cues (Warren et al., 2017; Tapper, 2022). Both Warren et al. (2017) and Tapper (2022) highlight the lack of research examining these potential mechanisms empirically. Understanding the underlying mechanisms of how mindfulness influences food intake is crucial for enhancing intervention development. Considering that there are numerous potential mechanisms, implications for developing and customising mindful eating interventions are diverse. Different individuals may struggle with distinct aspects of their relationship with food, some might benefit most from mindfulness techniques that heighten awareness of hunger and satiety cues, while others might need strategies that target the emotional triggers driving their eating behaviours. Identifying and understanding these pathways enables MBIs to be designed and tailored more effectively. Further empirical investigation into potential mechanisms responsible for the influence of mindfulness on food consumption is therefore imperative.

Interoceptive awareness of hunger and satiety signals

While evidence on all the aforementioned underlying mechanisms is generally scarce, one mechanism in particular that remains unexplored is increased interoceptive awareness of hunger and satiety signals (Vanzhula & Levison, 2020). It is hypothesised that certain mindfulness practices help individuals to become more attuned to their internal bodily signals of hunger and satiety, which may help them to regulate their eating in response to these cues as opposed to external cues such as the presence of food (Vanzhula & Levison, 2020). Evidence for this potential mechanism comes from research on interoception. Interoceptive awareness refers to the capacity to perceive and interpret internal cues that originate from within the body (Khalsa & Lapidus, 2016), such as the heartbeat, breathing rate, temperature as well as sensations of hunger and fullness. A large systematic review and meta-analysis of 87 studies by Robinson et al. (2021b) revealed that a higher BMI was associated with poor interoceptive awareness. Additionally, when exploring differences between populations with a healthy weight versus those with overweight or obesity, the review found that interoceptive awareness was significantly lower in those with overweight or obesity. Deficits in interoceptive awareness have also been reported in individuals with eating disorders such as anorexia, bulimia and binge eating disorder (Jenkinson et al., 2018; Herbert, 2020). It is important to note that as the literature predominantly comprises cross-sectional studies, the association between interoception and overweight and obesity as well as eating disorders remains correlational, and a causal relationship cannot be determined. Nevertheless, these findings suggest that interoceptive awareness of hunger and satiety may play a role in self-regulation of food intake and weight management.

Studies using functional magnetic resonance imaging (fMRI) have found that mindfulness training increases activity in the areas of the brain associated with interoception, suggesting that mindfulness enhances interoceptive awareness (Farb et al., 2013; Ives-Deliperi et al., 2011). Mindfulness has also been associated with enhanced interoceptive awareness as measured by self-report questionnaires (De Jong et al., 2016; Fissler et al., 2016; D'Antoni et al., 2022). There is also some evidence that mindfulness can improve interoceptive awareness measured by a heartbeat detection task (Fischer et al., 2017), although a recent meta-analysis has concluded the contrary (Khalsa et al., 2020). It is important to distinguish between an improved ability to perceive internal bodily signals and merely an increased attention towards these signals. Khalsa and Lapidus (2016) acknowledge that interoceptive awareness encompasses multiple aspects and is a multifaceted process. Further research by Khalsa et al. (2020) shows that mindfulness may not necessarily improve a person's skill or ability in interoceptive awareness, i.e., their 'interoceptive accuracy'. Rather, mindfulness may simply increase a person's attention towards their internal bodily sensations ('interoceptive sensibility').

Although the studies described above provide preliminary evidence that mindfulness may enhance interoceptive awareness of hunger and satiety signals, they have a number of limitations. Primarily, most of the research uses self-report questionnaires or the heartbeat perception task to measure interoception, which may not be reliable measures (Robinson et al., 2021b; Khalsa et al., 2020). Furthermore, while there is some evidence that interoceptive abilities extend across different sensory modalities (Herbert et al., 2012), it is not clear whether improvements in general interoceptive awareness translate to increased awareness of hunger and fullness signals. Research exploring mindfulness and interoceptive awareness specifically in the domain of hunger and fullness signals is limited and yields inconclusive findings (discussed in Chapter Three). There is therefore a need for more empirical research examining increased awareness of hunger and fullness as a potential mechanism of action underlying the effects of mindfulness on food consumption.

1.5 Implementation

The challenge of adherence

While the efficacy of many MBIs for weight management have been established (described above), it is important to consider their effectiveness in practice. One of the challenges which may prevent the achievement of optimal outcomes is adherence to the intervention. Adherence refers to the extent to which individuals engage with and follow the prescribed practices of the intervention (WHO, 2003). Adherence to behavioural interventions is typically measured using self-reported data such as questionnaires and self-monitoring logs, or objective measures such as attendance records and technology-assisted monitoring (Nagpal et al., 2017; Leung et al., 2017). There is evidence to suggest that individuals may have difficulty adhering to mindfulness-based programmes. A review of 19 studies evaluating web-based mindfulness interventions indicated that on average only 56% of participants adhered to the intervention (Winter et al., 2022). Similar results were observed in a review of 21 studies which examined adherence to home-based mindfulness practice across a mixture of online and in-person programmes; on average, participant engagement with the mindfulness practice was 60% of the recommended amount (Baydoun et al., 2021). Additionally, a review of MBIs found that on average, 29% of participants typically drop out of the intervention before completion (Nam & Toneatto, 2016).

Moreover, adherence rates to general weight management interventions also tend to be suboptimal. Lemstra et al. (2016) conducted a meta-analysis of 27 studies comprising different weight loss interventions. They found that the average adherence rate was 60.5%, however, in some studies, adherence was as low as 10%. This is a significant issue as poor adherence rates can undermine potential intervention benefits. Adherence to weight loss interventions is a key predictor of enhanced long-term outcomes (Dalle Grave et al., 2005; Acharya et al., 2009; Johnston et al., 2019). Notably, Del Corral et al. (2011) found that women who demonstrated greater adherence to a low-calorie diet programme not only lost more weight during the programme, but also regained significantly less weight (50%) than poorer adherers (97%) at the two-year follow-up.

Although there have been no published reviews on adherence in mindfulness-based weight management interventions specifically, data from individual studies suggest that such interventions may also be affected by poor adherence. For example, Tapper et al. (2009) reported that only 48% of participants attended all four workshop sessions of their ACT-based intervention for weight loss. An ACT-based weight management intervention delivered on the web yielded similar results, with only 52% of participants reported to have accessed all 12 sessions of the programme by the 12-month follow-up (Mueller et al., 2023). Likewise, overall class attendance during a 4-month mindfulness training programme for weight management was 68% (Daubenmier et al., 2011). The issue of adherence therefore needs to be addressed in order for interventions to achieve optimal results.

A number of reviews have explored factors that may be associated with poor adherence to weight management interventions, however, these reviews have mostly focused on participant characteristics such as sociodemographic factors as opposed to intervention characteristics (Leung et al., 2017; Burgess et al., 2017a; Wang et al., 2024). Some reviews have suggested that greater adherence is associated with financial incentives, a multicomponent approach, use of self-monitoring technology, social support, and supervision (Lemstra et al., 2016; Burgess et al., 2017b; Pirotta et al., 2019; Wang et al., 2024). However, these reviews have not examined more specific practical factors that may influence adherence to weight management interventions. For example, a systematic review by Marks et al. (2021) identified that difficulty with understanding the content hindered adherence to MBIs. It was reported that educational materials were difficult to digest and not engaging enough, and the jargon used prevented engagement with the content. This suggests that the way the intervention content itself is communicated to participants may also influence adherence. While existing research hints at ways in which adherence can be improved, to the author's knowledge there are currently no studies that have empirically examined methods that could enhance adherence to mindfulness-based weight management interventions. Research indicates that the way intervention information is communicated to participants and the use of action planning strategies such as implementation intentions may influence adherence (discussed in Chapter Four). However, to date there is a lack of research exploring the impact of these factors on adherence to weight management interventions. Identifying strategies to improve adherence is key to developing more effective interventions.

Personalisation of interventions

As highlighted above, participant characteristics impact adherence to weight management interventions. For example, higher adherence is typically associated with being male, older age, a higher level of education, and a lower baseline BMI (Wang et al., 2024). Furthermore, there is considerable variability in the outcomes of weight management interventions based on participant characteristics. For example, as with adherence, greater weight loss is achieved by older, male participants (Chopra et al., 2021). These findings are crucial as they suggest that a one-size-fits-all approach is not the best way to approach weight management interventions, and that individual differences can influence whether or not a particular intervention is effective. Fundamentally, this finding implies that participant characteristics should be considered when designing interventions. This idea aligns with the concept of personalised medicine (also referred to as precision medicine), which was first introduced in the medical field as an approach to develop "prevention and treatment strategies that take individual variability into account" (Collins & Varmus, 2011, p.793). Individual variability refers to factors such as genetic, environmental, and lifestyle differences. While initially developed as an approach to personalise pharmacological interventions, personalised medicine has since been extended to the field of behavioural interventions (Hekler et al., 2020). The core premise of personalised medicine is that tailoring interventions to individual characteristics significantly improves outcomes (Hekler et al., 2020).

Indeed, the literature examining the effects of tailored interventions in weight management demonstrates that these approaches are more effective than standard weight management interventions. A systematic review of 6 studies revealed that digital tailored weight management interventions resulted in better weight loss outcomes compared to generic interventions or waitlist controls (Ryan et al., 2019). Tailoring in these studies was based on a range of factors such as age, weight, prior weight loss experience, dietary and physical activity behaviours, weight goals, social support and location. Tailoring was achieved by employing strategies such as evaluative and comparative-progress feedback and matching intervention content to participant characteristics. Similarly, a later meta-analysis of 15 randomised controlled trials demonstrated that tailored digital weight management interventions resulted in a significant weight loss of -2.77kg compared to a standard intervention or waitlist control (Lau et al., 2020). Tailored interventions have also been found to improve specific health behaviours. Lustria et al. (2013) meta-analysed 40 studies that evaluated the effects of tailored web-based interventions targeting physical activity, diet and smoking behaviours. The meta-analysis revealed that tailored interventions were significantly more effective than non-tailored interventions in improving the targeted health behaviours. This evidence compellingly suggests that tailored interventions are the future of effective health behaviour change, including weight management.

To effectively tailor interventions, it is essential to first identify the specific participant characteristics that may influence intervention outcomes. While the research described above has pinpointed certain characteristics such as age and gender (e.g. Chopra et al., 2021), there may be other individual differences that could potentially moderate the effects of mindfulness-based weight management interventions. For example, individual need for cognition and planning abilities may influence effectiveness of interventions (discussed in Chapter Four) yet there is a noticeable absence of research exploring these alternative factors.

1.6 Present Research

The available research indicates that mindfulness and mindful eating practices may influence appetite and help to reduce energy consumption. Yet, the inconsistent findings observed across the literature and lack of meta-analyses synthesising these findings present challenges in reaching definitive conclusions. Therefore, the first aim of this thesis is to overcome this challenge by conducting a systematic review and meta-analysis of studies examining the effects of mindfulness and mindful eating on food intake and appetite. This will obtain more comprehensive insights on the role of mindfulness in weight management. The second aim of this thesis is to deepen the understanding of the role mindfulness plays in influencing food consumption by exploring potential mechanisms of action. Specifically, the thesis aims to empirically examine an understudied mechanism of action; that mindfulness enhances interoceptive awareness of internal signals of satiety which in turn regulates food intake. Finally, the thesis aims to investigate how implementation of mindfulness-based weight management interventions can be enhanced in practice. This will be achieved by exploring two approaches to improve adherence to mindfulness-based weight management strategies: manipulating information length and using implementation intentions. The overarching objective of this thesis is to enhance understanding of mindfulness approaches to weight management and offer practical insights for their effective implementation.

1.7 Note to readers

Chapters Three and Four of this thesis were written as separate journal articles, therefore these chapters may contain some overlapping content that appear in other chapters of the thesis, particularly in the introductory sections where the background and context of the research are established. Formatting of these chapters has been adjusted from the published versions to ensure consistency throughout the thesis.

Chapter Two – Effects of Mindfulness and Mindful Eating on Food Intake and Appetite: A Systematic Review and Meta-analysis

Abstract

Mindfulness and mindful eating have been proposed as potential practices that may reduce food intake, however, findings are inconsistent across the literature. The study designs and methodologies used also differ greatly across the field. Therefore, this systematic review aimed to synthesise the available research to gain a more conclusive understanding of the effects of mindfulness and mindful eating interventions on energy intake in adults and children. A secondary aim was to assess the impact of these interventions on appetite (immediate and delayed hunger and fullness), since it is possible that appetite mediates the effects of mindfulness/mindful eating on food intake. Five electronic databases were searched (PsycINFO, MEDLINE, EMBASE, Web of Science and Scopus) and 2,754 articles published until 2022 were identified. Studies were included if they experimentally manipulated mindfulness and/or mindful eating, included a non-mindfulness control group and measured energy intake (in kcal/grams or equivalent) and/or appetite (using visual analogue scales). Two independent researchers screened the articles and 38 studies across 36 articles were included. Ten studies across 9 articles measured appetite and 37 studies across 35 articles measured energy intake. The data were analysed using inverse variance meta-analysis, where the standardised mean difference (SMD) in food intake and appetite ratings between experimental and control groups were calculated. Sub-group analyses were conducted to compare effects in adults and children, and across different types of studies. There was an overall effect of mindfulness/mindful eating on food intake (SMD = -0.22), but there was no significant overall effect on any of the appetite measures. No subgroup differences were observed in effects between adults and children, or between different intervention types, food types or timing of food intake. Interventions appeared to be more effective in reducing food intake in experimental lab-based studies compared to long-term interventions, and in studies measuring food intake within a laboratory setting compared to studies where food intake was measured in real-world settings. The findings of this review bear significant implications for shaping the development of impactful mindfulness and mindful eating interventions, while also offering pivotal insights to guide future research in this field.

2.1 Introduction

As discussed in Chapter One, the practices of mindfulness and mindful eating have garnered considerable attention by researchers as potential strategies to reduce energy intake and subsequently improve weight loss outcomes. In more recent years a newer practice that is similar to mindful eating, known as intuitive eating, has also gained popularity as a more holistic approach to improving eating behaviour. Intuitive eating was originally introduced by Tribole and Resch (1995) and refers to an adaptive eating style in which individuals eat in response to physiological hunger and satiety cues rather than external and emotional cues. Tribole and Resch (1995) identified ten key principles of intuitive eating which are based on three central features: giving oneself unconditional permission to eat when hungry and to eat whichever food is desired, eating for physical rather than emotional reasons, and relying on internal hunger and satiety cues to determine when and how much to eat. A key distinction between mindful eating and intuitive eating is that intuitive eating solely focuses on internally focused eating and does not involve meditation (Warren, Smith & Ashwell, 2017). Moreover, mindful eating practices often consist of one specific exercise, such as focusing on the sensory properties of food, whereas intuitive eating is a more comprehensive approach consisting of a set of established practices.

Mindfulness, mindful eating and intuitive eating have all been associated with lower body mass index (BMI) in a considerable amount of cross-sectional research. In a large study of over 63,000 participants in France, individuals with higher scores on the Five Facet Mindfulness Questionnaire (indicating higher dispositional mindfulness) were found to be less likely to have obesity (Camilleri, Mejean, Bellisle, Hercberg & Peneau, 2015). Similarly, Loucks et al. (2016) found that individuals with lower scores on the Mindful Attention Awareness Scale (MAAS) were more likely to have a BMI over 30 than those with higher MAAS scores. Framson et al. (2009) developed the Mindful Eating Questionnaire (MEQ) and found that individuals who had higher MEQ scores, indicating that they eat mindfully, had lower BMIs. A number of other studies have also found a similar association between MEQ scores and BMI (Moor, Scott & McIntosh, 2013; Pintado-Cucarella & Rodríguez-Salgado, 2016; Durukan & Gül, 2019). Research in the intuitive eating field shows similar findings. In a literature review by Van Dyke and Drinkwater (2014), 10 studies that measured intuitive eating and BMI using survey measures reported that intuitive eaters had significantly lower BMI than non-intuitive eaters.

Collectively, these studies suggest that practicing mindfulness, mindful eating or intuitive eating may aid in weight management. Nevertheless, due to the cross-sectional nature of the research, it is not possible to establish causal relationships. Experimental research in the field may provide a more promising avenue for exploring cause and effect. However, as discussed in Chapter One, research exploring the effect of mindfulness and mindful eating interventions on food intake yield inconsistent findings. The effects of intuitive eating on food intake are likewise inconclusive. For example, Camilleri et al. (2017) found that higher scores on certain subscales of the Intuitive Eating Scale (IES) were associated with lower overall energy intake in women, and lower intake of unhealthier foods in both men and women. Jackson, Sano, Parker, Cox and Lanigan (2022) also found that certain intuitive eating practices were associated with a higher intake of vegetables, whole grains and calcium, and lower intake of added sugar. On the other hand, Horwath, Hagmann and Hartmann (2019) only found a small positive association between intuitive eating subscales and better diet quality in women, but no association in men. Furthermore, Ruzanska and Warschburger (2020) found that although intuitive eating was associated with healthier self-reported food intake, there was no association between intuitive eating and amount of food consumed during a laboratory taste test.

Much of the research exploring effects of mindfulness and mindful eating on food intake also investigate how these interventions affect appetite i.e. hunger and fullness (also referred to as satiety). However, these findings also appear to be inconsistent across studies. For example, Higgs and Donohoe (2011) found that participants who ate a test meal mindfully reported significantly lower hunger levels 2 hours later compared to a control group. On the other hand, in another study by Robinson, Kersbergen and Higgs (2014) who used a similar methodology, there were no differences in hunger ratings between a mindful eating group and a control group. It is important to establish how mindfulness and mindful eating interventions influence appetite, as it is possible that appetite may mediate the effect of such interventions on food intake. However, there are very few studies exploring the effects of mindfulness and mindful eating on appetite, findings are not consistent, and to date there have been no systematic reviews conducted to synthesise the available research.

Systematic reviews exploring the effect of mindfulness, mindful eating, and intuitive eating on food intake are also scarce. Tapper (2017, 2022) conducted two narrative reviews summarising the research looking at the effect of mindfulness and mindful eating interventions on eating behaviour. The reviews provide a comprehensive overview of the research, describing the various operationalisations of mindfulness and mindful eating as well as potential mechanisms of action. Tapper (2017, 2022) concludes that the evidence is inconclusive and mentions the lack of systematic reviews and meta-analyses exploring the effects of specific mindfulness and mindful eating strategies on eating behaviour, given the diversity of practices.

A structured literature review conducted by Warren, Smith and Ashwell (2017) aimed to examine the role of mindfulness, mindful eating and intuitive eating interventions in regulating eating habits, including dietary intake. The authors found some evidence for reduced food intake as a result of mindfulness and mindful eating interventions in populations with overweight and obesity, but not in healthy weight populations. The effects of intuitive eating were not clear due to the limited research in this area. A similar review was conducted by Grider, Douglas and Raynor (2021) which specifically examined the effects of mindful eating and intuitive eating approaches on food intake. This review identified six mindful eating studies and three intuitive eating studies that measured food intake and found that only one study reported reduced food intake as a result of a mindful eating intervention. Of the three intuitive eating studies, only one reported a significant difference in energy intake, which was found to be lower in the active comparison group as opposed to the intuitive eating group.

The previous reviews and much of the existing literature do not address the differences in effects based on a number of factors that tend to differ across studies. For example, although much of the research in this area has been conducted in adult samples, there are several studies that have tested the effects of mindfulness and mindful eating in children (e.g. Bennett, Copello, Jones, & Blissett, 2020; de Tomas et al., 2022). In Tapper's (2022) narrative review of this research, it was concluded that studies in children are limited and tend to have varying aims, with some aiming to increase consumption of healthy and novel foods while others aim to reduce unhealthy food intake. It would therefore be beneficial to investigate the difference in effects of mindfulness and mindful eating on food intake between adults and children.

Moreover, the previous reviews have not taken into account the diversity of the research in the field in terms of the variety of ways that mindful eating and mindfulness interventions have been operationalised. Many studies incorporate a variety of specific elements in their mindfulness/mindful eating interventions and to date it has not been tested whether the addition of such elements influence the effect of the interventions on food intake. For example, one component is incorporating an element of attention regulation, where participants are instructed to bring their attention back to the present moment in case their mind starts wandering. In Bishop et al.'s (2004) definition of mindfulness, attention regulation is a key component, however many mindfulness interventions do not include this component. In some studies which include a component of present moment awareness of the body or of internal bodily sensations, participants may or may not be encouraged to also develop an attitude of acceptance towards this awareness, which is essentially maintaining the awareness without any judgements. Monitor and Acceptance theory (MAT; Lindsay & Creswell, 2017) states that present moment awareness on its own tends to increase affective reactivity, and that an element of acceptance is required to reduce this. Therefore, it is necessary to explore the effects of mindfulness and mindful eating interventions with and without an acceptance component. Likewise, many interventions tend to include non-mindfulness components alongside mindfulness and/or mindful eating components, and previously it has not been explored whether these additional components drive effects differently. Previous reviews have not addressed the presence of non-mindfulness components and have compared mindfulness-only studies with studies including both mindfulness and non-mindfulness components such as nutrition education.

Mindfulness and mindful eating studies also differ across several other factors such as whether they test intake of snack food or a more calorific meal, whether they measure intake immediately following the intervention or after a delayed period, and whether they employ a long-term multi-component intervention or a simple one-off session. Additionally, studies use varying components in their interventions; some may use exclusively mindfulness components, while others may only use mindful eating components. Studies may also use a mixture of mindfulness and mindful eating elements. Previous research has not investigated whether these factors alter the interventions' influence on food intake.

Given the diversity of research across the field of mindfulness, mindful eating, and intuitive eating it is imperative to conduct a comprehensive systematic review and meta-analysis to synthesise the available evidence and gain a complete understanding of the effectiveness of mindfulness, mindful eating and intuitive eating in the context of food intake and appetite regulation. The reviews conducted previously in this area do not adequately synthesise the research for the reasons described above. In addition to this, the narrative reviews conducted do not formally compare mindfulness and mindful eating interventions with a control comparison and the reviews by Warren et al. (2017) and Grider et al. (2021) mainly include studies with self-reported food intake measures which may be unreliable (Schoeller, 1990). No systematic reviews to date have focused on the effects of mindfulness, mindful eating and intuitive eating on objectively measured food intake and there have been no meta-analyses to synthesise the available research.

The present research therefore aims to conduct a comprehensive systematic review and meta-analysis of studies investigating the effects of mindfulness, mindful eating or intuitive eating on energy intake in adults as well as in children compared to a control group. A secondary aim of the review is to explore the impact of mindfulness, mindful eating and intuitive eating interventions on appetite (hunger and fullness), including immediate effects as well as delayed effects. As the significance of mindfulness, mindful eating and intuitive eating in nutrition and health gains recognition, this systematic review endeavours to offer an evidence-based foundation for further investigations and inform health professionals and policymakers in designing effective interventions to promote mindful and intuitive eating behaviours.

2.2 Method

Protocol and registration

The systematic review was carried out according to the Preferred Reporting Items for Systematic Reviews and Meta Analyses (PRISMA) guidelines (Moher, Liberati, Tetzlaff, Altman, & PRISMA Group, 2009). The protocol for the review was registered with the International Prospective Register of Systematic Reviews (PROPSERO) on 15th July 2022 with registration number CRD42022346160.

Eligibility criteria

Participants

Studies with healthy adults and/or children were included. Studies were excluded if their participants consisted of patient groups such as patients with eating disorders, diabetes, or cancer.

Intervention

Studies that experimentally manipulated mindfulness, mindful eating or intuitive eating were included and a coding scheme was developed to define and highlight the key components of each type of intervention (Table 2.1). For mindfulness and mindful eating interventions, any study that had at least one of the intervention components was included. For intuitive eating interventions, all components had to be present in order to be included. This is due to the way intuitive eating is defined and the way intuitive eating programmes are structured (comprising of ten intuitive eating principles). The detailed coding scheme is provided in Appendix A.

Table 2.1

Mindfulness, Mindful Eating, and Intuitive Eating Intervention Components

Intervention	Components
Mindfulness	1. Present moment awareness general 2. Present moment awareness of the body 3. Acceptance 4. Decentering 5. Attention regulation
Mindful eating	1. Present moment awareness of the sensory properties of food 2. Present moment awareness of internal bodily sensations relating to hunger, fullness and eating 3. Present moment awareness of cues that elicit eating or the urge to eat 4. Present moment awareness of food-related thoughts 5. Present moment awareness of cravings 6. Acceptance of feelings relating to hunger and/or cravings 7. Acceptance of food-related thoughts 8. Decentering from feelings of hunger and/or cravings 9. Decentering from food-related thoughts 10. Attention regulation
Intuitive eating	1. Rejecting the diet mentality 2. Honouring hunger signals 3. Giving oneself unconditional permission to eat 4. Avoiding categorising foods as ‘good’ or ‘bad’ 5. Savouring the experience of eating 6. Stopping eating when full 7. Coping with emotions without using food 8. Accepting and respecting one’s body 9. Focusing on the enjoyable aspects of exercise 10. Making nutritional food choices and honouring one’s health

Comparator/control groups

To be eligible for inclusion, studies were required to include a control group in which participants either did not receive an intervention or received an intervention unrelated to mindfulness, mindful eating or intuitive eating.

Outcome measures

The primary outcome measure was food intake. Studies were included if they assessed food intake as either energy intake or quantity of food consumed. A secondary outcome measure was appetite (hunger and fullness). Studies were included if they assessed change in appetite from baseline to post intervention using visual analogue scales (VAS).

Study design

All study designs were eligible for inclusion as long as they consisted of an experimental and control group. Pre/post designs were excluded due to the lack of a control group. Both within-subjects and between-subjects designs were eligible for inclusion.

Information sources and search strategy

The search process followed PRISMA guidelines, and the main search strategy consisted of searching 5 electronic databases: Ovid PsycINFO (https://www.apa.org/pubs/databases/psycinfo), Medline (https://www.nlm.nih.gov/medline/index.html), Embase (http://www.embase.com), Web of Science (https://www.webofscience.com/wos/woscc/basic-search), and Scopus (https://www.scopus.com). Searches took place during July 2022, and all articles up to 18th July 2022 were included. A combination of key words and Medical Subject Headings relevant to mindfulness, mindful eating, intuitive eating, food intake and appetite were used. See Appendix B for the full search strategy used. Only published studies were reviewed and grey literature was not searched. In addition to the electronic searches, a manual search of the references of eligible studies were carried out. All searches were carried out independently by two reviewers. Results were then compared to ensure findings were the same. Where there were discrepancies in the number of articles identified between the two reviewers, the search results from the reviewer with the highest number of articles were used.

Selection process

All articles identified during the search process were imported into Rayyan (https://www.rayyan.ai), which automatically removed duplicates. The remaining articles were split into three sections, and three independent reviewers each screened titles and abstracts of two sections each, so that each article was double screened. Any inconsistencies were discussed and resolved amongst the three reviewers. At this point all articles deemed eligible for inclusion were then retrieved and further assessed based on the full text. The same screening strategy that was used for the title/abstract screening was used again for the full text screening. Inconsistencies were discussed and resolved amongst the three reviewers as well as with the wider review team.

Data extraction and coding

Data were extracted for the included studies by two independent reviewers using a data extraction table. The table included sample characteristics, details of the intervention (including which components were present), primary outcome measures (food intake) and secondary outcome measures (appetite). Authors were contacted for missing information. The initial inter-rater agreement was 70%. Inconsistencies were discussed and resolved amongst the two reviewers as well as with the wider review team until agreement was reached.

Risk of bias evaluation

An adapted checklist was used to evaluate the risk of bias for each study that met the inclusion criteria. This approach was adopted as any one existing risk of bias tool did not capture all key aspects of study methodology when examining the effect of mindfulness and mindful eating manipulations on food intake and appetite. Following other systematic reviews of studies examining food intake (e.g. Robinson, Khuttan, McFarland-Lesser, Patel & Jones, 2022), the adapted checklist was formed using multiple quality assessment tools, including the Downs and Black checklist (Downs & Black, 1998), and the revised Cochrane risk-of-bias tool for randomised trials (RoB 2; Sterne et al., 2019).

The final checklist consisted of 8 items which examined whether studies blinded researchers to participant allocation, blinded participants to the aims of the study / group allocation, randomised participants to conditions, measured food intake objectively, provided key methodological details, were pre-registered, had matched control and experimental groups, and included a manipulation check. Two independent reviewers carried out the quality assessment and the initial inter-rater agreement was 81%. Disagreements were resolved through discussion and consensus until agreement was achieved.

Statistical and subgroup analysis

The results were combined using an inverse variance meta-analysis with RevMan version 5.4. A random effects (RE) model was used as the studies used different methodologies and outcome measures. Mean, standard deviation (SD) and sample size (N) for each group were extracted from all studies where they were reported. Missing SDs were calculated using the standard error of the mean (SEM), standard error (SE) and range where available. Missing group Ns were estimated from the total N. The weighted standardised mean difference (SMD) between experimental and control groups and its 95% confidence interval (CI) were calculated and heterogeneity was assessed using the I^2 statistic; with I^2 <

25% indicating low heterogeneity; $I^2 < 50\%$ moderate; and $I^2 > 75\%$ indicative of substantial heterogeneity. Food intake was measured in either weight (g), energy (kcal or kJ), number of pieces of food, or percentage of food consumed. To account for this difference in measurement scales, the SMD was used to compute the effect size.

A positive SMD indicates that food intake was higher in the experimental group than the control group, and a negative SMD indicates that food intake was lower in the experimental group than the control group. The larger the SMD, the bigger the difference in food intake between the experimental and control groups. Several subgroup analyses were conducted. For these analyses SMDs were calculated for each subgroup and the effect of the intervention on food intake was compared using a chi-square test for differences between subgroups. To ensure reliable effect size estimates and adequately account for potential heterogeneity across samples, a minimum of 5 studies were required for each subgroup.

The majority of studies consisted of one experimental group, one control group, and one food intake measure, and so contributed one comparison to the analyses. Some studies either had two experimental groups, two control groups or more than one food intake measure. For studies with two control groups, the groups were either combined into one or one of the control groups were excluded from the analysis if it involved an element of distraction. Either way, these studies contributed one comparison to the analyses. Studies with two intervention groups contributed two comparisons to the analyses, and as is standard for these types of comparisons, the number of participants in the control group were divided by two. Studies with two food intake measures also contributed two comparisons to the analyses and these were entered as two separate comparisons. Studies with within-subjects designs were entered into the analyses as though they were between-subjects studies.

Further inverse variance meta-analyses were conducted to explore the effect of mindfulness/mindful eating on immediate and delayed appetite. Appetite ratings were measured on 100mm Visual Analog Scales. The immediate ratings were reported immediately after the mindfulness or mindful eating intervention while delayed ratings were collected 2 to 3 hours post-intervention. It is worth noting that a single study assessed delayed appetite ratings with a 10-minute delay, and this study was excluded from the analysis due to its deviation from the standard study design. No other studies in the analysis measured appetite ratings within the timeframe spanning from immediately post-intervention to 2 to 3 hours later. Due to a lack of data for delayed fullness ratings, effects of mindfulness/mindful eating on delayed appetite only explored hunger ratings. In these analyses, a negative SMD indicates lower appetite ratings in the experimental group than the control group, and a positive SMD indicates higher appetite ratings in the experimental than the control group.

To assess the potential presence of publication bias, funnel plots were visually examined and Egger's test of asymmetry (Egger, Smith, Schneider & Minder, 1997) and a Trim and Fill procedure (Duval & Tweedie, 2000) were used. The evidence was examined for outliers to identify influential cases and leave-one-out analyses were conducted by removing each study from the analyses and refitting the model (Viechtbauer & Cheung, 2010). The publication bias analyses were conducted in R, using the 'metafor' package.

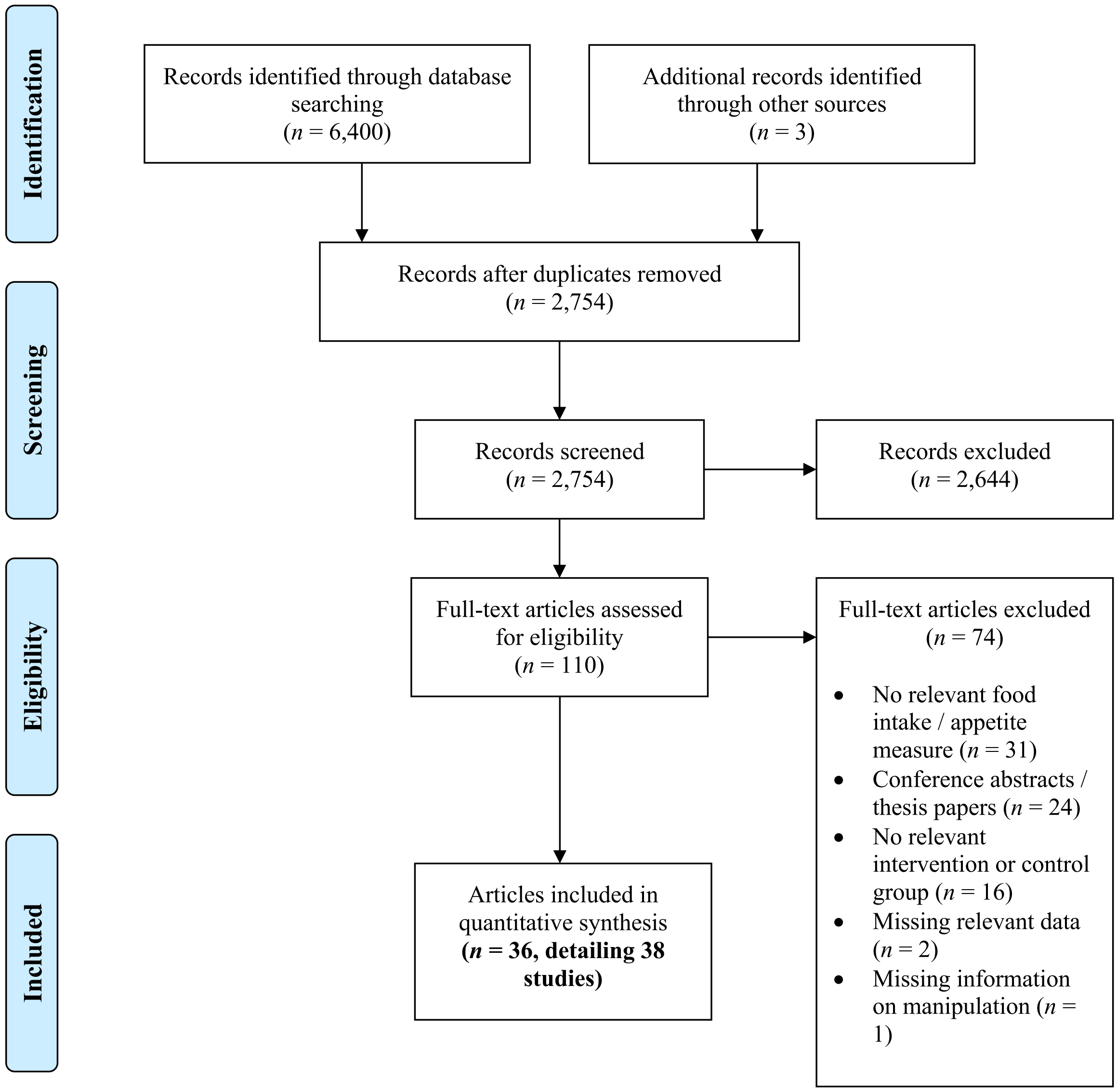
2.3 Results

Study selection

The initial database search produced 6,400 articles, which resulted in 2,751 possible articles once duplicates were removed. An additional 3 articles were suggested for screening by members of the review team and a total of 2,754 articles were screened for relevance based on their title and abstract. A total of 110 articles were identified for full text screening, of which 74 were excluded because they either had no relevant measure of food intake or appetite (n = 31), were conference abstracts or thesis papers (n = 24), did not have a relevant intervention or control group (n = 16), were missing relevant data about the outcome measures (n = 2) or were missing information about the manipulation (n = 1). As some articles had more than one study which met the inclusion criteria, a total of 38 studies across 36 articles were included in the review. The PRISMA flow diagram is presented in Figure 2.1.

Figure 2.1

PRISMA Flow Chart of the Study Selection Procedure



Study characteristics

The key study characteristics are presented in Table 2.2. All studies were reported in published journal articles. Studies were conducted in the UK (*n* = 19), the USA (*n* = 7), the Netherlands (*n* = 4), Spain (*n* = 3), Australia (*n* = 2), Belgium (*n* = 1), Canada (*n* = 1), and Brazil (*n* = 1).

Study design

Of the 38 studies, all but 2 of them used a between-subjects design. Twenty-seven studies were lab-based experimental studies, and 11 studies were long-term intervention studies ranging from 3 days to 6 months.

Participant characteristics

The total number of participants in each study ranged from 24 to 213. Four studies were conducted with children and 34 were conducted with adults. The mean age of participants across all studies ranged from 6 years to 50 years. For studies in children, the mean age ranged from 6 years to 10 years, and for adults it was from 20 years to 50 years. The ratio of participants was reported in 36 of 38 studies and ranged from 0% women to 100% women. Twelve studies were conducted in women only, one in men only, and 23 studies included both men and women. Mean BMI was reported in 30 of 38 studies and ranged from 16.89kg/m^2 to 35.55kg/m^2. In children, mean BMI was reported in only two studies, with a mean of 17.12kg/m^2. In adults, mean BMI ranged from 21.53kg/m^2 to 35.55kg/m^2.

Intervention

Twenty-three studies employed a mindful eating intervention, 8 employed a mindfulness intervention, and 7 studies involved both mindfulness and mindful eating components. The number of studies incorporating each of the mindfulness and mindful eating components are presented in Table 2.3. See Appendix C for details of the specific components in each study. There were no studies with an intuitive eating intervention that met the inclusion criteria.

Outcome measures

Of the 38 studies, 37 had a measure of food intake, 10 had a measure of immediate hunger, 6 had a measure of immediate fullness, and 5 had a measure of delayed hunger. Only

1 study had a measure of delayed fullness. There was a total of 46 mindfulness versus control comparisons for the food intake outcome as several studies provided more than one unique comparison group. There were 12 comparisons for immediate hunger, 8 comparisons for immediate fullness, and 5 comparisons for delayed hunger. For the food intake measure, 28 studies provided an objective laboratory measure while 7 studies provided a self-reported measure. Two studies provided both objective and self-reported measures.

Table 2.2

Summary Information on Included Studies

Reference	Participants				Study Information		Outcome Measures	
	N	Age (*M*)	Gender (% women)	BMI (*M*; m^2/kg)	Study design and schedule	Manipulation	Food intake	Appetite
Allirot et al. (2018)	70	35	100%	22.8	Between-subjects, single experimental session	7-minute mindful eating video	Subsequent ad libitum intake of snack food	Immediate hunger and fullness ratings
Arch et al. (2016)	102	21	42%	-	Between-subjects, single experimental session	5–7-minute mindful eating audio	Subsequent ad libitum intake of snack food	-
Bennett et al. (2020)	63	10	69%	-	Cluster-randomised controlled trial, one experimental session per day for five days	5-minute mindful breathing audio; 5-minute mindful raisin-eating audio	Subsequent ad libitum intake of a novel fruit	-
Cavanagh et al. (2014)	96	20	100%	21.5	Between-subjects, single experimental session	6-minute mindful eating audio while eating a raisin	Subsequent ad libitum intake of a meal	-
Chang et al. (2018)	97	21	96%	23.5	Between-subjects, single experimental session	4-minute decentering task in response to images of food	Subsequent ad libitum intake of snack food	-
De Tomas et al. (2022)	101	9	58%	17.4	Between-subjects, single experimental session	1-hour mindful eating workshop consisting of mindfulness audios and mindful eating exercises	Subsequent ad libitum intake of a meal	-
Dutt et al. (2019)	74	21	-	-	Between-subjects, single experimental session	12-minute guided mindfulness breathing audio	Subsequent ad libitum intake of snack food	-
Fisher et al. (2016)	40	30	100%	25.4	Between-subjects, single experimental session	10-minute guided breath awareness meditation	Subsequent ad libitum intake of snack food	Immediate hunger and fullness ratings

Table 2.2

Summary Information on Included Studies (continued)

Reference	Participants				Study Information		Outcome Measures	
	N	Age (*M*)	Gender (% women)	BMI (*M*; m^2/kg)	Study design and schedule	Manipulation	Food intake	Appetite
Gayoso et al. (2021)	96	9	-	16.9	Between-subjects, one experimental session per week for three weeks	1-hour mindful eating workshop consisting of mindfulness audios and mindful eating exercises	Subsequent ad libitum intake of a meal	-
Hsu & Forestell (2021)	126	21	70%	23.2	Between-subjects, single experimental session	15-minute mindfulness meditation audio	Subsequent ad libitum intake of snack food	-
Higgs & Donohoe (2011)	29	20	100%	23.3	Between-subjects, two experimental sessions, 2 hours apart	3-minute mindful eating audio while eating lunch	Subsequent ad libitum intake of snack food	Immediate and delayed hunger ratings
Hinton et al. (2021)	65	27	75%	22.4	Between-subjects, single experimental session	Rating fullness or taste every 1.5 minutes while eating lunch	Subsequent ad libitum intake of snack food	Immediate hunger and fullness ratings
Hong et al. (2018)	65	6	49%	-	Between-subjects, four experimental sessions per week for four weeks	30-minute sessions consisting of mindfulness and mindful eating exercises	Concurrent ad libitum intake of vegetables	-
Hussain et al. (2020)	120	24	76%	22.3	Between-subjects, single experimental session	Self-distanced or self-immersed adapted Mindful Construal Diary while eating	Concurrent ad libitum intake of snack food	-
Hussain et al. (2021)	85	20	85%	24.5	Between-subjects, single experimental session	Mindful Construal Reflection task while eating	Concurrent ad libitum intake of snack food	-

Table 2.2

Summary Information on Included Studies (continued)

Reference	Participants				Study Information		Outcome Measures	
	N	Age (*M*)	Gender (% women)	BMI (*M*; m^2/kg)	Study design and schedule	Manipulation	Food intake	Appetite
Jenkins & Tapper (2014)	135	21	72%	-	Between-subjects, two experimental sessions five days apart	Mindbus metaphor (cognitive defusion) or urge surfing strategy (acceptance) when craving chocolate	Subsequent ad libitum intake of snack food	-
Jordan et al. (2014)	60	20	50%	-	Between-subjects, single experimental session	15-minute body scan audio	Subsequent ad libitum intake of snack food	-
Long et al. (2011)	27	21	100%	23.8	Within-subjects, one experimental session per week for three weeks	30-minute mindful eating audio while eating a meal	Concurrent ad libitum intake of a meal	-
Masih et al. (2020)	34	36	67%	25.3	Between subjects, one intervention session per week for 8 weeks	30-minute class consisting of 20-minute guided muscle relaxation exercise or mindfulness meditation	Subsequent ad libitum intake of a meal	-
Mantzios et al. (2019)	121	20	95%	23.9	Between-subjects, single experimental session	4-minute mindful eating audio while eating chocolate; 4-minute Mindful Construal Diary while eating chocolate	Subsequent ad libitum intake of snack food	-
Mantzios et al. (2020)	128	21	65%	24.7	Between-subjects, single experimental session	Mindful eating audio while eating chocolate	Subsequent ad libitum intake of snack food	-

Table 2.2

Summary Information on Included Studies (continued)

Reference	Participants				Study Information		Outcome Measures	
	N	Age (*M*)	Gender (% women)	BMI (*M*; m^2/kg)	Study design and schedule	Manipulation	Food intake	Appetite
Marchiori & Papies (2014)	110	21	71%	22.3	Between-subjects, single experimental session	14-minute body scan audio	Subsequent ad libitum intake of snack food	-
Martin et al. (2017)	53	39	72%	32.6	Randomised controlled trial, three intervention sessions across 6 weeks	4-hour Mindful Decision-making or Mindful-Eating workshop and two 1-hour booster workshops	Change in 24-hour dietary recall from baseline to 6 weeks	-
Palascha et al. (2021)	213	22	100%	22.0	Between-subjects, single experimental session	4-minute body scan audio	-	Immediate hunger and fullness ratings
Robinson et al. (2014)	48	33	100%	29.3	Between-subjects, two experimental sessions 2-3 hours apart	3-minute mindful eating audio while eating lunch	Subsequent ad libitum intake of snack food	Immediate and delayed hunger ratings
Sant'Anna et al. (2022)	52	37	100%	32.3	Randomised controlled trial, one intervention session per week for 8 weeks	2-hour mindfulness intervention sessions consisting of education and meditations	Subsequent 24-hour dietary recall	-
Seguias & Tapper (2018)	51	24	53%	23.4	Between-subjects, two experimental sessions 2 hours apart	2.5-minute mindful eating audio while eating lunch	Subsequent ad libitum intake of snack food	Immediate hunger and fullness ratings

Table 2.2

Summary Information on Included Studies (continued)

Reference	Participants				Study Information		Outcome Measures	
	N	Age (*M*)	Gender (% women)	BMI (*M;* m^2/kg)	Study design and schedule	Manipulation	Food intake	Appetite
Seguias & Tapper (2022)	99	22	100%	22.3	Randomised controlled trial, three-day online intervention	Daily messages on smartphone app prompting awareness of sensory properties of food and access to mindful eating audio	Daily 24-hour dietary recall	-
Simonson et al. (2020)	24	24	50%	29.1	Between-subjects, three experimental sessions, 2 to 4 days apart	Mindful eating audio while eating a meal	Concurrent ad libitum intake of a meal	-
Spadaro et al. (2018)	46	45	87%	32.5	Randomised controlled trial, one intervention session per week for 6 months	1-hour intervention sessions consisting of Mindfulness-Based Stress Reduction and Mindfulness-Based Eating Awareness Training strategies	Subsequent daily energy intake using Food Frequency Questionnaire	-
Tapper & Seguias (2020)	48	44	100%	25.5	Between-subjects, single experimental session	Written instructions to pay attention to the sensory properties of food while eating lunch and throughout the rest of the day	Subsequent ad libitum intake of snack food, and subsequent 24-hour dietary recall for half day period	-
Timmerman et al. (2012)	35	50	100%	31.8	Randomised controlled trial, one intervention session per week for 6 weeks	2-hour intervention sessions consisting of education and mindful eating meditations	Subsequent 24-hour dietary recall	-

Table 2.2

Summary Information on Included Studies (continued)

Reference	Participants				Study Information		Outcome Measures	
	N	Age (*M*)	Gender (% women)	BMI (*M*; m^2/kg)	Study design and schedule	Manipulation	Food intake	Appetite
Van de Veer et al. (2016) Study 2	117	20	68%	-	Between-subjects, single experimental session	4-minute body scan audio	Subsequent ad libitum intake of snack food	-
Van de Veer et al. (2016) Study 4	85	21	84%	-	Between-subjects, single experimental session	4-minute body scan audio	Subsequent ad libitum intake of snack food	-
Whitelock et al. (2018) Study 1	108	29	53%	25.8	Between-subjects, two experimental sessions 3 hours apart	3-minute mindful eating audio while eating lunch	Subsequent ad libitum intake of snack food	Immediate and delayed hunger ratings
Whitelock et al. (2018) Study 2	147	33	100%	25.2	Between-subjects, two experimental sessions 3 hours apart	3-minute mindful eating audio while eating lunch	Subsequent ad libitum intake of snack food	Immediate and delayed hunger and fullness ratings
Whitelock et al. (2019a)	34	29	0%	23.7	Within-subjects, two experimental sessions 3 hours apart, repeated after 7 days	10-minute mindful eating audio while eating lunch	Subsequent ad libitum intake of snack food	Immediate and delayed hunger ratings
Whitelock et al. (2019b)	107	44	74%	35.6	Randomised controlled trial, 8-week online intervention	Attentive eating smartphone application including a 2.5-minute mindful eating audio	Subsequent ad libitum intake of snack food, and 24-hour dietary recall	-

Table 2.3

Number of Studies Incorporating each Mindfulness and Mindful Eating Component

Intervention	Components	Number of studies
Mindfulness	Present moment awareness general	6
	Present moment awareness of the body	16
	Acceptance	7
	Decentering	0
	Attention regulation	4
Mindful eating	Present moment awareness of the sensory properties of food	26
	Present moment awareness of internal bodily sensations relating to hunger, fullness and eating	12
	Present moment awareness of cues that elicit eating or the urge to eat	2
	Present moment awareness of food-related thoughts	4
	Present moment awareness of cravings	2
	Acceptance of feelings relating to hunger and/or cravings	2
	Acceptance of food-related thoughts	2
	Decentering from feelings of hunger and/or cravings	0
	Decentering from food-related thoughts	2
	Attention regulation	4

Risk of bias

Of the 38 included studies, only 6 studies made an attempt to blind researchers to group allocation. The majority of studies (*n* = 24) made an attempt to blind participants to group allocation or to the study aims by using a cover story. All but 3 of the studies randomised participants to conditions (or counterbalanced order if within subjects). Furthermore, all but 3 studies provided key methodological details. These three studies lacked information about participant randomisation and blinding. Food intake was measured objectively in 28 studies, while 7 studies provided a self-reported measure and 2 studies included both an objective food intake measure and a self-reported measure. One study was included in the systematic review for the appetite outcomes only, and therefore did not include a food intake measure.

Only 7 of the 38 studies were pre-registered on the Open Science Framework. Twenty-three studies employed control groups that were well matched to the intervention group for factors not specific to mindfulness, but that may affect the outcomes. Fourteen studies failed to match the control group for factors such as relaxation, attention, and contact time. One study included two intervention groups, one which was well matched to the control group and one which was not well matched. Only 5 studies had a manipulation check that closely matched what those in the experimental group were asked to do. See Appendix D for individual study risk of bias information.

Overall, 17 studies demonstrated a low risk of bias. These were studies that satisfied the most important risk of bias criteria, which were determined to be 1) blinding participants to group allocation or study aims, 2) randomising participants to conditions, 3) providing key methodological details, 4) measuring food intake objectively, and 5) matching the control and experimental conditions for factors that are not specific to mindfulness. Pre-registration was also considered to be important, however, as very few studies were pre-registered the inclusion of this criteria was futile.

Primary analyses

Effect of mindfulness and mindful eating on food intake

Forest plots examining the effect of mindfulness and mindful eating interventions on food intake in adults and children are presented in Figure 2.2. There was a total of 46 comparisons; 41 comparisons across 33 studies in adults and 5 comparisons across 4 studies in children. An overall effect was observed, suggesting that mindfulness/mindful eating interventions reduced food intake (SMD = -0.22, 95% CI [-0.35, -0.09], p <0.001, I^2 = 62%) and that there was moderate heterogeneity across comparisons. There were no subgroup differences between studies in children and studies in adults, χ^2 = 2.92, p = 0.09, I^2 = 65.8%.

There was no evidence for publication bias. The funnel plot is presented in Figure 2.3 and shows that the data were symmetrical. Egger's test for funnel plot asymmetry was not significant (z = -0.32, p = 0.75) and the Trim and Fill analysis did not impute any missing studies. There were no influential cases.

Figure 2.2

Forest Plot of all Studies Included in Primary Meta-analysis

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
1.2.1 Adults								
Allirot 2018	275.55	202.9807	35	388.82	248.4162	35	2.4%	−0.49 [−0.97, −0.02]
Arch 2016	196.68	135.24	33	259.65	159.23	36	2.4%	−0.42 [−0.90, 0.06]
Cavanagh 2014	273.41	153.24	32	319.91	150.05	64	2.6%	−0.31 [−0.73, 0.12]
Chang 2018	5.39	3.7	33	5.7	8.42	27	2.3%	−0.05 [−0.56, 0.46]
Dutt 2019	2.21	3.67	38	5.33	6.82	36	2.5%	−0.57 [−1.03, −0.10]
Fisher 2016	0.7	0.75	20	2.2	1.75	20	1.8%	−1.09 [−1.76, −0.42]
Higgs 2011	26.22	15.97	10	53.38	28	10	1.2%	−1.14 [−2.10, −0.18]
Hinton 2021 Fullness	249	236	22	255	208	10	1.6%	−0.03 [−0.77, 0.72]
Hinton 2021 Taste	279	231	22	255	208	11	1.7%	0.10 [−0.62, 0.83]
Hsu 2021	280.75	225.16	63	254.37	188.17	63	2.9%	0.13 [−0.22, 0.48]
Hussain 2020 Self-distanced MCD	76.88	59.34	40	170.25	136.19	20	2.1%	−1.00 [−1.57, −0.43]
Hussain 2020 Self-immersed MCD	98.25	103.92	40	170.25	136.19	20	2.2%	−0.62 [−1.16, −0.07]
Hussain 2021	48.22	67.55	43	94.48	102.95	42	2.6%	−0.53 [−0.96, −0.09]
Jenkins 2014 Acceptance	51.78	111.43	45	44.02	75.56	22	2.3%	0.08 [−0.43, 0.59]
Jenkins 2014 Cognitive Defusion	13.43	31.28	45	44.02	75.56	23	2.3%	−0.60 [−1.11, −0.09]
Jordan 2014	149.17	91.11	27	197.58	90.24	29	2.2%	−0.53 [−1.06, 0.01]
Long 2011	443.4	182.9046	27	425.8	177.7084	27	2.2%	0.10 [−0.44, 0.63]
Mantzios 2019 MCD	1	1.16	40	1.63	1.14	20	2.2%	−0.54 [−1.09, 0.01]
Mantzios 2019 Mindful Raisin Exercise	0.74	1.11	40	1.63	1.14	21	2.2%	−0.78 [−1.33, −0.24]
Mantzios 2020 First Intake	16.44	15.76	32	26.64	18.38	32	2.4%	−0.59 [−1.09, −0.09]
Mantzios 2020 Second Intake	5.11	10.2	32	6.38	8.54	32	2.4%	−0.13 [−0.62, 0.36]
Marchiori 2014	171.51	95.04	55	190.78	122.97	55	2.8%	−0.17 [−0.55, 0.20]
Martin 2017 Mindful Decision-Making	444.3	653.35	8	624.1	660.1	17	1.4%	−0.26 [−1.11, 0.58]
Martin 2017 Mindful Eating	444.3	653.35	9	264.7	634.65	19	1.5%	0.27 [−0.52, 1.07]
Masih 2020	3,190	1,359	17	3,104	1,291	17	1.8%	0.06 [−0.61, 0.74]
Robinson 2014	250	92	25	356	185	23	2.1%	−0.72 [−1.31, −0.14]
Sant'Anna 2022	1,222	435	28	1,380	480	24	2.2%	−0.34 [−0.89, 0.21]
Seguias 2018	112.3	70.24	26	203.2	88.05	25	2.1%	−1.13 [−1.72, −0.53]
Seguias 2022	1,594	425	33	1,543.5	530.8386	66	2.7%	0.10 [−0.32, 0.52]
Simonson 2020	700.08	300.66	8	861.46	299.4	8	1.1%	−0.51 [−1.51, 0.49]
Spadaro 2018	1,380.4	674.9508	22	1,602.7	721.6197	21	2.0%	−0.31 [−0.91, 0.29]
Tapper 2020 Half-day Period	839	496	11	759	403	12	1.5%	0.17 [−0.65, 0.99]
Tapper 2020 Taste-test	166	105	11	144	96	12	1.5%	0.21 [−0.61, 1.03]
Timmerman 2012	1,417.1	330.1	19	1,782	400.1	16	1.7%	−0.98 [−1.69, −0.27]
Van de Veer 2016 Study 2	37.2	25.69	40	32.2701	20.5065	77	2.8%	0.22 [−0.16, 0.60]
Van de Veer 2016 Study 4	22.37	15.06	43	24.86	18.07	42	2.6%	−0.15 [−0.57, 0.28]
Whitelock 2018 Study 1	365.03	221.99	34	364.145	192.615	74	2.7%	0.00 [−0.40, 0.41]
Whitelock 2018 Study 2	328.46	157.58	70	334.73	145.73	77	3.0%	−0.04 [−0.36, 0.28]
Whitelock 2019a	419.97	193.45	34	375.25	204.44	34	2.4%	0.22 [−0.25, 0.70]
Whitelock 2019b Self-report	1,831.46	869.28	26	1,720.15	716.04	27	2.2%	0.14 [−0.40, 0.68]
Whitelock 2019b Taste-test	162.24	109.59	27	125.09	105.15	27	2.2%	0.34 [−0.20, 0.88]
Subtotal (95% CI)			**1265**			**1273**	**89.1%**	**−0.27 [−0.39, −0.15]**
Heterogeneity: Tau² = 0.08; Chi² = 84.07, df = 40 (P < 0.0001); I² = 52%								
Test for overall effect: Z = 4.37 (P < 0.0001)								
1.2.2 Children								
Bennett 2020 Mindful Breathing	51.32	45.76	20	18.48	29.58	10	1.5%	0.77 [−0.01, 1.56]
Bennett 2020 Mindful Raisin Eating	51.47	48	23	18.48	29.58	10	1.6%	0.74 [−0.03, 1.51]
de Tomas 2022	421.83	205.02	50	470.95	233.57	51	2.8%	−0.22 [−0.61, 0.17]
Gayoso 2021	295.27	166.52	46	393.37	181.85	49	2.7%	−0.56 [−0.97, −0.15]
Hong 2018	2.15	0.73	31	1.33	0.95	34	2.3%	0.95 [0.44, 1.47]
Subtotal (95% CI)			**170**			**154**	**10.9%**	**0.29 [−0.34, 0.93]**
Heterogeneity: Tau² = 0.44; Chi² = 28.35, df = 4 (P < 0.0001); I² = 86%								
Test for overall effect: Z = 0.91 (P = 0.36)								
Total (95% CI)			**1435**			**1427**	**100.0%**	**−0.22 [−0.35, −0.09]**
Heterogeneity: Tau² = 0.11; Chi² = 118.61, df = 45 (P < 0.00001); I² = 62%								
Test for overall effect: Z = 3.37 (P = 0.0007)								
Test for subgroup differences: Chi² = 2.92, df = 1 (P = 0.09), I² = 65.8%								

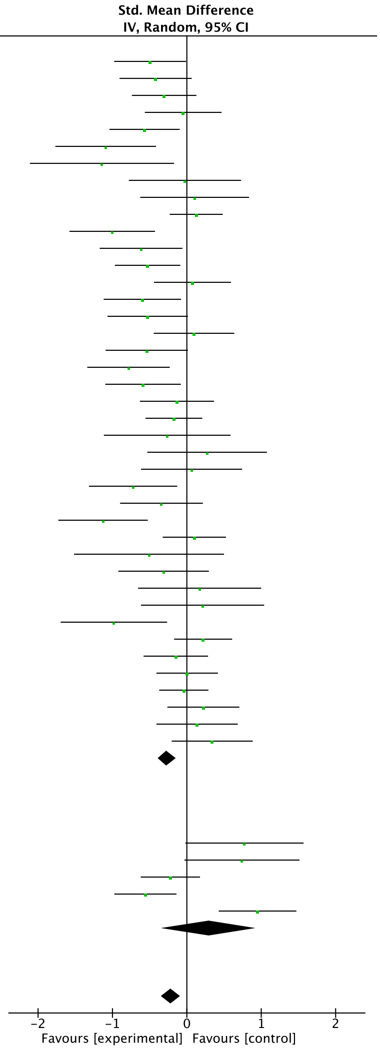
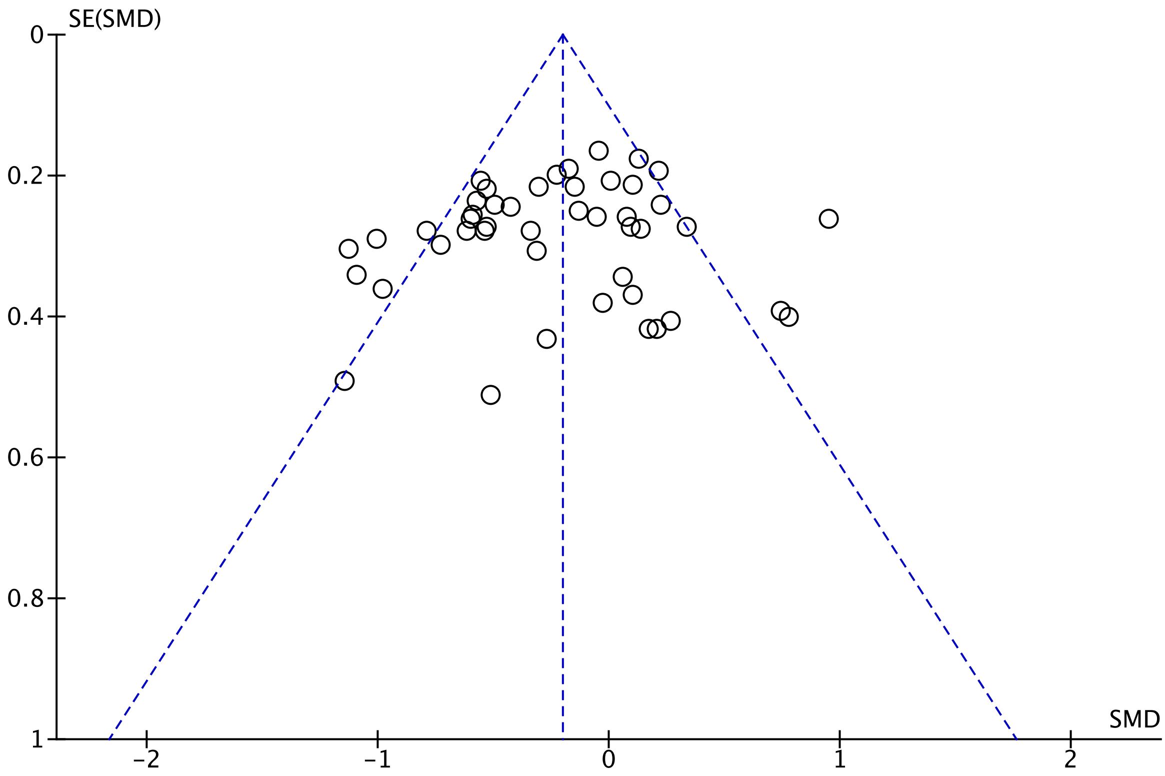


Figure 2.3

Funnel Plot of all Studies Included in Primary Meta-analysis



Subgroup analyses

The forest plots for all subgroup analyses are provided in Appendix E.

Additional non-mindfulness components

Of all 46 comparisons measuring food intake, there were 36 comparisons with interventions composing strictly of mindfulness or mindful eating components, and 10 comparisons that involved additional non-mindfulness components in the intervention, such as self-compassion and nutrition education. We found no subgroup differences between interventions with and without additional non-mindfulness components, $\chi^2 = 2.26$, $p = 0.13$, $I^2 = 55.8\%$.

Present moment awareness of the sensory properties of food

The 46 comparisons were divided into those that included the ‘present moment awareness of the sensory properties of food’ component in isolation (13 comparisons), those that included it in combination with other mindfulness and/or mindful eating components (17 comparisons), and those that did not include the component at all (16 comparisons). There were no significant subgroup differences observed between the three groups, $\chi^2 = 0.13$, $p = 0.94$, $I^2 = 0\%$.

Present moment awareness of the body/internal bodily sensations and acceptance

Twenty-eight of the 46 comparisons incorporated a component of 'present moment awareness of the body' or 'present moment awareness of internal bodily sensations relating to hunger, fullness and eating'. An overall effect was observed across the 28 comparisons, suggesting that within studies that included these components mindfulness/mindful eating reduced food intake (SMD = -0.17, 95% CI [-0.34, -0.00], $p = 0.04$, $I^2 = 66\%$). The studies were split into two subgroups; those that included a component of acceptance (11 comparisons) and those that did not (17 comparisons). There were no significant subgroup differences between the two groups, $\chi^2 = 0.38$, $p = 0.54$, $I^2 = 0\%$.

Attention regulation

The 46 comparisons were further split into two groups; those that included an attention regulation component (8 comparisons), and those that did not (38 comparisons). There were no subgroup differences found between the two groups, $\chi^2 = 0.60$, $p = 0.44$, $I^2 = 0\%$.

Time from intervention to food intake measure

Of the 46 comparisons, there were 32 comparisons that involved experimental studies. An overall effect was observed across the 32 comparisons, indicating that mindfulness/mindful eating resulted in a reduced food intake within these studies (SMD = -0.28, 95% CI [-0.43, -0.13], $p < 0.001$, $I^2 = 64\%$). The 32 comparisons were divided into groups based on the time from the intervention to the food intake measure. There were 6 comparisons that measured concurrent intake, 19 comparisons that measured subsequent food intake up to 20 minutes following the intervention (immediate), and 7 comparisons that measured subsequent intake between 2 to 3 hours following the intervention (delayed). There were no subgroup differences between the three groups, $\chi^2 = 0.05$, $p = 0.97$, $I^2 = 0\%$.

Food type

Thirty-eight of the 46 comparisons measured intake of a snack or a meal and an overall effect was observed within these studies (SMD = -0.23, 95% CI [-0.37, -0.08], $p < 0.05$; $I^2 = 67\%$). The 38 comparisons were split into groups based on the type of food offered in the study. Thirty-two comparisons measured intake of a snack while 6 measured intake of a meal. No subgroup differences were observed between the two food types, $\chi^2 = 0.08$, $p = 0.78$, $I^2 = 0\%$.

Experimental studies versus long-term interventions

The 46 comparisons were split into subgroups based on the type of study; experimental studies or long-term interventions. There were 15 comparisons for long-term interventions and 31 comparisons for experimental studies. There was a significant subgroup difference between the two types of studies ($\chi^2 = 4.45$, p <0.05, $I^2 = 77.5\%$), with a significant reduction in food intake observed in experimental studies (SMD = -0.31. 95% CI [-0.45, -0.18], p <0.001, $I^2 = 54\%$) but not in long-term intervention studies (SMD = 0.01, 95% CI: [-0.26, 0.28], $p = 0.92$; $I^2 = 69\%$).

Laboratory versus non-laboratory measures

The 46 comparisons were split into two subgroups based on whether they measured food intake in a laboratory (33 comparisons) or outside the laboratory (13 comparisons). A significant subgroup difference was observed ($\chi^2 = 4.43$, p <0.05, $I^2 = 77.4\%$), with food intake being lower in the experimental group than the control group in the laboratory subgroup (SMD = -0.30, 95% CI [-0.43, -0.17], p <0.001; $I^2 = 55\%$), but not in the non-laboratory subgroup (SMD = 0.05, 95% CI [-0.25, 0.35], $p = 0.76$; $I^2 = 67\%$).

Other planned subgroup analyses

There were not enough data available to conduct analyses on studies that included a decentering component. Additionally, there were not enough data to allow subgroup analysis between dieting and non-dieting populations.

Quality of evidence

To determine the overall quality of evidence, an additional meta-analysis was conducted including only studies that were rated as having a low risk of bias. A total of 18 comparisons met the inclusion criteria for this analysis. The overall effect suggests that mindfulness/mindful eating interventions significantly reduced food intake in studies with low risk of bias (SMD = -0.27*,* 95% CI [-0.41, -0.12], p <0.001, $I^2 = 43\%$).

Secondary analyses

Effect of mindfulness and mindful eating on immediate hunger

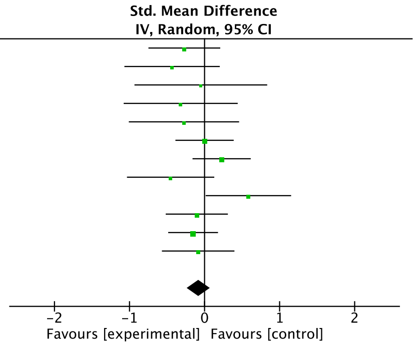
There were 12 comparisons across 10 studies that measured the effect of mindfulness and/or mindful eating on immediate hunger (Figure 2.4). No overall effect was observed, suggesting that mindfulness and mindful eating interventions did not influence immediate hunger (SMD = -0.08, 95% CI [-0.23, 0.07], $p = 0.31$, $I^2 = 11\%$). There was some evidence of publication bias as Egger's test for funnel plot asymmetry was significant ($z = -0.77$, $p < 0.05$). Trim and Fill analysis identified 3 missing effect sizes (Appendix F). The inclusion of these studies changed the pooled SMD to -0.02, 95% CI [-0.16 to 0.13]. No influential cases were identified. The presence of publication bias does not influence the findings as no overall effects were identified.

Figure 2.4

Forest Plot of Mindfulness/Mindful Eating and Immediate Hunger Meta-analysis

	Experimental			Control				Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
Allirot 2018	2.09	1.7748	35	2.66	2.3664	35	8.9%	−0.27 [−0.74, 0.20]
Fisher 2016	47	26.6	20	57.9	22.6	20	5.3%	−0.43 [−1.06, 0.19]
Higgs 2011	12.889	8.49	10	13.4	11.037	10	2.8%	−0.05 [−0.93, 0.83]
Hinton 2021 Fullness	9.59	11.6	22	14.24	19.06	10	3.8%	−0.32 [−1.07, 0.43]
Hinton 2021 Taste	9.59	15.17	22	14.24	19.06	11	4.0%	−0.27 [−1.00, 0.45]
Palascha 2021 Early Symptoms	6.83	12.47	53	6.83	13.48	53	12.8%	0.00 [−0.38, 0.38]
Palascha 2021 Late Symptoms	11.7	11.99	53	9.25	9.24	54	12.8%	0.23 [−0.15, 0.61]
Robinson 2014	13.4	14	25	20.9	18.5	23	6.2%	−0.45 [−1.03, 0.12]
Seguias 2018	1.37	1.17	26	0.78	0.77	25	6.5%	0.58 [0.02, 1.15]
Whitelock 2018 Study 1	15.74	14.55	34	17.405	16.5883	74	11.5%	−0.10 [−0.51, 0.30]
Whitelock 2018 Study 2	16.74	18.66	70	19.87	21.82	77	16.6%	−0.15 [−0.48, 0.17]
Whitelock 2019a	16.12	15.5	34	17.62	19.12	34	8.7%	−0.09 [−0.56, 0.39]
Total (95% CI)			**404**			**426**	**100.0%**	**−0.08 [−0.23, 0.07]**

Heterogeneity: $Tau^2 = 0.01$; $Chi^2 = 12.37$, df = 11 (P = 0.34); $I^2 = 11\%$
Test for overall effect: Z = 1.01 (P = 0.31)



Effect of mindfulness and mindful eating on immediate fullness

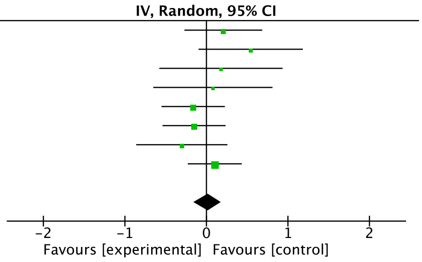
There were 8 comparisons across 6 studies that measured the effect of mindfulness and/or mindful eating on immediate fullness (Figure 2.5). No overall effect was observed, suggesting that mindfulness and mindful eating interventions did not influence immediate fullness (SMD = 0.02, 95% CI [-0.15, 0.18], $p = 0.85$, $I^2 = 0\%$). There was some evidence of publication bias as Egger's test for funnel plot asymmetry was significant ($z = 0.82$, $p < 0.05$). Trim and Fill analysis identified 1 missing effect size (Appendix G). The inclusion of this study changed the pooled SMD to -0.02, 95% CI [-0.19 to 0.14]. No influential cases were identified. The presence of publication bias does not influence the findings as no overall effects were identified.

Figure 2.5

Forest Plot of Mindfulness/Mindful Eating and Immediate Fullness Meta-analysis

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
Allirot 2018	6.7	1.834	35	6.27	2.2481	35	12.1%	0.21 [−0.26, 0.68]
Fisher 2016	48	25.1	20	35.4	20.1	20	6.7%	0.54 [−0.09, 1.18]
Hinton 2021 Fullness	80.71	13.96	22	78.24	12.38	10	4.8%	0.18 [−0.57, 0.93]
Hinton 2021 Taste	79.23	12.07	22	78.24	12.38	11	5.1%	0.08 [−0.64, 0.80]
Palascha 2021 Early Symptoms	61.38	16.08	53	64.19	18.19	53	18.4%	−0.16 [−0.54, 0.22]
Palascha 2021 Late Symptoms	18.06	14.81	53	20.47	16.7	54	18.6%	−0.15 [−0.53, 0.23]
Seguias 2018	4.25	0.82	26	4.52	0.94	25	8.8%	−0.30 [−0.85, 0.25]
Whitelock 2018 Study 2	60.9	26.57	70	58.12	27.48	77	25.5%	0.10 [−0.22, 0.43]
Total (95% CI)			**301**			**285**	**100.0%**	**0.02 [−0.15, 0.18]**

Heterogeneity: Tau² = 0.00; Chi² = 6.65, df = 7 (P = 0.47); I² = 0%
Test for overall effect: Z = 0.19 (P = 0.85)



Effect of mindfulness and mindful eating on delayed hunger

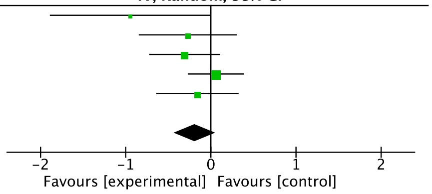
There were 5 studies that measured effects of mindfulness/mindful eating on delayed hunger (Figure 2.6). No overall effect was observed, suggesting that mindfulness and mindful eating interventions did not influence delayed hunger (SMD = -0.19; 95% CI [-0.43, 0.05], p = 0.13; I^2 = 22%). Publication bias was not carried out for this outcome as there were only 5 effect sizes.

Figure 2.6

Forest Plot of Mindfulness/Mindful Eating and Delayed Hunger Meta-analysis

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
Higgs 2011	27.444	19.98	10	45.9	17.201	10	6.1%	−0.95 [−1.88, −0.01]
Robinson 2014	35.8	23	25	42.7	27.1	23	14.9%	−0.27 [−0.84, 0.30]
Whitelock 2018 Study 1	41.21	25.08	34	48.81	24.2582	74	25.0%	−0.31 [−0.72, 0.10]
Whitelock 2018 Study 2	50.71	28.1	70	49.14	24.6	77	34.1%	0.06 [−0.26, 0.38]
Whitelock 2019a	40.59	23.48	34	44.38	24.16	34	19.8%	−0.16 [−0.63, 0.32]
Total (95% CI)			**173**			**218**	**100.0%**	**−0.19 [−0.43, 0.05]**

Heterogeneity: Tau² = 0.02; Chi² = 5.14, df = 4 (P = 0.27); I² = 22%
Test for overall effect: Z = 1.52 (P = 0.13)



2.4 Discussion

The purpose of this systematic review and meta-analysis was to examine the effects of mindfulness, mindful eating and intuitive eating on food intake and appetite. Thirty-seven studies were reviewed that examined the influence of mindfulness and/or mindful eating on food intake. The results suggest that overall mindfulness and mindful eating interventions may lead to a reduction in food intake, with a small effect size. Although the effect size may be considered relatively modest, in the context of eating behaviour even a small reduction in intake can lead to improvements in weight management and health if sustained over time (Hills, Byrne, Lindstrom & Hill, 2013). Additionally, the overall effect remained significant when only considering studies with low risk of bias. Therefore, this review provides moderate-quality evidence supporting the incorporation of mindfulness and mindful eating practices in interventions aimed at improving eating behaviour.

These findings partially align with Warren et al.'s (2017) review who also found some evidence that mindfulness and mindful eating interventions influence food consumption. However, the findings are not consistent with Grider et al.'s (2021) review who concluded that mindful eating interventions do not appear to influence dietary intake. There are several differences between the present review and that carried out by Grider et al. (2021) which may potentially explain the discrepancy in findings. First, the present review primarily comprised of lab-based experimental studies whereas Grider et al. (2021) focused only on randomised controlled trials and long-term intervention studies. Second, the present review included a significantly larger number of studies (37 studies as opposed to 13). In addition to this, the present review analysed findings using a meta-analysis whereas Grider et al. (2021) relied solely on a narrative synthesis. A meta-analysis increases statistical power, making it easier to detect small but meaningful effects which might be missed in a systematic review that only provides a narrative summary.

It is important to note that the findings of this review may not be generalisable to the general population as there was a lack of diversity in participant composition across the majority of studies reviewed, which comprised predominantly adult women. The number of studies involving men and children were notably limited. There is a need for further research in more diverse populations, especially in children. The present review only identified 4 studies conducted in children, two of which aimed to use mindfulness and/or mindful eating interventions as a means to increase food intake as opposed to reduce it. Although the subgroup analysis did not identify significant differences between studies in adults and those in children, the pooled effect size of studies in children show that food intake was greater in the mindfulness group compared to the control group, whereas the opposite effect was observed for studies in adults. Unlike interventions in adult studies, where the focus is primarily on diminishing food intake, interventions in children's studies often revolve around addressing selective eating habits and promoting the consumption of novel foods such as vegetables. Given these disparities between studies in adults and children, and the lack of research in men, a pressing need emerges for more extensive research involving men and children to draw more definitive conclusions.

Another noteworthy consideration is that most of the studies included in the review were lab-based and of an experimental nature, with reliance on objectively measured food intake. While measurement of food intake in a laboratory setting provides enhanced reliability, it does also present an inherent drawback in that it may not reflect eating behaviour as it manifests in real world scenarios, primarily due to the influence of social desirability bias. Despite employing techniques such as cover stories and participant blinding to mitigate this bias, the disparity between lab-controlled conditions and genuine environments remains apparent. This is evident in the sub-group analyses comparing studies which measured food intake in the laboratory and those that measured consumption outside the laboratory. The observed lack of significance in findings from non-laboratory studies suggests that the effectiveness of mindfulness in reducing food intake may be confined to controlled laboratory settings, potentially not extending to real-world eating behaviour.

On the other hand, it is possible that participants may be more likely to be affected by social desirability bias when self-reporting food intake. Since the majority of studies using this method are delivered in the real world, it is likely that participants are more aware of the aim even if they are in the control group therefore making self-reported food intake unreliable. Self-reports may also not be sufficiently sensitive to capture small changes in portion size. Future research may benefit from discerning novel ways to measure food intake objectively outside the laboratory in order to explore the effects of mindfulness and mindful eating on real-world eating behaviour. Researchers could explore technologies such as wearable devices, smartphone applications, or other sensor-based tools to capture and quantify dietary habits with a higher degree of ecological validity.

The review also found a significantly larger effect of mindfulness and/or mindful eating in experimental studies compared to long-term intervention studies. This suggests that the effects of mindfulness and mindful eating interventions are more apparent when they are delivered as a one-off session, as is the case in most of the experimental studies, as opposed to an intervention delivered over several weeks. This may be because it is possible that although participants may appear to eat less immediately following the mindfulness or mindful eating intervention, they may compensate for this reduction in energy intake by eating more at a later point and thus any differences in consumption may not be as noticeable when food intake is measured at the end of a lengthy intervention period. To discern whether this is the case, future research should explore the effects of mindfulness and mindful eating on immediate food intake as well as at various time points following the intervention.

The findings from the various subgroup analyses of the review also shed light on the effects of specific mindfulness and mindful eating components. There were no differences in effects between studies that incorporated an element of paying attention to the sensory properties of food, either in isolation or in combination with other components, and studies that incorporated other mindfulness and/or mindful eating strategies. This suggests that the overall effect identified was likely not driven by this specific mindful eating strategy. This finding is consistent with Tapper (2022) who concluded that studies exploring the element of attending to the sensory properties of food show mixed findings, and therefore this mindful eating strategy may not reliably reduce food intake. It is likely that this component of mindful eating is only effective for certain types of individuals or in specific situations. Further research on the underlying mechanisms of this type of mindful eating may help to determine some of these key moderators.

The results show that in studies that incorporated present moment awareness of the body or of internal bodily sensations, the mindfulness/mindful eating intervention significantly reduced food intake. The subgroup analysis shows that there were no significant differences in effect sizes between studies that also included a component of acceptance and those that did not. This finding appears to contradict the Monitor and Acceptance theory (MAT; Lindsay & Creswell, 2017) which suggests that acceptance is a key component of mindfulness which reduces affective reactivity and leads to improved outcomes. The present findings, on the other hand, seem to suggest that there does not seem to be a difference in the effect of mindfulness interventions with and without acceptance on food intake. However, despite the lack of significance, the pattern of results do appear to support the MAT theory, as the studies with an acceptance component displayed a greater pooled effect size than those without an acceptance element. It may be possible that the analysis may not be able to detect subgroup differences due to the smaller number of studies that included an acceptance component.

Similarly, there were no differences identified in effects between studies that included an attention regulation component and those that did not. This suggests that contrary to Bishop et al.'s (2004) model of mindfulness, an attention regulation component may not be necessary for mindfulness and mindful eating interventions to be effective. However, the number of studies that employed an attention regulation component were considerably lower than studies that did not therefore it is possible that there were not sufficient data available to detect subgroup differences. Another possibility may be that although some studies did not explicitly include an attention regulation element, participants still engaged in attention regulation. In Bishop et al.'s (2004) model of mindfulness, the attention regulation component is described as the ability to maintain attention to the present moment in a sustained fashion. It is very much possible that participants inherently maintain their attention on the present moment and self-regulate when their mind begins to wander, even if the intervention does not specifically instruct them to do so. Conducting studies to investigate whether participants engage in attention regulation in the absence of explicit instructions could provide valuable insights into the significance of attention regulation components in mindfulness interventions.

Further subgroup analyses revealed that there were no differences in effects between studies that employed additional non-mindfulness components, such as self-compassion or nutrition education, and those that solely used mindfulness and/or mindful eating strategies. This suggests that the inclusion of additional non-mindfulness components does not significantly improve effects on food intake. However, once again there were a smaller number of studies that included additional non-mindfulness components, therefore the analysis may not be able to sufficiently detect subgroup differences. It is interesting to note that the pooled effect size of these studies display a greater reduction in food intake compared to the studies with mindfulness/mindful eating components only, eluding to the possibility that these effects may be driven by non-mindfulness components.

With regards to the appetite outcome, the findings show that there is no effect of mindfulness/mindful eating on either immediate or delayed hunger, or immediate fullness. This finding is peculiar as one of the ways in which mindfulness and mindful eating is thought to influence food intake is through appetite. For example, some mindful eating strategies such as paying attention to internal bodily sensations is assumed to make individuals more aware of their fullness or satiety signals and help them discern whether they are truly hungry, which in turn enables them to regulate their food intake (Tapper, 2022). However, the findings from this review suggest that this may not be the case. A possible explanation for this may be that under normal circumstances participants may already be aware of their hunger and fullness signals but may be ignoring them and continuing to eat past the point of fullness. However, practicing mindfulness or mindful eating may help them to acknowledge these signals instead of ignore them, and thus consume less food. This may explain why mindfulness appears to influence food intake but not appetite ratings. This aligns with the view that eating is largely an automatic process (Cohen & Farley, 2008) and that mindfulness and mindful eating may reduce eating automaticity by making the decision to keep eating a more conscious one rather than an automatic one (Teper, Segal, & Inzlicht, 2013; Tapper, 2017). Exploring the effects of mindfulness/mindful eating on eating automaticity may help shed more light on this matter.

There is also the possibility that VAS measures of hunger and fullness are simply not sensitive enough to capture subtle changes in appetite ratings. The sensitivity of VAS measures can vary among individuals. Some people may be very adept at self-assessing and accurately reporting their appetite on a VAS, while others may find it more challenging. There may also be differences in the way the VAS questions are framed, and the scale used across the different studies. Future research may benefit from a well-designed standardised VAS with clear anchor points to allow for more sensitivity and validity in appetite measures. Overall, the available body of literature demonstrates a scarcity of studies examining the effects of mindfulness and mindful eating interventions on appetite. This area remains relatively underexplored and requires further in-depth investigation to enhance understanding of how mindfulness and mindful eating may or may not influence appetite.

The findings for intuitive eating interventions face similar limitations. There were no intuitive eating studies identified that met the inclusion criteria for this review. As such, conclusions about the effects of intuitive eating interventions on food intake and appetite cannot be drawn. One of the reasons for the lack of studies may be that the criteria for this review required studies to employ an intuitive eating manipulation, but most studies in this field typically explored the effects of intuitive eating using questionnaire measures such as the Intuitive Eating Scale (IES). Furthermore, the few studies that did include an intuitive eating intervention did not measure energy intake; many of them only explored the quality of food consumed rather than the quantity. At first this observation appears to be inconsistent with previous reviews in this field that have identified such studies (Warren et al., 2017; Grider et al., 2021). However, upon closer inspection it can be observed that Warren et al. (2017) only identified intuitive eating studies exploring effects on eating behaviour and BMI as opposed to energy intake, and Grider et al. (2021) only identified 3 intuitive eating studies. One of these studies employed a Health at Every Size (HAES) intervention which only uses some of the principles of an intuitive eating intervention, and two studies do not appear to report energy intake. It is therefore evident that there is an overall lack of research exploring the effects of intuitive eating interventions on energy intake.

Given that the concept of intuitive eating was developed to improve an individual's relationship with food and their eating behaviour, it does not aim to reduce food intake but rather improve eating habits. Therefore, it is logical that studies investigating the effects of intuitive eating are not concerned with its influence on the amount of food consumed, but rather the diet quality and individuals' eating habits. Nevertheless, it would be beneficial for future research to explore the effects of intuitive eating interventions on energy intake to explore whether they inadvertently help individuals to reduce their intake.

One of the limitations of the present review is that the risk of bias analysis revealed that almost all of the included studies were subject to some risk of bias. Only one of the thirty-eight studies reviewed satisfied all the risk of bias criteria. The majority of studies were not pre-registered, which increases the likelihood of selectively reporting significant findings while ignoring non-significant ones. Selective reporting can undermine the integrity and reliability of the study's conclusions. Furthermore, most studies did not attempt to blind researchers to group allocation. Being aware of group allocations can unintentionally influence how researchers interact with participants, gather data, and interpret results which may ultimately impact the study findings.

Another key risk of bias factor that was not addressed by most studies was the use of a manipulation check that closely matched what those in the experimental group were asked to do. The lack of a manipulation check may mean that it is not possible to ascertain whether the mindfulness or mindful eating manipulations were successful in having the desired effect. Including a manipulation check also aids in ruling out alternative explanations for the results, enhancing the overall rigour and credibility of the research. Neglecting to include a manipulation check may result in researchers potentially attributing effects to manipulated variables (i.e. mindfulness or mindful eating) that were actually caused by other uncontrolled factors. Future studies in the field should attempt to reduce the risk of bias by pre-registering studies, blinding researchers to group allocation, and including a manipulation check in order to attain more reliable findings.

Finally, it is also important to note that the findings of the sub-group analyses within this review should be interpreted with caution. It may be argued that the statistical power for detecting meaningful differences between subgroups may be limited due to the relatively small number of studies in each subgroup. This is evident in the analyses where differences in effect sizes appeared to be in line with predictions (such as in studies with and without the acceptance component) but the subgroup analysis was not statistically significant. Future reviews may consider taking an alternative approach, such as reporting and comparing effect sizes for each subgroup without performing formal statistical tests. This approach may provide a clearer overview of the variability in the intervention's impact across different study characteristics and allow for a more meaningful interpretation of the data.

Despite the aforementioned considerations, the present review has numerous strengths. Primarily, it is the first review in the field to conduct a meta-analysis of mindfulness and mindful eating studies and therefore provide more conclusive findings of their effects on food intake and appetite. All phases of the review, including searches, data extraction, and analyses, were methodically carried out by two independent reviewers, reinforcing its overall credibility. It is the largest review conducted to date, encompassing a total of 38 studies. Notably, the review's adherence to stringent standards is evidenced by its pre-registration on PROSPERO and its adherence to PRISMA guidelines. The inclusion of five distinct databases for article identification further enhance the review's comprehensiveness. Rigorous inclusion criteria were maintained, ensuring that only studies involving manipulated mindfulness or mindful eating interventions were included, as opposed to those simply measuring mindfulness or mindful eating. Furthermore, a comprehensive coding scheme was used, identifying different aspects of mindfulness and mindful eating and allowing the review to provide a more complete overview of the effects of different mindfulness and mindful eating interventions on food intake and appetite.

2.5 Conclusion

This systematic review and meta-analysis found that mindfulness and mindful eating interventions significantly reduce food consumption, with a small effect size. Contrary to expectations, such interventions do not appear to influence appetite (hunger and fullness). The review did not identify subgroup differences in the effects of mindfulness and mindful eating on food intake across studies with different intervention components or participant demographics. Nonetheless, disparities emerged with regards to study design and the nature of food intake measures, with mindfulness and mindful eating interventions appearing to be more effective in reducing consumption in lab-based experimental studies compared to long-term intervention studies, as well as in studies measuring food intake objectively compared to studies with self-reported measures. The findings of this review have important implications for the development of effective mindfulness and mindful eating interventions, as well as providing key considerations for future research in the field.

Chapter Three – The Effects of a Mindfulness-based Body Scan Exercise on Food Intake During TV Watching

Abstract

In some studies mindfulness is associated with reduced food consumption, but the underlying mechanisms are less well researched. One potential mechanism is that mindfulness increases attention toward feelings of fullness. Additionally, experimental research on mindfulness and food intake has primarily been conducted in constrained laboratory settings, where it may be easier for participants to notice their internal bodily signals, as opposed to the real-world where individuals are often engaged in other activities while eating. The effect of mindfulness on food intake while participants are distracted remains unexplored. This study therefore aimed to examine whether a mindfulness-based body scan exercise reduced food consumption within a distracted environment by increasing attention toward feelings of fullness. Participants (n = 137) listened to a 10-minute body scan meditation, or a 10-minute visualisation (control) meditation. They were then given a bowl of crisps to consume while watching a 10-minute TV show segment. Participants also completed measures assessing proposed mediators, including state mindfulness, attention to bodily sensations and eating automaticity. The body scan manipulation increased state mindfulness but had no direct effect on the other mediators or on food intake (intervention M = 34.79g, SD = 24.06; control M = 33.16g, SD = 23.88). State mindfulness was positively correlated with attention to bodily sensations while eating. Lower eating automaticity and greater reliance on decreased food appeal and physical satisfaction to stop eating were found to be associated with lower food intake. Contrary to previous studies, we found no evidence that a mindfulness body scan reduces food consumption when participants are distracted. Future research should examine the specific conditions under and mechanisms by which mindfulness may influence food consumption.

Keywords: mindfulness; mindful eating; body scan; food intake; food consumption; distraction

3.1 Introduction

There is evidence from experimental studies that practicing mindfulness may be associated with short-term reductions in food intake. However, findings are inconsistent across different mindfulness-based interventions (Tapper, 2017, 2022). Findings are also inconsistent across different populations. For example, Warren, Smith and Ashwell (2017) concluded that mindfulness was more effective at reducing food intake in populations with overweight and obesity, compared to healthy-weight populations. Additionally, there is considerable variation in the mindfulness practices used across different studies (Tapper, 2022). For example, mindfulness manipulations may focus on inducing present moment awareness of the sensory properties of food (Seguias & Tapper, 2022) or of internal bodily sensations (Fisher, Lattimore & Malinowski, 2016). Alternatively, studies have also manipulated mindfulness by encouraging acceptance or decentering from feelings of hunger, cravings, or food-related thoughts (Jenkins & Tapper, 2014).

Given the variety of ways in which mindful eating can be operationalised, there are several possible mechanisms of action underlying the effects of mindfulness on food consumption. One proposed mechanism centers around the idea that mindfulness enhances interoceptive awareness of hunger and satiety (Tapper, 2022; Warren et al., 2017). Interoceptive awareness is defined as the process of perception and interpretation of internal bodily signals (Khalsa & Lapidus, 2016). This means that mindfulness may allow individuals to better perceive and interpret their physiological signals of hunger and fullness, which may in turn cause them to reduce their food intake by only eating when they are hungry and stopping eating when they are full. One widely used mindfulness exercise is the body scan meditation (Fischer, Messner & Pollatos, 2017), which instructs participants to focus on their breath and physical sensations while sequentially attending to different body parts. The exercise typically prompts listeners to notice when they become distracted and to redirect their attention back to the body, encouraging meta-awareness and attention regulation, which may enhance attention toward bodily sensations and therefore heighten interoceptive awareness of hunger and satiety.

Although much of the research exploring mindfulness and interoceptive awareness has measured interoception using a heartbeat perception task or self-report measures (Gibson, 2019), there is some evidence for the effect of mindfulness on interoceptive awareness of hunger and satiety cues. For example, Van de Veer, van Herpen and van Trijp (2016) found that a body scan exercise improved awareness of satiety signals as assessed using a self-reported questionnaire. Palascha, van Kleef, de Vet and van Trijp (2021) found that participants who had performed a body scan exercise detected the onset of hunger approximately 18 minutes earlier than those in a control group following a standardised lunch preload. Moreover, higher self-reported mindfulness has also been associated with greater awareness of self-reported physiological signals of hunger and satiety (Beshara, Hutchinson & Wilson, 2013). Nevertheless, empirical studies investigating increased interoceptive awareness of hunger and satiety signals as an underlying mechanism for the impact of mindfulness on consumption are scarce and yield inconclusive findings (Vanzhula & Levinson, 2020).

Some evidence for this mechanism of action comes from studies indicating that engaging in a body scan meditation is associated with a reduction in food intake. For example, Jordan, Wang, Donatoni and Meier (2014) found that participants who performed a body scan exercise consumed 24% fewer calories than a control group in a subsequent taste testing task. Fisher et al. (2016) similarly observed a reduction in food intake following a mindful attention induction in which participants were encouraged to notice physical sensations similar to a body scan. Questionnaire measures of awareness of physiological signals of hunger and satiety were also found to be associated with smaller self-reported portions of energy dense foods consumed over a 1-week period (Beshara et al., 2013).

However, several studies have failed to find an effect of interoceptive awareness on food consumption. For example, Martin et al. (2017) did not find a reduction in calorie intake following a 6-week intervention where participants were instructed to attend to internal signals of hunger and satiety during their meals. Likewise, Hsu and Forestell (2021) reported no significant difference in food intake between participants who listened to a body scan meditation and a control group. Some studies have only observed effects under certain conditions. For example, Marchiori and Papies (2014) found that a body scan only had an effect on unhealthy food intake when participants were hungry. Van de Veer et al. (2016) observed that compared to two control groups, a body scan exercise resulted in increased consumption following a small preload. However, there were no differences in consumption across the three conditions after a large preload. These inconsistencies suggest there may be variations in the strength of hunger and satiety cues, with hunger signals being more noticeable compared to satiety cues.

This idea is supported by Palascha et al. (2021) who identified discrepancies in the effect of mindfulness on perception of hunger and satiety signals. Awareness of hunger was investigated by asking participants to report the time of their first hunger signal following a standardised lunch preload and awareness of satiety was explored using a water-load task that measured satiation threshold. Participants who performed a body scan were able to perceive their first hunger signals sooner compared to a control group. However, the body scan intervention did not have a significant impact on awareness of satiety.

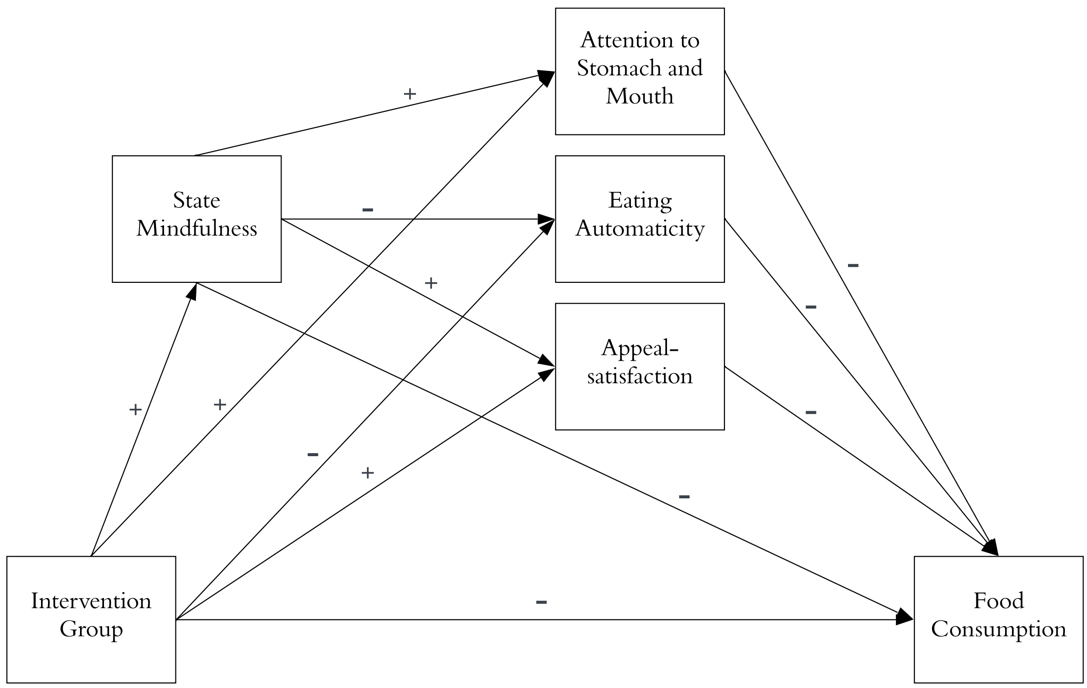
One reason for this finding may be that awareness of satiety signals was measured in a constrained laboratory setting with no distractions, and therefore ceiling effects were reached in terms of participants' attention to their satiety cues. In contrast, hunger signals were explored outside the laboratory in a real-world setting. It could be argued that in everyday life, people tend to eat while busy with other tasks and their attention may be elsewhere whereas in the laboratory there is naturally more focus on their eating and their body and thus the body scan may not increase awareness any further. This could explain why the mindfulness intervention appeared to be effective at increasing attention to hunger, but ineffective at improving awareness of satiation. Thus, it can be speculated that a mindfulness intervention may be more effective in increasing awareness of satiety cues outside of a quiet laboratory environment, when participants' attention is divided. This notion is supported by the literature exploring food consumption under distracted conditions. A systematic review and meta-analysis by Robinson et al. (2013) found that distraction increases both immediate and subsequent food consumption. Therefore, it is possible that a mindfulness exercise could be more effective at reducing food intake when a person is in a distracted environment, by prompting them to repeatedly return their attention to their bodily sensations of hunger and satiety. However, to date, there are no studies exploring this possibility.

In light of the above, the present study had two key aims. First, to examine whether a mindfulness body scan is effective at reducing food intake when participants are distracted. Second, to further explore a possible underlying mechanism of action; that mindfulness increases awareness of satiety signals, which in turn reduces food intake. Food consumption was compared following a body scan meditation or a visualisation exercise (control). Food consumption was measured while participants were watching a segment from a TV show to distract them, thus better replicating an everyday scenario in which individuals often consume food.

We predicted that participants in the mindfulness body scan condition would subsequently consume less snack food compared to the control group. Additionally, if the body scan condition increased awareness of satiety signals, we expected participants in the body scan condition to have higher state mindfulness and report greater attention to their stomach and mouth while watching the video clip. We also expected them to report lower eating automaticity and to stop eating for reasons relating to decreased food appeal and physical satisfaction (appeal-satisfaction). The study also collected data on these additional measures, and it was predicted that these four variables would mediate the effect of condition on food consumption (see Figure 3.1). Specifically, we expected that the body scan would increase state mindfulness, which would in turn increase attention to the stomach and mouth, decrease eating automaticity, and increase the likelihood of stopping eating due to decreased food appeal and physical satisfaction. This would in turn lead to reduced food consumption.

Figure 3.1

Hypothesised Model Displaying the Expected Relationships between the Intervention, Food Consumption and Mediator Variables



3.2 Method

Sample size

Based on a similar study by Jordan et al. (2014), a medium effect size of mindfulness body scan on food intake was used to inform power analysis. Assuming 80% power and 5% alpha for an independent samples *t*-test, a sample size of 128 participants was calculated using G*Power. An additional 10% (13 participants) were recruited to account for any exclusions.

Participants

A total of 141 participants took part in the study. Participants were aged between 18 and 59 years and the mean age was 21.34 (*SD* = 7.43). The sample consisted of 85.8% female participants (*n* = 121) and over half (52.5%) were current university students (*n* = 74). Participants' ethnic backgrounds were White (26.2%), Mixed (7.8%) Asian (47.5%), Black (5%) and other (13.5%). Participants were recruited via online platforms and poster advertisements around City, University of London. They received either course credits or a £5 shopping voucher for their participation. The study received ethical approval from the City, University of London Psychology Department Research Ethics Committee (ETH2122-0935). The method and analysis strategy were pre-registered with the Open Science Framework (https://osf.io/c5qug/).

Materials

Audio recordings

Scripts were developed for the intervention and control audio recordings, and they were recorded at City, University of London. There were two audio recordings per condition: a 3-minute practice audio and the main 10-minute audio. The practice audios began and ended in the same way as the main audios but were shortened. The intervention audios consisted of an adapted version of a body scan meditation developed by Kabat-Zinn (2002). The audios instructed participants to pay attention to specific parts of their body starting from the head down to the toes, and included prompts to remind participants to bring back their attention to their body if their mind began to wander. The control audios consisted of a visualisation exercise which was adapted from a guided imagery meditation by May, Andrade, Batey, Berry and Kavanagh (2010). The exercise required participants to imagine themselves walking through a forest. See Appendix H for the full scripts.

Snack food

Following Ogden et al. (2013), participants were provided with 100g (526kcal) of Walkers ready salted crisps as a snack while they watched the TV show. Only one type of food was offered to limit measurement to food intake, as opposed to food choice.

TV show

A 10-minute clip from the American sitcom 'Friends' was selected based on use in previous studies (Ogden et al., 2013). An episode was chosen in which there was no mention of food and no scenes in which the characters were eating.

Measures

Demographics. Participants indicated their age, sex, ethnicity, and education level.

Hunger. Participants indicated their hunger level on a 100cm Visual Analogue Scale (VAS). This measure was disguised as a general mood assessment amongst nine other emotions and feelings, such as 'jittery' and 'excited'. Note, it was not possible to control for baseline fullness as this would have required telling participants to avoid eating prior to the study which would have resulted in aim guessing. Previous studies have used a measurement of the last time at which participants ate, however, it has been shown that this is not a good indication of hunger or fullness levels (Rogers & Hardman, 2015). Additionally, controlling for baseline fullness was not imperative as we offered a snack as opposed to a meal, and research has shown that individuals do not only snack when they are hungry (Cleobury & Tapper, 2014).

State mindfulness. State mindfulness was measured using three items from the State Mindfulness Scale (Tanay & Bernstein, 2013). These were 'I felt aware of what was happening inside of me', 'I clearly physically felt what was going on in my body' and 'I felt in contact with my body'. Participants rated how well each statement described their experiences while they were listening to the audio on a scale of 1 (not at all) to 5 (very well). The state mindfulness measure served as a manipulation check to determine whether the body scan exercise resulted in higher levels of state mindfulness than the control exercise.

Manipulation check. Three statements relating to the visualisation exercise were used in the manipulation check. These were 'I saw a clear image of trees in my mind's eye', 'I felt transported outside of the room' and 'I could see vivid colours in my mind's eye'. Participants rated how well each statement described their experiences while listening to the audio on a scale of 1 (not at all) to 5 (very well).

Suspicion probe. Participants indicated whether they had any ideas about the study's hypotheses, whether they had previously learned anything about the study and whether their behaviour was influenced by any of the tasks they did in the study. Their responses were used to ascertain whether they guessed the study aims.

Attention to the stomach and mouth. Six items were used to assess participants' attention to their stomach and mouth areas while they were watching the show. These items asked participants to indicate to what extent they were paying attention to the sensations in their stomach, their body's hunger and fullness signals, the sensations inside their mouth, the taste of the food in their mouth, the texture of the food in their mouth, and how full they felt. Each item was rated on a 5-point Likert scale ranging from 1 (not at all) to 5 (very well).

Eating automaticity. The extent to which participants ate automatically while watching the show was assessed using the 4 automaticity items from the Self-report Habit Index (Verplanken & Orbell, 2003). Each item was rated on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

Reasons individuals stop eating. The 'Decreased food appeal' (3 items) and 'Physical satisfaction' (3 items) subscales from the 15-item Reasons Individuals Stop Eating Questionnaire (RISE-Q; Chawner, Yu, Cunningham & Rolls, 2022) were used to assess the extent to which participants stopped eating the crisps due to decreased food appeal and physical satisfaction while watching the show. Each item was rated on a 7-point Likert scale ranging from 1 (completely untrue for me) to 7 (completely true for me). This variable will henceforth be referred to as appeal-satisfaction.

Trait interoceptive awareness. Trait interoceptive awareness was measured using the Sensitivity to Physiological Signals of Hunger and Satiation subscales of the Multidimensional Internally Regulated Eating Scale (MIRES; Palascha, van Kleef, de Vet & van Trijp, 2020). There were 6 items, and each item was rated on a 7-point scale ranging from 1 (completely untrue for me) to 7 (completely true for me).

Trait mindful eating. Trait mindful eating was assessed using 3 domains ('Eating while paying attention to hunger and satiety cues', 'Being aware of eating' and 'Eating while not being distracted') from the Mindful Eating Behaviour Scale (Winkens et al., 2018). Each item was rated on a 5-point Likert scale ranging from 1 (never) to 5 (very often).

Restrained eating. Restrained eating was assessed using the cognitive restraint scale (6 items) from the 21-item Three Factor Eating Questionnaire (TFEQ; Cappelleri et al., 2009). Five items were rated on a scale of 1 (definitely true/almost never/unlikely) to 4 (definitely false/almost always/very likely) and one item was rated on a scale of 1 to 8.

Dieting and healthy eating. Participants indicated whether they were currently dieting to lose weight, and how important healthy eating is to them on a scale of 1 (not at all important) to 5 (extremely important).

Crisps liking and consumption. Participants indicated how much they like the taste of ready salted crisps on a scale of 1 (dislike a lot) to 5 (like a lot). In addition, participants were asked to indicate whether they had eaten any crisps, and to give a reason if they did not.

Height and weight. Height and weight were measured via self-report.

Crisp consumption. The amount of crisps consumed by participants was calculated by weighing the crisps before and after consumption (grams).

Procedure

To ensure participants were not aware that their food intake was being measured, they were told that the study was investigating the effect of relaxation on cognitive performance. The study was carried out during the day from 10am to 5pm apart from during lunch hours (between 12pm and 2pm), to avoid participants being too hungry and treating the snack provided as their lunch.

The study was delivered on Qualtrics. Upon signing the consent form, participants entered their demographics and were randomised to either the intervention or control condition. Due to sex differences in food intake, randomisation was stratified by sex to ensure there were equal numbers of males and females in the two conditions. Participants completed a measure of hunger and a bogus cognitive performance task to keep in line with the cover story. This consisted of 4 questions where participants were presented with 4 colour names (blue, yellow, green, red) written in different print colours and they had to identify the option where the colour name corresponded to the print colour. This took approximately 1 minute.

Participants then listened to the mindfulness or control audio, which they were told was a relaxation exercise. In both conditions, participants were first introduced to the short 3-minute practice audio before the main 10-minute audio, following a similar repeated practice methodology used by Wilson, Senior and Tapper (2021). This allowed participants a chance to practice the exercise. At the end of the audio, participants in both conditions were told to continue using the relaxation technique throughout the rest of the study. This was in line with the cover story and aimed to encourage participants in the mindfulness condition to continue to pay attention to their body during food consumption. Following this they completed the state mindfulness questionnaire and manipulation check. Participants then repeated the cognitive performance task to keep in line with the cover story.

Participants then moved to a sofa where they watched 10 minutes of a TV show on a monitor that was placed on the coffee table in front of them. They were told this was another relaxation exercise. A tray with a bowl of crisps (100g) and a glass of water was placed next to them on the sofa and they were told to relax, make themselves comfortable and help themselves to the crisps. Participants then returned to the computer to complete the suspicion probe and some more questionnaires on Qualtrics. They were then debriefed about the real aims of the study and consent was obtained to measure their food intake. Once participants left the room, the leftover crisps were weighed.

Data analysis

Data were analysed in the IBM SPSS statistical analysis package (version 28). An independent *t*-test was used to assess the effect of intervention group on the visualisation measure (manipulation check). To test the effect of intervention group on food consumption, and the mediating effects of state mindfulness, attention to the stomach and mouth, eating automaticity and appeal-satisfaction, a combined parallel and serial mediation model via the PROCESS macro in SPSS was used (Hayes, 2017). Indirect effects were subjected to follow-up bootstrap analyses with 5000 bootstrap samples and 95% bias corrected confidence intervals. Indirect effect estimates were considered significant when the confidence intervals did not contain zero.

In the pre-registered protocol for this study, we planned to run one model with intervention group as the predictor variable, food consumption as the outcome variable, and state mindfulness, attention to the stomach and mouth, eating automaticity and appeal-satisfaction as mediator variables with hunger as a covariate. However, 11 participants did not consume any food and therefore had missing appeal-satisfaction scores. As the PROCESS macro excludes cases listwise, running the planned model would have resulted in a loss of data. Therefore, in a deviation from the protocol, two separate models were run. First, the model was run without appeal-satisfaction as a mediator in order to capture data from all participants. The main findings are reported from this model. The model was then run again with the addition of appeal-satisfaction as a mediator to capture the findings relating to this variable.

3.3 Results

Participant characteristics

Two participants were excluded because they correctly guessed the aims of the study and a further two participants were excluded because they stated that they did not consume any food due to reasons unrelated to hunger and dieting status (1 did not like crisps and 1 had retainers in), therefore the final sample consisted of 137 participants. Results from sensitivity analyses with the inclusion of data from the excluded participants are reported below under *Sensitivity analyses*. Due to an additional 9 participants not consuming any food, the analyses with the appeal-satisfaction mediator consisted of 128 participants. Table 3.1 shows participant characteristics across the experimental and control groups. Participants were well matched across all characteristics with the exception of dieting status, as substantially more participants in the control group reported that they were dieting to lose weight. Results from sensitivity analysis with dieters excluded are reported below under *Exploratory sensitivity analyses*.

Manipulation check

The manipulation check consisted of three visualisation items and three state mindfulness items. Visualisation scores were calculated using the average of the ratings on the three visualisation items, and state mindfulness scores were calculated by summing ratings of the three state mindfulness items. Higher scores indicate greater visualisation and state mindfulness following the manipulation respectively. Participants in the control group (M = 3.75, SD = 1.02) had significantly higher visualisation scores than those in the experimental group (M = 2.06, SD = 0.84), $t(135)$ = -10.55, p <0.001. There was also a significant effect of intervention group on state mindfulness score (b = 1.11, SE = 0.48, 95% CI [-2.05, -0.17], β = 0.40, p <0.05). State mindfulness was higher in the mindfulness group (M = 11.22, SD = 2.75) compared to the control group (M = 10.11, SD = 2.80) indicating that the body scan was effective in increasing state mindfulness as hypothesised.

Table 3.1

Characteristics of Study Participants as a Function of Condition

Characteristic	Experimental (*n* = 67)	Control (*n* = 70)
Age (*M, SD*)	20.2 (4.5)	21.7 (8.3)
Sex (% of females)	86.6%[a]	87.1%
Education		
A-level	23.9%	32.9%
BTEC	4.5%	1.4%
Currently studying an undergraduate degree	47.8%	50%
Undergraduate degree	3%	4.3%
Currently studying a postgraduate degree	4.5%	2.9%
Postgraduate degree	1.5%	4.3%
Other	14.9%	4.3%
Ethnicity		
Asian/ Asian British	41.8%	52.9%
Black/ African/ Caribbean/ Black British	9%	1.4%
White	26.9%	25.7%
Mixed/ Multiple ethnic groups	10.4%	4.3%
Other	11.9%	15.7%
BMI (*M, SD*)[b]	23.1 (4.2)	22.1 (4.1)
Baseline hunger on VAS of 0-100 (*M, SD*)	31 (25)	29 (28)
Percentage that consumed the food	95.5%	91.4%
Percentage dieting to lose weight	7.5%[c]	22.9%
Importance of healthy eating score on Likert scale of 1-5 (*M, SD*)	3.2 (0.9)	3.2 (0.9)
Liking of crisps on Likert scale of 1-5 (*M, SD*)	4.0 (1.0)	4.1 (0.9)

[a] *n* = 65 due to missing data

[b] *n* = 48 and 53 respectively due to missing data

[c] *n* = 65 due to missing data

Effect of the mindfulness intervention on food intake

The mean amount of food consumed (in grams) in the experimental and control conditions are presented in Table 3.2. The direct effect of intervention group on food consumption was not significant (*b* = 0.69, *SE* = 3.83, 95% CI [-6.88, 8.26], partially standardised *β* = 0.03, *p* = 0.85), therefore our hypothesis that the mindfulness intervention would reduce food intake was not supported.

Table 3.2

The Amount of Food Consumed in Grams as a Function of Condition

Condition	Food intake in grams (*M, SD*)
Experimental (*n* = 67)	34.79 (24.06)
Control (*n* = 70)	33.16 (23.88)

Mediation analyses

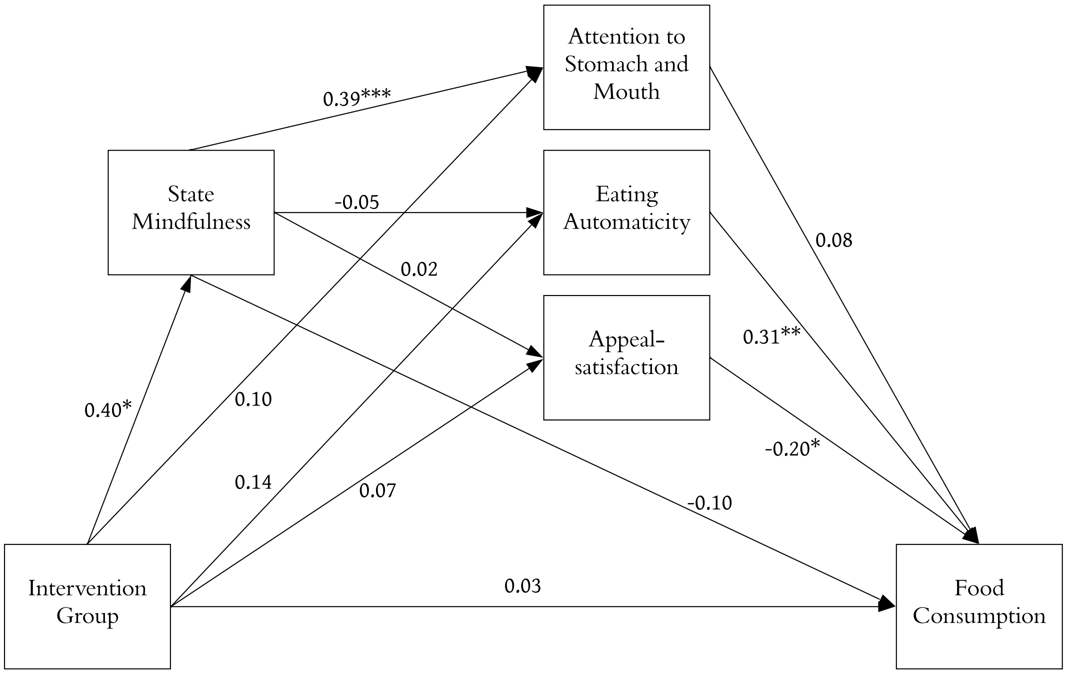
The hypothesised mediation model with standardised coefficients is presented in Figure 3.2. Contrary to our hypotheses, intervention group did not significantly affect attention to the stomach and mouth (*b* = 0.08, *SE* = 0.13, 95% CI [-0.18, 0.34], *β* = 0.10, *p* = 0.54), eating automaticity (*b* = 0.62, *SE* = 0.74, 95% CI [-0.85, 2.08], *β* = 0.14, *p* = 0.41), or appeal-satisfaction (*b* = 0.53, *SE* = 1.33, 95% CI [-2.11, 3.16], *β* = 0.07, *p* = 0.69).

As predicted, state mindfulness was significantly positively associated with attention to the stomach and mouth (*b* = 0.11, *SE* = 0.02, 95% CI [0.07, 0.16], *β* = 0.39, *p* <.001), however, it did not relate to eating automaticity (*b* = -0.07, *SE* = 0.13, 95% CI [-0.33, 0.19], *β* = -0.05, *p* = 0.59), appeal-satisfaction (*b* = 0.06, *SE* = 0.24, 95% CI [-0.41, 0.53], *β* = 0.02, *p* = 0.80) or food intake (*b* = -0.88, *SE* = 0.74, 95% CI [-2.33, 0.58], *β* = -0.10, *p* = 0.23).

Attention to the stomach and mouth did not significantly relate to food consumption (*b* = 2.34, *SE* = 2.50, 95% CI [-2.61, 7.28], *β* = 0.08, *p* = 0.35) contrary to hypotheses. However, results did indicate that eating automaticity was positively related to increased food intake (*b* = 1.73, SE = 0.45, 95% CI [0.84, 2.62], *β* = 0.31, *p* <0.01) and appeal-satisfaction decreased food intake (*b* = -0.59, SE = 0.26, 95% CI [-1.11, -0.07], *β* = -0.20, *p* <0.05) as predicted. These results indicate that individuals with higher eating automaticity scores consumed more food, and those with greater reliance on decreased food appeal and physical satisfaction to stop eating consumed less food.

Figure 3.2

Hypothesised Mediation Model with Standardised Coefficients



Note. Direct effect of intervention group on food consumption is partially standardised.
*p < 0.05, **p < 0.01, ***p < 0.001.

Table 3.3 presents the three serial mediation pathways that were hypothesised. The analyses revealed that contrary to our hypotheses, the effect of condition on food intake was not serially mediated by state mindfulness and attention to the stomach and mouth, state mindfulness and eating automaticity, or state mindfulness and appeal-satisfaction.

Table 3.3

Path Coefficients for Mediated Relationships in Hypothesised Model

Path	*b*	*SE*	*β*	95% CI LL	95% CI UL
Intervention group -> State Mindfulness -> Attention to Stomach and Mouth -> Food Consumption	0.29	0.37	0.01	-0.28	1.20
Intervention group -> State Mindfulness -> Eating Automaticity -> Food Consumption	-0.14	0.29	-0.01	-0.80	0.40
Intervention group -> State Mindfulness -> Appeal-satisfaction -> Food Consumption	-0.03	0.17	-0.002	-0.47	0.26

b = indirect path coefficient, *SE* = bootstrapped standard error, *β* = partially standardised coefficient, CI = confidence interval, LL = lower level, UL = upper level.

Hunger

Hunger was entered as a covariate in the model, and it was found that increased hunger was associated with increased food intake (b = 0.20, SE = 0.07, 95% CI [0.06, 0.34], β = 0.22, p < 0.01).

Sensitivity analyses

Sensitivity analyses were conducted with data from the two aim guessers included, and the pattern of effects remained unchanged. Analyses were also repeated with data from the two participants who did not consume any food due to reasons other than hunger or dieting included. The pattern of results remained unchanged.

Analyses were repeated excluding data from 11 participants who did not consume any food (i.e. using the same model in which appeal-satisfaction was included as a mediator). The effect of group on state mindfulness (b = 0.92, SE = 0.50, 95% CI [-0.06, 1.91], β = 0.31, p = 0.07) and the effect of hunger on food intake (b = 0.13, SE = 0.08, 95% CI [-0.02, 0.28], β = 0.16, p = 0.08) became non-significant. The pattern of effects for the rest of the analyses remained unchanged.

Further sensitivity analyses were conducted with data from 12 participants excluded due to minor deviations from the protocol. These included those whose participation in the study did not follow the standard procedure (3 observed using their phone during the study, 3 where the crisps had to be placed on the table instead of the sofa, 2 brought and consumed their own drink during the study, 2 completed the study quicker than the standard time, 1 interrupted by a fire alarm, and 1 who went to the kitchen to wash their hands). The pattern of effects remained unchanged.

Exploratory analyses: effects of other variables on food consumption

The effects of trait mindful eating, interoceptive awareness, age, BMI, sex, and education on food consumption were explored in a multiple regression model. The overall model was not significant, $F(12, 87) = 1.01$, $p = 0.45$, $R^2 = 0.12$, $R^2_{adjusted} = 0.001$. Because hunger may moderate any association between mindful eating or interoceptive awareness and food intake, it was not entered in the initial model. Therefore the model was run again with the addition of hunger as a predictor, but the overall model was still not significant, $F(13, 86) = 1.48$, $p = 0.14$, $R^2 = 0.18$, $R^2_{adjusted} = 0.06$.

Exploratory sensitivity analyses

Sensitivity analyses were carried out with data from 21 participants who reported that they were dieting excluded. The pattern of effects remained unchanged in the main model. The direct effect of intervention group on food consumption was not significant ($b = 1.08$, $SE = 4.31$, 95% CI [-7.46, 9.61], partially standardised $\beta = 0.05$, $p = 0.80$). The mean amount of food intake was 34.75g ($SD = 23.38$) in the mindfulness group and 34.33g ($SD = 24.42$) in the control group. In the model with appeal-satisfaction, intervention group significantly predicted state mindfulness ($b = 1.28$, $SE = 0.53$, 95% CI [0.22, 2.36], $\beta = 0.45$, $p < 0.05$). For all other analyses the pattern of effects remained unchanged.

Analyses were also repeated with data from 31 participants who reported that they did not like crisps excluded. These were participants who rated their liking of crisps as either ‘dislike a lot’, ‘dislike a little’ or ‘neither like nor dislike’. The pattern of effects remained unchanged in the main model. The direct effect of intervention group on food consumption was not significant ($b = 4.07$, $SE = 4.31$, 95% CI [-4.48, 12.63], partially standardised $\beta = 0.18$, $p = 0.35$). Mean food intake was 39.76g ($SD = 21.97$) in the mindfulness group and 35.49g ($SD = 23.92$) in the control group. In the model with appeal-satisfaction, intervention group significantly predicted state mindfulness ($b = 1.18$, $SE = 0.55$, 95% CI [0.10, 2.27], $\beta = 0.42$, $p < 0.05$), and hunger significantly predicted food intake ($b = 0.21$, $SE = 0.09$, 95% CI

[0.03, 0.39], $\beta = 0.24$, $p < 0.05$). The pattern of effects remained unchanged for all other analyses. Supplementary analyses are presented in Appendix I.

3.4 Discussion

Contrary to our hypotheses, the results of this study showed no direct or indirect effects of a mindfulness-based body scan on subsequent food consumption during TV watching. This finding is inconsistent with prior research by Jordan et al. (2014), who reported that a body scan exercise resulted in significantly lower food consumption, and Fisher et al. (2016) who also found a reduction in food intake following a similar mindfulness-based exercise. These previous studies were not carried out under distracted conditions, suggesting that the effects of a body scan exercise on consumption may only occur in non-distracted environments.

However, the observed absence of an effect of the body scan on food intake is in line with previous studies by Martin et al. (2017), Hsu and Forestell (2021), Marchiori and Papies (2014), and Van de Veer et al. (2016) that failed to find an effect of similar mindfulness exercises on food consumption. Furthermore, this finding aligns with the broader body of research in the mindful eating field that has assessed food intake outside the laboratory such as recent studies by Whitelock et al. (2019), Tapper and Seguias (2020) and Seguias and Tapper (2022). These studies employed a mindful eating exercise in which participants were instructed to pay attention to the sensory properties of their food as they ate and found no effect on the amount of food consumed. The collective evidence suggests a consistent pattern of mindfulness exercises demonstrating limited impact on overall food intake across various studies.

While the body scan practice did not influence food consumption, it was found that participants in the intervention group demonstrated higher levels of state mindfulness, which were associated with greater attention toward the stomach and mouth while watching the video clip and eating the crisps. However, this heightened awareness did not lead to reduced food intake which suggests that increased awareness of satiety signals alone may not be sufficient to curb food consumption, as individuals may choose to continue eating beyond the point of fullness. Alternatively, it may be the case that participants did not actually achieve fullness while eating during the study, although we did not measure satiety. It is also plausible that the effects of the intervention dissipated quickly following the body scan exercise, thus failing to translate into a change in behaviour. These findings indicate that simply encouraging individuals to "be more mindful" may not be enough to reduce their food intake, and future research should explore alternative strategies and mechanisms of action.

Furthermore, there was no evidence that mindfulness influenced eating automaticity or individuals' tendency to stop eating due to decreased food appeal and physical satisfaction. This suggests that although mindfulness may increase awareness of bodily sensations, including feelings of fullness, it may not directly impact the specific psychological processes involved in food consumption. Several key novel findings emerged from the analyses in relation to these processes. Notably, individuals who reported eating automatically while watching the show consumed more food, emphasising the potential importance of conscious awareness in regulating food intake. Moreover, participants who reported stopping eating due to decreased food appeal and physical satisfaction consumed less food, validating the 'Decreased food appeal' and 'Physical satisfaction' subscales of the 15-item RISE-Q (Chawner et al., 2022). This supports the notion that attending to food appeal and physical satisfaction may help individuals to stop eating sooner and thus reduce their overall food intake. This is the first study we are aware of to find associations between these variables and an objective measure of food intake. Collectively, these findings highlight the potential importance of present moment awareness in regulating food intake. Future mindfulness interventions targeting eating automaticity may therefore be more promising in influencing food consumption.

The exploratory analysis revealed no indications of a relationship between food intake and trait mindful eating or trait interoceptive awareness. This finding is in contrast to previous research by Jordan et al. (2014) and Farrar, Plagnol and Tapper (2022) who found that higher trait mindfulness was associated with making healthier food choices, and Beshara et al. (2013) who found trait mindful eating to be associated with consuming smaller portion sizes. However, Beshara et al. (2013) used self-report to measure portion sizes which may be unreliable, and Jordan et al. (2014) and Farrar et al.'s (2022) results related to food choice, as opposed to intake. It is plausible that having higher levels of trait mindfulness or interoceptive awareness does not necessarily translate to consuming less food. Individuals in the present study may have been mindful and aware of their satiety signals but consumed food according to their personal satisfaction levels. This interpretation is supported by the finding that increased hunger was associated with higher food intake, as it suggests that participants consume food in accordance with their hunger levels.

The study has a number of limitations that should be considered. Firstly, it is worth noting that the research focused solely on one aspect of mindfulness (present moment awareness of bodily sensations), and the interpretation of findings may not extend to other types of mindfulness practice. To avoid drawing attention to the aims of the study and demand characteristics, participants were told to continue using the "relaxation technique" throughout the rest of the study but were not explicitly instructed to maintain mindfulness and attention to their body while they were watching the TV show and consuming the food, potentially limiting the effectiveness of the intervention. Therefore, it is possible that although state mindfulness increased immediately following the body scan exercise, participants did not continue to be mindful while they were distracted with the TV show. Providing specific instructions for participants to continue paying attention to their bodies in a distracted setting may yield more pronounced effects on food intake. This could be explored in future research by encouraging participants to engage in a mindfulness practice while they are consuming food in a distracted environment. Future research could also explore the effects of a body scan exercise on food consumption during a longer mealtime period to assess its potential efficacy.

The design of the study poses a further limitation. Although several measures were taken to match the study conditions to a real-world eating scenario, the study was conducted in a controlled laboratory environment. This means the findings may not accurately reflect individuals' eating behaviour in the real world and future research may explore the effects of a body scan on food consumption while distracted in a more ecologically valid scenario. A final limitation of the study relates to the participant characteristics. Over half of the sample consisted of university students and the mean age was 21 years, therefore the findings may be specific to a university-aged sample. It is recommended for future research to use a sample beyond university students. A further recommendation for future research would be to examine the efficacy of the body scan practice with individuals who are trying to manage their weight, given that Warren et al. (2017) found mindfulness interventions to be more effective at reducing food intake in populations with overweight and obesity compared to healthy weight populations. The mean BMI of participants in this study was 22.6 which falls within the healthy range. Therefore, it is plausible that findings may be different in individuals with higher BMIs.

Despite its limitations, the study has strengths. Primarily, the study was pre-registered and used a relatively well powered and larger sample size than previous studies on mindfulness and food intake. In addition, the use of a cover story ensured that participants were blind to the study aims, reducing demand characteristics and social desirability bias. Furthermore, the study employed an active control condition which was carefully matched to the intervention condition to control for the effect of relaxation, as relaxation has been shown to influence food consumption (Masih, Dimmock, Epel & Guelfi, 2017). A significant portion of existing studies in this field have failed to control for these aspects (Tapper, 2022). Therefore, these differences in methodological best practice may in part explain why we failed to find an effect of a mindfulness-based body scan on food intake, unlike some earlier studies.

3.5 Conclusion

In conclusion, a brief body scan exercise increased state mindfulness but did not appear to reduce subsequent food consumption while participants were distracted. However, two key findings emerged from the study showing that reduced food intake was associated with lower eating automaticity and a greater reliance on reasons related to decreased food appeal and physical satisfaction to stop eating. These findings highlight the complex nature of food consumption and the multifaceted factors that contribute to eating behaviour. Considering the contextual specificity of mindfulness, further investigation is needed to determine the conditions under which mindfulness is effective or ineffective in reducing food consumption and to explore other potential underlying mechanisms.

Chapter Four – Improving Adherence to Weight Management Strategies: Information Length and Implementation Intentions

Chapter Two established that mindfulness and mindful eating practices are associated with a reduction in food intake and Chapter Three revealed that further investigation is required to understand the mechanisms of action responsible for this effect. As highlighted in Chapter One, while it is important to conduct research to enhance understanding of the effects of mindfulness and mindful eating in theory, it is equally as important to examine its implementation in practice. Therefore, this next chapter aims to address the final aim of this thesis; investigating how adherence to mindfulness and mindful eating strategies can be improved to ensure such interventions are effective in real-world settings.

The study described here investigates whether providing individuals with shorter information about the mindfulness or mindful eating strategy and encouraging them to form implementation intentions helps to increase their adherence to the strategy over a 2-week period. To identify potential differences in adherence between different types of mindful eating strategies, two distinct mindful eating strategies were examined. The chosen strategies were attending to feelings of fullness and attending to the sensory properties of food, as these emerged as the most prominent strategies in the systematic review presented in Chapter Two. Additionally, two further evidence-based, non-mindfulness weight management strategies were included in the study to identify any differences between strategies that require mental effort as opposed to those that require physical effort. These strategies were eating vegetables before other food groups and doing 5 minutes of physical activity immediately following a meal. Evidence shows that these strategies help to control blood sugar levels which in turn help individuals to consume less food (Nishino et al., 2018; Buffey et al., 2022).

The study is therefore framed within the broader context of weight management strategies as opposed to specifically focusing on mindfulness, however the findings directly relate to the thesis' aim of investigating implementation of mindfulness strategies in practice.

Abstract

Objective: Adherence to weight management strategies may be undermined where lengthy strategy explanations limit engagement and understanding, weakening intervention efficacy. By contrast, implementation intentions have been shown to promote adherence across various health behaviours. This study investigated the impact of explanation length and implementation intentions on adherence to brief weight management strategies. **Methods:** Participants (n = 200) with a BMI above 25 and an interest in losing weight were recruited from a commercial weight management service provider. Participants received information about one of four weight management strategies on a smartphone application in either a brief or detailed format and were asked to plan their use of the strategy with implementation intentions or were given tips on strategy use. Participants received daily prompts over a 2-week period to report whether they used their assigned strategy. Proposed moderators (need for cognition and planning skills) were measured at baseline. **Results:** Strategy adherence was greater with brief information (M = 74%, SD = 23) compared to detailed information (M = 69%, SD = 23), however this small effect size (Cohen's d = 0.24) was not statistically significant (p = .13). There was no moderation by need for cognition (p = .25). Adherence did not differ significantly between implementation intentions (M = 71%, SD = 27) and tips (M = 72%, SD = 21; p = .73), however there was moderation by planning skills (p = .04); as predicted, adherence was greater with implementation intentions compared to tips among those with poorer planning skills. **Conclusions:** Shorter explanation length and implementation intentions (in poorer planners) may enhance adherence to brief weight management strategies; further investigation is required to confirm these effects.

Keywords: implementation intentions, weight management, behaviour change, adherence

Public significance statement

This study contributes to our understanding of methods that enhance adherence in digital health interventions. It describes an efficient method for identifying those with weaker planning skills who may benefit from being prompted to form implementation intentions. It also provides preliminary evidence for the benefits of imparting information more succinctly (in 70 to 100 words instead of 600 to 700 words) though further research is needed to confirm this.

4.1 Introduction

Successful weight loss and weight loss maintenance requires adjustments to food intake and physical activity; the key behaviours targeted by most weight management interventions (Chao et al., 2021). These interventions include a variety of behavioural and psychological strategies, ranging from calorie counting (Hartmann-Boyce et al., 2014) to mindful eating (Carrière et al., 2018) and intermittent fasting (Welton et al., 2020). While the efficacy of many of these interventions is well-established (Twells et al., 2021), their impact on weight management remains contingent upon individual adherence. However, evidence shows that adherence is often suboptimal and can be as low as 10%, undermining intervention effectiveness (Lemstra et al., 2016). There is also some evidence that adherence is lower in individuals with lower socioeconomic status (Birch et al., 2022), which may contribute to health inequalities. Therefore, it is crucial to explore methods by which adherence can be increased to maximise the potential benefits of interventions.

One important factor to consider is the way the information is presented. Communication in health promotion is crucial (Rimal & Lapinski, 2009), and effective communication involves tailoring messages for the intended audience (Ngigi & Busolo, 2018). The Information-Motivation-Strategy (IMS) model (Martin & DiMatteo, 2014) states that one of the main reasons individuals do not adhere to behaviour change advice is because they are not given adequate, understandable information. One aspect that could influence understanding is the length of written information provided. Although longer more detailed information may enhance understanding, it is possible that longer material reduces engagement, which in turn limits understanding and implementation. By contrast, briefer information may enhance engagement, leading to increased understanding and implementation.

This idea is supported by research on attentional processes, which plays a critical role in how individuals process information (Cohen, 2014). In recent years there has been a decline in attention span, attributed in part to increased information overload due to the rapid rise of digital technology (Carr, 2020). Yeykelis et al. (2014) found that individuals tend to switch between different types of online content as frequently as every 19 seconds, and 75% of all content is typically viewed for less than one minute. This type of media multi-tasking is associated with worse performance on cognitive tasks requiring sustained attention (Uncapher & Wagner, 2018). This trend emphasises the importance of capturing and maintaining individuals' attention to enhance their engagement with the content of weight management strategies. Given the reduction in attention span, individuals may be more likely to engage with shorter, more focused content, while longer information may lead to cognitive overload and skim-reading or disengagement entirely.

Nevertheless, preference for longer versus shorter information may vary from person to person. For example, the Need for Cognition Scale (NCS; Cacioppo & Petty, 1982) assesses individuals' inclination to engage in and enjoy cognitive activities. Therefore, those with higher need for cognition may be more willing to engage with lengthier written material and more interested in learning the rationale behind a particular weight management strategy. By contrast, those with low need for cognition may be put off by lengthier material, preferring information that is more succinct and to the point. This hypothesis has been partially supported by Williams-Piehota et al. (2003) who found that women who were high in need for cognition were more likely to follow more detailed (compared to more succinct) mammography advice. However, the format made no difference for those who were low in need for cognition.

Another key factor that may influence adherence is difficulty translating intentions into action, i.e., the intention-behaviour gap (Sheeran, 2002). Many individuals may understand, and be motivated to use, strategy information, yet still fail to implement it. The Rubicon Model of Action Phases (Heckhausen & Gollwitzer, 1987) posits two key phases of goal pursuit; a motivational (pre-decisional) phase when the individual forms the intention to perform the behaviour, and a volitional (post-decisional) phase when the behaviour is implemented. The theory suggests that behaviour change can be promoted by targeting motivation in the pre-decisional phase and implementation of the behaviour in the post-decisional phase (Gollwitzer, 2012). A powerful strategy for the latter phase is the formation of an implementation intention, which involves the development of a specific plan of action in the form of an if-then statement, for example, "If situation X is encountered, then I will initiate behaviour Y" (Gollwitzer, 1999). Systematic reviews have found implementation intentions to be effective in improving general goal attainment (Gollwitzer & Sheeran, 2006), and adherence to a range of health behaviours such as healthy eating (Adriaanse et al., 2011; Carrero et al., 2019), physical activity (Bélanger-Gravel et al., 2013; Silva et al., 2018; Kompf, 2020) and smoking cessation (Hagerman et al., 2021). The use of implementation intentions in weight loss interventions have also been associated with greater weight loss (Luszczynska et al., 2007; Armitage et al., 2014). However, findings are mixed; Benyamini et al. (2013) and Hayes et al. (2021) found implementation intentions resulted in similar weight loss outcomes as simple goal intentions. Additionally, Knäuper et al. (2018) found that the addition of implementation intentions to the NIH-developed Diabetes Prevention Program did not result in greater weight loss.

This discrepancy may be due to the different ways implementation intentions are employed across studies. A range of variables may moderate the effects of implementation intentions, including the quantity (Verhoeven et al., 2013) and specificity of the intentions (de Vet et al., 2011). Individual differences in self-regulation may be another potential moderator; whether implementation intentions are helpful for an individual could be contingent upon their proficiency in planning skills. Allan et al. (2013) instructed participants to complete an online food diary to monitor their snack intake, and half were also instructed to generate an implementation intention to help them achieve this goal. The implementation intention intervention was significantly associated with higher completion rates in poorer planners, but not in skilled planners, suggesting that adherence can be enhanced by tailoring interventions to individuals' planning skill abilities.

In light of the above, the present study investigated whether adherence to brief weight management strategies over a 2-week period is influenced by length of strategy information and use of implementation intentions. The aims were to 1) explore the effect of information length on adherence, and whether this differs depending on need for cognition, and 2) examine the effect of implementation intentions on adherence, and whether this differs depending on planning skills. Given an absence of previous research, we did not formulate any confirmatory hypotheses related to the first aim. However, for the second aim we predicted that use of implementation intentions would increase adherence, and that this increase would be larger for those with poorer planning skills.

The study also examined whether higher NCS scores were associated with a preference for longer information and whether use of implementation intentions was associated with increased strategy automaticity during the 2-week period. Additionally, the study investigated whether briefer, more lay friendly measures may be adequate substitutes for the longer, standardised measures of need for cognition and planning skills. This was considered important since although these measures may prove useful for increased personalisation of interventions, their length may make them too burdensome and impractical for digital interventions, especially where multiple characteristics are being assessed.

Additional exploratory aims related to the effects of participants' free time and priority of diet/weight on strategy adherence, and whether preferences for amount of time spent learning new things moderated effects of information length on adherence. Effects of information length on ease of understanding and remembering strategy content as well as memory of strategy rationale were also investigated. Additionally, differences in adherence to mental and physical strategies were explored, as well as differences in their helpfulness ratings. Finally, the research also aimed to gain qualitative insights into participants' views on the weight management strategies and their experiences during the study.

4.2 Method

Sample size

A minimum sample size of 128 participants was calculated on G*Power based on a medium effect size, 80% power and 5% alpha for a 2 x 2 ANOVA. To account for participant attrition and exclusions, and the testing of exploratory hypotheses, the target sample size was set at 200 participants.

Participants

Participants were recruited from Oviva, a digital commercial weight management service provider. Individuals on the 9-month NHS Diabetes Prevention Programme, 12-week Tier 2 Weight Management and 12-week Diabetes Structured Education programmes were invited to take part in the study by email. To prevent the study interfering with programme engagement, participants were invited when they had completed the programme or were close to completion. Additional eligibility criteria were age 18 or over, access to a smartphone, BMI over 25, an interest in losing weight or avoiding weight gain and not on a meal replacement diet. Participants received Amazon vouchers worth up to £20 based on participation duration, with an extra £5 for completing the optional qualitative part of the study.

Two hundred participants enrolled onto the study. Participants' age ranged from 23 to 79 years, with a mean of 52 years (*SD* = 11.2). The sample consisted of 63% women. BMI ranged from 25.3 to 64.9kg/m^2 with a mean of 35.5kg/m^2 (*SD* = 7.3). Most participants (78%) were White, 12% were Asian or Asian British, 5% were Black, African, Caribbean or Black British, 4% were Mixed or multiple ethnic groups, and 1% were from other ethnic groups. Half of the sample (51%) had an undergraduate degree or higher, 22% were educated to GCSE level, 11% had a BTEC qualification, 11% had A-levels, 4% had no formal education and 3% had another form of qualification.

The study received ethical approval from the City, University of London Psychology Department Research Ethics Committee (ETH2223-2482). The method and analysis strategy were pre-registered with the Open Science Framework (https://osf.io/nx3gj/).

Study design

The study employed a 2 x 2 x 4 between-groups experimental design. Participants were randomly assigned to one of 16 groups, which varied by information length (short or long), implementation intentions (present or absent) and strategy content (sensory eating, attending to fullness, eating vegetables first, or increasing physical activity). The dependent variable was the percentage of days participants adhered to their assigned strategy.

Experimental manipulation

Strategy content

Evidence-based written information was provided for one of four brief weight management strategies: paying attention to the sensory properties of food while eating (Segiuas & Tapper, 2018), paying attention to feelings of fullness while eating (Jordan et al., 2014), eating vegetables or salad before the rest of the meal (Nishino et al., 2018) and doing 5 minutes of physical activity following a meal (Buffey et al., 2022). The information provided the rationale behind the strategy as well as instructions on how to practice it. See Appendix J for full strategy information.

Information length

The strategy information was either presented in a short format (approximately 70 – 100 words) with a focus on action (e.g., pay attention to the taste and texture of food in your mouth) or a long format (approximately 600 – 700 words) with a focus on outcome (e.g., how to slow down your eating) and additional detail on the strategy rationale.

Implementation intentions

Participants were either presented with planning prompts to help them form implementation intentions (present), or they received tips on strategy use (absent). The planning prompts involved first indicating when they would use the strategy (e.g. *If* I am eating breakfast / lunch / my evening meal / my daily snack), followed by how they would use it (e.g. *then* I will keep reminding myself to notice the taste, texture, and temperature of the food). The same content was presented in the tips condition in the form of tips on strategy use (e.g. When you're eating a meal or snack, keep reminding yourself to notice the taste, texture, and temperature of the food).

Materials

The study was delivered on the Avicenna Research (formerly Ethica Data) smartphone application (https://avicennaresearch.com). A baseline survey, a schedule of 14 daily surveys, and a follow up survey were triggered upon enrolment. Participants were notified to complete the surveys via phone notifications.

Measures

Baseline measures

Demographics. Participants indicated their age, gender, ethnicity, and education level.

Height and weight. Self-report measures were provided in kilograms / pounds and centimetres / feet and inches.

Weight loss intentions. Participants responded to *"Which of the following best describes you?"* with *'I'm trying to lose some weight' / 'I'm not trying to lose weight but I'm trying to avoid gaining weight' / 'I'm not currently trying to lose weight'*.

Priority of diet/weight. Participants were asked *"Thinking about all the things going on in your life right now, how much of a concern is your diet or weight?"* with response options of '*It's the thing I'm most concerned about right now' / 'It's one of several important concerns I have right now' / 'There are other things I'm more concerned about right now'*.

Free time. Participants responded to *"Which of the following best describes you?"* with *'I'm very busy, and never seem to have enough time for everything I need to do' / 'I'm quite busy, but if something unexpected comes up, I can usually make time to deal with it' / 'I typically have plenty of free time to spend how I choose'*.

Planning skills. This was assessed using 10 items from the 'goal setting' subscale of the Short-form Self-Regulation Questionnaire (SSRQ; Neal & Carrey, 2005). Items were rated on a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). Total SSRQ score was computed by summing the 10 items; higher scores indicated greater planning skills.

Alternative measure of planning skills. Participants responded to *"Which of the following best describes you?"* with '*I'm good at making plans and sticking to them. If I set myself a goal, I'll spend time figuring out exactly how to reach it. If I'm not making good progress toward a goal, I'll go back to my plans and think again.' / 'I struggle to make plans and stick to them. I often find myself forgetting to do things I'd planned to do or getting distracted with other things'*.

Need for cognition. This was assessed using the short form of the Need for Cognition Scale (NCS; Lins de Holanda Coelho et al., 2020) which consisted of 6 items, each rated on a 5-point Likert scale ranging from 1 (*extremely uncharacteristic of me*) to 5 (*extremely characteristic of me*). A mean NCS score was computed from the 6 ratings, with higher scores indicating greater need for cognition.

Alternative measure of need for cognition. Participants responded to *"Which of the following best describes you?"* with *'If a doctor gives me advice, I like to understand the reasoning behind that advice. I'll ask questions or search the internet until I feel I really understand the issue.' / 'If a doctor gives me advice, I'm usually happy to simply take that advice. I don't feel the need for lengthy explanations and justifications'.*

Preference for time spending learning new things. Participants were asked *"If you were part of a weight management programme, how much time would you prefer to spend learning new things?"* with response options '*No more than a few minutes a day or 30 minutes a week' / 'Up to 15 minutes a day or 1 to 2 hours a week' / 'Up to 30 minutes a day or 3 to 4 hours a week'.*

Daily measures

Adherence. Each day for 14 days participants were asked *"Did you use the strategy today?"* with response options '*Yes, I used it at least once' / 'No, I forgot to use it' / 'No, I didn't have time or didn't use it for another reason'.* Adherence was calculated as the percentage of days participants indicated they used the strategy out of the total number of daily surveys they completed.

Follow up measures

Ease of understanding / remembering strategy information. Participants responded to *"How easy was it to understand the instructions for the strategy?"* and *"How easy was it to remember the information you were given about the strategy over the 2-week period?"* on a 100mm visual analogue scale (VAS) anchored from 0 (*very difficult*) to 100 (*very easy*).

Views on length of strategy. Participants were asked *"When we gave you the strategy, we also explained why it might be helpful. Was this explanation…"* with response options '*too short?*' / '*about right?*' / '*too long?*'.

Helpfulness of strategy. Participants responded to *"How helpful did you find the strategy?"* on a 5-point scale ranging from 1 (*very unhelpful*) to 5 (*very helpful*).

Automaticity of strategy use. The 4-item Self-report Behavioural Automaticity Index (SRBAI; Gardner et al., 2012) assessed whether the assigned strategy became a habit over the 2-week period. Items were rated on a 7-point scale ranging from 1 (*strongly agree*) to 7 (*strongly disagree*). The 4 ratings were reverse-coded and summed to form a total score with higher scores indicating higher levels of automaticity.

Memory of strategy rationale. Four multiple choice questions, one relating to each of the strategies, were used to assess participants' knowledge of the rationale behind each strategy (see Appendix K).

Qualitative questions. Four optional open-ended questions were administered to explore participants' experiences during the study. See Appendix L for details of the qualitative aspect of the study.

Procedure

Data collection took place between August and November 2023. Eligible Oviva patients were emailed the study advert, and interested participants first completed a screening survey on Qualtrics to confirm eligibility. Participants then completed the consent form and were given enrolment instructions. Once enrolled, participants completed the baseline measures and were randomised to one of the 16 possible groups where they were presented with their assigned strategy followed by planning prompts or tips on strategy use. It took approximately 30 minutes to complete baseline measures and read the strategy information. Participants then selected their preferred notification time (between 6pm and 11pm) for the daily surveys and were notified at their chosen time each day over the next 14 days to complete the surveys. To avoid participants mistakenly recording answers for the wrong day, each daily survey expired within 24 hours.

At 9am on the day following the last daily survey, participants were prompted to complete the follow up measures. This took approximately 30 minutes. Following this, participants were given the option to complete the qualitative survey, which took an additional 30 minutes. Participants were then provided with a written debrief and payment vouchers were issued via email.

Data analysis

Data were analysed in the IBM SPSS statistical analysis package (version 28). All analyses were subject to bootstrapping at 5,000 resamples. Linear regression models were used to test the effects of information length and implementation intentions on strategy adherence. The moderating effects of NCS and SSRQ scores were examined using multiple regression models (Model 1) via the PROCESS macro (Hayes, 2017). The association between NCS score and participants' preference for information length was explored with an ordinal logistic regression model. An independent *t*-test examined the effect of implementation intentions on SRBAI scores.

Point-biserial correlation tests were used to test the association between the two need for cognition measures and the association between the two planning skills measures. The moderating effect of the alternative need for cognition measure on the association between information length and adherence was explored using ANOVA, as was the moderating effect of the alternative planning skills measure on the association between implementation intentions and adherence.

Linear regression models tested the effects of participants' free time and priority of diet/weight on adherence. The moderating effect of information length in these analyses was explored using PROCESS Model 1. PROCESS Model 1 also assessed the moderating effect of preference for amount of time spending learning new things on the association between information length and adherence. ANOVA models were used to explore the differences in adherence and helpfulness ratings across the four strategies.

The effect of information length on ease of understanding and remembering strategy information was explored using linear regression, and PROCESS Model 1 tested the moderating effect of NCS score. A logistic regression model evaluated the effect of information length on the likelihood that participants remember the rationale for the strategy they were assigned to, with NCS score entered as a moderator.

4.3 Results

Participant characteristics

Figure 4.1 presents the flow of participants through the study. As per the pre-registration, only participants with data for 7 or more daily surveys were included in the main analyses exploring the effects of information length and implementation intentions ($n = 169$). Analyses relating to follow-up measures were restricted to participants who completed the follow-up survey ($n = 140$). For all other analyses the full sample was used ($n = 200$). Participant characteristics of those included in the main analyses ($n = 169$) were well matched across conditions (Table 4.1).

Figure 4.3

Flow Chart of Participants Through the Study

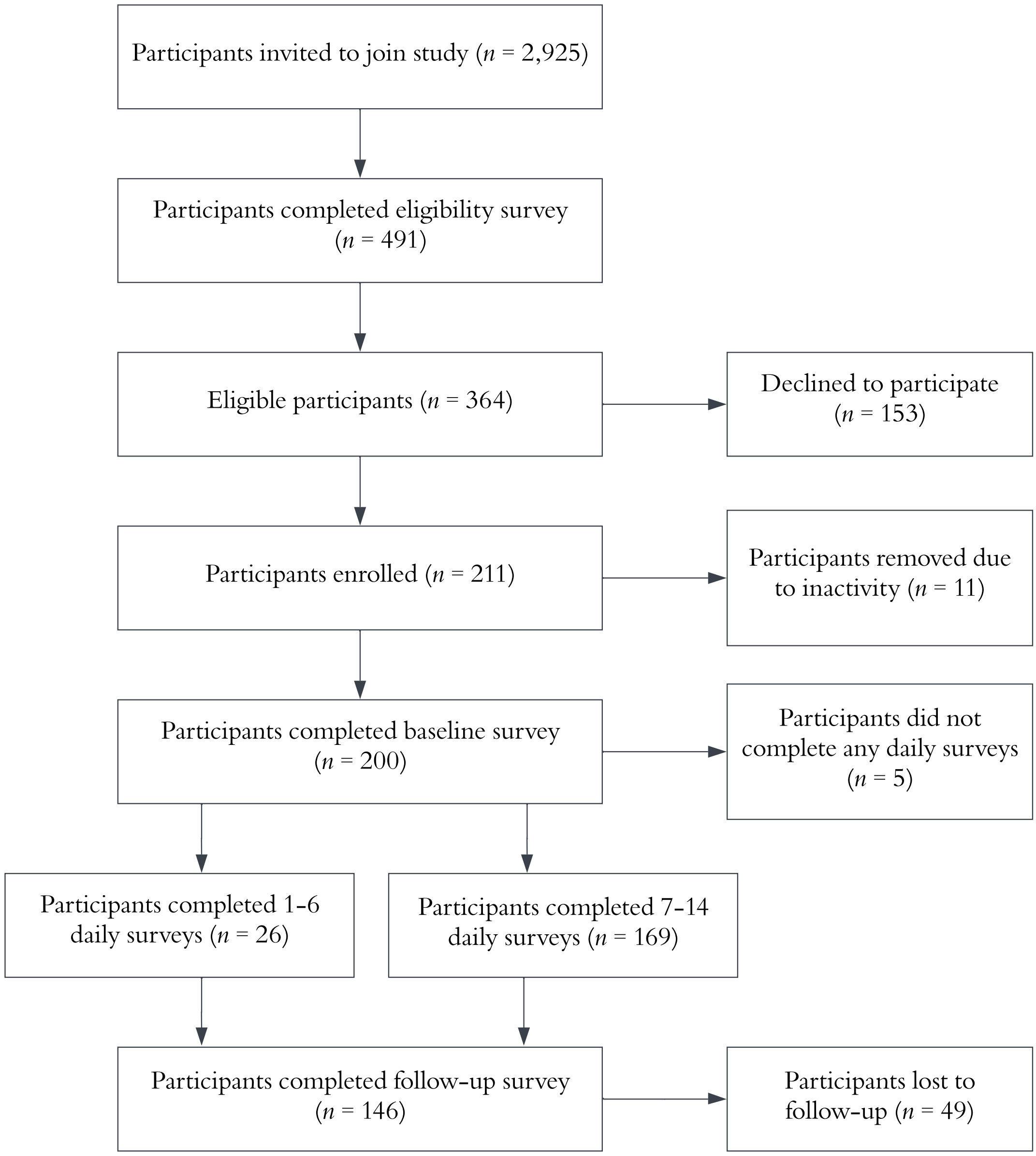


Table 4.1

Participant Characteristics as a Function of Condition

Characteristic	Implementation Intentions (*n* = 80)	Tips (*n* = 89)	Short Format (*n* = 85)	Long Format (*n* = 84)
Age (*M, SD*)	53 (12)	51 (10)	51 (11)	53 (11)
Gender (% women)	66%[a]	65%	63%[b]	68%
BMI (*M, SD)*	35.3 (6.5)	35.9 (8.3)	35.7 (7.2)	35.6 (7.8)
Education				
No formal education	3%	5%	2%	5%
GCSEs / O-levels or equivalent	23%	23%	20%	25%
A-levels or equivalent	9%	8%	7%	10%
BTEC or equivalent	13%	10%	11%	12%
Undergraduate degree or equivalent	29%	37%	33%	33%
Master's degree or equivalent	20%	17%	21%	16%
Doctoral degree or equivalent	1%	0%	1%	0%
Other	4%	1%	5%	0%
Ethnicity[c]				
Arab	0%	0%	0%	0%
Asian or Asian British	8%	13%	12%	8%
Black, Black British, Caribbean or African	4%	5%	6%	2%
Mixed or multiple ethnic groups	3%	2%	2%	2%
White	85%	81%	80%	86%
Other ethnic group	1%	0%	0%	1%
Percentage trying to lose weight	98%	94%	97%	95%
Percentage trying to avoid weight gain	3%	6%	4%	5%
Priority of diet/weight				
High	28%	29%	34%	23%
Medium	71%	67%	65%	74%
Low	1%	3%	1%	4%
Free time				
Very busy	26%	37%	27%	37%
Quite busy	53%	49%	53%	49%
Have plenty of free time	21%	14%	20%	14%
Preference for time spending learning new things in a weight management programme				
Few minutes a day/30 mins a week	26%	24%	19%	31%
15 mins a day/1-2 hours a week	56%	57%	62%	51%
30 mins a day/3-4 hours a week	18%	19%	19%	18%
SSRQ Score (*M, SD*)	34.3 (6.8)	35.3 (5.8)	35.3 (6.5)	34.3 (6.1)
NCS Score (*M, SD*)	3.4 (0.8)	3.6 (0.7)	3.6 (0.8)	3.5 (0.8)

[a]*n* = 79 due to missing data.
[b]n = 84 due to missing data
[c]*n* = 79, 87, 83 and 83 respectively due to missing data.

Main analyses

Effect of information length on adherence

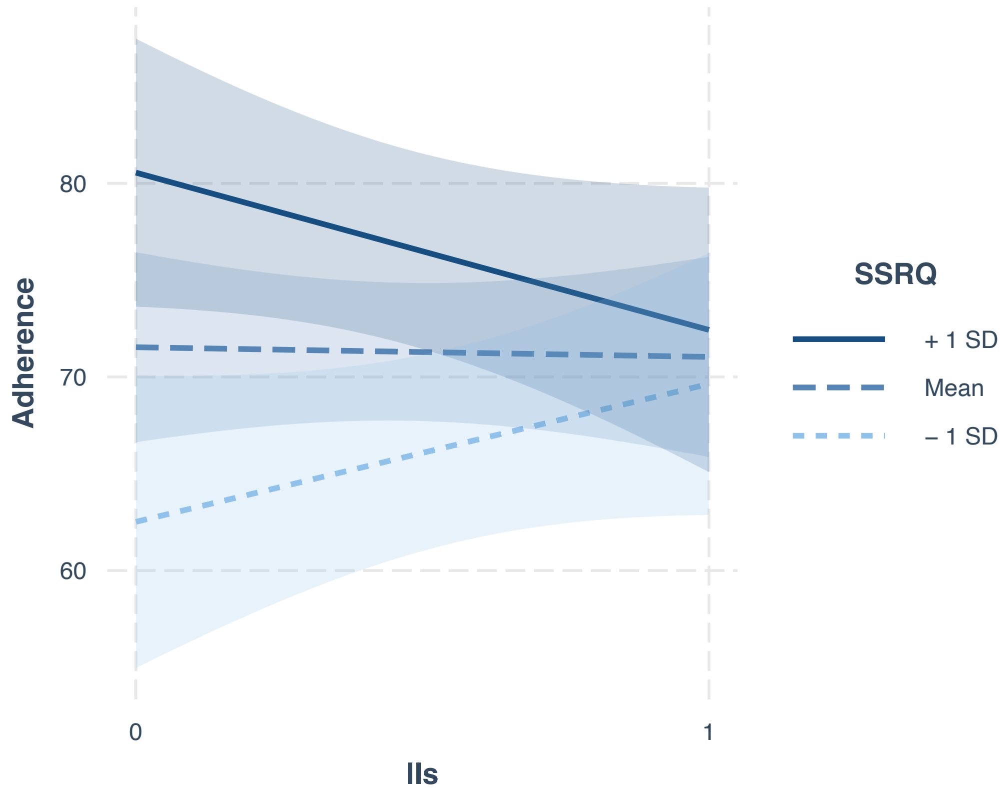
Mean adherence to the strategy was 74% (*SD* = 25) in the short information group and 69% (*SD* = 23) in the long information group. This difference was not statistically significant (*b* = -5.70, *SE* = 3.74, 95% CI [-13.00, 1.77], *p* = .13), however, Cohen's *d* indicated a small effect size (0.24). There was no significant moderation by need for cognition (*b* = 5.50, *SE* = 4.72, 95% CI [-3.82, 14.82], *p* = .25).

Effect of implementation intentions on adherence

Mean adherence to the strategy was 71% (*SD* = 27) in the implementation intentions group and 72% (*SD* = 21) in the group who received tips on strategy use. Contrary to predictions, there was no significant association between forming implementation intentions and strategy adherence (*b* = -1.34, *SE* = 3.71, 95% CI [-8.61, 5.84], *p* = .73) but as predicted, there was a significant interaction between implementation intentions and SSRQ (*b* = -1.21, *SE* = 0.58, 95% CI [-2.34, -0.07], *p* = .04). The Johnson-Neyman technique (Appendix N) revealed that implementation intentions (as opposed to tips) significantly increased adherence among those who scored below 13.01 on the SSRQ (poorer planners), however this only represented 0.6% of the sample, or 1 participant. Additional to our predictions, implementation intentions decreased adherence among those who scored above 48.88 (skilled planners) but again, this only represented 0.6% of the sample, or 1 participant. This was further explored with simple slopes analysis which revealed a similar pattern (Figure 4.2); implementation intentions increased adherence among participants with poor planning skills, and decreased adherence among participants with good planning skills. These results suggest that planning skills may moderate the effect of implementation intentions on adherence, but the effect may be small.

Figure 4.4

Simple Slopes for the Moderation Effect of Planning Skills on the Association Between Implementation Intentions and Adherence



IIs: implementation intentions (0 absent, 1 present); SSRQ: Short-form Self-regulation Questionnaire.

Effect of need for cognition on preference for information length

Contrary to predictions, there was no significant association between NCS score and odds of preference for shorter information length, OR = 0.96, 95% CI [0.45, 2.05], $p = .92$.

Effect of implementation intentions on automaticity

Also contrary to predictions, there was no significant difference in SRBAI scores between participants who formed implementation intentions ($M = 17.0$, $SD = 7.1$) and those who were given tips ($M = 17.4$, $SD = 6.6$), $t(138) = 0.35$, $p = .73$.

Additional exploratory analyses

Alternative need for cognition measure

As expected, there was a significant positive correlation between the two need for cognition measures, $r_{pb}(198) = .19$, $p = .01$. Participants who reported they like to understand the reasoning behind doctors' advice ($n = 155$) had a greater NCS score ($M = 3.6$, $SD = 0.8$) than those who reported they are happy to simply take doctors' advice ($n = 45$, $M = 3.2$, $SD = 0.8$).

Contrary to the confirmatory analyses, the ANOVA exploring the moderating effect of the alternative need for cognition measure revealed a significant main effect of information length on adherence; adherence was greater in the short format group (M = 74%, $SD = 25$) than the long format group (M = 69%, $SD = 23$), $F(1, 165) = 4.97$, $p = .03$, $\eta_p^2 = .03$. For individuals with low need for cognition ($n = 37$), mean adherence was 83% ($SD = 16$) in the short format group and 66% ($SD = 29$) in the long format group. For individuals with high need for cognition ($n = 132$), mean adherence was 72% ($SD = 26$) in the short format group and 69% ($SD = 21$) in the long format group. These figures are in line with expectations, however, the interaction effect between information length and the alternative need for cognition measure was not significant, $F(1,165) = 2.61$, $p = .11$, $\eta_p^2 = .02$.

Alternative planning skills measure

Also as expected, there was a significant positive correlation between the two planning skills measures, $r_{pb}(198) = .58$, $p <.001$. Participants who reported they were good at making plans ($n = 84$) had a greater SSRQ score ($M = 38.8$, $SD = 5.4$) than those who reported they struggle to make plans ($n = 116$, $M = 31.5$, $SD = 5.0$).

Participants who reported being good at making plans also reported significantly greater adherence (M = 76%, $SD = 25$) than those who struggled to make plans (M = 68%, $SD = 23$), $F(1,165) = 3.97$, $p = .048$, $\eta_p^2 = .02$. For individuals with good planning skills ($n = 74$), mean adherence was 71% ($SD = 30$) in the implementation intentions group and 81% ($SD = 17$) in the tips group. For individuals with poor planning skills ($n = 95$), mean adherence was 71% ($SD = 24$) in the implementation intentions group and 66% ($SD = 22$) in the tips group. The interaction between implementation intentions and the alternative planning skills measure was significant, $F(1,165) = 4.66$, $p = .03$, $\eta_p^2 = .03$. However, independent samples *t*-tests revealed no significant effect of implementation intentions on adherence in individuals with good planning skills ($t(72) = 1.80$, $p = .09$) or individuals with poor planning skills ($t(93) = -1.19$, $p = .25$).

Effects of other variables on adherence

Mean strategy adherence was 67% (*SD* = 25) among participants who stated they were *'very busy'* (*n* = 54), 73% (*SD* = 24) among those who were *'quite busy'* (*n* = 86), and 77% (*SD* = 21) among those who stated they had *'plenty of free time'* (*n* = 29). However, there was no significant main effect of free time on adherence (*b* = 4.99, *SE* = 2.64, 95% CI [-.29, 10.28], *p* = .06) and no moderation by information length (*p*s > .05). Mean adherence was 77% (*SD* = 19) in individuals whose diet/weight was of high priority (*n* = 48), 69% (*SD* = 26) in those with medium priority (*n* = 117) and 74% (*SD* = 9) in those with low priority (*n* = 4). The main effect of diet/weight priority on adherence approached significance (*b* = -6.20, *SE* = 3.15, 95% CI [-12.58, -0.11], *p* = .054). There was no significant moderation by information length (*p*s > .05). Additionally, preference for time spending learning new things did not moderate the impact of information length on strategy adherence (*p*s > 0.05). See Appendix M for more details on the above analyses.

Mean strategy adherence was 72% (*SD* = 28) for sensory eating, 68% (*SD* = 25) for attending to fullness, 61% (*SD* = 30) for vegetables first and 70% (*SD* = 29) for physical activity. There was no significant difference between the four strategies, *F*(3, 196) = 1.53, *p* = .21. There were also no significant differences in helpfulness ratings across sensory eating (M = 3.8, *SD* = 1.0), attending to fullness (*M* = 3.9, *SD* = 0.9), vegetables first (*M* = 3.9, *SD* = 1.1) and physical activity (*M* = 4.1, *SD* = 0.9), *F*(3, 139) = 0.44, *p* = .73 (*n* = 143 as not all participants used the strategy). The pattern of results remained the same when participants with less than 7 days of data were excluded (*n* = 169).

Effect of information length on self-reported ease of understanding and remembering

There was no significant association between information length and self-reported ease of understanding the strategy information (*b* = -2.62, *SE* = 2.01, 95% CI [-6.77, 1.41], *p* = .22) and no significant interaction between information length and NCS score (*b* = 0.72, *SE* = 2.80, 95% CI [-4.81, 6.25], *p* = .80). However, ease of remembering was significantly higher among participants in the short format group (*M* = 83%, *SD* = 22) compared to those in the long format group (*M* = 74%, *SD* = 25), *b* = -9.08, *SE* = 3.98, 95% CI [-16.83, -1.14], *p* = .02. There was no evidence for a moderation effect of NCS score (*b* = -0.84, *SE* = 5.33, 95% CI [-11.39, 9.71], *p* = .87).

Effect of information length on memory for the strategy

Participants in the long format group were more likely to correctly remember the rationale for their assigned strategy than those in the short format group (OR = 3.08, 95% CI [1.18, 8.05], $p = .02$). There was no moderation by NCS score (OR = 0.81, 95% CI [0.22, 2.94], $p = .75$). See Appendix M for details of additional exploratory analyses.

Sensitivity analyses

The analyses using the adherence variable were repeated using data from all 200 participants where adherence was calculated over the full 2-week period (missing data were replaced with 'non-adherent'). The pattern of results for all analyses remained unchanged apart from the ANOVA model exploring the moderating effect of the alternative need for cognition measure, where the main effect of information length became non-significant ($p = .47$).

4.4 Discussion

The novel key aim of this study was to explore whether adherence to brief weight management strategies over a 2-week period could be enhanced by manipulating information length, and whether this varied for individuals with different levels of need for cognition. The findings revealed no significant effect of information length on strategy adherence, however, the observed means were in the expected direction with adherence 5 percentage points higher among those who viewed the shorter information. This represented a small effect size which the study had not been powered to detect; whilst the planned regression analyses revealed a non-significant effect, an ANOVA, conducted as part of additional exploratory analyses, showed it as significant ($p = .048$). Because digital health interventions are often delivered to large numbers, an effect of this size may still be clinically significant. As such, these results warrant further exploration with an appropriately powered sample.

Contrary to Williams-Piehota et al.'s (2003) findings, the study failed to show that the effect of information length on adherence was influenced by need for cognition. Indeed, the overall pattern of results seem to suggest that even those with high need for cognition may benefit from shorter information. In line with this finding, need for cognition also failed to predict preference for information length. Findings from the exploratory analyses provide some insights into why shorter information may lead to better adherence; although memory for strategy rationale was better among those given the longer information, those given the shorter information reported that it was easier to remember the strategy. Thus, it is possible that shorter information leads to greater adherence simply because it helps people remember the strategy. A key implication of these findings is that digital health interventions may enhance adherence by limiting information length to no more than 100 words of action-oriented text. Optional links to additional detail could then be provided for those who would prefer extra information.

In contrast to ease of remembering, ease of understanding was relatively high across both the short and long information groups (93% and 90% respectively). It was also not influenced by need for cognition, suggesting that need for cognition did not impact engagement with strategy content. It is possible that strategy understanding is better predicted by other participant characteristics such as health literacy and cognitive ability. Health literacy encompasses skills in understanding and applying information about health issues (Ishikawa & Kiuchi, 2010) and higher levels have been associated with better health behaviours (Šulinskaitė et al., 2022). Likewise, engagement in health promoting behaviours has been associated with greater cognitive ability as measured by general intelligence (Auld & Sidhu, 2005), processing speed (Anstey et al., 2009), and analytic reasoning (Junger & van Kampen, 2010). Given these correlations, it is possible that participants in this study had relatively high health literacy skills and cognitive abilities, which could have contributed to the high reported ease of understanding, regardless of information length or need for cognition level. However, without direct measures of health literacy and cognitive ability, these interpretations remain speculative. Future studies may consider incorporating these measures in addition to need for cognition.

The study's second aim was to examine whether adherence could be enhanced with implementation intentions, and whether this varied for individuals with different levels of planning skills. In contrast to previous research (Adriaanse et al., 2011; Carrero et al., 2019; Bélanger-Gravel et al., 2013; Silva et al., 2018; Kompf, 2020), we found no evidence for benefits of implementation intentions over and above similar advice phrased as 'tips'. This discrepancy may be due to the use of different types of control groups in previous research. In Adriaanse et al.'s (2011) systematic review most studies employed a passive control group where participants received no instructions or considerably fewer instructions than the experimental group. Effects of implementation intentions were stronger across studies with these weaker control groups compared to studies with active control conditions which administered identical instructions to both control and experimental groups (apart from the manipulation). In these latter studies, the active control condition itself may promote goal achievement to some extent, thus reducing (but not entirely eliminating) the relative advantage of implementation intentions. It is therefore plausible that while implementation intentions may be effective in promoting goal achievement, other strategies, such as the provision of 'tips' (i.e. suggestions on how to implement a particular behaviour), may be just as effective.

Furthermore, contrary to predictions, the study failed to find evidence to support the notion that implementation intentions achieve their effect by increasing automaticity. Automaticity of the strategies over the 2-week period did not differ significantly between those who formed implementation intentions and those who were given 'tips' with both groups reporting high automaticity (17.0 and 17.4 out of 20, respectively). Although it is plausible that the 2-week duration of the study was not sufficient to allow for any noticeable differences in automaticity to manifest, the high scores suggest that the 'tips' were just as effective as implementation intentions in promoting automaticity. Further research with an additional control group would be needed to confirm this.

Nevertheless, in line with our predictions and with previous research (Allan et al., 2013), we did find that individuals with poorer planning skills reported greater adherence when given implementation intentions instead of 'tips'. Unexpectedly, we also found that those with better planning skills reported greater adherence when provided with 'tips' rather than implementation intentions. One possible explanation is that by asking good planners to form implementation intentions we prevented them from using their own well-rehearsed, more flexible implementation strategies. Nevertheless, the moderation effect size was relatively small. Given our sample comprised weight management programme patients who had volunteered to take part in our study, their motivation to try the strategies we provided them with may have been higher than the whole cohort of weight management programme patients. As such, larger effect sizes may emerge across the whole population or over longer timeframes during which motivation may wane. Testing this type of personalised content directly within a digital weight management programme would be the next most useful step for this line of research.

Another aim of the study was to explore whether simplified and more user-friendly versions of established measures of need for cognition and planning skills were effective substitutes. As expected, the short-form NCS was positively correlated with the alternative need for cognition measure ($r = .19$) and the SSRQ goal setting subscale was positively correlated with the alternative planning skills measure ($r = .58$). Furthermore, the alternative measures produced similar results to the standardised measures when examining their moderating effects on the influence of information length and implementation intentions on adherence. These findings are key, as both the short-form NCS and SSRQ goal setting subscale consist of several questions (6 and 10 respectively) and are more burdensome to complete than our alternative measures, which consist of one question each, yet both measures yield similar results. The use of these brief alternative measures could facilitate personalised intervention by digital health companies since they make it more feasible to capture a range of different important psychological differences among patients. However, it must be noted that while correlations between the alternative single-item measures and the standardised measures of need for cognition and planning skills were significant, they were relatively modest, therefore further research is necessary to strengthen the evidence for these findings.

A key strength of the present study is the sample, as participants were all patients who had been referred to a digital weight management programme. They are therefore representative of the types of participants who would typically be targeted by this type of intervention. However, a key limitation is that participants had already completed the weight management programme and thus may have been more motivated and had more practice at implementing behavioural advice. As participants were recruited at the end of the programme, the sample we obtained is likely to represent individuals with higher adherence rates since individuals with poor adherence may have dropped out before completing the programme. This is evident in the high adherence levels observed across both mental and physical strategies during the 2-week period, despite the different levels of effort and skill required for these two strategy types. As noted above, significant differences may have emerged with an alternative sample, such as patients at the start of a weight management programme, due to differences in motivation level and experience. It is therefore recommended to further investigate the effects of information length and implementation intentions within real-world digital weight management programmes. These initiatives would enhance our understanding of what fosters adherence, enabling the development of more effective interventions.

Another limitation of the study was the similarity between the implementation intentions group and the control group who received tips, as the structure of the tips closely resembled a simplified implementation intention. For instance, the instruction to "When you’re eating a meal or snack, keep reminding yourself to notice the taste, texture, and temperature of the food" mirrors the cue-behaviour link characteristic of implementation intentions. While phrasing the tips in this way enabled us to control for content among the two groups, this similarity may partly explain the lack of difference in adherence observed between the two groups. Additionally, while both groups were presented with three options for each strategy, participants in the implementation intentions group were explicitly instructed to select one option to form an implementation intention. In contrast, participants in the tips group were presented with all three options without being required to commit to a specific one. This flexibility may have encouraged more frequent or varied use of the strategies among the tips group, further reducing the distinction between the two conditions. Future studies may consider employing a more neutral control condition to better distinguish the unique contributions of implementation intentions.

4.5 Conclusion

In conclusion, participants' adherence to brief weight management strategies over a 2-week period appeared to be greater with shorter information compared to longer information, however, the study was not adequately powered to detect the observed small effect size. This effect was not moderated by need for cognition, suggesting that shorter information may be effective for both individuals with low and high need for cognition. There was no evidence that implementation intentions improved adherence compared to the same advice presented in the form of tips. There was some evidence suggesting that implementation intentions enhanced adherence for individuals with poorer planning skills while the use of tips improved adherence in skilled planners, highlighting the need for personalisation of behaviour change interventions. The study demonstrated that simplified versions of standardised measures of need for cognition and planning skills may potentially be used as suitable substitutes, offering practitioners tools to assess user characteristics more easily. While these findings offer valuable insights, they are preliminary and necessitate replication in future research.

Chapter Five – General Discussion

The overarching objective of this thesis was to investigate mindfulness approaches to weight management, focusing on efficacy, underlying mechanisms of action and implementation in practice. Specifically, the thesis aimed to 1) investigate the effects of mindfulness and mindful eating on food consumption and appetite, 2) explore enhanced interoceptive awareness of satiety signals as a potential mechanism of action underlying the effect of mindfulness on food intake, and 3) investigate whether adherence to mindfulness-based weight management strategies could be enhanced in practice by manipulating information length and using implementation intentions. The following section outlines how each of these aims were addressed and highlights the key contributions of the thesis. Later sections describe the practical implications of this research, comment on limitations and provide recommendations for future research in this field.

5.1 Overview of Findings and Thesis Contributions

Mindfulness and food intake

The first aim of this thesis was addressed in Chapter Two, which presents a systematic review and meta-analysis of the existing literature that has explored the effects of mindfulness and mindful eating interventions on food consumption and appetite (hunger and satiety). The findings from this chapter revealed that mindfulness and mindful eating practices were associated with significant reductions in food consumption, exhibiting a small effect size (SMD = -0.22). Conversely, no significant overall effects were observed with regards to the effect of mindfulness and mindful eating on appetite. The key conclusion from the review was that practicing mindfulness and mindful eating significantly reduces food intake. No significant differences were identified between different types of mindfulness and mindful eating practices. The review failed to find evidence that mindfulness and mindful eating influence appetite, however definitive conclusions cannot be drawn due to the small number of studies that reported on appetite.

This chapter makes a key contribution to the literature in the field of mindfulness and food consumption. As outlined in Chapter One, there is an abundance of research on the effects of mindfulness on weight loss outcomes, showing both significant effects (O'Reilley et al., 2014; Olson & Emery, 2015; Rogers et al., 2017; Carrière et al., 2018; Dunn et al., 2018; Fuentes Artiles et al., 2019; Lawlor et al., 2020) and absence of effects (Katterman et al., 2014; Ruffault et al, 2017; Mercado et al., 2021; Sosa-Cordobés et al., 2022). Numerous reviews on the effects of mindfulness on binge eating (Katterman et al., 2014; O'Reilly et al., 2014; Godfrey et al, 2015; Warren et al., 2017; Carrière et al., 2018; Yu et al., 2020), emotional eating (Katterman et al., 2014; O'Reilly et al., 2014; Warren et al., 2017; Carrière et al., 2018; Yu et al., 2020) and external eating (O'Reilly et al., 2014; Warren et al., 2017, Yu et al., 2020) are also documented in the literature. Likewise, an accumulating body of work has also explored effects of mindfulness and mindful eating practices on energy intake specifically, however, findings have been mixed with some studies reporting significant effects (e.g. Dutt et al., 2019) and others reporting null findings (e.g. Tapper & Seguias, 2020). While some earlier reviews attempted to consolidate the findings across the literature (Tapper, 2017, 2022; Warren et al., 2017, Grider et al., 2021), they yielded inconclusive results and there was a substantial gap in the field. The systematic review and meta-analysis presented in Chapter Two of this thesis fills this major gap to an extent, as it provides more definitive insights on the association between mindfulness and food consumption. In contrast to the previous reviews which provided a narrative summary of the literature (Tapper, 2017, 2022; Warren et al., 2017, Grider et al., 2021), the review in this thesis was the first to synthesise findings across studies using a meta-analysis. This makes it superior to prior reviews in that it has enhanced statistical power and provides a more precise and objective estimate of effects. Furthermore, the present review is the largest review conducted to date in this research area, consolidating findings across a substantial body of 38 studies.

The small effect size observed in the meta-analysis may be attributed to the variability in the implementation of mindfulness interventions across studies, as well as the heterogeneity in study populations. Therefore, despite this small effect size, the findings have added clarity and advanced understanding of the effects of mindfulness on food intake. In addition, the review employed numerous subgroup analyses comparing specific components of mindfulness and mindful eating as well as identifying specific conditions under which effects are significant; an element that previous reviews had not explored in detail. Two key findings that emerged here were that effects of mindfulness were more pronounced in studies that measured food intake objectively as opposed to using self-report measures, as well as in studies that employed one-off experimental sessions compared to long-term intervention studies spanning several weeks or months.

The review also provides preliminary support for the efficacy of an acceptance element in mindfulness practice. As described in Chapter One, many definitions of mindfulness posit that acceptance is a key component of mindfulness; the practice of adopting a non-judgmental attitude and observing the present moment without reacting to it

(Kabat-Zinn, 2003). The review compared studies which included explicit instructions to practice acceptance as part of the mindfulness intervention, and those that did not. Although the findings failed to show a significant difference between these two types of studies, the pattern of effect sizes suggested that mindfulness had a greater effect on food intake in studies which included an explicit acceptance component. This non-significant finding may primarily be due to the small number of studies that incorporated acceptance, resulting in insufficient data to detect subgroup differences. Nevertheless, the pattern of results observed contribute to the literature highlighting the important role of acceptance in mindfulness.

Moreover, this was the first review in the literature integrating findings across studies that have examined the effect of mindfulness and mindful eating on appetite. This is an important area of enquiry, as appetite may potentially mediate the effect of mindfulness on food consumption. Although no significant effects were identified, the review provides valuable insights as it highlights the lack of research in this area. This thesis therefore contributes a novel perspective to the field by bringing to light a key aspect of the relationship between mindfulness and eating behaviour that has been overlooked; how mindfulness influences appetite.

Mechanisms of action

Chapter Three presents an empirical laboratory-based study which addressed the second aim of this thesis; to explore enhanced interoceptive awareness of satiety as a potential mechanism that may be underlying the association between mindfulness and food consumption. The study randomised participants to either a mindfulness-based body scan or a control visualisation meditation. Following this exercise individuals were provided with food to consume ad-libitum while watching a 10-minute clip from a popular TV show. The purpose of this aspect of the study was to induce a situation in which individuals may be consuming food in everyday life, i.e. while they are distracted. If the mindfulness-based body scan exercise increased individual's attention to their internal signals of satiety, it was predicted that this would then result in less food consumption. However, no significant differences in food intake were found between the mindfulness and control groups, therefore the study failed to find evidence supporting the premise that mindfulness influences food intake by increasing interoceptive awareness of satiety signals.

Despite the null finding, this study contributes to the limited body of research exploring mechanisms of action underlying the effect of mindfulness on food intake. As portrayed in Chapters One and Two, there are a significant number of studies exploring the effects of mindfulness and mindful eating practices on food consumption. However, there is a notable scarcity of research examining the underlying mechanisms of action that underpin the impact of mindfulness. Enhanced awareness of satiety signals in particular is a key underlying mechanism which has not been well researched (Vanzhula & Levison, 2020). Although this thesis failed to find evidence for this mechanism, the findings remain valuable as they expand the existing literature and help inform future research in this area.

The absence of effects may be explained by the study's design. The aim of the study was concealed from participants to avoid demand characteristics; therefore, participants were not explicitly told to practice mindfulness while they were eating. Consequently, even though the mindfulness body scan was found to increase attention towards the stomach and mouth (and relatedly satiety signals) immediately following the exercise, it is possible that this attention was not maintained when participants were then distracted by the TV show due to the absence of explicit instructions. Furthermore, the finding that mindfulness increased attention to internal bodily sensations in itself suggests that interoceptive awareness may still be relevant in the relationship between mindfulness and food intake. Therefore, despite the lack of effects observed, Chapter Three serves as a strong starting point for continued research on enhanced interoceptive awareness as an underlying mechanism of mindfulness.

Implementation

Chapter Four focused on the third and final aim of this thesis. The chapter describes an empirical field study which investigated whether adherence to mindfulness-based weight management strategies over a two-week period could be improved by manipulating the way information was presented to individuals and providing them with action planning prompts. Individuals interested in losing weight were introduced to one of four brief weight management strategies, two of which consisted of mindful eating practices (namely attending to the sensory properties of food and attending to feelings of fullness while eating). Participants were either provided with brief information about their assigned strategy, focusing on taking action, or longer information focusing on the rationale behind the strategy. Additionally, participants were either provided with prompts to help them plan when and how they would use their assigned strategy (implementation intentions) or were simply provided with 'tips' on how to use the strategies. Adherence was measured over the span of two weeks by asking participants to report whether they used their strategy at the end of each day. A complementary aim of this final study was to explore whether the effects of information length and implementation intentions on adherence were moderated by individual characteristics. Specifically, the moderating effect of need for cognition in relation to information length, and the moderating effect of planning skills in relation to implementation intentions were tested. Adherence was found to be higher when individuals were provided with shorter information compared to longer information, however this difference was not statistically significant despite a small effect size. There was also no evidence for the moderating effect of need for cognition. The study failed to find an overall effect of implementation intentions on adherence. However, there was evidence for moderation by planning skills, as the use of implementation intentions significantly increased adherence to brief weight management strategies compared to 'tips' in individuals with poorer planning skills.

This study makes notable contributions to the literature on implementing mindfulness in weight management approaches. As discussed in Chapter One, regardless of the efficacy of mindfulness in influencing food intake and subsequently weight management, its effectiveness can be undermined if individuals do not adhere to the practice. Challenges with low adherence are common in both weight management interventions as well as mindfulness-based interventions (e.g. Lemstra et al., 2016; Winter et al., 2022). While some research has explored factors that may be associated with low adherence rates (e.g. Wang et al., 2024), the existing literature is limited regarding methods by which adherence to mindfulness-based weight management interventions can be improved. The study described in Chapter Four therefore significantly advances the literature by offering insights on two potential methods which can be used to foster adherence i.e. providing shorter information and using implementation intentions.

In particular, this study was the first to investigate the effects of manipulating information length in the context of weight management interventions. Since a small effect size was identified, it is possible that the lack of statistical significance was primarily due to the study not having adequate power. This effect may be clinically significant in larger samples, which is common in digital weight management interventions. This study also provided further insights on the role that implementation intentions play in enhancing adherence to interventions. Previous research has extensively explored the effects of implementation intention interventions on a variety of health behaviours (e.g. Adriaanse et al., 2011; Silva et al., 2018), and investigations of potential moderators have been limited to factors pertaining to the implementation intentions such as goal type, and personality traits such as conscientiousness (Prestwich & Kellar, 2010). There is considerably less research exploring planning ability as a potential moderator (e.g. Allan et al., 2013). This thesis strengthens the evidence for planning ability as a moderator that can influence the effectiveness of implementation intentions on intervention adherence, specifically in the context of weight management. Therefore, in addition to advancing the literature by providing insights on methods (i.e. implementation intentions) by which adherence can be improved, the study also identifies who these methods may be particularly useful for.

Taken together, the findings from this thesis make significant contributions to the fields of implementation science and personalised medicine; two important emerging areas of research in the context of weight management interventions. Chapters Two and Three revealed that mindfulness and mindful eating interventions are not always effective in reducing food consumption, suggesting that effectiveness may potentially rely on specific contextual factors. This is a key element of the field of implementation science, which recognises that simply establishing efficacy of a particular intervention does not guarantee its effectiveness in practice (Bauer & Kirchner, 2020). The discipline of implementation science therefore focuses on identifying and addressing factors that may influence the effectiveness of evidence-based interventions in practice to increase their impact on health outcomes. In line with this, Chapter Four progresses implementation science research with regards to weight management interventions by providing insights on factors that may impact adherence.

In a similar vein, personalised medicine maintains that individualised interventions that consider the unique traits and needs of individuals lead to better outcomes compared to broad generalised approaches (Hekler et al., 2020). This suggests that effectiveness of interventions may depend on their alignment with the participant's individual characteristics. By demonstrating that tailoring interventions to characteristics such as planning ability influences adherence, this thesis highlights the critical role of individual differences in moderating the effectiveness of weight management interventions. This aligns with the overarching goal of personalised medicine, which seeks to move away from a one-size-fits-all approach towards more customised approaches that take the specific personal attributes of individuals into account and ultimately achieve more optimal outcomes.

5.2 Practical Implications

Mindfulness and weight management

First and foremost, the findings of this thesis propose that integrating mindfulness into weight management approaches is a promising endeavour. As noted above, findings illustrate that engaging in a mindfulness or mindful eating practice can help individuals to regulate their food intake and consume less food, thus contributing to an improved energy balance which is the basis of weight loss (Mitchell et al., 2011). Though the evidence is modest, it points to the possibility that there is a potential implication for practitioners to adopt mindfulness-based weight management interventions or integrate mindfulness practices into existing interventions. This is an important implication, as mindfulness approaches to weight management offer several unique advantages that make them more effective than other existing approaches. For example, while pharmacological interventions and bariatric surgery can help with weight loss (Arterburn et al., 2020; Drew et al., 200; Suran, 2023), the adverse effects associated with these approaches render them high-risk (Arterburn et al., 2020; Krentz et al., 2016; Feier et al., 2024). These approaches are also short-lived as they do not address the behavioural factors that contribute to weight gain, such as overconsumption, in the long-term. Once individuals stop taking medication or the benefits of surgery begin to diminish, the lack of behavioural change increases the likelihood of future weight regain. Mindfulness approaches on the other hand, offer a safer and more sustainable alternative which targets behaviour without the risk of adverse effects.

Additionally, mindfulness approaches provide benefits beyond those of population-level approaches to weight management. Unlike population-level public health interventions that often rely on broad messaging and regulations, such as the UK "sugar tax" or mandatory calorie labelling (Department of Health and Social Care, 2021; 2024), mindfulness focuses on self-awareness and self-regulation of behaviour. This personalised attention can be more effective in changing long-term eating habits as it empowers individuals to take control of their behaviour in a way that external regulations cannot. Moreover, population-level interventions are designed to target the general public and therefore may fail to address the specific needs and circumstances of individuals. In contrast, mindfulness-based interventions can be highly personalised, ensuring they are applicable to the target audience which enhances their effectiveness. While this potential for personalisation exists, it is important to acknowledge that existing mindfulness-based interventions, like other behavioural interventions, may not all be tailored to individual needs. Future interventions should prioritise personalisation to maximise effectiveness.

Mindfulness-based interventions are also more advantageous than lifestyle weight loss interventions which focus on diet and exercise plans alone (e.g. Kim, 2020; Lee & Lee, 2021). Weight loss resulting from these plans can be difficult to maintain as they fail to address the underlying psychological factors that influence eating behaviour and weight management. The benefit of adding mindfulness is that it addresses the holistic nature of eating behaviours through heightened self-awareness and self-regulation, promoting sustainable changes and potentially resulting in long-term weight loss (Godsey, 2013).

It is important to note, however, that mindfulness-based interventions, while beneficial, are not a comprehensive solution to the rising rates of overweight and obesity. Firstly, it is possible that mindfulness approaches may be more useful for certain individuals than others. This is evident in the mixed findings of mindfulness-based interventions on both weight loss outcomes (e.g. Katterman et al., 2014) and food intake (e.g. Arch et al., 2016; Tapper & Seguias, 2020) as discussed in Chapter One. The findings from Chapters Two and Three also support this idea. Different individuals may respond to different approaches based on their unique needs, preferences and circumstances. For some, mindfulness may be transformative in addressing underlying psychological factors and improving their eating behaviours while others might find it less impactful or challenging to incorporate consistently. It is possible that mindfulness may only be useful for individuals who have extra time to commit to it rather than for a wide range of people (e.g. people who may lead busy lifestyles). Though this limitation may not be specific to mindfulness as it may be true of all weight management interventions. It may be the case that some individuals simply benefit more from education on how to manage their weight, such as structured diet and exercise programmes which provide clear guidelines. Furthermore, public health strategies are valuable for targeting the environmental factors that influence weight management, and some individuals may benefit more from an environment which makes healthy choices more accessible, such as the UK's mandatory calorie labelling on menus (Department of Health and Social Care, 2021).

Pharmacological interventions and bariatric surgery may also be necessary in certain cases, for example, for individuals with medical conditions such as diabetes. Additionally, these interventions may potentially be beneficial in preventing conditions such as diabetes, which could subsequently reduce the risk of developing obesity (Majety et al., 2023). In such cases the potential benefits of pharmacological intervention may outweigh the risks and challenges associated with long-term sustainability of these treatments. A combination of approaches may therefore be the most effective means to address the obesity epidemic, as this would cater to a broader range of individuals, ensuring that everyone has access to tools and methods that work best for them.

While mindfulness stands out for its ability to address the psychological aspects of eating behaviour, it is important to note that other psychological approaches have also been explored in relation to weight management. For example, cognitive behavioural therapy

(CBT) focuses on identifying and modifying dysfunctional thought patterns and behaviours relating to eating (Castelnuovo et al., 2017). CBT has been established as an effective treatment for eating disorders such as binge eating disorder (Linardon et al., 2017), however its effects on weight management are modest (Castelnuovo et al., 2017). On the other hand, third-wave cognitive behaviour therapies (such as ACT), which emphasise accepting rather than changing thoughts and feelings, have been shown to be highly effective for weight management in comparison to no or minimal intervention (Lawlor et al., 2020). Other psychological approaches include motivational interviewing, which is a collaborative and person-centred counselling method aiming to enhance intrinsic motivation for behaviour change (Suire et al., 2021). Evidence for this type of intervention is mixed, with some studies showing significant effects on weight management while others report no benefits over and above standard care (Barnes & Ivezak, 2015).

Nevertheless, while each of these methods may contribute valuable strategies for addressing the complex psychological dimensions of weight management, the focus of this thesis was on the role of mindfulness in particular. Although the evidence presented is limited, it offers some preliminary support for the potential role of mindfulness in the context of weight management. The findings suggest that the addition of mindfulness components could potentially enhance effectiveness of weight management interventions by reducing food consumption.

Designing mindfulness and mindful eating interventions

In terms of applied implications, the systematic review in Chapter Two provides several key considerations for designing more effective mindfulness-based interventions targeting food consumption. The meta-analysis did not identify subgroup differences between different types of mindfulness and mindful eating practices thus no significant advantage was found for any specific approach in reducing food intake. For example, there was no significant difference in food consumption whether participants were focusing on sensory attributes of food or employing strategies such as present moment awareness of bodily sensations. Consequently, conclusions about which types of mindfulness or mindful eating practice may be more effective in reducing food intake cannot be drawn. The findings simply suggest that there is no evidence that one particular practice is more effective than another. The implication is therefore that incorporating any form of mindfulness or mindful eating practice in an intervention is likely to be effective.

Selecting which practice to employ may be based on factors such as ease of use and implementation of the practice or the individual's previous experience with mindfulness. For example, it may be difficult for certain individuals to focus their attention to internal bodily sensations, especially if they have impaired interoceptive awareness, such as individuals with eating disorders (Herbert, 2020). These individuals may benefit more from focusing attention to external stimuli such as the sensory properties of food. For individuals with more mindfulness experience, advanced strategies such as decentering or present moment awareness of bodily sensations may be more beneficial. Similarly, the way in which mindfulness or mindful eating is practiced may also inform which type of strategy to employ. Less experienced individuals, or those with attention deficit disorder, may find it difficult to stay still long enough for practices which are based on meditation, such as breathing meditations or body scans. Practical strategies such as noticing cravings and the urge to eat, or simply focusing on the texture of their food may be easier to implement.

Findings from Chapter Three of this thesis also hold important implications for intervention design. Despite not influencing food intake, the finding that the mindfulness-based body scan was associated with increased attention to the stomach and mouth suggests that interoceptive awareness may still play a crucial role in mindful eating. It is plausible that simply engaging in mindfulness, or a heightened awareness of internal bodily sensations, may not be enough to influence food intake. Perhaps the null effect is due to the fact that this was a one-off occurrence, and individuals may need to consistently practice mindfulness in order for increased awareness of satiety signals to translate to reduced food intake. It may also require effort on the part of the individual to apply it in specific contexts, for example, when they are distracted. Practically, the lack of effects suggests that mindfulness-based interventions aimed at reducing food intake may need to incorporate strategies beyond simply increasing interoceptive awareness. For example, they may include elements that help individuals translate their heightened awareness into mindful eating practices (e.g. repeated practice or explicit instructions to become attuned to internal signals while distracted) or addressing factors that drive food consumption independently of bodily signals (e.g. external eating).

Improving adherence to mindfulness-based interventions

Another significant implication of this thesis relates to further enhancing the effectiveness of mindfulness-based weight management interventions in practice by improving adherence rates. Findings from Chapter Four provide practical advice for health professionals and practitioners on promoting adherence to mindfulness and mindful eating interventions. To ensure adherence to these interventions, it is recommended that information about the intervention is limited to no more than 100 words with a focus on taking action, rather than providing excessive background information. Additionally, if individuals struggle with poor self-regulation and planning ability, practitioners may encourage the use of implementation intentions to maximise adherence.

This implication is especially relevant for digital health interventions. Advancements in technology has given rise to the widespread development of electronic and mobile health (e- and mHealth) interventions for behaviour change in recent decades (Kay et al., 2011). The use of technology makes these interventions more cost-effective than face-to-face interventions, as well as facilitating their large-scale implementation (Vandelanotte et al., 2016). Although such interventions may be more accessible and convenient for users, they often involve less human interaction than face-to-face interventions, potentially removing the accountability feature that may be more prominent in face-to-face interventions. It is therefore even more crucial to consider how adherence can be increased and ensure that users consistently engage with the programme. Ensuring that information is kept brief and action-orientated is highly pertinent for digital health interventions, as research shows that information overload as a result of technology has potentially decreased attention span (Carr, 2020) and individuals may not engage with online content for long enough to benefit from it (Uncapher & Wagner, 2018). Keeping information brief and to the point may ensure that users engage with the content and subsequently implement the advice. Additionally, simply offering advice may not be beneficial for individuals who lack the ability to plan and follow through with the advice, therefore leveraging technology to encourage the formation of implementation intentions would be of utmost importance.

Personalisation of interventions

As alluded to in previous sections, one of the key implications of this thesis is that mindfulness-based weight management interventions should be personalised to the individual in order to be optimally effective in practice. Specifically, ensuring that intervention components meet the specific needs of individuals, such as their planning skills, can facilitate the individual's engagement with the intervention. There are several reasons why personalisation of weight management interventions may improve adherence and intervention outcomes. Personalised interventions are more likely to be perceived as relevant and attainable by the individual, therefore increasing their motivation and commitment.

Additionally, when interventions are personalised, they target the specific behaviours that may have contributed to weight gain or difficulty losing weight. For example, individuals with poor planning skills may struggle to implement behaviour change advice on their own, therefore the provision of tools such as action planning strategies addresses this underlying cause. This thesis provides encouraging support for tailoring interventions to individual characteristics beyond just that of planning skills. Practitioners could also consider assessing other factors that may influence adherence to weight management strategies, such as health literacy or self-efficacy.

Personalising weight management interventions requires a thorough and detailed initial assessment of the individual. An important outcome of the empirical study reported in Chapter Four was that simplified versions of the short-from Need for Cognition Scale and the goal setting subscale of the Short-form Self-Regulation Questionnaire were modestly correlated with the standardised versions, which has important implications for measuring need for cognition and planning ability. Though further validation is necessary, Chapter Four of this thesis provides some evidence for alternative single-item measures that practitioners may use to easily and quickly obtain need for cognition and planning skill measures which can be subsequently used for tailoring interventions. This is particularly useful in cases where time and resources are limited, as briefer measures can facilitate quicker assessments, enabling more individuals to be evaluated and tailored interventions to be delivered without compromising quality of care.

The use of simpler measures is also likely to be well received by the individuals completing them. Lengthy and complex assessments may be daunting and time-consuming, potentially putting participants off before the intervention has even begun. Simple measures consisting of one question only are more user-friendly and participants are likely to provide more accurate data as opposed to when they answer multiple questions about the same concept. Additionally, the use of brief measures allows practitioners to assess multiple characteristics easily and quickly in one session. This work therefore not only demonstrates the necessity for personalisation of mindfulness-based weight management interventions, but also equips practitioners with the potential tools needed to achieve this.

5.3 Limitations and Future Directions

While this thesis has made significant contributions to the field of mindfulness and weight management, it has certain limitations that must be considered. First, the scope of the thesis is limited, as it focused on specific aspects of mindfulness and did not encompass the full spectrum of mindfulness-based approaches. For instance, the study in Chapter Three tested the effects of 'present moment awareness of the body', and Chapter Four explored adherence to 'present moment awareness of the body' and 'present moment awareness of the sensory properties of food'. In addition, although the systematic review in Chapter Two aimed to capture insights across all types of mindfulness and mindful eating interventions, the components mentioned above were most prominent, with limited inclusion of other types of studies, such as those on decentering. Another limitation of the thesis is the potential lack of statistical power, which may have contributed to some of the null findings observed across the chapters. The modest effect sizes, particularly in Chapter Two, further limit the ability to draw definitive conclusions. Larger sample sizes would have enhanced the statistical power and strengthened the quality of the evidence.

In addition to the above, each chapter presents its own set of limitations. Many of the studies included in the meta-analysis in Chapter Two exhibited some risk of bias. For example, most studies were not pre-registered, did not blind researchers to participant allocation and did not include a manipulation check to ensure their mindfulness or mindful eating manipulation was successful. Neglecting pre-registrations and manipulation checks introduces risk of bias in terms of increasing the likelihood of selective reporting and potentially attributing any effects to the mindfulness manipulation even if the manipulation failed to work as expected. Failing to blind researchers to group allocations can result in researcher bias as researchers may unintentionally alter their interactions with participants or the way they handle and interpret data, ultimately influencing the outcomes of the study. Risk of bias observed among the studies in the systematic review and meta-analysis suggests that the observed effect of mindfulness on food intake should be interpreted with caution.

Furthermore, this provides a key consideration for future research exploring the effects of mindfulness on food intake as it highlights the need for research to incorporate more rigorous methods in order to produce more robust findings. Specifically, it is important for researchers to pre-register their studies to ensure accurate reporting of results, whether they are significant or non-significant. Where possible, researchers should attempt to employ a double-blind design so that in addition to participant blinding, researchers are also unaware of the condition participants are assigned to. This will prevent any bias that could arise from variations in the researcher's interactions with participants, methods of data collection, or data analysis. This may be less important if the study is otherwise carefully controlled, for example if food intake is measured objectively and interactions between researchers and participants are both limited and tightly scripted. Nonetheless, it is a worthwhile consideration to be aware of to enhance the study's robustness. Perhaps the most important recommendation for future research in this area is to ensure that studies incorporate a manipulation check to ensure that their mindfulness manipulation did indeed result in increased mindfulness. This can be as simple as using a brief questionnaire to measure state mindfulness following the manipulation, as employed in Chapter Three of this thesis. This is important to ensure that any observed effects are correctly attributed to the mindfulness manipulation. It may also help identify instances when the mindfulness manipulation may have failed, and any lack of effects can correctly be attributed to the failure of the manipulation.

Chapter Two also revealed that most of the research conducted in the field of mindfulness and food intake tends to rely exclusively on samples consisting of women. This limitation extends to the studies reported in Chapters Three and Four, as despite best efforts to recruit a balanced sample, the majority of the participants in these studies were also women. This is an important limitation as it may mean that findings cannot be generalised to the wider population, as it is possible that mindfulness may exert different effects among men and women. More importantly, in relation to Chapter Four, effects of different methods to increase adherence to mindfulness-based weight management interventions may also differ according to gender. As reported by Wang et al. (2024), adherence to general weight management interventions is typically greater among males than females. This suggests that adherence may be driven by different factors for men and women, and therefore methods to enhance adherence may need to differ accordingly. Thus, it is crucial for future research in this field to target men and identify any potential gender differences in respect to the effects of mindfulness and strategies which may enhance adherence to mindfulness-based weight management interventions.

Additionally, while the review in Chapter Two included some studies conducted in children, it was evident that the majority of research was conducted in adults. This is a significant consideration, as the effects of mindfulness and mindful eating may differ between adults and children. Furthermore, researchers often employ mindfulness interventions for different purposes in these two populations. For instance, most of the studies conducted in children aim to use mindfulness interventions to increase food consumption as opposed to reduce it (e.g. Bennett et al., 2020; Hong et al., 2018). These studies use mindfulness practices to foster healthier eating habits in children, such as encouraging vegetable consumption. In contrast, research in adults focuses on curbing excess intake. Given the limited research available in children, an exciting avenue for future research would be to further explore the effects of mindfulness on food consumption in children. It is also crucial for researchers to identify the specific aspects of mindfulness and mindful eating interventions that lead to a reduction in food consumption versus those that encourage consumption. Understanding these nuances is essential for tailoring interventions effectively across different age groups and ensuring interventions are aligned with the specific goals and needs of the target population.

As highlighted above and extensively throughout this thesis, there appears to be complex moderation by individual and situational factors in the relationship between mindfulness and food consumption. Mindfulness and mindful eating interventions are not always effective for all participants in all contexts. Individual differences, the intervention components as well as the context in which they are applied may determine whether or not mindfulness results in a reduction in food intake and ultimately facilitates weight management. A promising direction for future research may be to conduct n-of-1 studies, which can help to identify specifically which mindfulness techniques or strategies work best for each individual and under what circumstances. N-of-1 studies, also known as 'single-case' studies, focus on repeated measurements within individual participants over time (McDonald et al., 2017). This would allow researchers to closely monitor the individual's mindfulness practice and dietary behaviours in real-world settings, uncovering nuanced patterns of behaviour that may be obscured in group-level studies. This methodology allows for different mindfulness interventions to be tested and compared in one individual over time. N-of-1 studies can integrate multiple data sources, including subjective reports, physiological measures, and contextual factors such as mood or stress levels (McDonald et al., 2017). This holistic approach provides a comprehensive view of the influence of mindfulness on food consumption patterns over time, offering valuable insights that can inform the development of personalised interventions.

This thesis has also established a foundation for further investigation on the mechanisms of action underlying the effect of mindfulness on food intake. One of the main limitations of the study described in Chapter Three is that it was based in the laboratory. Despite efforts to ensure ecological validity by requiring participants to watch a TV show in order to replicate a real-world eating scenario, the fact remains that the study was conducted in a laboratory environment. While this allowed for the study conditions to be tightly controlled, enhancing its internal validity, findings could potentially differ in a natural environment. Therefore, a key recommendation for future research is to explore potential underlying mechanisms in real-world settings. While the mechanism of increased interoceptive awareness requires further investigation, the findings from Chapter Three indicate that it may not be the most promising avenue of research. Future research may focus on alternative mechanisms of action relating to other types of mindful eating practices which may have more potential. Outcomes from the review in Chapter Two show that a common mindful eating practice employed in studies is paying attention to the sensory properties of food. Given the abundance of research on this particular mindful eating strategy it would be beneficial to understand the mechanisms of action responsible for its effects on food intake.

One of the limitations pertaining to Chapter Four of this thesis is that the study was conducted over a short time period of two weeks. Given that weight management interventions in the real world tend to span several weeks or months, it is possible this time period was not sufficient to produce reliable findings in relation to factors that influence adherence. It is therefore important for future research to examine intervention adherence over longer time periods that more closely match real-world interventions. This would also enable insights to be drawn in relation to sustained impacts of mindfulness interventions.

On a related note, it would be beneficial for factors that influence adherence, such as information format and implementation intentions, to be explored within the context of weight management interventions in real-world settings. The pattern of results observed in Chapter Four suggest that manipulating information length may significantly impact adherence if explored within a larger sample, such as those typically employed in digital health interventions. Furthermore, the sample used in the study reported in Chapter Four may have been subject to self-selection bias in that individuals were recruited from a cohort of patients on a weight management programme. Participants who chose to take part in the study may have had higher motivation than the rest of the cohort, which may explain why the moderating effect of implementation intentions on adherence was relatively small. It is plausible that larger effects may be observed within a weight management programme that consists of individuals with varying levels of motivation. Thus, a promising direction for future research would be to test how information length and implementation intentions influence adherence to existing mindfulness-based weight management interventions. There is also scope for exploring other strategies that may enhance intervention adherence.

Lastly, another exciting prospect for future work would be to investigate and develop more practical tools to facilitate personalisation of interventions by making it easier to assess individuals' characteristics. Chapter Four validated two such tools that can be used by practitioners to easily measure individual need for cognition and planning ability. Future research endeavours could expand upon this foundation by investigating and refining other standardised measures to assess a broader spectrum of personal traits relevant to intervention adherence. These include measures of traits such as self-efficacy, motivation and emotion regulation among others. Creating simplified versions of the standardised measures of these traits would further support the personalisation of interventions.

5.4 Conclusion

This thesis demonstrated the role that mindfulness plays in the context of weight management. In a programme of three research studies, it was first illustrated that mindfulness and mindful eating practices result in a small reduction in food intake. Next, a potential underlying mechanism of action for this effect was explored. It was found that while a mindfulness-based body scan enhanced interoceptive awareness of bodily sensations, this did not ultimately reduce food consumption, warranting further investigation into alternative underlying mechanisms. Finally, this thesis investigated adherence to mindfulness-based weight management strategies and showed that providing shorter information about the strategy may potentially improve adherence. Additionally, implementation intentions were found to be beneficial in improving adherence for individuals with poorer planning skills. These findings have contributed novel insights to the literature on the effects of mindfulness and mindful eating on food consumption and expanded the limited literature on underlying mechanisms of action. Additionally, findings have made significant contributions to the literature on implementing mindfulness-based weight management interventions. Taken together, the findings of this thesis illustrate that integrating mindfulness into weight management initiatives is a promising solution to addressing the rising rates of overweight and obesity. Findings also provide insights on how to effectively design and implement mindfulness-based interventions in practice in order to maximise their effectiveness.

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Appendices

Appendix A

Chapter Two: Intervention Coding Scheme

Definitions

Mindfulness

Any practice that involves one or more of the following:

- Present moment awareness – intentionally maintaining attention on one's present moment experience. Typically includes bodily sensations, thoughts and/or emotions.
- Acceptance – taking a non-judgemental attitude of acceptance, non-judgement or curiosity towards one's experience rather than trying to control or change it. Sometimes referred to as non-reactivity.
- Decentering – Viewing one's thoughts and emotions as fleeting events that are separate from oneself and not necessarily a true reflection of reality.

Mindful Eating

Mindful eating – the application of mindfulness to eating-related thoughts, emotions, bodily sensations and behaviours (Tapper, 2022).

Intuitive Eating

Intuitive eating comprises four key features (Tylka & Kroon Van Diest, 2013):

- Giving oneself unconditional permission to eat when hungry and without restriction
- Eating for physical rather than emotional reasons
- Relying on internal hunger and satiety cues to determine when and how much to eat
- Honouring one's health, or practicing 'gentle nutrition'

Notes

- There needs to be one or more sessions in which mindfulness/mindful eating/intuitive eating is practiced by participants. DO NOT include studies that simply measure trait mindfulness/mindful eating/intuitive eating using questionnaires.
- Code interventions using the descriptions/scripts only, ignore any labels with no descriptions.

Intervention components / subgroups for coding

Mindfulness

Must include AT LEAST ONE of the below components to be considered mindfulness

- Present moment awareness general
    - o Any exercise or meditation promoting awareness of thoughts and/or emotions etc.
    - o Instruction to observe and/or describe current experience – but not if applied to the body
    - o E.g. paying attention to sounds

- *Do not use this code for any studies that only provide information about mindfulness in general – participants must be involved in the practice*
    - *Do not use this code for any general/brief mindfulness instructions that precedes the main intervention*

- Present moment awareness of the body
    - Any exercise or meditation that draws attention to different body parts and/or physical sensations e.g. body scan
    - Any meditation drawing attention to the breath
    - E.g. heartbeat perception task / awareness of heartbeat
    - E.g. MBSR walking meditation, MBSR three-minute check in/three-minute breathing space

- Acceptance
    - Noticing arising thoughts, emotions and physical sensations without reaction or judgement (e.g. not labelling them as good or bad)
    - Non-judgemental awareness
    - Avoiding moral judgement of thoughts, emotions, physical sensations etc.

- Decentering
    - Any instruction to view thoughts as separate from the self
    - e.g. Leaves on a stream exercise
    - e.g. Mindbus exercise

- Attention regulation component
    - Reminders/prompts to bring attention back to the body/breath etc.
    - *Papers may not explicitly state this, but it can be evident in the script if provided.*
    - *This code would generally be used in addition to one of the above codes. An attention regulation component aims to stop participants from being distracted from the meditation/exercise by reminding them to bring their attention back to the present.*

Mindful Eating

Must include AT LEAST ONE of the below components to be considered mindful eating

- Present moment awareness of the sensory properties of food
    - Instruction to attend to the taste, smell, texture, sight etc. Of food whilst eating. E.g. instruction to observe and/or describe properties of the food via sight, taste, smell, touch etc.
    - Any exercise encouraging participants to savour the flavour of the food they are eating
    - Exclude: any instructions to imagine the sensory properties of the food e.g. whilst looking at photos

    - Exclude: any instruction to slow down eating
    - e.g. Focused attention to eating/food
    - Exclude any demonstration of mindful eating, participants must practice mindful eating themselves.
        - E.g. Training or teaching how to eat food whilst attending to its sensory properties without the opportunity to practice it
    - Instruction to focus on chewing and swallowing whilst eating.
    - e.g. Mindful Construal Reflection exercise – participants are given a list of questions to consider whilst eating a snack, such as 'how does this snack taste?' and 'how does this snack smell?'
    - e.g. Raisin eating meditation
    - Rating how pleasant the food tastes at regular intervals throughout a meal. Exclude any one-off ratings before or after an intervention.

- Present moment awareness of internal bodily sensations relating to hunger, fullness and eating
    - Any exercise that directs attention towards hunger, fullness, satiety and/or other internal bodily sensations related to eating
    - e.g. body scan meditation with a focus on feelings in the stomach
    - Paying attention to body sensations whilst swallowing/eating/ immediately after eating (ingestive effects)
    - Prompts to rate fullness at regular intervals throughout a meal as a way to encourage attention to fullness
        - Exclude any one-off measures of fullness rating e.g. at the beginning or end of an intervention/task
    - *Do not use this code for any studies that only provide information about attending to hunger/satiety etc. – participants must be involved in the practice*
    - *Do not use this code for instructions to attend to the movement of the mouth etc. (anything above the neck) that is a part of 'present moment awareness of the sensory properties of food'*

- Present moment awareness of cues that elicit eating or the urge to eat
    - Instruction to notice internal (e.g. urges, salivation) and/or external (e.g. smell, sight) cues to eat
    - E.g. Mindful decision-making training (drawing attention to internal and external cues that typically drive consumption at each phase of the eating process)

- Present moment awareness of food-related thoughts
    - Any exercise that instructs participants to notice their thoughts e.g. keeping a diary of any food-related thoughts that pop in their head
    - E.g. Mindful Construal Diary (MCD) or Mindful Construal Reflection (MCR)

        - Participants consider questions such as 'what passes through my mind whilst eating this snack?'

- Present moment awareness of cravings
    - Any exercise that instructions participants to notice their cravings e.g. keeping a diary or just noticing when they increase or decrease
    - e.g. the urge surfing strategy – being aware of cravings but not giving in to them (only use this code if instructions explicitly encourage awareness of cravings - most of the time it may simply refer to acceptance)

- Acceptance of feelings relating to hunger and/or cravings
    - Non-judgmental awareness of bodily sensations or feelings relating to hunger and/or cravings e.g. what you feel physically in the body
    - E.g. urge surfing strategy – instruction to surf cravings rather than give in to them
    - Acceptance of internal drives to eat I.e. acknowledging that you have a craving but overriding it and not eating as much as desired

- Acceptance of food-related thoughts
    - Non-judgemental awareness in relation to thoughts about food/eating
    - Not labelling thoughts as good or bad
    - E.g. non-judgmental awareness of internal verbalisations such as talking to yourself about food/eating but not labelling as good or bad
    - e.g. Mindful Construal Diary
    - *This would generally be used with 'present moment awareness of food-related thoughts' – present moment awareness is simply being aware of the thought whilst acceptance is being non-judgemental about the thought.*

- Decentering from feelings of hunger and/or cravings
    - Instruction to view feelings of hunger and/or cravings as separate from the self
    - E.g. leaves on a stream exercise

- Decentering from food-related thoughts
    - Thinking of these thoughts as separate from the self
    - Imagining thoughts as constructions of the mind which appear and disappear
    - Imagining thoughts as transient states of mind
    - Cognitive defusion strategy e.g. mindbus metaphor – seeing oneself as a driver of a bus and one's thoughts as passengers

- Attention regulation component
    - Instruction to notice when your mind has wandered off and to bring your attention back e.g. to your food

Intuitive eating

Must include ALL below components to be considered intuitive eating

- Rejecting the diet mentality
- Honouring hunger signals
- Giving oneself unconditional permission to eat
- Avoiding categorising foods as ‘good’ or ‘bad’
- Savouring the experience of eating
- Stopping eating when full
- Coping with emotions without using food
- Accepting and respecting one’s body
- Focusing on the enjoyable aspects of exercise
- Making nutritional food choices and honouring one’s health

Appendix B

Chapter Two: Search Strategy

PsycINFO

1. Mindfulness/
2. Mindfulness-Based Interventions/
3. Focused attention/
4. Mindful*.mp
5. Intuitive eating.mp
6. Attentive eating.mp
7. Focused attention.mp
8. Savouring.mp
9. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8
10. Food intake/
11. Ingestion/
12. Eating behavior/
13. Food intake.mp
14. Energy intake.mp
15. Food consumption.mp
16. Eating*.mp
17. Eating behavio?r.mp
18. Ingestion.mp
19. 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18
20. Hunger/
21. Appetite/
22. Satiation/
23. Hunger.mp
24. Fullness.mp
25. Satiety.mp
26. Satiation.mp
27. Appetite.mp
28. 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27
29. 9 and 19
30. 9 and 28
31. 29 or 30
32. 19 or 28
33. 9 and 32

Medline

1. Mindfulness/
2. Mindful*.mp
3. Intuitive eating.mp
4. Attentive eating.mp
5. Focused attention.mp

6. Savouring.mp
7. 1 or 2 or 3 or 4 or 5 or 6
8. Eating/
9. Energy intake/
10. Food intake/
11. Feeding behavior/
12. Food intake.mp
13. Energy intake.mp
14. Food consumption.mp
15. Eating*.mp
16. Eating behavio?r.mp
17. Ingestion.mp
18. 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17
19. Hunger/
20. Satiety response/
21. Satiation/
22. Appetite/
23. Hunger.mp
24. Fullness.mp
25. Satiety.mp
26. Satiation.mp
27. Appetite.mp
28. 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27
29. 7 and 18
30. 7 and 28
31. 29 or 30
32. 18 or 28
33. 7 and 32

Embase

1. Mindfulness/
2. Mindfulness meditation/
3. Focused attention meditation/
4. Intuitive eating/
5. Mindful*.mp
6. Intuitive eating.mp
7. Attentive eating.mp
8. Focused attention.mp
9. Savouring.mp
10. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9
11. Food intake/
12. Food consumption/
13. Food ingestion/
14. Caloric intake/

15. Eating/
16. Feeding behavior/
17. Food intake.mp
18. Energy intake.mp
19. Food consumption.mp
20. Eating*.mp
21. Eating behavio?r.mp
22. Ingestion.mp
23. 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22
24. Hunger/
25. Satiety/
26. Satiety response/
27. Satiation/
28. Appetite/
29. Hunger.mp
30. Fullness.mp
31. Satiety.mp
32. Satiation.mp
33. Appetite.mp
34. 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33
35. 10 and 23
36. 10 and 34
37. 35 or 36
38. 23 or 34
39. 10 and 38

Web of Science
Topic (searches title, abstract, author keywords and keywords plus): "mindful*"OR "intuitive eating" OR "attentive eating" OR "focused eating" OR "savouring"
[AND]
Topic: "food intake" OR "energy intake" OR "food consumption" OR "eating*" OR "eating behaviour" OR "ingestion"
[OR]
Topic: "mindful*"OR "intuitive eating" OR "attentive eating" OR "focused eating" OR "savouring"
[AND]
Topic: "hunger" OR "fullness" OR "satiety" OR "satiation" OR "appetite"

SCOPUS
Article title, abstract, keywords: "mindful*"OR "intuitive eating" OR "attentive eating" OR "focused eating" OR "savouring"
[AND]
Article title, abstract, keywords: "food intake" OR "energy intake" OR "food consumption" OR "eating*" OR "eating behaviour" OR "ingestion"

[OR]
Article title, abstract, keywords: “mindful*”OR “intuitive eating” OR “attentive eating” OR “focused eating” OR “savouring”
[AND]
Article title, abstract, keywords: “hunger” OR “fullness” OR “satiety” OR “satiation” OR “appetite”

Appendix C

Chapter Two: Intervention Components in Included Studies

Table C1

Mindfulness Components in Included Studies

Study	Present moment awareness general	Present moment awareness of the body	Acceptance	Decentering	Attention regulation
Allirot 2018	N	N	N	N	N
Arch 2016	N	N	N	N	N
Bennett 2020 (Mindful Breathing)	Y	Y	Y	N	Y
Bennett 2020 (Mindful Raisin Eating)	N	N	N	N	N
Cavanagh 2014	N	N	N	N	N
Chang 2018	N	N	N	N	N
De Tomas 2022	N	Y	N	N	N
Dutt 2019	N	Y	N	N	N
Fisher 2016	Y	Y	Y	N	N
Gayoso 2021	N	Y	Y	N	N
Higgs 2011	N	N	N	N	N
Hinton 2021 (Fullness)	N	N	N	N	N
Hinton 2021 (Taste)	N	N	N	N	N
Hong 2018	Y	Y	Y	N	N
Hsu 2021	Y	Y	N	N	Y
Hussain 2020 (Self-distanced MCD)	N	N	N	N	N
Hussain 2020 (Self-immersed MCD)	N	N	N	N	N
Hussain 2021	N	N	N	N	N
Jenkins 2014 (Acceptance)	N	N	N	N	N

Table C1

Mindfulness Components in Included Studies (continued)

Study	Present moment awareness general	Present moment awareness of the body	Acceptance	Decentering	Attention regulation
Jenkins 2014 (Cognitive Diffusion)	N	N	N	N	N
Jordan 2014	N	Y	Y	N	N
Long 2011	N	N	N	N	N
Mantzios 2019 (MCD)	N	N	N	N	N
Mantzios 2019 (Mindful Raisin Exercise)	N	N	N	N	N
Mantzios 2020	N	N	N	N	N
Marchiori 2014	N	Y	Y	N	Y
Martin 2017 (Mindful Decision-Making)	Y	N	N	N	N
Martin 2017 (Mindful Eating)	Y	N	N	N	N
Masih 2020	N	Y	N	N	N
Palascha 2021	N	Y	N	N	N
Robinson 2014	N	N	N	N	N
Sant-Anna 2022	N	Y	Y	N	Y
Seguias 2018	N	N	N	N	N
Seguias 2022	N	N	N	N	N
Simonson 2020	N	Y	N	N	N
Spadaro 2018	Y	Y	N	N	N
Tapper 2020	N	N	N	N	N
Timmerman 2012	N	N	N	N	N
Van de Veer 2016 Study 2	N	Y	N	N	N
Van de Veer 2016 Study 4	N	Y	N	N	N
Whitelock 2018 Study 1	N	N	N	N	N
Whitelock 2018 Study 2	N	N	N	N	N
Whitelock 2019a	N	N	N	N	N
Whitelock 2019b	N	N	N	N	N

Table C2

Mindful Eating Components in Included Studies

Study	Present moment awareness of the sensory properties of food	Present moment awareness of internal bodily sensations relating to hunger, fullness and eating	Present moment awareness of cues that elicit eating or the urge to eat	Present moment awareness of food-related thoughts	Present moment awareness of cravings	Acceptance of feelings of hunger and/or cravings	Acceptance of food-related thoughts	Decentering from feelings of hunger and/or cravings	Decentering from food-related thoughts	Attention regulation
Allirot 2018	Y	Y	N	N	N	N	N	N	N	N
Arch 2016	Y	N	N	N	N	N	N	N	N	Y
Bennett 2020 (Mindful Breathing)	N	N	N	N	N	N	N	N	N	N
Bennett 2020 (Mindful Raisin Eating)	Y	N	N	N	N	N	Y	N	N	Y
Cavanagh 2014	Y	Y	N	N	N	N	N	N	N	Y
Chang 2018	N	N	N	Y	N	N	N	N	Y	N
De Tomas 2022	Y	Y	N	N	N	N	N	N	N	N
Dutt 2019	N	N	N	N	N	N	N	N	N	N
Fisher 2016	N	N	N	N	N	N	N	N	N	N
Gayoso 2021	Y	Y	N	N	N	N	N	N	N	N
Higgs 2011	Y	N	N	N	N	N	N	N	N	N
Hinton 2021 (Fullness)	N	Y	N	N	N	N	N	N	N	N
Hinton 2021 (Taste)	Y	N	N	N	N	N	N	N	N	N

Table C2

Mindful Eating Components in Included Studies (continued)

Study	Present moment awareness of the sensory properties of food	Present moment awareness of internal bodily sensations relating to hunger, fullness and eating	Present moment awareness of cues that elicit eating or the urge to eat	Present moment awareness of food-related thoughts	Present moment awareness of cravings	Acceptance of feelings of hunger and/or cravings	Acceptance of food-related thoughts	Decentering from feelings of hunger and/or cravings	Decentering from food-related thoughts	Attention regulation
Hong 2018	Y	N	N	N	N	N	Y	N	N	N
Hsu 2021	N	N	N	N	N	N	N	N	N	N
Hussain 2020 (Self-distanced MCD)	N	N	N	Y	N	N	Y	N	N	N
Hussain 2020 (Self-immersed MCD)	N	N	N	Y	N	N	Y	N	N	N
Hussain 2021	Y	N	N	Y	N	N	N	N	N	N
Jenkins 2014 (Acceptance)	N	N	N	N	Y	Y	N	N	N	N
Jenkins 2014 (Cognitive Diffusion)	N	N	N	N	N	N	N	N	Y	N
Jordan 2014	N	N	N	N	N	N	N	N	N	N
Long 2011	Y	N	N	N	N	N	N	N	N	N
Mantzios 2019 (MCD)	Y	N	N	Y	N	N	N	N	N	N

Table C2

Mindful Eating Components in Included Studies (continued)

Study	Present moment awareness of the sensory properties of food	Present moment awareness of internal bodily sensations relating to hunger, fullness and eating	Present moment awareness of cues that elicit eating or the urge to eat	Present moment awareness of food-related thoughts	Present moment awareness of cravings	Acceptance of feelings of hunger and/or cravings	Acceptance of food-related thoughts	Decentering from feelings of hunger and/or cravings	Decentering from food-related thoughts	Attention regulation
Mantzios 2019 (Mindful Raisin Exercise)	Y	N	N	N	N	N	N	N	N	Y
Mantzios 2020	Y	N	N	N	N	N	N	N	N	N
Marchiori 2014	N	N	N	N	N	N	N	N	N	N
Martin 2017 (Mindful Decision-Making)	N	Y	Y	N	Y	Y	N	N	N	N
Martin 2017 (Mindful Eating)	Y	Y	N	N	N	N	N	N	N	N
Masih 2020	N	N	N	N	N	N	N	N	N	N
Palascha 2021	N	N	N	N	N	N	N	N	N	N
Robinson 2014	Y	N	N	N	N	N	N	N	N	N
Sant-Anna 2022	Y	Y	N	N	N	N	N	N	N	N

Table C2

Mindful Eating Components in Included Studies (continued)

Study	Present moment awareness of the sensory properties of food	Present moment awareness of internal bodily sensations relating to hunger, fullness and eating	Present moment awareness of cues that elicit eating or the urge to eat	Present moment awareness of food-related thoughts	Present moment awareness of cravings	Acceptance of feelings of hunger and/or cravings	Acceptance of food-related thoughts	Decentering from feelings of hunger and/or cravings	Decentering from food-related thoughts	Attention regulation
Seguias 2018	Y	N	N	N	N	N	N	N	N	N
Seguias 2022	Y	Y	N	N	N	N	N	N	N	N
Simonson 2020	Y	Y	N	N	N	N	N	N	N	N
Spadaro 2018	Y	Y	N	N	N	N	N	N	N	N
Tapper 2020	Y	N	N	N	N	N	N	N	N	N
Timmerman 2012	Y	Y	Y	N	N	N	N	N	N	N
Van de Veer 2016 Study 2	N	N	N	N	N	N	N	N	N	N
Van de Veer 2016 Study 4	N	N	N	N	N	N	N	N	N	N
Whitelock 2018 Study 1	Y	N	N	N	N	N	N	N	N	N
Whitelock 2018 Study 2	Y	N	N	N	N	N	N	N	N	N
Whitelock 2019a	Y	N	N	N	N	N	N	N	N	N
Whitelock 2019b	Y	Y	N	N	N	N	N	N	N	N

Appendix D

Chapter Two: Risk of Bias Information

Table D1

Risk of Bias Information for Included Studies

Study	Researchers blinded to group allocation OR interactions limited or tightly scripted	Participants blinded to group allocation or study aims	Participants randomised to conditions (or counterbalanced if within subjects)	Key methodological details present	Food intake measured objectively	Study was pre-registered	Control and experimental conditions matched for factors not specific to mindfulness	Included manipulation check
Allirot 2018	N	Y	Y	Y	Y	N	Y	N
Arch 2016	Y	Y	Y	Y	Y	N	Y	Y
Bennett 2020	Y	N	Y	Y	Y	N	N	N
Cavanagh 2014	N	Y	Y	Y	Y	N	Y	N
Chang 2018	Y	Y	Y	Y	Y	Y	Y	N
De Tomas 2022	N	N	Y	Y	Y	N	N	N
Dutt 2019	N	Y	Y	Y	Y	N	Y	N
Fisher 2016	N	Y	Y	Y	Y	N	Y	N
Gayoso 2021	N	N	Y	Y	Y	N	N	N
Higgs 2011	N	Y	Y	Y	Y	N	N	N
Hinton 2021	N	Y	Y	Y	Y	N	Y	N
Hong 2018	N	Y	Y	Y	N	N	Y	N
Hsu 2021	N	N	Y	Y	Y	N	Y	N
Hussain 2020	N	Y	Y	Y	Y	N	N	N
Hussain 2021	N	Y	Y	Y	Y	N	Y	N
Jenkins 2014	N	N	N	Y	N	N	Y	N
Jordan 2014	N	Y	Y	Y	Y	N	Y	N
Long 2011	N	Y	Y	Y	Y	N	N	N

Table D1

Risk of Bias Information for Included Studies (continued)

Study	Researchers blinded to group allocation OR interactions limited or tightly scripted	Participants blinded to group allocation or study aims	Participants randomised to conditions (or counterbalanced if within subjects)	Key methodological details present	Food intake measured objectively	Study was pre-registered	Control and experimental conditions matched for factors not specific to mindfulness	Included manipulation check
Mantzios 2019 (MCD)	N	Y	Y	Y	Y	N	Y	N
Mantzios 2019 (Mindful Raisin Exercise)	N	Y	Y	Y	Y	N	N	N
Mantzios 2020	N	N	Y	N	Y	N	N	N
Marchiori 2014	N	Y	Y	Y	Y	N	Y	N
Martin 2017	N	N	Y	N	N	N	Y	N
Masih 2020	N	N	Y	Y	Y	N	N	Y
Palascha 2021	N	N	N	N	N/A	Y	Y	N
Robinson 2014	N	Y	Y	Y	Y	N	Y	N
Sant-Anna 2022	Y	N	Y	Y	N	N	N	N
Seguias 2018	N	Y	N	Y	Y	N	N	N
Seguias 2022	N	Y	Y	Y	N	N	Y	N
Simonson 2020	N	N	Y	Y	Y	N	Y	N
Spadaro 2018	N	N	Y	Y	N	N	N	N
Tapper 2020 (Half-day Period)	Y	Y	Y	Y	N	Y	Y	Y
Tapper 2020 (Taste-test)	Y	Y	Y	Y	Y	Y	Y	Y

Table D1

Risk of Bias Information for Included Studies (continued)

Study	Researchers blinded to group allocation OR interactions limited or tightly scripted	Participants blinded to group allocation or study aims	Participants randomised to conditions (or counterbalanced if within subjects)	Key methodological details present	Food intake measured objectively	Study was pre-registered	Control and experimental conditions matched for factors not specific to mindfulness	Included manipulation check
Timmerman 2012	Y	N	Y	Y	N	N	N	N
Van de Veer 2016 Study 2	N	Y	Y	Y	Y	N	Y	Y
Van de Veer 2016 Study 4	N	Y	Y	Y	Y	N	Y	Y
Whitelock 2018 Study 1	N	Y	Y	Y	Y	Y	Y	N
Whitelock 2018 Study 2	N	Y	Y	Y	Y	Y	Y	N
Whitelock 2019a	N	Y	Y	Y	Y	Y	N	N
Whitelock 2019b (Self-report)	N	N	Y	Y	N	Y	N	N
Whitelock 2019b (Taste-test)	N	N	Y	Y	Y	Y	N	N

Appendix E

Chapter Two: Forest Plots for Planned Subgroup Analyses

Figure E5

Forest Plot of Studies with Mindfulness vs Non-Mindfulness Components

	Experimental			Control				Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
1.3.1 Mindfulness/mindful eating components only								
Allirot 2018	275.55	202.9807	35	388.82	248.4162	35	2.4%	−0.49 [−0.97, −0.02]
Arch 2016	196.68	135.24	33	259.65	159.23	36	2.4%	−0.42 [−0.90, 0.06]
Bennett 2020 Mindful Breathing	51.32	45.76	20	18.48	29.58	10	1.5%	0.77 [−0.01, 1.56]
Bennett 2020 Mindful Raisin Eating	51.47	48	23	18.48	29.58	10	1.6%	0.74 [−0.03, 1.51]
Chang 2018	5.39	3.7	33	5.7	8.42	27	2.3%	−0.05 [−0.56, 0.46]
de Tomas 2022	421.83	205.02	50	470.95	233.57	51	2.8%	−0.22 [−0.61, 0.17]
Dutt 2019	2.21	3.67	38	5.33	6.82	36	2.5%	−0.57 [−1.03, −0.10]
Fisher 2016	0.7	0.75	20	2.2	1.75	20	1.8%	−1.09 [−1.76, −0.42]
Higgs 2011	26.22	15.97	10	53.38	28	10	1.2%	−1.14 [−2.10, −0.18]
Hinton 2021 Fullness	249	236	22	255	208	10	1.6%	−0.03 [−0.77, 0.72]
Hinton 2021 Taste	279	231	22	255	208	11	1.7%	0.10 [−0.62, 0.83]
Hong 2018	2.15	0.73	31	1.33	0.95	34	2.3%	0.95 [0.44, 1.47]
Hsu 2021	280.75	225.16	63	254.37	188.17	63	2.9%	0.13 [−0.22, 0.48]
Jenkins 2014 Acceptance	51.78	111.43	45	44.02	75.56	22	2.3%	0.08 [−0.43, 0.59]
Jenkins 2014 Cognitive Defusion	13.43	31.28	45	44.02	75.56	23	2.3%	−0.60 [−1.11, −0.09]
Jordan 2014	149.17	91.11	27	197.58	90.24	29	2.2%	−0.53 [−1.06, 0.01]
Long 2011	443.4	182.9046	27	425.8	177.7084	27	2.2%	0.10 [−0.44, 0.63]
Mantzios 2019 Mindful Raisin Exercise	0.74	1.11	40	1.63	1.14	21	2.2%	−0.78 [−1.33, −0.24]
Mantzios 2020 First Intake	16.44	15.76	32	26.64	18.38	32	2.4%	−0.59 [−1.09, −0.09]
Mantzios 2020 Second Intake	5.11	10.2	32	6.38	8.54	32	2.4%	−0.13 [−0.62, 0.36]
Marchiori 2014	171.51	95.04	55	190.78	122.97	55	2.8%	−0.17 [−0.55, 0.20]
Martin 2017 Mindful Decision-Making	444.3	653.35	8	624.1	660.1	17	1.4%	−0.26 [−1.11, 0.58]
Martin 2017 Mindful Eating	444.3	653.35	9	264.7	634.65	19	1.5%	0.27 [−0.52, 1.07]
Robinson 2014	250	92	25	356	185	23	2.1%	−0.72 [−1.31, −0.14]
Sant'Anna 2022	1,222	435	28	1,380	480	24	2.2%	−0.34 [−0.89, 0.21]
Seguias 2018	112.3	70.24	26	203.2	88.05	25	2.1%	−1.13 [−1.72, −0.53]
Seguias 2022	1,594	425	33	1,543.5	530.8386	66	2.7%	0.10 [−0.32, 0.52]
Simonson 2020	700.08	300.66	8	861.46	299.4	8	1.1%	−0.51 [−1.51, 0.49]
Spadaro 2018	1,380.4	674.9508	22	1,602.7	721.6197	21	2.0%	−0.31 [−0.91, 0.29]
Tapper 2020 Half-day Period	839	496	11	759	403	12	1.5%	0.17 [−0.65, 0.99]
Tapper 2020 Taste-test	166	105	11	144	96	12	1.5%	0.21 [−0.61, 1.03]
Van de Veer 2016 Study 2	37.2	25.69	40	32.2701	20.5065	77	2.8%	0.22 [−0.16, 0.60]
Van de Veer 2016 Study 4	22.37	15.06	43	24.86	18.07	42	2.6%	−0.15 [−0.57, 0.28]
Whitelock 2018 Study 1	365.03	221.99	34	364.145	192.615	74	2.7%	0.00 [−0.40, 0.41]
Whitelock 2018 Study 2	328.46	157.58	70	334.73	145.73	77	3.0%	−0.04 [−0.36, 0.28]
Whitelock 2019a	419.97	193.45	34	375.25	204.44	34	2.4%	0.22 [−0.25, 0.70]
Subtotal (95% CI)			**1105**			**1125**	**77.5%**	**−0.17 [−0.31, −0.03]**
Heterogeneity: Tau² = 0.11; Chi² = 89.87, df = 35 (P < 0.00001); I² = 61%								
Test for overall effect: Z = 2.31 (P = 0.02)								
1.3.2 Mindfulness/mindful eating and other components								
Cavanagh 2014	273.41	153.24	32	319.91	150.05	64	2.6%	−0.31 [−0.73, 0.12]
Gayoso 2021	295.27	166.52	46	393.37	181.85	49	2.7%	−0.56 [−0.97, −0.15]
Hussain 2020 Self-distanced MCD	76.88	59.34	40	170.25	136.19	20	2.1%	−1.00 [−1.57, −0.43]
Hussain 2020 Self-immersed MCD	98.25	103.92	40	170.25	136.19	20	2.2%	−0.62 [−1.16, −0.07]
Hussain 2021	48.22	67.55	43	94.48	102.95	42	2.6%	−0.53 [−0.96, −0.09]
Mantzios 2019 MCD	1	1.16	40	1.63	1.14	20	2.2%	−0.54 [−1.09, 0.01]
Masih 2020	3,190	1,359	17	3,104	1,291	17	1.8%	0.06 [−0.61, 0.74]
Timmerman 2012	1,417.1	330.1	19	1,782	400.1	16	1.7%	−0.98 [−1.69, −0.27]
Whitelock 2019b Self-report	1,831.46	869.28	26	1,720.15	716.04	27	2.2%	0.14 [−0.40, 0.68]
Whitelock 2019b Taste-test	162.24	109.59	27	125.09	105.15	27	2.2%	0.34 [−0.20, 0.88]
Subtotal (95% CI)			**330**			**302**	**22.5%**	**−0.39 [−0.65, −0.14]**
Heterogeneity: Tau² = 0.10; Chi² = 21.78, df = 9 (P = 0.010); I² = 59%								
Test for overall effect: Z = 2.99 (P = 0.003)								
Total (95% CI)			**1435**			**1427**	**100.0%**	**−0.22 [−0.35, −0.09]**
Heterogeneity: Tau² = 0.11; Chi² = 118.61, df = 45 (P < 0.00001); I² = 62%								
Test for overall effect: Z = 3.37 (P = 0.0007)								
Test for subgroup differences: Chi² = 2.26, df = 1 (P = 0.13), I² = 55.8%								

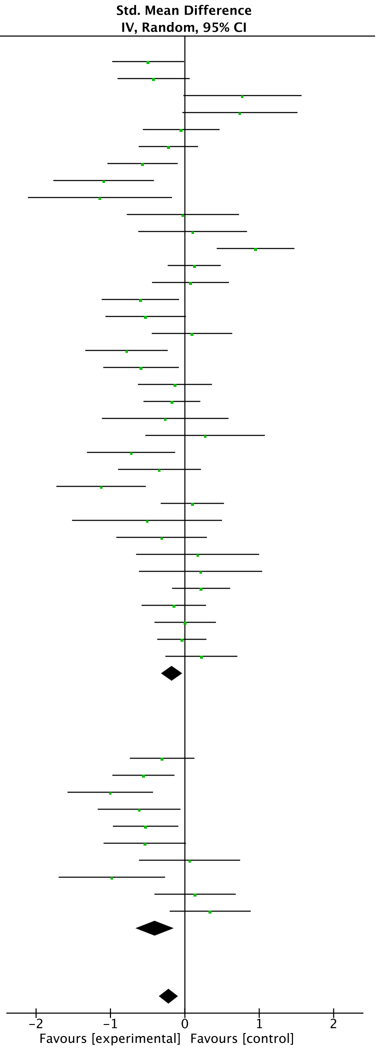


Figure E6

Forest Plot of Studies with and without the 'Present Moment Awareness of the Sensory Properties of Food' Component

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
1.20.1 Present moment awareness of the sensory properties of food in isolation								
Arch 2016	196.68	135.24	33	259.65	159.23	36	2.4%	−0.42 [−0.90, 0.06]
Higgs 2011	26.22	15.97	10	53.38	28	10	1.2%	−1.14 [−2.10, −0.18]
Hinton 2021 Taste	279	231	22	255	208	11	1.7%	0.10 [−0.62, 0.83]
Long 2011	443.4	182.9046	27	425.8	177.7084	27	2.2%	0.10 [−0.44, 0.63]
Mantzios 2020 First Intake	16.44	15.76	32	26.64	18.38	32	2.4%	−0.59 [−1.09, −0.09]
Mantzios 2020 Second Intake	5.11	10.2	32	6.38	8.54	32	2.4%	−0.13 [−0.62, 0.36]
Robinson 2014	250	92	25	356	185	23	2.1%	−0.72 [−1.31, −0.14]
Seguias 2018	112.3	70.24	26	203.2	88.05	25	2.1%	−1.13 [−1.72, −0.53]
Tapper 2020 Half-day Period	839	496	11	759	403	12	1.5%	0.17 [−0.65, 0.99]
Tapper 2020 Taste-test	166	105	11	144	96	12	1.5%	0.21 [−0.61, 1.03]
Whitelock 2018 Study 1	365.03	221.99	34	364.145	192.615	74	2.7%	0.00 [−0.40, 0.41]
Whitelock 2018 Study 2	328.46	157.58	70	334.73	145.73	77	3.0%	−0.04 [−0.36, 0.28]
Whitelock 2019a	419.97	193.45	34	375.25	204.44	34	2.4%	0.22 [−0.25, 0.70]
Subtotal (95% CI)			**367**			**405**	**27.5%**	**−0.24 [−0.47, −0.00]**
Heterogeneity: Tau² = 0.10; Chi² = 27.79, df = 12 (P = 0.006); I² = 57%								
Test for overall effect: Z = 1.99 (P = 0.05)								
1.20.2 Present moment awareness of the sensory properties of food in combination with other components								
Allirot 2018	275.55	202.9807	35	388.82	248.4162	35	2.4%	−0.49 [−0.97, −0.02]
Bennett 2020 Mindful Raisin Eating	51.47	48	23	18.48	29.58	10	1.6%	0.74 [−0.03, 1.51]
Cavanagh 2014	273.41	153.24	32	319.91	150.05	64	2.6%	−0.31 [−0.73, 0.12]
de Tomas 2022	421.83	205.02	50	470.95	233.57	51	2.8%	−0.22 [−0.61, 0.17]
Gayoso 2021	295.27	166.52	46	393.37	181.85	49	2.7%	−0.56 [−0.97, −0.15]
Hong 2018	2.15	0.73	31	1.33	0.95	34	2.3%	0.95 [0.44, 1.47]
Hussain 2021	48.22	67.55	43	94.48	102.95	42	2.6%	−0.53 [−0.96, −0.09]
Mantzios 2019 MCD	1	1.16	40	1.63	1.14	20	2.2%	−0.54 [−1.09, 0.01]
Mantzios 2019 Mindful Raisin Exercise	0.74	1.11	40	1.63	1.14	21	2.2%	−0.78 [−1.33, −0.24]
Martin 2017 Mindful Eating	444.3	653.35	9	264.7	634.65	19	1.5%	0.27 [−0.52, 1.07]
Sant'Anna 2022	1,222	435	28	1,380	480	24	2.2%	−0.34 [−0.89, 0.21]
Seguias 2022	1,594	425	33	1,543.5	530.8386	66	2.7%	0.10 [−0.32, 0.52]
Simonson 2020	700.08	300.66	8	861.46	299.4	8	1.1%	−0.51 [−1.51, 0.49]
Spadaro 2018	1,380.4	674.9508	22	1,602.7	721.6197	21	2.0%	−0.31 [−0.91, 0.29]
Timmerman 2012	1,417.1	330.1	19	1,782	400.1	16	1.7%	−0.98 [−1.69, −0.27]
Whitelock 2019b Self-report	1,831.46	869.28	26	1,720.15	716.04	27	2.2%	0.14 [−0.40, 0.68]
Whitelock 2019b Taste-test	162.24	109.59	27	125.09	105.15	27	2.2%	0.34 [−0.20, 0.88]
Subtotal (95% CI)			**512**			**534**	**37.1%**	**−0.18 [−0.42, 0.05]**
Heterogeneity: Tau² = 0.16; Chi² = 51.78, df = 16 (P < 0.0001); I² = 69%								
Test for overall effect: Z = 1.56 (P = 0.12)								
1.20.3 No present moment awareness of the sensory properties of food								
Bennett 2020 Mindful Breathing	51.32	45.76	20	18.48	29.58	10	1.5%	0.77 [−0.01, 1.56]
Chang 2018	5.39	3.7	33	5.7	8.42	27	2.3%	−0.05 [−0.56, 0.46]
Dutt 2019	2.21	3.67	38	5.33	6.82	36	2.5%	−0.57 [−1.03, −0.10]
Fisher 2016	0.7	0.75	20	2.2	1.75	20	1.8%	−1.09 [−1.76, −0.42]
Hinton 2021 Fullness	249	236	22	255	208	10	1.6%	−0.03 [−0.77, 0.72]
Hsu 2021	280.75	225.16	63	254.37	188.17	63	2.9%	0.13 [−0.22, 0.48]
Hussain 2020 Self-distanced MCD	76.88	59.34	40	170.25	136.19	20	2.1%	−1.00 [−1.57, −0.43]
Hussain 2020 Self-immersed MCD	98.25	103.92	40	170.25	136.19	20	2.2%	−0.62 [−1.16, −0.07]
Jenkins 2014 Acceptance	51.78	111.43	45	44.02	75.56	22	2.3%	0.08 [−0.43, 0.59]
Jenkins 2014 Cognitive Defusion	13.43	31.28	45	44.01	75.56	23	2.3%	−0.60 [−1.11, −0.09]
Jordan 2014	149.17	91.11	27	197.58	90.24	29	2.2%	−0.53 [−1.06, 0.01]
Marchiori 2014	171.51	95.04	55	190.78	122.97	55	2.8%	−0.17 [−0.55, 0.20]
Martin 2017 Mindful Decision-Making	444.3	653.35	8	624.1	660.1	17	1.4%	−0.26 [−1.11, 0.58]
Masih 2020	3,190	1,359	17	3,104	1,291	17	1.8%	0.06 [−0.61, 0.74]
Van de Veer 2016 Study 2	37.2	25.69	40	32.2701	20.5065	77	2.8%	0.22 [−0.16, 0.60]
Van de Veer 2016 Study 4	22.37	15.06	43	24.86	18.07	42	2.6%	−0.15 [−0.57, 0.28]
Subtotal (95% CI)			**556**			**488**	**35.4%**	**−0.24 [−0.45, −0.03]**
Heterogeneity: Tau² = 0.11; Chi² = 39.03, df = 15 (P = 0.0006); I² = 62%								
Test for overall effect: Z = 2.21 (P = 0.03)								
Total (95% CI)			**1435**			**1427**	**100.0%**	**−0.22 [−0.35, −0.09]**
Heterogeneity: Tau² = 0.11; Chi² = 118.61, df = 45 (P < 0.00001); I² = 62%								
Test for overall effect: Z = 3.37 (P = 0.0007)								
Test for subgroup differences: Chi² = 0.13, df = 2 (P = 0.94), I² = 0%								

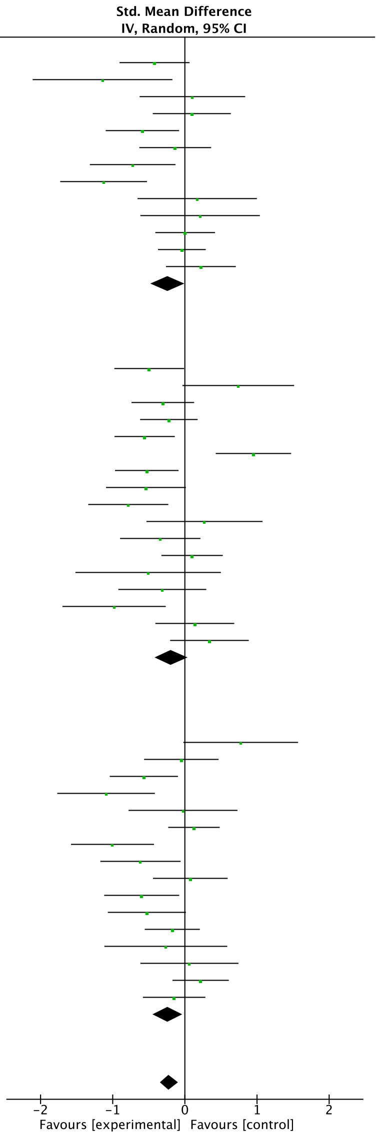


Figure E7

Forest Plot of Studies with and without an 'Acceptance' Component

	Experimental			Control				Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
1.6.1 Present moment awareness with acceptance								
Bennett 2020 Mindful Breathing	51.32	45.76	20	18.48	29.58	20	3.0%	0.84 [0.19, 1.48]
Fisher 2016	0.7	0.75	20	2.2	1.75	20	3.0%	−1.09 [−1.76, −0.42]
Gayoso 2021	295.27	166.52	46	393.37	181.85	49	4.2%	−0.56 [−0.97, −0.15]
Hong 2018	2.15	0.73	31	1.33	0.95	34	3.7%	0.95 [0.44, 1.47]
Hussain 2020 Self-distanced MCD	76.88	59.34	40	170.25	136.19	20	3.4%	−1.00 [−1.57, −0.43]
Hussain 2020 Self-immersed MCD	98.25	103.92	40	170.25	136.19	20	3.5%	−0.62 [−1.16, −0.07]
Jenkins 2014 Acceptance	51.78	111.43	45	44.02	75.56	45	4.2%	0.08 [−0.33, 0.49]
Jordan 2014	149.17	91.11	27	197.58	90.24	29	3.6%	−0.53 [−1.06, 0.01]
Marchiori 2014	171.51	95.04	55	190.78	122.97	55	4.4%	−0.17 [−0.55, 0.20]
Martin 2017 Mindful Decision-Making	444.3	653.35	8	624.1	660.1	17	2.3%	−0.26 [−1.11, 0.58]
Sant'Anna 2022	1,222	435	28	1,380	480	24	3.5%	−0.34 [−0.89, 0.21]
Subtotal (95% CI)			**360**			**333**	**38.9%**	**−0.24 [−0.60, 0.12]**
Heterogeneity: Tau² = 0.29; Chi² = 51.96, df = 10 (P < 0.00001); I² = 81%								
Test for overall effect: Z = 1.31 (P = 0.19)								
1.6.2 Present moment awareness without acceptance								
Cavanagh 2014	273.41	153.24	32	319.91	150.05	64	4.1%	−0.31 [−0.73, 0.12]
Chang 2018	5.39	3.7	33	5.7	8.42	27	3.7%	−0.05 [−0.56, 0.46]
de Tomas 2022	421.83	205.02	50	470.95	233.57	51	4.3%	−0.22 [−0.61, 0.17]
Dutt 2019	2.21	3.67	38	5.33	6.82	36	3.9%	−0.57 [−1.03, −0.10]
Hinton 2021 Fullness	249	236	22	255	208	21	3.3%	−0.03 [−0.62, 0.57]
Hsu 2021	280.75	225.16	63	254.37	188.17	63	4.6%	0.13 [−0.22, 0.48]
Mantzios 2019 MCD	1	1.16	40	1.63	1.14	41	4.0%	−0.54 [−0.99, −0.10]
Martin 2017 Mindful Eating	444.3	653.35	9	264.7	634.65	19	2.5%	0.27 [−0.52, 1.07]
Masih 2020	3,190	1,359	17	3,104	1,291	17	2.9%	0.06 [−0.61, 0.74]
Seguias 2022	1,594	425	33	1,543.5	530.8386	66	4.2%	0.10 [−0.32, 0.52]
Simonson 2020	700.08	300.66	8	861.46	299.4	8	1.9%	−0.51 [−1.51, 0.49]
Spadaro 2018	1,380.4	674.9508	22	1,602.7	721.6197	21	3.3%	−0.31 [−0.91, 0.29]
Timmerman 2012	1,417.1	330.1	19	1,782	400.1	16	2.8%	−0.98 [−1.69, −0.27]
Van de Veer 2016 Study 2	37.2	25.69	40	32.2701	20.5065	77	4.4%	0.22 [−0.16, 0.60]
Van de Veer 2016 Study 4	22.37	15.06	43	24.86	18.07	42	4.1%	−0.15 [−0.57, 0.28]
Whitelock 2019b Self-report	1,831.46	869.28	26	1,720.15	716.04	27	3.6%	0.14 [−0.40, 0.68]
Whitelock 2019b Taste-test	162.24	109.59	27	125.09	105.15	27	3.6%	0.34 [−0.20, 0.88]
Subtotal (95% CI)			**522**			**623**	**61.1%**	**−0.12 [−0.27, 0.04]**
Heterogeneity: Tau² = 0.04; Chi² = 25.71, df = 16 (P = 0.06); I² = 38%								
Test for overall effect: Z = 1.49 (P = 0.14)								
Total (95% CI)			**882**			**956**	**100.0%**	**−0.17 [−0.34, −0.00]**
Heterogeneity: Tau² = 0.13; Chi² = 79.09, df = 27 (P < 0.00001); I² = 66%								
Test for overall effect: Z = 2.01 (P = 0.04)								
Test for subgroup differences: Chi² = 0.38, df = 1 (P = 0.54), I² = 0%								

Std. Mean Difference
IV, Random, 95% CI

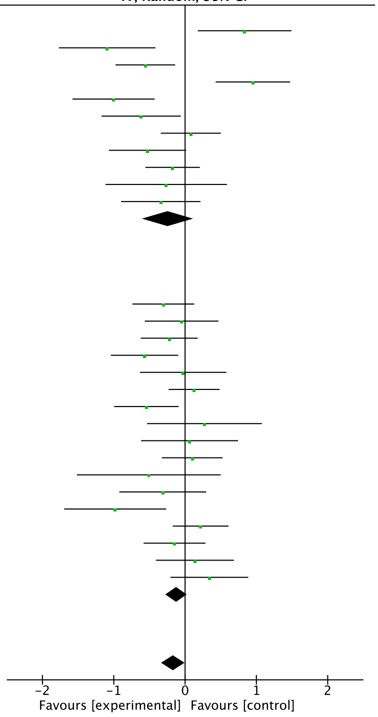


Figure E8

Forest Plot of Studies with and without an 'Attention Regulation' Component

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
1.7.1 Attention regulation component								
Arch 2016	196.68	135.24	33	259.65	159.23	36	2.4%	−0.42 [−0.90, 0.06]
Bennett 2020 Mindful Breathing	51.32	45.76	20	18.48	29.58	10	1.5%	0.77 [−0.01, 1.56]
Bennett 2020 Mindful Raisin Eating	51.47	48	23	18.48	29.58	10	1.6%	0.74 [−0.03, 1.51]
Cavanagh 2014	273.41	153.24	32	319.91	150.05	64	2.6%	−0.31 [−0.73, 0.12]
Hsu 2021	280.75	225.16	63	254.37	188.17	63	2.9%	0.13 [−0.22, 0.48]
Mantzios 2019 Mindful Raisin Exercise	0.74	1.11	40	1.63	1.14	21	2.2%	−0.78 [−1.33, −0.24]
Marchiori 2014	171.51	95.04	55	190.78	122.97	55	2.8%	−0.17 [−0.55, 0.20]
Sant'Anna 2022	1,222	435	28	1,380	480	24	2.2%	−0.34 [−0.89, 0.21]
Subtotal (95% CI)			**294**			**283**	**18.3%**	**−0.11 [−0.41, 0.19]**
Heterogeneity: $Tau^2 = 0.12$; $Chi^2 = 20.24$, df = 7 (P = 0.005); $I^2 = 65\%$								
Test for overall effect: Z = 0.73 (P = 0.46)								
1.7.2 No attention regulation component								
Allirot 2018	275.55	202.9807	35	388.82	248.4162	35	2.4%	−0.49 [−0.97, −0.02]
Chang 2018	5.39	3.7	33	5.7	8.42	27	2.3%	−0.05 [−0.56, 0.46]
de Tomas 2022	421.83	205.02	50	470.95	233.57	51	2.8%	−0.22 [−0.61, 0.17]
Dutt 2019	2.21	3.67	38	5.33	6.82	36	2.5%	−0.57 [−1.03, −0.10]
Fisher 2016	0.7	0.75	20	2.2	1.75	20	1.8%	−1.09 [−1.76, −0.42]
Gayoso 2021	295.27	166.52	46	393.37	181.85	49	2.7%	−0.56 [−0.97, −0.15]
Higgs 2011	26.22	15.97	10	53.38	28	10	1.2%	−1.14 [−2.10, −0.18]
Hinton 2021 Fullness	249	236	22	255	208	10	1.6%	−0.03 [−0.77, 0.72]
Hinton 2021 Taste	279	231	22	255	208	11	1.7%	0.10 [−0.62, 0.83]
Hong 2018	2.15	0.73	31	1.33	0.95	34	2.3%	0.95 [0.44, 1.47]
Hussain 2020 Self-distanced MCD	76.88	59.34	40	170.25	136.19	20	2.1%	−1.00 [−1.57, −0.43]
Hussain 2020 Self-immersed MCD	98.25	103.92	40	170.25	136.19	20	2.2%	−0.62 [−1.16, −0.07]
Hussain 2021	48.22	67.55	43	94.48	102.95	42	2.6%	−0.53 [−0.96, −0.09]
Jenkins 2014 Acceptance	51.78	111.43	45	44.02	75.56	22	2.3%	0.08 [−0.43, 0.59]
Jenkins 2014 Cognitive Defusion	13.43	31.28	45	44.02	75.56	23	2.3%	−0.60 [−1.11, −0.09]
Jordan 2014	149.17	91.11	27	197.58	90.24	29	2.2%	−0.53 [−1.06, 0.01]
Long 2011	443.4	182.9046	27	425.8	177.7084	27	2.2%	0.10 [−0.44, 0.63]
Mantzios 2019 MCD	1	1.16	40	1.63	1.14	20	2.2%	−0.54 [−1.09, 0.01]
Mantzios 2020 First Intake	16.44	15.76	32	26.64	18.38	32	2.4%	−0.59 [−1.09, −0.09]
Mantzios 2020 Second Intake	5.11	10.2	32	6.38	8.54	32	2.4%	−0.13 [−0.62, 0.36]
Martin 2017 Mindful Decision-Making	444.3	653.35	8	624.1	660.1	17	1.4%	−0.26 [−1.11, 0.58]
Martin 2017 Mindful Eating	444.3	653.35	9	264.7	634.65	19	1.5%	0.27 [−0.52, 1.07]
Masih 2020	3,190	1,359	17	3,104	1,291	17	1.8%	0.06 [−0.61, 0.74]
Robinson 2014	250	92	25	356	185	23	2.1%	−0.72 [−1.31, −0.14]
Seguias 2018	112.3	70.24	26	203.2	88.05	25	2.1%	−1.13 [−1.72, −0.53]
Seguias 2022	1,594	425	33	1,543.5	530.8386	66	2.7%	0.10 [−0.32, 0.52]
Simonson 2020	700.08	300.66	8	861.46	299.4	8	1.1%	−0.51 [−1.51, 0.49]
Spadaro 2018	1,380.4	674.9508	22	1,602.7	721.6197	21	2.0%	−0.31 [−0.91, 0.29]
Tapper 2020 Half-day Period	839	496	11	759	403	12	1.5%	0.17 [−0.65, 0.99]
Tapper 2020 Taste-test	166	105	11	144	96	12	1.5%	0.21 [−0.61, 1.03]
Timmerman 2012	1,417.1	330.1	19	1,782	400.1	16	1.7%	−0.98 [−1.69, −0.27]
Van de Veer 2016 Study 2	37.2	25.69	40	32.2701	20.5065	77	2.8%	0.22 [−0.16, 0.60]
Van de Veer 2016 Study 4	22.37	15.06	43	24.86	18.07	42	2.6%	−0.15 [−0.57, 0.28]
Whitelock 2018 Study 1	365.03	221.99	34	364.145	192.615	74	2.7%	0.00 [−0.40, 0.41]
Whitelock 2018 Study 2	328.46	157.58	70	334.73	145.73	77	3.0%	−0.04 [−0.36, 0.28]
Whitelock 2019a	419.97	193.45	34	375.25	204.44	34	2.4%	0.22 [−0.25, 0.70]
Whitelock 2019b Self-report	1,831.46	869.28	26	1,720.15	716.04	27	2.2%	0.14 [−0.40, 0.68]
Whitelock 2019b Taste-test	162.24	109.59	27	125.09	105.15	27	2.2%	0.34 [−0.20, 0.88]
Subtotal (95% CI)			**1141**			**1144**	**81.7%**	**−0.24 [−0.39, −0.10]**
Heterogeneity: $Tau^2 = 0.12$; $Chi^2 = 97.73$, df = 37 (P < 0.00001); $I^2 = 62\%$								
Test for overall effect: Z = 3.34 (P = 0.0008)								
Total (95% CI)			**1435**			**1427**	**100.0%**	**−0.22 [−0.35, −0.09]**
Heterogeneity: $Tau^2 = 0.11$; $Chi^2 = 118.61$, df = 45 (P < 0.00001); $I^2 = 62\%$								
Test for overall effect: Z = 3.37 (P = 0.0007)								
Test for subgroup differences: $Chi^2 = 0.60$, df = 1 (P = 0.44), $I^2 = 0\%$								

Std. Mean Difference
IV, Random, 95% CI

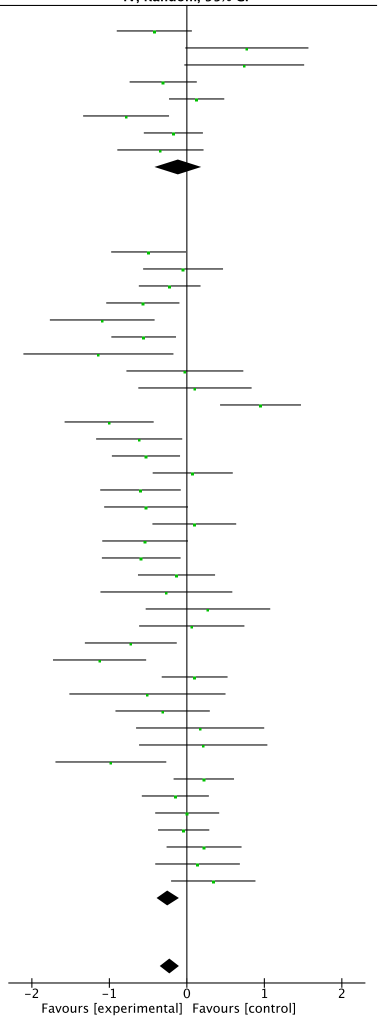


Figure E9

Forest Plot of Time from the Intervention to the Food Intake Measure

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
1.8.1 Concurrent intake								
Hong 2018	2.15	0.73	31	1.33	0.95	34	3.2%	0.95 [0.44, 1.47]
Hussain 2020 Self-distanced MCD	76.88	59.34	40	170.25	136.19	20	3.0%	−1.00 [−1.57, −0.43]
Hussain 2020 Self-immersed MCD	98.25	103.92	40	170.25	136.19	20	3.1%	−0.62 [−1.16, −0.07]
Hussain 2021	48.22	67.55	43	94.48	102.95	42	3.6%	−0.53 [−0.96, −0.09]
Long 2011	443.4	182.9046	27	425.8	177.7084	27	3.1%	0.10 [−0.44, 0.63]
Simonson 2020	700.08	300.66	8	861.46	299.4	8	1.6%	−0.51 [−1.51, 0.49]
Subtotal (95% CI)			**189**			**151**	**17.6%**	**−0.25 [−0.84, 0.33]**
Heterogeneity: $Tau^2 = 0.45$; $Chi^2 = 32.74$, df = 5 (P < 0.00001); $I^2 = 85\%$								
Test for overall effect: Z = 0.85 (P = 0.40)								
1.8.2 Subsequent intake (immediate to 20 mins)								
Allirot 2018	275.55	202.9807	35	388.82	248.4162	35	3.4%	−0.49 [−0.97, −0.02]
Arch 2016	196.68	135.24	33	259.65	159.23	36	3.4%	−0.42 [−0.90, 0.06]
Cavanagh 2014	273.41	153.24	32	319.91	150.05	64	3.7%	−0.31 [−0.73, 0.12]
Chang 2018	5.39	3.7	33	5.7	8.42	27	3.3%	−0.05 [−0.56, 0.46]
de Tomas 2022	421.83	205.02	50	470.95	233.57	51	3.8%	−0.22 [−0.61, 0.17]
Dutt 2019	2.21	3.67	38	5.33	6.82	36	3.5%	−0.57 [−1.03, −0.10]
Fisher 2016	0.7	0.75	20	2.2	1.75	20	2.6%	−1.09 [−1.76, −0.42]
Hinton 2021 Fullness	249	236	22	255	208	10	2.3%	−0.03 [−0.77, 0.72]
Hinton 2021 Taste	279	231	22	255	208	11	2.3%	0.10 [−0.62, 0.83]
Hsu 2021	280.75	225.16	63	254.37	188.17	63	4.0%	0.13 [−0.22, 0.48]
Jordan 2014	149.17	91.11	27	197.58	90.24	29	3.1%	−0.53 [−1.06, 0.01]
Mantzios 2019 MCD	1	1.16	40	1.63	1.14	20	3.1%	−0.54 [−1.09, 0.01]
Mantzios 2019 Mindful Raisin Exercise	0.74	1.11	40	1.63	1.14	21	3.1%	−0.78 [−1.33, −0.24]
Mantzios 2020 First Intake	16.44	15.76	32	26.64	18.38	32	3.3%	−0.59 [−1.09, −0.09]
Mantzios 2020 Second Intake	5.11	10.2	32	6.38	8.54	32	3.3%	−0.13 [−0.62, 0.36]
Marchiori 2014	171.51	95.04	55	190.78	122.97	55	3.9%	−0.17 [−0.55, 0.20]
Tapper 2020 Taste-test	166	105	11	144	96	12	2.0%	0.21 [−0.61, 1.03]
Van de Veer 2016 Study 2	37.2	25.69	40	32.2701	20.5065	77	3.9%	0.22 [−0.16, 0.60]
Van de Veer 2016 Study 4	22.37	15.06	43	24.86	18.07	42	3.7%	−0.15 [−0.57, 0.28]
Subtotal (95% CI)			**668**			**673**	**61.6%**	**−0.27 [−0.42, −0.13]**
Heterogeneity: $Tau^2 = 0.04$; $Chi^2 = 30.85$, df = 18 (P = 0.03); $I^2 = 42\%$								
Test for overall effect: Z = 3.62 (P = 0.0003)								
1.8.3 Subsequent intake (2 to 3 hours)								
Higgs 2011	26.22	15.97	10	53.38	28	10	1.7%	−1.14 [−2.10, −0.18]
Robinson 2014	250	92	25	356	185	23	2.9%	−0.72 [−1.31, −0.14]
Seguias 2018	112.3	70.24	26	203.2	88.05	25	2.9%	−1.13 [−1.72, −0.53]
Tapper 2020 Half-day Period	839	496	11	759	403	12	2.0%	0.17 [−0.65, 0.99]
Whitelock 2018 Study 1	365.03	221.99	34	364.145	192.615	74	3.8%	0.00 [−0.40, 0.41]
Whitelock 2018 Study 2	328.46	157.58	70	334.73	145.73	77	4.2%	−0.04 [−0.36, 0.28]
Whitelock 2019a	419.97	193.45	34	375.25	204.44	34	3.4%	0.22 [−0.25, 0.70]
Subtotal (95% CI)			**210**			**255**	**20.8%**	**−0.32 [−0.71, 0.07]**
Heterogeneity: $Tau^2 = 0.18$; $Chi^2 = 21.77$, df = 6 (P = 0.001); $I^2 = 72\%$								
Test for overall effect: Z = 1.62 (P = 0.11)								
Total (95% CI)			**1067**			**1079**	**100.0%**	**−0.28 [−0.43, −0.13]**
Heterogeneity: $Tau^2 = 0.11$; $Chi^2 = 85.57$, df = 31 (P < 0.00001); $I^2 = 64\%$								
Test for overall effect: Z = 3.63 (P = 0.0003)								
Test for subgroup differences: $Chi^2 = 0.05$, df = 2 (P = 0.97), $I^2 = 0\%$								

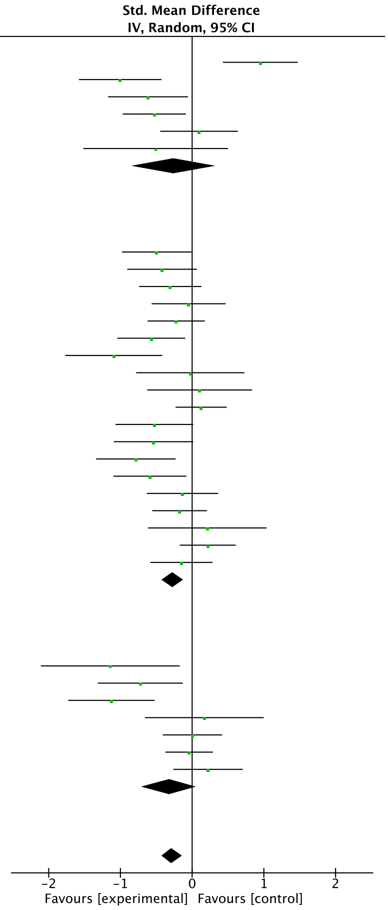


Figure E10

Forest Plot of Intake of a Snack versus a Meal

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
1.9.1 Snack								
Allirot 2018	275.55	202.9807	35	388.82	248.4162	35	2.8%	−0.49 [−0.97, −0.02]
Arch 2016	196.68	135.24	33	259.65	159.23	36	2.8%	−0.42 [−0.90, 0.06]
Bennett 2020 Mindful Breathing	51.32	45.76	20	18.48	29.58	10	1.8%	0.77 [−0.01, 1.56]
Bennett 2020 Mindful Raisin Eating	51.47	48	23	18.48	29.58	10	1.9%	0.74 [−0.03, 1.51]
Chang 2018	5.39	3.7	33	5.7	8.42	27	2.7%	−0.05 [−0.56, 0.46]
Dutt 2019	2.21	3.67	38	5.33	6.82	36	2.9%	−0.57 [−1.03, −0.10]
Fisher 2016	0.7	0.75	20	2.2	1.75	20	2.2%	−1.09 [−1.76, −0.42]
Higgs 2011	26.22	15.97	10	53.38	28	10	1.4%	−1.14 [−2.10, −0.18]
Hinton 2021 Fullness	249	236	22	255	208	10	1.9%	−0.03 [−0.77, 0.72]
Hinton 2021 Taste	279	231	22	255	208	11	2.0%	0.10 [−0.62, 0.83]
Hong 2018	2.15	0.73	31	1.33	0.95	34	2.7%	0.95 [0.44, 1.47]
Hsu 2021	280.75	225.16	63	254.37	188.17	63	3.3%	0.13 [−0.22, 0.48]
Hussain 2020 Self−distanced MCD	76.88	59.34	40	170.25	136.19	20	2.5%	−1.00 [−1.57, −0.43]
Hussain 2020 Self−immersed MCD	98.25	103.92	40	170.25	136.19	20	2.6%	−0.62 [−1.16, −0.07]
Hussain 2021	48.22	67.55	43	94.48	102.95	42	3.0%	−0.53 [−0.96, −0.09]
Jenkins 2014 Acceptance	51.78	111.43	45	44.02	75.56	22	2.7%	0.08 [−0.43, 0.59]
Jenkins 2014 Cognitive Defusion	13.43	31.28	45	44.02	75.56	23	2.7%	−0.60 [−1.11, −0.09]
Jordan 2014	149.17	91.11	27	197.58	90.24	29	2.6%	−0.53 [−1.06, 0.01]
Mantzios 2019 MCD	1	1.16	40	1.63	1.14	20	2.6%	−0.54 [−1.09, 0.01]
Mantzios 2019 Mindful Raisin Exercise	0.74	1.11	40	1.63	1.14	21	2.6%	−0.78 [−1.33, −0.24]
Mantzios 2020 First Intake	16.44	15.76	32	26.64	18.38	32	2.7%	−0.59 [−1.09, −0.09]
Mantzios 2020 Second Intake	5.11	10.2	32	6.38	8.54	32	2.8%	−0.13 [−0.62, 0.36]
Marchiori 2014	171.51	95.04	55	190.78	122.97	55	3.2%	−0.17 [−0.55, 0.20]
Robinson 2014	250	92	25	356	185	23	2.4%	−0.72 [−1.31, −0.14]
Seguias 2018	112.3	70.24	26	203.2	88.05	25	2.4%	−1.13 [−1.72, −0.53]
Tapper 2020 Taste−test	166	105	23	144	96	25	2.5%	0.22 [−0.35, 0.78]
Van de Veer 2016 Study 2	37.2	25.69	40	32.2701	20.5065	77	3.2%	0.22 [−0.16, 0.60]
Van de Veer 2016 Study 4	22.37	15.06	43	24.86	18.07	42	3.0%	−0.15 [−0.57, 0.28]
Whitelock 2018 Study 1	365.03	221.99	34	364.145	192.615	74	3.1%	0.00 [−0.40, 0.41]
Whitelock 2018 Study 2	328.46	157.58	70	334.73	145.73	77	3.4%	−0.04 [−0.36, 0.28]
Whitelock 2019a	419.97	193.45	34	375.25	204.44	34	2.8%	0.22 [−0.25, 0.70]
Whitelock 2019b Taste−test	162.24	109.59	53	125.09	105.15	54	3.2%	0.34 [−0.04, 0.73]
Subtotal (95% CI)			**1137**			**1049**	**84.6%**	**−0.23 [−0.39, −0.06]**
Heterogeneity: Tau² = 0.16; Chi² = 107.49, df = 31 (P < 0.00001); I² = 71%								
Test for overall effect: Z = 2.66 (P = 0.008)								
1.9.2 Meal								
Cavanagh 2014	273.41	153.24	32	319.91	150.05	64	3.0%	−0.31 [−0.73, 0.12]
de Tomas 2022	421.83	205.02	50	470.95	233.57	51	3.2%	−0.22 [−0.61, 0.17]
Gayoso 2021	295.27	166.52	46	393.37	181.85	49	3.1%	−0.56 [−0.97, −0.15]
Long 2011	443.4	182.9046	27	425.8	177.7084	27	2.6%	0.10 [−0.44, 0.63]
Masih 2020	3,190	1,359	17	3,104	1,291	17	2.2%	0.06 [−0.61, 0.74]
Simonson 2020	700.08	300.66	8	861.46	299.4	8	1.4%	−0.51 [−1.51, 0.49]
Subtotal (95% CI)			**180**			**216**	**15.4%**	**−0.26 [−0.46, −0.06]**
Heterogeneity: Tau² = 0.00; Chi² = 4.93, df = 5 (P = 0.42); I² = 0%								
Test for overall effect: Z = 2.55 (P = 0.01)								
Total (95% CI)			**1317**			**1265**	**100.0%**	**−0.23 [−0.37, −0.08]**
Heterogeneity: Tau² = 0.13; Chi² = 112.88, df = 37 (P < 0.00001); I² = 67%								
Test for overall effect: Z = 3.08 (P = 0.002)								
Test for subgroup differences: Chi² = 0.08, df = 1 (P = 0.78), I² = 0%								

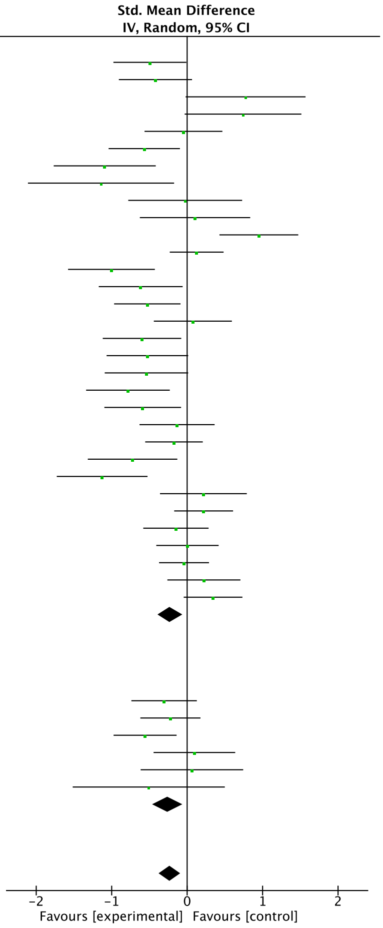


Figure E11

Forest Plot of Experimental Studies versus Long-Term Interventions

	Experimental			Control				Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
1.12.1 Experimental								
Allirot 2018	275.55	202.9807	35	388.82	248.4162	35	2.4%	−0.49 [−0.97, −0.02]
Arch 2016	196.68	135.24	33	259.65	159.23	36	2.4%	−0.42 [−0.90, 0.06]
Cavanagh 2014	273.41	153.24	32	319.91	150.05	64	2.6%	−0.31 [−0.73, 0.12]
Chang 2018	5.39	3.7	33	5.7	8.42	27	2.3%	−0.05 [−0.56, 0.46]
de Tomas 2022	421.83	205.02	50	470.95	233.57	51	2.8%	−0.22 [−0.61, 0.17]
Dutt 2019	2.21	3.67	38	5.33	6.82	36	2.5%	−0.57 [−1.03, −0.10]
Fisher 2016	0.7	0.75	20	2.2	1.75	20	1.8%	−1.09 [−1.76, −0.42]
Higgs 2011	26.22	15.97	10	53.38	28	10	1.2%	−1.14 [−2.10, −0.18]
Hinton 2021 Fullness	249	236	22	255	208	10	1.6%	−0.03 [−0.77, 0.72]
Hinton 2021 Taste	279	231	22	255	208	11	1.7%	0.10 [−0.62, 0.83]
Hsu 2021	280.75	225.16	63	254.37	188.17	63	2.9%	0.13 [−0.22, 0.48]
Hussain 2020 Self-distanced MCD	76.88	59.34	40	170.25	136.19	20	2.1%	−1.00 [−1.57, −0.43]
Hussain 2020 Self-immersed MCD	98.25	103.92	40	170.25	136.19	20	2.2%	−0.62 [−1.16, −0.07]
Hussain 2021	48.22	67.55	43	94.48	102.95	42	2.6%	−0.53 [−0.96, −0.09]
Jordan 2014	149.17	91.11	27	197.58	90.24	29	2.2%	−0.53 [−1.06, 0.01]
Long 2011	443.4	182.9046	27	425.8	177.7084	27	2.2%	0.10 [−0.44, 0.63]
Mantzios 2019 MCD	1	1.16	40	1.63	1.14	20	2.2%	−0.54 [−1.09, 0.01]
Mantzios 2019 Mindful Raisin Exercise	0.74	1.11	40	1.63	1.14	21	2.2%	−0.78 [−1.33, −0.24]
Mantzios 2020 First Intake	16.44	15.76	32	26.64	18.38	32	2.4%	−0.59 [−1.09, −0.09]
Mantzios 2020 Second Intake	5.11	10.2	32	6.38	8.54	32	2.4%	−0.13 [−0.62, 0.36]
Marchiori 2014	171.51	95.04	55	190.78	122.97	55	2.8%	−0.17 [−0.55, 0.20]
Robinson 2014	250	92	25	356	185	23	2.1%	−0.72 [−1.31, −0.14]
Seguias 2018	112.3	70.24	26	203.2	88.05	25	2.1%	−1.13 [−1.72, −0.53]
Simonson 2020	700.08	300.66	8	861.46	299.4	8	1.1%	−0.51 [−1.51, 0.49]
Tapper 2020 Half-day Period	839	496	11	759	403	12	1.5%	0.17 [−0.65, 0.99]
Tapper 2020 Taste-test	166	105	11	144	96	12	1.5%	0.21 [−0.61, 1.03]
Van de Veer 2016 Study 2	37.2	25.69	40	32.2701	20.5065	77	2.8%	0.22 [−0.16, 0.60]
Van de Veer 2016 Study 4	22.37	15.06	43	24.86	18.07	42	2.6%	−0.15 [−0.57, 0.28]
Whitelock 2018 Study 1	365.03	221.99	34	364.145	192.615	74	2.7%	0.00 [−0.40, 0.41]
Whitelock 2018 Study 2	328.46	157.58	70	334.73	145.73	77	3.0%	−0.04 [−0.36, 0.28]
Whitelock 2019a	419.97	193.45	34	375.25	204.44	34	2.4%	0.22 [−0.25, 0.70]
Subtotal (95% CI)			**1036**			**1045**	**69.4%**	**−0.31 [−0.45, −0.18]**
Heterogeneity: $Tau^2 = 0.07$; $Chi^2 = 64.60$, df = 30 (P = 0.0002); $I^2 = 54\%$								
Test for overall effect: Z = 4.55 (P < 0.00001)								
1.12.2 Long-term intervention								
Bennett 2020 Mindful Breathing	51.32	45.76	20	18.48	29.58	10	1.5%	0.77 [−0.01, 1.56]
Bennett 2020 Mindful Raisin Eating	51.47	48	23	18.48	29.58	10	1.6%	0.74 [−0.03, 1.51]
Gayoso 2021	295.27	166.52	46	393.37	181.85	49	2.7%	−0.56 [−0.97, −0.15]
Hong 2018	2.15	0.73	31	1.33	0.95	34	2.3%	0.95 [0.44, 1.47]
Jenkins 2014 Acceptance	51.78	111.43	45	44.02	75.56	22	2.3%	0.08 [−0.43, 0.59]
Jenkins 2014 Cognitive Defusion	13.43	31.28	45	44.02	75.56	23	2.3%	−0.60 [−1.11, −0.09]
Martin 2017 Mindful Decision-Making	444.3	653.35	8	624.1	660.1	17	1.4%	−0.26 [−1.11, 0.58]
Martin 2017 Mindful Eating	444.3	653.35	9	264.7	634.65	19	1.5%	0.27 [−0.52, 1.07]
Masih 2020	3,190	1,359	17	3,104	1,291	17	1.8%	0.06 [−0.61, 0.74]
Sant'Anna 2022	1,222	435	28	1,380	480	24	2.2%	−0.34 [−0.89, 0.21]
Seguias 2022	1,594	425	33	1,543.5	530.8386	66	2.7%	0.10 [−0.32, 0.52]
Spadaro 2018	1,380.4	674.9508	22	1,602.7	721.6197	21	2.0%	−0.31 [−0.91, 0.29]
Timmerman 2012	1,417.1	330.1	19	1,782	400.1	16	1.7%	−0.98 [−1.69, −0.27]
Whitelock 2019b Self-report	1,831.46	869.28	26	1,720.15	716.04	27	2.2%	0.14 [−0.40, 0.68]
Whitelock 2019b Taste-test	162.24	109.59	27	125.09	105.15	27	2.2%	0.34 [−0.20, 0.88]
Subtotal (95% CI)			**399**			**382**	**30.6%**	**0.01 [−0.26, 0.28]**
Heterogeneity: $Tau^2 = 0.19$; $Chi^2 = 45.49$, df = 14 (P < 0.0001); $I^2 = 69\%$								
Test for overall effect: Z = 0.10 (P = 0.92)								
Total (95% CI)			**1435**			**1427**	**100.0%**	**−0.22 [−0.35, −0.09]**
Heterogeneity: $Tau^2 = 0.11$; $Chi^2 = 118.61$, df = 45 (P < 0.00001); $I^2 = 62\%$								
Test for overall effect: Z = 3.37 (P = 0.0007)								
Test for subgroup differences: $Chi^2 = 4.45$, df = 1 (P = 0.03), $I^2 = 77.5\%$								

Std. Mean Difference
IV, Random, 95% CI

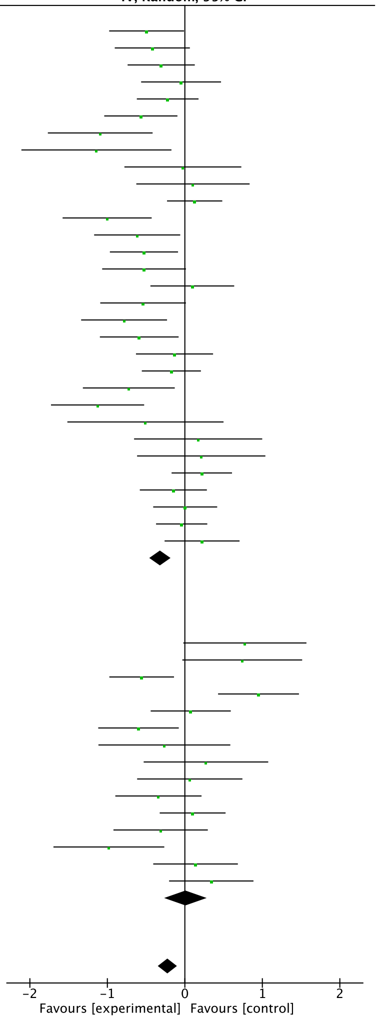


Figure E12

Forest Plot of Laboratory Measures of Food Intake versus Non-Laboratory Measures

	Experimental			Control				Std. Mean Difference
Study or Subgroup	**Mean**	**SD**	**Total**	**Mean**	**SD**	**Total**	**Weight**	**IV, Random, 95% CI**
1.11.1 Laboratory measure								
Allirot 2018	275.55	202.9807	35	388.82	248.4162	35	2.4%	−0.49 [−0.97, −0.02]
Arch 2016	196.68	135.24	33	259.65	159.23	36	2.4%	−0.42 [−0.90, 0.06]
Cavanagh 2014	273.41	153.24	32	319.91	150.05	64	2.6%	−0.31 [−0.73, 0.12]
Chang 2018	5.39	3.7	33	5.7	8.42	27	2.3%	−0.05 [−0.56, 0.46]
de Tomas 2022	421.83	205.02	50	470.95	233.57	51	2.8%	−0.22 [−0.61, 0.17]
Dutt 2019	2.21	3.67	38	5.33	6.82	36	2.5%	−0.57 [−1.03, −0.10]
Fisher 2016	0.7	0.75	20	2.2	1.75	20	1.8%	−1.09 [−1.76, −0.42]
Gayoso 2021	295.27	166.52	46	393.37	181.85	49	2.7%	−0.56 [−0.97, −0.15]
Higgs 2011	26.22	15.97	10	53.38	28	10	1.2%	−1.14 [−2.10, −0.18]
Hinton 2021 Fullness	249	236	22	255	208	10	1.6%	−0.03 [−0.77, 0.72]
Hinton 2021 Taste	279	231	22	255	208	11	1.7%	0.10 [−0.62, 0.83]
Hsu 2021	280.75	225.16	63	254.37	188.17	63	2.9%	0.13 [−0.22, 0.48]
Hussain 2020 Self-distanced MCD	76.88	59.34	40	170.25	136.19	20	2.1%	−1.00 [−1.57, −0.43]
Hussain 2020 Self-immersed MCD	98.25	103.92	40	170.25	136.19	20	2.2%	−0.62 [−1.16, −0.07]
Hussain 2021	48.22	67.55	43	94.48	102.95	42	2.6%	−0.53 [−0.96, −0.09]
Jordan 2014	149.17	91.11	27	197.58	90.24	29	2.2%	−0.53 [−1.06, 0.01]
Long 2011	443.4	182.9046	27	425.8	177.7084	27	2.2%	0.10 [−0.44, 0.63]
Mantzios 2019 MCD	1	1.16	40	1.63	1.14	20	2.2%	−0.54 [−1.09, 0.01]
Mantzios 2019 Mindful Raisin Exercise	0.74	1.11	40	1.63	1.14	21	2.2%	−0.78 [−1.33, −0.24]
Mantzios 2020 First Intake	16.44	15.76	32	26.64	18.38	32	2.4%	−0.59 [−1.09, −0.09]
Mantzios 2020 Second Intake	5.11	10.2	32	6.38	8.54	32	2.4%	−0.13 [−0.62, 0.36]
Marchiori 2014	171.51	95.04	55	190.78	122.97	55	2.8%	−0.17 [−0.55, 0.20]
Masih 2020	3,190	1,359	17	3,104	1,291	17	1.8%	0.06 [−0.61, 0.74]
Robinson 2014	250	92	25	356	185	23	2.1%	−0.72 [−1.31, −0.14]
Seguias 2018	112.3	70.24	26	203.2	88.05	25	2.1%	−1.13 [−1.72, −0.53]
Simonson 2020	700.08	300.66	8	861.46	299.4	8	1.1%	−0.51 [−1.51, 0.49]
Tapper 2020 Taste-test	166	105	11	144	96	12	1.5%	0.21 [−0.61, 1.03]
Van de Veer 2016 Study 2	37.2	25.69	40	32.2701	20.5065	77	2.8%	0.22 [−0.16, 0.60]
Van de Veer 2016 Study 4	22.37	15.06	43	24.86	18.07	42	2.6%	−0.15 [−0.57, 0.28]
Whitelock 2018 Study 1	365.03	221.99	34	364.145	192.615	74	2.7%	0.00 [−0.40, 0.41]
Whitelock 2018 Study 2	328.46	157.58	70	334.73	145.73	77	3.0%	−0.04 [−0.36, 0.28]
Whitelock 2019a	419.97	193.45	34	375.25	204.44	34	2.4%	0.22 [−0.25, 0.70]
Whitelock 2019b Taste-test	162.24	109.59	27	125.09	105.15	27	2.2%	0.34 [−0.20, 0.88]
Subtotal (95% CI)			**1115**			**1126**	**74.7%**	**−0.30 [−0.43, −0.17]**
Heterogeneity: $Tau^2 = 0.08; Chi^2 = 71.27, df = 32 (P < 0.0001); I^2 = 55\%$								
Test for overall effect: Z = 4.52 (P < 0.00001)								
1.11.2 Non-laboratory measure								
Bennett 2020 Mindful Breathing	51.32	45.76	20	18.48	29.58	10	1.5%	0.77 [−0.01, 1.56]
Bennett 2020 Mindful Raisin Eating	51.47	48	23	18.48	29.58	10	1.6%	0.74 [−0.03, 1.51]
Hong 2018	2.15	0.73	31	1.33	0.95	34	2.3%	0.95 [0.44, 1.47]
Jenkins 2014 Acceptance	51.78	111.43	45	44.02	75.56	22	2.3%	0.08 [−0.43, 0.59]
Jenkins 2014 Cognitive Defusion	13.43	31.28	45	44.02	75.56	23	2.3%	−0.60 [−1.11, −0.09]
Martin 2017 Mindful Decision-Making	444.3	653.35	8	624.1	660.1	17	1.4%	−0.26 [−1.11, 0.58]
Martin 2017 Mindful Eating	444.3	653.35	9	264.7	634.65	19	1.5%	0.27 [−0.52, 1.07]
Sant'Anna 2022	1,222	435	28	1,380	480	24	2.2%	−0.34 [−0.89, 0.21]
Seguias 2022	1,594	425	33	1,543.5	530.8386	66	2.7%	0.10 [−0.32, 0.52]
Spadaro 2018	1,380.4	674.9508	22	1,602.7	721.6197	21	2.0%	−0.31 [−0.91, 0.29]
Tapper 2020 Half-day Period	839	496	11	759	403	12	1.5%	0.17 [−0.65, 0.99]
Timmerman 2012	1,417.1	330.1	19	1,782	400.1	16	1.7%	−0.98 [−1.69, −0.27]
Whitelock 2019b Self-report	1,831.46	869.28	26	1,720.15	716.04	27	2.2%	0.14 [−0.40, 0.68]
Subtotal (95% CI)			**320**			**301**	**25.3%**	**0.05 [−0.25, 0.35]**
Heterogeneity: $Tau^2 = 0.20; Chi^2 = 36.79, df = 12 (P = 0.0002); I^2 = 67\%$								
Test for overall effect: Z = 0.31 (P = 0.76)								
Total (95% CI)			**1435**			**1427**	**100.0%**	**−0.22 [−0.35, −0.09]**
Heterogeneity: $Tau^2 = 0.11; Chi^2 = 118.61, df = 45 (P < 0.00001); I^2 = 62\%$								
Test for overall effect: Z = 3.37 (P = 0.0007)								
Test for subgroup differences: $Chi^2 = 4.43, df = 1 (P = 0.04), I^2 = 77.4\%$								

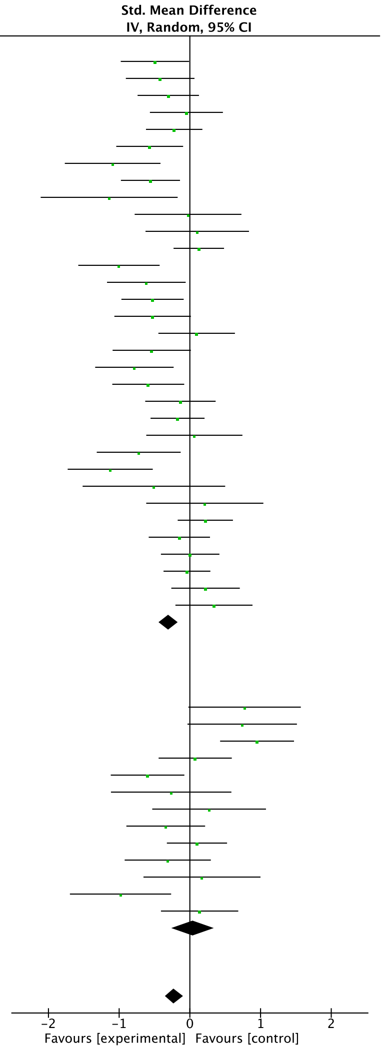
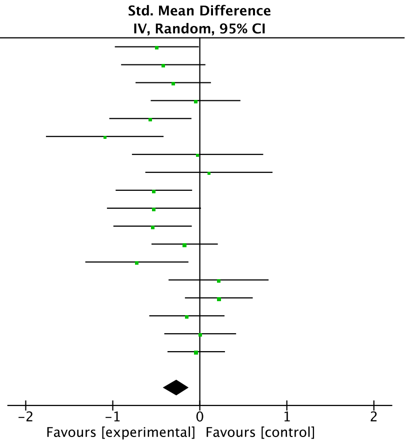


Figure E13

Forest Plot of Studies with Low Risk of Bias

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
Allirot 2018	275.55202	202.9807	35	388.82	248.4162	35	5.6%	−0.49 [−0.97, −0.02]
Arch 2016	196.68	135.24	33	259.65	159.23	36	5.6%	−0.42 [−0.90, 0.06]
Cavanagh 2014	273.41	153.24	32	319.91	150.05	64	6.4%	−0.31 [−0.73, 0.12]
Chang 2018	5.39	3.7	33	5.7	8.42	27	5.2%	−0.05 [−0.56, 0.46]
Dutt 2019	2.21	3.67	38	5.33	6.82	36	5.8%	−0.57 [−1.03, −0.10]
Fisher 2016	0.7	0.75	20	2.2	1.75	20	3.6%	−1.09 [−1.76, −0.42]
Hinton 2021 Fullness	249	236	22	255	208	10	3.0%	−0.03 [−0.77, 0.72]
Hinton 2021 Taste	279	231	22	255	208	11	3.2%	0.10 [−0.62, 0.83]
Hussain 2021	48.22	67.55	43	94.48	102.95	42	6.3%	−0.53 [−0.96, −0.09]
Jordan 2014	149.17	91.11	27	197.58	90.24	29	4.9%	−0.53 [−1.06, 0.01]
Mantzios 2019 MCD	1	1.16	40	1.63	1.14	41	6.1%	−0.54 [−0.99, −0.10]
Marchiori 2014	171.51	95.04	55	190.78	122.97	55	7.2%	−0.17 [−0.55, 0.20]
Robinson 2014	250	92	25	356	185	23	4.3%	−0.72 [−1.31, −0.14]
Tapper 2020 Taste-test	166	105	23	144	96	25	4.5%	0.22 [−0.35, 0.78]
Van de Veer 2016 Study 2	37.2	25.69	40	32.2701	20.5065	77	7.1%	0.22 [−0.16, 0.60]
Van de Veer 2016 Study 4	22.37	15.06	43	24.86	18.07	42	6.4%	−0.15 [−0.57, 0.28]
Whitelock 2018 Study 1	365.03	221.99	34	364.145	192.615	74	6.7%	0.00 [−0.40, 0.41]
Whitelock 2018 Study 2	328.46	157.58	70	334.73	145.73	77	8.2%	−0.04 [−0.36, 0.28]
Total (95% CI)			**635**			**724**	**100.0%**	**−0.27 [−0.41, −0.12]**

Heterogeneity: $Tau^2 = 0.04$; $Chi^2 = 29.90$, $df = 17$ ($P = 0.03$); $I^2 = 43\%$
Test for overall effect: $Z = 3.51$ ($P = 0.0004$)

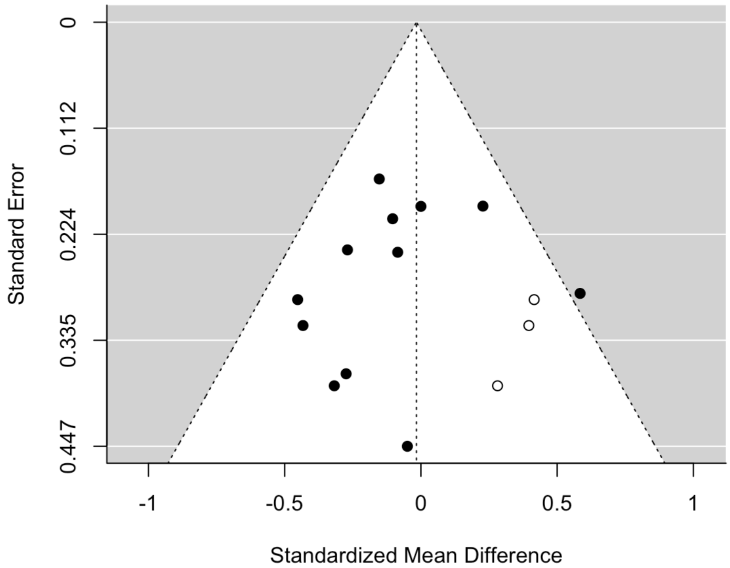


Appendix F

Chapter Two: Trim and Fill Output for Immediate Hunger Outcome

Figure F1

Funnel Plot of Studies Measuring Immediate Hunger with Missing Effect Sizes

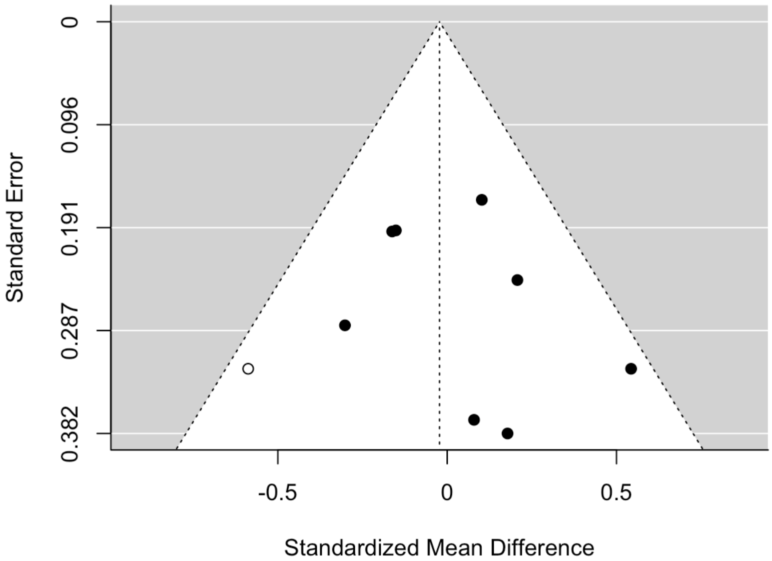


Appendix G

Chapter Two: Trim and Fill Output for Immediate Fullness Outcome

Figure G1

Funnel Plot of Studies Measuring Immediate Fullness with Missing Effect Sizes



Appendix H

Chapter Three: Audio Scripts

Practice body scan (3 minutes)

0 mins: Begin by making yourself comfortable. Sitting in the chair, allowing your back to be straight, but not stiff, with your feet on the ground. Resting your hands gently in your lap. Allowing your eyes to close slowly…
5 second pause

0:25 mins: …and bringing your attention to the fact that you are breathing.
5 second pause

0:35 mins: Taking several long, slow, deep breaths.
5 second pause

0:45 mins: Breathing in through your nose and out through your mouth.
5 second pause

55 min: Feeling your stomach expand on an inhale and relax as you exhale.
5 second pause

1:05 mins: If you notice your mind beginning to wander, gently bringing it back to focus on your breathing.
5 second pause

1:15 mins: Allowing the breath to return to its natural rhythm and just feeling the weight of the body pressed down on the chair.
5 second pause

1:30 mins: Bringing your attention to the top of the head, and gently scanning down, through the body, from head to toe. What sensations are you experiencing?
10 second pause

1:50 mins: Just noticing the different sensations as you scan down. Not moving, not trying to change anything. Just observing, watching as you move the mind down through the body.
10 second pause

2:15 mins: Allowing thoughts to come and go. The moment you realise you've been distracted, lost in thought, just letting go of that thinking and bringing the attention back again to the body as you continue to scan down towards the toes.
10 second pause

2:40 mins: Taking a full deep breath as you come to the end of this exercise.
5 second pause

2:50 mins: Exhaling fully, and when you feel ready, slowly open your eyes and bring your attention back to the room.

3 mins: End

Main body scan (10 minutes)
0 mins: Begin by making yourself comfortable. Sitting in the chair, allowing your back to be straight, but not stiff, with your feet on the ground. Resting your hands gently in your lap. Allowing your eyes to close slowly…
5 second pause

0:25 mins: …and bringing the focus of your attention to your breath, taking several slow deep breaths.
5 second pause

0:40 mins: Breathing in through your nose and out through your mouth.
5 second pause

0:50 mins: Noticing how the breath feels as it moves through your nose and mouth.
10 second pause

1:10 min: And allowing the breath to return to its natural rhythm, simply experiencing it as the air moves in and out of your body.
5 second pause

1:25 mins: If you notice your mind beginning to wander, gently bringing it back to focus on your breathing.
5 second pause

1:40 mins: Now bringing your attention to the top of your head, noticing the sensations that are here.
5 second pause

1:55 mins: Thinking about how your head is positioned. Is it aligned with your spine, or is it drooping?
5 second pause

2:10 mins: Exploring next the sensations across your scalp, in your forehead and your ears. What feelings are present here?
5 second pause

2:25 mins: Moving your attention down to your face, noticing how it feels.
5 second pause

2:35 mins: Thinking about your brow, is it smooth and flat or is it crinkled up?
5 second pause

2:45 mins: Now moving your attention to your eyes and your cheeks, noticing any sensations present. What expression is on your face?
5 second pause

3 mins: Moving your awareness into your nostrils, noticing the air pass in and out as you breathe. How does your breath feel? Is it warm or is it cold?
5 second pause
3:15 mins: Moving your attention down your face and noticing any sensations in your lips and jaw.
5 second pause

3:25 mins: If you notice your mind wandering, gently bringing your attention back to the sensations in your face.
5 second pause

3:40 mins: Now moving your awareness to your mouth, how is it positioned? Is it open or closed? Is it pursed?
5 second pause

3:55 mins: Paying attention to the inside of your mouth now, exploring the sensations in your tongue and your teeth.
5 second pause

4:10 mins: How does the inside of your mouth feel? Is it wet or is it dry?
5 second pause

4:20 mins: Moving awareness to your throat, explore the sensations present here.
5 second pause

4:30 mins: Can you feel your saliva coat the inside of your mouth and throat?
5 second pause

4:40 mins: Allowing thoughts to come and go. The moment you realise you've been distracted, lost in thought, just letting go of that thinking and bringing the attention back again to the body.
10 second pause

5:05 mins: Now moving awareness down into your neck and your shoulders. Observing what sensations are present here. Does it feel stiff or relaxed?
5 second pause

5:20 mins: Now moving your attention down into your chest and upper back, noticing the sensations of movement as you breath in and out.
5 second pause

5:35 mins: Noticing how each breath feels, not trying to control your breathing, simply paying attention.
5 second pause

5:45 mins: Noticing the air flowing through you, filling your chest and emptying out again.
5 second pause

5:55 mins: Now moving your attention down into your upper and then lower arms, noticing how they feel.
5 second pause

6:10 mins: Next, moving your attention down into your hands. Seeing how they feel as they rest in your lap.
5 second pause

6:25 mins: Continuously bringing your attention back to the body as soon you notice your mind wandering.
5 second pause

6:40 mins: Now directing your attention to your belly, to your stomach and becoming aware of whatever sensations are present in this part of your body.
10 second pause

7 mins: Exploring how your stomach feels. Does it feel full or empty? Is it making any noises?
5 second pause

7:10 mins: Staying here, paying attention to any sensations you find.
5 second pause

7:20 mins: And now moving your attention down into your lower back and then your hips, noticing any sensations present.
5 second pause

7:35 mins: Now directing your attention down into your bottom and your thighs, observing the sensations present here, noticing the pressure of the chair supporting you.
5 second pause

7:55 mins: Gently bringing your attention back to the body if your mind begins to wander.

5 second pause

8:05 mins: Next, moving the focus of your attention into your knees and down into your legs, noticing how they feel. What sensations are you aware of?
5 second pause

8:20 mins: Bringing your awareness down to your ankles, noticing what sensations are present here.
5 second pause

8:30 mins: Moving awareness further down, tuning into sensations in your toes, noticing how they feel.
5 second pause

8:45 mins: Now moving your focus to the bottom of your feet, the soles, and heel. Noticing whatever sensations are here, right now.
5 second pause

9 mins: If you notice your mind starting to wander, just gently bringing your attention back to your feet.
5 second pause

9:15 mins: Taking a full deep breath as you come to the end of this exercise.
5 second pause

9:25 mins: Bringing your awareness back to your body again and feeling it as a whole.
5 second pause

9:35 mins: Exhaling fully, and when you feel ready, slowly open your eyes and bring your attention back to the room.
5 second pause

9:50 mins: As you continue with the rest of this study, every now and again, please try to repeat parts of this relaxation technique.

10 mins: End

Practice guided imagery (3 minutes)
0 mins: Begin by making yourself comfortable. Sitting in the chair, allowing your back to be straight, but not stiff, with your feet on the ground. Resting your hands gently in your lap. Allowing your eyes to close slowly…
5 second pause

0:25 mins: Imagine that you are walking along the edge of a field towards a small wood just ahead of you.
5 second pause

0:35 mins: The sun is out and the air is bright and fresh.
5 second pause

0:45 mins: You walk into the woods along a narrow path between the trees.
5 second pause

0:55 mins: The trees extend their leafy branches down to the earth.
5 second pause

1:05 min: Brightly coloured birds call from the woods, their voices rising and fading.
5 second pause

1:15 mins: You can smell the damp earth and can see a haze of blue in the distance. Look up to see bits of the blue, blue sky through the tops of the trees.
5 second pause

1:30 mins: In front of you a winding path leads uphill through the trees. You look down at the earthy path beneath your feet as you travel through the woods.
10 second pause

1:50 mins: Ahead of you is a large log that has fallen and settled in the middle of the woods. You notice the contours of its rough, old bark. You sit on the log and look around you at the woods.
10 second pause

2:15 mins: You can hear a stream running past somewhere nearby. There are sounds of bird song and the breeze in the tree branches. Catch glimpses of birds as they fly from one tree to the next.
10 second pause

2:40 mins: The sounds of the woods are all around you.
5 second pause

2:50 mins: As you come to the end of this exercise, when you feel ready, slowly open your eyes and bring your attention back to the room.

3 mins: End

Main guided imagery (10 minutes)
0 mins: Begin by making yourself comfortable. Sitting in the chair, allowing your back to be straight, but not stiff, with your feet on the ground. Resting your hands gently in your lap. Allowing your eyes to close slowly…
5 second pause

0:25 mins: Imagine that you are standing at the edge of a field. The sun is out and the air is bright and fresh.
5 second pause

0:40 mins: You see a tree line where a forest begins only a few feet away.
5 second pause

0:50 mins: Just on the other side of the tree line, you see a trail. So you walk out of the field towards the path and enter into the woods.
10 second pause

1:10 min: Brightly coloured birds call from the woods, their voices rising and fading. The light in the forest cascades down through the leaves in a soft spray of light.
5 second pause

1:25 mins: Sunlight plays with the leaves and casts shadows on the path. The layers of the forest have various textures.
5 second pause

1:40 mins: There are ferns, moss, and small growths reaching towards the light. Thousands of shades of green moss carpet the ground beneath the trees.
5 second pause

1:55 mins:. The upper canopy of the trees covers you like a stained glass roof overhead. You look up and catch glimpses of birds as they fly from one tree to the next.
5 second pause

2:10 mins: The light green leaves against the light blue and white sky create a soft glowing light. The light is gentle, ambient, and soothing.
5 second pause

2:25 mins: The path you are walking upon winds down a slight hill and curves.
5 second pause

2:35 mins: The path is a combination of soil, roots, twigs and small plants, and it is easy to walk upon.
5 second pause

2:45 mins: It's well-trodden, and you continue to follow it. You can smell the damp earth and you hear the twigs breaking under your feet.
5 second pause

3 mins: You look down and see the earthy path beneath your feet as you travel through the forest.
5 second pause

3:15 mins: The trees become denser and the air becomes cooler.
5 second pause

3:25 mins: It becomes darker as the trees grow closer together. You can see blue sky through the trees.
5 second pause

3:40 mins: All around you are bluebells, bobbing their heads in the breeze. The scent of the bluebells wafts around you.
5 second pause

3:55 mins: Once you round the corner, you see a stream. You continue toward it, admiring the large trees and the different types of bark on each tree trunk.
5 second pause

4:10 mins: Some trees have rough bark, and some have smooth bark; some are light, and others dark.
5 second pause

4:20 mins: As you near the stream, you can hear the rippling water sounds getting louder in a constant rhythm.
5 second pause

4:30 mins: You see the rocks just under the surface of the water.
5 second pause

4:40 mins: The water swirls around some of the rocks and pours over others. You decide to sit upon a large tree that has fallen over and notice the contours of its rough, old bark.
10 second pause

5:05 mins: The woodland creatures are going about their daily business, unaware of your presence. A robin comes close, and you can see the red of his chest.
5 second pause

5:20 mins: Further away you see beetles and ants scurrying along. You slip your shoes off and dip your bare feet in the stream.
5 second pause

5:35 mins: You notice that the water is swirling around and over your feet.
5 second pause

5:45 mins: You sit there and watch the water flow slowly down the stream.
5 second pause

5:55 mins: You can hear birds chirping around the forest. There are several different birds sounding. You can also hear the breeze fluttering through the leaves on the trees.
5 second pause

6:10 mins: The sounds of the forest are all around you. You close your eyes and listen to the sounds.
5 second pause

6:25 mins: After you rest for a while, watching your surroundings, you decide that you are ready to leave.
5 second pause

6:40 mins: You grab your shoes, put each one on, and step to the dry bank of the stream. You see the path that brought you here and start back up the hill and around the bend.
10 second pause

7 mins: As you walk back, many of the trees seem familiar.
5 second pause

7:10 mins: The breeze continues to blow through the treetops.
5 second pause

7:20 mins: But you are sheltered on the path, and the air around you is calm. You can still hear the sounds of the forest.
5 second pause

7:35 mins: The birds singing, the leaves on the trees swaying in the breeze and the rippling of the stream faintly in the distance. You once again notice the smell of the bluebells and the damp earth on the forest floor.
5 second pause

7:55 mins: You see the earthy path beneath your feet again as you travel out of the forest.
5 second pause

8:05 mins: You see the sunlight filter down through the trees, soft and golden. You see the bright entrance to your path up ahead.
5 second pause

8:20 mins: As you approach the entrance, you stop and linger.
5 second pause

8:30 mins: You turn around and look down the path, taking note of everything that you are seeing and hearing.
5 second pause

8:45 mins: For one final time, you take in the immense array of greens around you and the different textures of the forest.
5 second pause

9 mins: You catch a final glimpse of the woodland creatures scurrying about, darting in and out of sight.
5 second pause

9:15 mins: The different sounds of the forest start to fade out in the distance.
5 second pause

9:25 mins: Finally, you exit the forest, and find yourself in a bright field.
5 second pause

9:35 mins: As you come to the end of this exercise, when you feel ready, slowly open your eyes and bring your attention back to the room.
5 second pause

9:50 mins: As you continue with the rest of this study, every now and again, please try to repeat parts of this relaxation technique.

10 mins: End

Appendix I

Chapter Three: Supplementary Analyses

Relationship between hunger and mediators

Hunger was entered as a covariate in the main PROCESS model, and it was found that increased hunger was associated with increased eating automaticity ($b = 0.04$, $SE = 0.01$, 95% CI [0.01, 0.07], $\beta = 0.24$, $p < 0.01$) and decreased appeal-satisfaction scores ($b = -0.09$, $SE = 0.02$, 95% CI [-0.14, -0.05], $\beta = -0.33$, $p < 0.01$). However, hunger did not predict state mindfulness ($b = -0.00$, $SE = 0.01$, 95% CI [-0.02, 0.02], $\beta = -0.01$, $p = 0.90$) or attention to the stomach and mouth ($b = -0.00$, $SE = 0.002$, 95% CI [-0.01, 0.01], $\beta = -0.004$, $p = 0.96$).

Exploratory moderation analysis

PROCESS Model 1 was employed to test whether hunger, trait mindful eating, interoceptive awareness, dieting status, restrained eating, and motivation to eat healthy moderated the effect of intervention condition on food intake. Each moderator was tested in a separate model and all variables were mean centred. The results are presented in Table I1. These findings show that the effect of condition on food intake was not moderated by any of the variables.

Exploratory analyses: mediating effect of external reasons individuals stopped eating

As part of the Reasons Individuals Stop Eating questionnaire (RISE-Q), two additional items (‘The researcher came back’ and ‘The show had ended’) were used to assess the extent to which participants relied on external reasons to stop eating while watching the TV show. These items were rated on a 7-point Likert scale ranging from 1 (completely untrue for me) to 7 (completely true for me).

PROCESS model 4 was employed to explore whether the extent to which participants relied on external reasons to stop eating mediated the effect of condition on food intake. Greater reliance on external reasons to stop eating significantly predicted food intake ($b = 1.18$, $SE = 0.45$, 95% CI [0.30, 2.07], $\beta = 0.23$, $p < 0.001$), however, the indirect effect of condition on food intake was not significant ($b = 0.70$, $SE = 1.06$, 95% CI [-1.13, 3.18], partially standardised $\beta = 0.03$). This indicates that individuals with increased reliance on external reasons consumed more food, however, reliance on external reasons to stop eating did not mediate the relationship between condition and food consumption.

Table I1

Predictors and Moderators of Food Consumption

Predictor	*b*	*SE*	*p*	95% CI LL	95% CI UL
Hunger					
Condition	1.12	3.94	0.78	-6.68	8.93
Hunger	0.26	0.07	<0.001	0.12	0.41
Condition x hunger	0.02	0.15	0.89	-0.27	0.32
Trait mindful eating					
Condition	1.26	4.12	0.76	-6.88	9.41
Trait mindful eating	-0.33	0.29	0.26	-0.91	0.25
Condition x trait mindful eating	0.22	0.59	0.71	-0.95	1.38
Interoceptive awareness					
Condition	1.67	4.08	0.68	-6.40	9.73
Interoceptive awareness	-0.11	0.28	0.70	-0.65	0.44
Condition x interoceptive awareness	0.98	0.55	0.08	-0.11	2.07
Dieting status					
Condition	1.69	4.30	0.69	-6.81	10.19
Dieting status	-0.60	3.25	0.85	-7.03	5.83
Condition x dieting status	4.10	6.61	0.54	-8.98	17.17
Restrained eating					
Condition	2.20	4.14	0.60	-6.00	10.40
Restrained eating	-0.04	0.91	0.96	-1.85	1.77
Condition x restrained eating	3.17	1.83	0.09	-0.44	6.79
Healthy eating motivation					
Condition	1.38	4.10	0.74	-6.72	9.48
Motivation	-2.80	2.29	0.22	-7.34	1.73
Condition x motivation	4.70	4.58	0.31	-4.36	13.75

b: unstandardised beta coefficient; *SE:* standard error; CI: confidence interval; LL: lower level; UL: upper level.

Appendix J

Chapter Four: Strategy Information

STRATEGY 1: SENSORY EATING (SHORT)

Pay attention to the taste and texture of food in your mouth

People who eat more slowly, eat less. And the longer food spends in your mouth, the more it promotes the release of gut hormones that help you feel full. To slow your eating, pay attention to the sensory properties of your food - its taste, texture, and temperature. Notice how these change as you chew. Imagine you are a culinary critic, trying to describe the food you're eating.

STRATEGY 1: SENSORY EATING (LONG)

How to slow down your eating

The speed at which you eat tends to vary depending on the situation. For example, you may eat faster when you're very hungry, when you're in a hurry, or simply when you're enjoying a really good food! However, eating rate also varies between individuals with some people being naturally fast eaters and others being inclined to eat more slowly. Those who do eat more slowly tend to eat less and are less likely to struggle with their weight.

There are several reasons why slower eating could help you eat less. First, it can take around 20 minutes for fullness signals from your stomach to register in your brain. This means that if you eat very quickly you could overeat before you realise it. You may have experienced this yourself, when you've been very hungry, eaten a very large portion and perhaps regretted it later when your stomach felt uncomfortably full. Eating more slowly allows you to monitor more accurately how full you're getting, which may help prevent you from overeating.

The body also responds to food in the mouth by releasing hormones that help you feel full. The longer food spends in the mouth, the greater the release of these hormones. This means that chewing your food more slowly or chewing it for longer may make you feel fuller - this in turn could help you feel more satisfied with smaller servings.

Additionally, as you eat a food, your enjoyment of that food goes down relative to other foods with contrasting tastes. This is why you can sometimes feel like you've 'had enough' of a savoury main course but still have room for dessert! Eating a food more slowly may mean you reach this point of having 'had enough' after a smaller serving.

Slower eating has a couple of other advantages too – it can improve digestion and help your body absorb more nutrients from your food.

So, how can you slow down your rate of eating? There are plenty of suggestions out there. Some experts recommend chewing every mouthful for 30 seconds or putting your cutlery down between each bite. Others propose counting the number of times you chew each bite then trying to double this number. You can even buy an electronic fork that will beep at you if you're eating too fast! However, those who try these strategies don't always enjoy them, which means they can give up on them quite quickly.

An alternative strategy is to focus on the sensory properties of your food as you eat. This may be an easier strategy to stick to as it can actually increase the amount of pleasure you get from your food.

How can you go about doing this? Start by simply noticing the food in your mouth before you bite into it. Explore the feel and taste of it on your tongue and against the roof of your mouth. Is it smooth or textured? Sweet or salty? Sour or bitter? Warm or cool? Does the food taste different in different parts of your mouth?

As you bite into your food, notice any change in these sensations. Are new tastes released? What flavours can you detect? Is there anything surprising about the texture, or was it how you imagined it would be? Does your food make a sound?

Continue to notice these things as you chew. How do the tastes and textures change over time? Are there many different flavours or just one or two? Do new flavours emerge as the food breaks down? Do they get stronger or weaker?

You might find it helpful to imagine you are a culinary critic, who has been asked to comment on the food you're eating. How would you describe it to others? Is the texture hard or soft? Crumbly or crisp? What do the tastes and flavours remind you of? As sharp and lemony as a Spring morning? Or with hints of cinnamon that bring memories of Christmas? Which words and phrases best capture your experience? Feel free to be as poetic as you like!

STRATEGY 2: ATTENDING TO FULLNESS (SHORT)

Pay attention to your fullness

Feelings of fullness can prompt you to stop eating. However, sometimes it's easy to ignore these signals, especially if your attention is elsewhere. When you eat, try to notice how your body feels, especially your stomach. If you're doing something else, like watching TV or using your phone, keep asking yourself if you're still hungry or if you're feeling satisfied. If you're satisfied, stop eating and put any remaining food out of reach.

STRATEGY 2: ATTENDING TO FULLNESS (LONG)

How to avoid overeating

Eating too much in one sitting can cause your stomach to stretch beyond its normal size, making you feel uncomfortable. Unsurprisingly, this type of overeating can lead to weight gain. However, even eating just a little more than you need can lead to weight gain if it's something you do regularly. For example, eating an extra 100 calories a day could lead to weight gain of 10 lb (4.5 kg) by the end of the year. It's easy to eat an extra 100 calories without really noticing it, for example by having an extra slice of bread, chunk of cheese or scoop of ice cream.

There are lots of reasons why you may eat more than you need. Sometimes it might simply be that you're really enjoying the taste of the food! However, at other times you may eat too much because you're reluctant to waste food or you've simply got into the habit of eating everything on your plate. Large servings in restaurants and other food outlets don't help, as the more food you're served, the more you're likely to eat.

Another important contributor to overeating is environmental distractions. People tend to eat more when they're doing other things such as watching TV, chatting or using a smartphone. For example, one study found that people ate 15% more when distracted by a smartphone! This happens because you can only pay attention to one thing at a time, so if you're engrossed in a TV show or conversation, you can end up eating on autopilot and fail to notice when you've had enough or when you're no longer really enjoying the food. As a result, you may eat much more than you want or need.

So, how can you avoid overeating? Serving yourself smaller portions is a good place to start. You could also try eating without distractions, for example by turning off your phone or TV. However, this will not always be practical or desirable. Sometimes you may need to multi-task to get things done and other times you may get a lot of pleasure from pairing food with conversation or entertainment.

An alternative strategy is to cultivate the habit of periodically bringing your attention back to your food and your body, to monitor your feelings of hunger and fullness. By repeatedly bringing your awareness to your body as you eat, you're more likely to spot the point at which you've eaten enough. In this way, you can avoid eating too much.

To become more aware of sensations of fullness, keep pausing to check in with your body. Stop eating for a moment, put down your utensils and pay attention to how hungry or satisfied you feel. Are you still truly hungry, or are you starting to feel full? Take a moment to assess how full you are and then consciously decide whether or not you want to keep eating. If you feel you've eaten enough, put any remaining food out of reach.

This awareness will allow you to adjust your portions and stop eating before you eat more than you need and before you reach the point of uncomfortable fullness. Remember, it's okay to leave food on your plate.

You may also find it helpful to use a hunger-fullness scale. Before and during your meals, assess your hunger and fullness levels on a scale from 1 to 10, with 1 being starving and 10 being uncomfortably stuffed. Aim to start eating when you're at a moderate level of hunger (around 3-4) and stop eating when you're comfortably satisfied (around 6-7). This can help you keep in touch with your body's signals and avoid eating too much.

STRATEGY 3: VEGETABLES FIRST (SHORT)

Eat fibre-rich vegetables or salad first

Hunger and cravings may sometimes be the result of a dip in blood glucose levels. You may experience a dip in blood glucose after eating carbohydrate-rich foods that release glucose into the bloodstream very quickly. To slow glucose absorption, try eating fibre-rich vegetables or salad at the start of your meal. If you're having a carbohydrate-based snack or breakfast, try grabbing a handful of salad to eat first.

STRATEGY 3: VEGETABLES FIRST (LONG)

A tip for reducing hunger and cravings

Hunger and cravings may sometimes be caused by low blood glucose levels. Blood glucose refers to the amount of glucose in your bloodstream. Glucose is a type of sugar and blood glucose levels are influenced by a range of different factors including the food you eat.

When you eat foods containing carbohydrates, this is broken down by the body into glucose and absorbed into the bloodstream. If you eat complex carbohydrates (like wholegrains) they take longer for your body to break down, and the glucose enters your bloodstream more slowly. However, other types of carbohydrates (such as refined sugars) result in glucose entering your bloodstream much more quickly.

When glucose enters your bloodstream quickly, it can lead to a rapid rise (or 'spike') in blood glucose levels. Your body responds by releasing lots of insulin in order to bring these levels down. This can in turn lead to a sharp drop (or 'dip') in blood glucose levels. It is this dip that could make you feel hungry and could lead you to crave sugary, high calorie foods.

If you find yourself experiencing hunger and cravings a few hours after eating, it may be because of a dip in your blood glucose levels. By keeping your blood glucose levels more stable, and avoiding large spikes and dips, you may be able to reduce hunger and cravings.

There may also be other benefits to keeping your blood glucose levels more stable. Blood glucose dips may be associated with feelings of tiredness, irritability, and low mood as well as difficulties with concentration. More stable blood glucose could therefore help improve your mood and concentration and help you feel more energised throughout the day.

So, how can you keep your blood glucose levels more stable when eating? There are a few things you can try. Instead of choosing refined carbohydrates like white bread, white rice, and white pasta, go for wholegrains like wholewheat bread, brown rice and brown pasta. These complex carbohydrates are digested more slowly, causing a slower rise in blood glucose. It's also a good idea to try to limit highly processed foods that contain lots of refined sugars, such as biscuits, cakes, sweets and sugary drinks as these foods will release glucose into the bloodstream more quickly.

However, eating any kind of carbohydrate leads to an increase in blood glucose. And some people are more prone to blood glucose spikes and dips than others. Another way of reducing the impact of carbohydrates is to eat vegetables or salad first. Vegetables and salad are high in fibre which can slow down the absorption of glucose, preventing your blood glucose from rising too quickly.

Vegetables and salad also tend to have a high water content which makes them more filling. This means that if you eat them first, you may end up eating less of the high carbohydrate foods that could cause your blood glucose to spike and dip.

So, for more stable blood glucose levels, try to eat the salad or vegetables on your plate first, before eating the rest of your meal. If you're having a carbohydrate-based snack or a breakfast that doesn't contain vegetables, try to grab a handful of salad to eat first.

To make your vegetables even tastier, you could try different ways of cooking them, like steaming, sautéing, or roasting. You could also try them stir-fried or raw in salads. Different herbs, spices, and healthy dressings can add extra flavour whilst a squeeze of lemon or a sprinkle of vinegar can give them a tangy twist. So, next time you eat, start with your veggies!

STRATEGY 4: INCREASE PHYSICAL ACTIVITY (SHORT)
Do 5 minutes of physical activity after eating
Hunger and cravings may sometimes be the result of a dip in blood glucose levels. These dips can occur after carbohydrate-rich food has led to a rapid rise then fall in blood glucose. You can reduce this rise (and subsequent fall) by doing at least 5 minutes of physical activity after eating, since this makes your muscles use some of your blood glucose. This activity could take the form of a short walk, some resistance exercises or even just catching up on daily chores.

STRATEGY 4: INCREASE PHYSICAL ACTIVITY (LONG)
A tip for reducing hunger and cravings
Hunger and cravings may sometimes be caused by low blood glucose levels. Blood glucose refers to the amount of glucose in your bloodstream. Glucose is a type of sugar and blood glucose levels are influenced by a range of different factors including the food you eat.

When you eat foods containing carbohydrates, this is broken down by the body into glucose and absorbed into the bloodstream. If you eat complex carbohydrates (like wholegrains) they take longer for your body to break down, and the glucose enters your bloodstream more slowly. However, other types of carbohydrates (such as refined sugars) result in glucose entering your bloodstream much more quickly.

When glucose enters your bloodstream quickly, it can lead to a rapid rise (or 'spike') in blood glucose levels. Your body responds by releasing lots of insulin in order to bring these levels down. This can in turn lead to a sharp drop (or 'dip') in blood glucose levels. It is this dip that could make you feel hungry and could lead you to crave sugary, high calorie foods.

If you find yourself experiencing hunger and cravings a few hours after eating, it may be because of a dip in your blood glucose levels. By keeping your blood glucose levels more stable, and avoiding large spikes and dips, you may be able to reduce hunger and cravings.

There may also other benefits to keeping your blood glucose levels more stable. Blood glucose dips may be associated with feelings of tiredness, irritability, and low mood as well as difficulties with concentration. More stable blood glucose could therefore help improve your mood and concentration and help you feel more energised throughout the day.

So, how can you keep your blood glucose levels more stable when eating? There are a few things you can try. Instead of choosing refined carbohydrates like white bread, white rice, and white pasta, go for wholegrains like wholewheat bread, brown rice and brown pasta. These complex carbohydrates are digested more slowly, causing a slower rise in blood glucose. It’s also a good idea to try to limit highly processed foods that contain lots of refined sugars, such as biscuits, cakes, sweets and sugary drinks as these foods will release glucose into the bloodstream more quickly.

However, eating any kind of carbohydrate leads to an increase in blood glucose. And some people are more prone to blood glucose spikes and dips than others. Another way of reducing the impact of carbohydrates is to be physically active for at least 5 minutes after eating. This will make your muscles use some of your blood glucose for energy, which will in turn help reduce the amount your blood glucose rises. And if you can prevent your blood glucose from rising too high, you will reduce the size of any subsequent dip.

Aim to start your 5 minutes of physical activity as soon as possible after finishing your meal, though ideally within 30 minutes. The timing is important because it corresponds with when your blood glucose starts to rise.

Choose an activity that is practical, convenient, and enjoyable. It doesn’t have to be too intense - the important thing is that it gets your muscles moving. Walking is a good choice because you can do it anywhere, indoors or outdoors. Simple strength exercises like squats, sit-ups or lunges can work well too. Or you could just catch up on daily chores, such as tidying, cleaning or running errands – anything that gets you up on your feet for 5 minutes. If you have limited mobility, seated exercises or gentle stretching routines can be a good option. The key is to get your body moving and increase your heart rate. So, next time you eat, remember to also get moving!

Appendix K

Chapter Four: Multiple Choice Questions

Sensory eating

1. Paying attention to the taste and texture of food as you eat:
    a. slows eating, which helps reduce the number of calories your body absorbs
    b. slows eating, which promotes the release of gut hormones that help you feel full
    c. stimulates the senses, which can lead you to eat more
    d. helps your body distinguish between healthier and less healthy foods

Attending to fullness

2. Attending to feelings of fullness during a meal:
    a. helps direct your attention toward healthier foods
    b. may distract you from making healthy food choices
    c. can help you stop eating when you've had enough
    d. may mean you prioritise fullness over healthiness

Vegetables first

3. Eating fibre-rich vegetables or salad at the start of the meal:
    a. provides specific vitamins and minerals that satisfy hunger and reduce cravings
    b. slows the absorption of glucose, reducing blood glucose dips
    c. triggers a hormone response that suppresses appetite
    d. can lead to carbohydrate cravings that make you more likely to snack

Increase physical activity MCQ

4. Light physical activity after eating:
    a. helps muscles use glucose, reducing subsequent blood glucose dips
    b. increases your awareness of fullness signals
    c. can distract the mind from food
    d. interferes with digestion

Appendix L
Chapter Four: Qualitative Analyses

Method

Four optional open-ended questions were administered on the study app at the end of the study: *"Please describe your experience of taking part in this study over the past 2 weeks. How did you find using the strategy? How did you feel about this as a strategy to help you manage your weight?"*, *"Was there anything you particularly liked about the strategy, or the way it was delivered? Which aspects (if any) worked well for you?"*, *"What challenges (if any) did you encounter when using the strategy? What made it difficult, or what prevented you from using the strategy?"* and *"How do you think the strategy, or the way it was delivered, could be improved?".* The app enabled participants to either type or audio record their responses.

Data were analysed using content analysis on NVivo (version 12). Audio responses were transcribed and collated with written responses. Codes were then developed based on common responses. Data for each question were first coded separately, then condensed across all four questions by combining similar codes and developing overarching themes. A subset of responses (10%) was double coded, and the inter-observer reliability was 85%.

Results

A total of 120 participants completed the qualitative survey at the end of the study. A summary of participant characteristics is provided in Table L1. Four overarching themes were identified and are described below. See Table L2 for full details of the themes and subcategories.

Theme 1: Delivery

Many responses indicated that the Avicenna Research app was easy and simple to use and the daily survey notifications were useful. The strategy information was reported to be helpful, with many reporting that the rationale behind the strategy was explained well and was easy to understand. A small number of responses indicated the need for a longer timeframe to use the strategy in order to see benefits.

A common comment about the delivery of the study was the lack of reminders to use the strategy. The majority of responses indicated that notifications to remind participants to use their assigned strategy would have been helpful. The need for reminders was mentioned more in the two mindfulness conditions compared to the two physical strategies. This response was also more common among those who received tips than those who formed implementation intentions. A small number of responses indicated that more information about the assigned strategy would have been helpful, including both background information and more detail on using the strategy.

Theme 2: Strategy content

The majority of responses indicated that the assigned strategy was easy to use, and many reported that it was easy to get into the habit of using the strategy. This response was more common among those in the physical activity condition. The strategy content was reported to be helpful in many responses, particularly in relation to the 'attending to fullness' condition. About half of responses indicated that although the strategy was easy to use, it was difficult to remember to use it. This was more common among those in the two mindfulness conditions than the two physical conditions, and among those in the short format group than the long format group.

Theme 3: Outcomes

Many responses indicated that participants noticed an improvement in their health behaviours as a result of using their assigned strategy. The most common behaviours reported were improvements in eating habits, where participants noticed they were less prone to snacking and overeating, and more mindful of their food intake. Improvements in physical activity were also reported. Some responses indicated that using the assigned strategy helped with weight management. Other positive outcomes reported included feeling better and healthier and learning something new. A small number of responses indicated that participants had not noticed a change in their weight, or that they did not believe the strategy would help them with their weight management.

Theme 4: Personal factors

Some responses indicated that having a family interfered with use of the assigned strategy. This was often due to family responsibilities keeping participants too busy, thus having no time to use the strategy, or that their family distracted them and thus they were not able to focus on using the strategy. Work responsibilities were also reported to interfere with strategy use in some responses. Participants were either too busy with work to use the strategy, or the nature of their work did not allow them to use the strategy, e.g., they had no space to do physical activity, or they had no or short lunch breaks. Other interferences were also mentioned in some responses, such as having health issues, pet responsibilities, travelling, and financial issues.

Discussion

The qualitative aspect of the study revealed that comments about the study delivery were generally positive. Participants found the app simple and easy to use but reported that reminders would have been helpful. The assigned strategy was mostly reported to be helpful, effective, and easy to implement though there were some reports of finding it difficult to remember to use the strategy. There were reported improvements in health behaviours such as eating habits and physical activity as well as supporting weight management. Lack of adherence was commonly attributed to personal factors such as family or work commitments and other interferences such as health issues, financial issues and travelling. These findings provide useful insights on the acceptability of brief weight management interventions and highlight additional barriers which can be targeted to enhance adherence, such as difficulty remembering to use the strategy.

Table L1

Summary of Participant Characteristics who Participated in the Qualitative Survey

Characteristic	Count
Gender	
Woman	77
Man	41
Prefer not to say	1
Age	
20-29	5
30-29	11
40-49	36
50-59	38
60-69	24
70-79	6
Education	
No formal education	3
GCSEs/O-levels or equivalent	23
BTEC or equivalent	16
A-levels or equivalent	10
Undergraduate degree or equivalent	45
Master's degree or equivalent	21
Doctoral degree or equivalent	1
Prefer not to say	1
Ethnicity	
Asian or Asian British	11
Black, African, Caribbean or black British	5
Mixed or multiple ethnic groups	2
White	99
Prefer not to say	3
BMI	
25 – 29.9 (overweight)	31
>30 (obese)	89
Strategy content	
Sensory eating	27
Fullness	34
Vegetables first	28
Physical activity	31
Planning prompts	
Implementation intentions	52
Tips	68
Information format	
Short	55
Long	65

Table L2

Themes and Subcategories Identified in Qualitative Analysis

Themes	Subcategories	Responses
Delivery	App features were useful	52
	Strategy information was helpful	26
	Need a longer timeframe	10
	Need more app features	41
	Need reminders to use strategy	47
	Need more information about strategy	10
Strategy content	Easy to use strategy or form a habit	103
	Strategy was helpful or effective	68
	Difficult to use strategy or form a habit	45
	Difficult to remember to use strategy	67
	Strategy was not helpful or effective	16
Outcomes	Enjoyed the experience of study	3
	Improved health behaviours	68
	Helped with weight management	15
	Helped feel better	4
	Learnt something new	6
	Did not help with weight management	9
Personal factors	Family	10
	Work	13
	Other interferences	38

Appendix M

Chapter Four: Additional Analyses

Additional reporting for the moderating effect of SSRQ on association between implementation intentions and adherence

There was a significant positive association between SSRQ scores and strategy adherence (b = 2.63, SE = 0.94, 95% CI [0.78, 4.48], p = .01), suggesting that greater planning skills were associated with greater adherence.

Additional reporting for the effect of free time on adherence

There was no significant difference in adherence between the *'very busy'* and *'quite busy'* group (b = 17.92, SE = 13.47, 95% CI [-8.68, 44.52], p = .10) or the *'plenty of free time'* group (b = 10.71, SE = 17.27, 95% CI [-23.39, 44.80], p = .54). The effect of information length on adherence did not significantly differ between the *'very busy'* group and the *'quite busy'* group (b = -8.59, SE = 8.34, 95% CI [-25.05, 7.87], p = .30) or the *'plenty of free time'* group. (b = -0.65, SE = 11.13, 95% CI [-22.61, 21.32], p = .95).

Additional reporting for the effect of diet/weight priority on adherence

The analysis revealed no significant difference in adherence between the high priority group and medium priority group (b = -6.17, SE = 12.64, 95% CI [-31.13, 18.78], p = .63) or the low priority group (b = -7.58, SE = 50.85, 95% CI [-108.00, 92.83], p = .88). The effect of information length on adherence did not significantly differ between the high priority group and the medium priority group (b = -0.65, SE = 8.33, 95% CI [-17.10, 15.80], p = .94) or the low priority group (b = 3.66, SE = 28.50, 95% CI [-52.60, 59.93], p = .90).

Additional reporting for the moderating effect of preference for time spending learning new things on the association between information format and adherence

The impact of information length on strategy adherence did not significantly differ between participants who preferred to spend a few minutes a day/30 mins a week learning new things and those who preferred to spend 15 mins a day/1-2 hours a week (b = 2.13, SE = 9.12, 95% CI [-15.85, 20.11], p = .82) or those who preferred to spend 30 mins a day/2-4 hours a week (b = 0.83, SE = 11.43, 95% CI [-21.75, 23.41], p = .94).

Additional exploratory analyses

Moderating effect of information format on association between need for cognition and preference for information length

Information format and the mean centred interaction between information length and NCS was added to the ordinal logistic regression model testing the effect of need for cognition on preference for information length. The interaction effect was not significant (OR = 0.93, 95% CI [0.20, 4.29], p = .93), suggesting that information length did not moderate the association between need for cognition and odds of preference for shorter information length.

Reasons for non-adherence

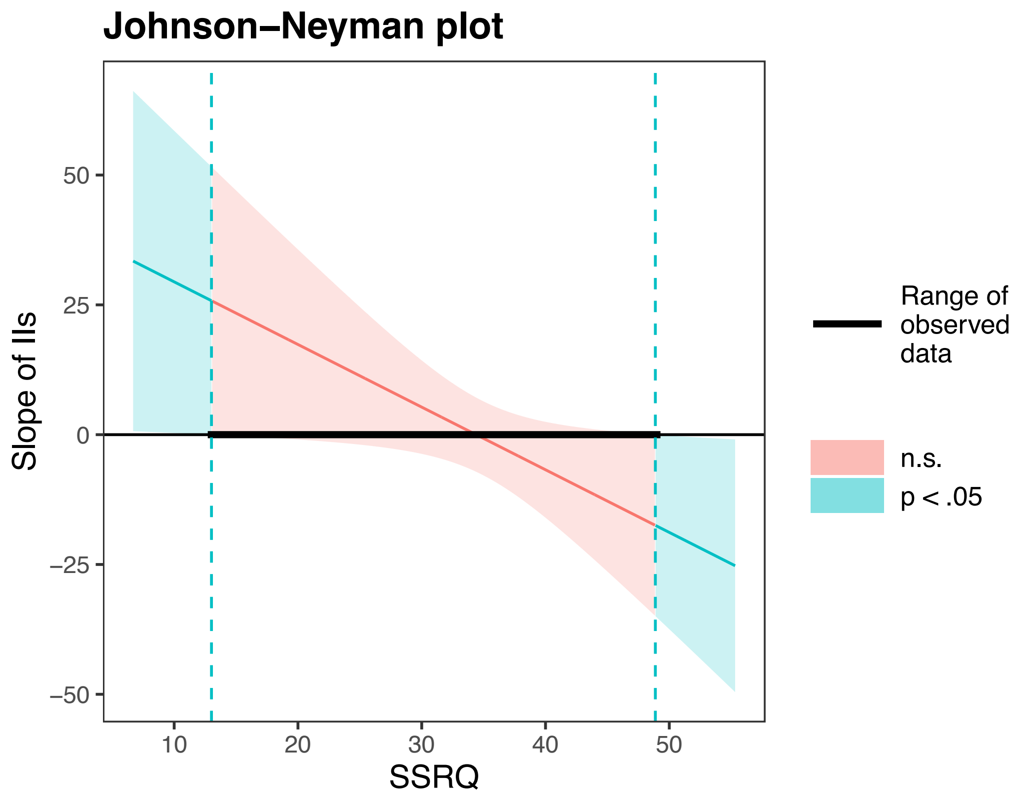
Additional descriptive analyses were conducted to explore whether non-adherence was a result of forgetting to use the strategy or for other reasons. The mean percentage of days that participants forgot to use the strategy was 16% (*SD* = 20) and the mean percentage of days that participants did not use the strategy for another reason was 14% (*SD* = 18) for those who completed at least 1 daily survey (n = 195). For those who completed at least 7 daily surveys (n = 169), the mean percentage of days participants forgot to use the strategy was 15% (*SD* = 18) and the mean percentage of days they reported not using the strategy for another reason was 14% (*SD* = 17). The data suggest that non-adherence was a result of both forgetting to use the strategy and other reasons.

Appendix N

Chapter Four: Johnson-Neyman Plot

Figure N1

Johnson-Neyman Plot for the Moderation Effect of Planning Skills on the Association Between Implementation Intentions and Adherence



IIs: implementation intentions; SSRQ: Short-form Self-Regulation Questionnaire.