# The role of mental health in adult behavioural weight management interventions

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This thesis is submitted for the degree of Doctor of Philosophy



### PREFACE

#### DECLARATION

This thesis is the result of my own work and includes nothing which is the outcome of work done in collaboration except as declared in the Preface and specified in the text. I further state that no substantial part of my thesis has already been submitted, or, is being concurrently submitted for any such degree, diploma or other qualification at the University of Cambridge or any other University or similar institution except as declared in the Preface and specified in the text. It does not exceed the prescribed word limit for the relevant Degree Committee

## ABSTRACT

# The role of mental health in adult behavioural weight management interventions - Rebecca A. Jones.

Established evidence reports that there is a bidirectional relationship between obesity and mental health, with obesity as both a cause and consequence of poor mental health. Treatments for obesity and poor mental health should account for this relationship, but often this is not the case. Behavioural weight management interventions are the most common form of obesity treatment across the United Kingdom. Whilst there is good evidence that these interventions can benefit physical health, the evidence for the effect on mental health is limited and unclear. By understanding how these interventions may impact mental health, potential adverse effects can be identified, and future intervention development informed to provide more effective support.

The overall aim of this thesis was to investigate the role of participant mental health in adult behavioural weight management interventions. The specific objectives were (i) to determine the short- and long-term impact of behavioural weight management interventions on the mental health of adults with overweight and obesity; (ii) to identify how participant mental health is associated with attendance and engagement with a behavioural weight management intervention and trial; (iii) to identify participant characteristics associated with changes in mental health in adults with obesity during and after a behavioural weight management intervention; and (iv) to explore participant experiences of a behavioural weight management intervention to better understand how well the intervention supports participant mental health, and how the intervention could be adapted to provide more effective support.

In Chapter Two, I conducted a systematic review and meta-analysis to assess the impact of behavioural weight management interventions on mental health in adults with overweight and obesity, compared to minimal intervention, 'standard care', or inactive control groups. I found evidence to suggest that, on average, interventions may benefit some aspects of mental health at intervention-end and 12 months from baseline. Notably, I found no evidence to suggest that interventions negatively impacted mental health (relative to comparator groups).

In Chapter Three, I present the study details and participant characteristics from the Weight loss Referrals for Adults in Primary care (WRAP) trial, which acted as a data source for Chapters Four, Five, and Six.

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In Chapter Four, I conducted quantitative analyses to investigate whether participant mental health at baseline was associated with attendance and engagement with a behavioural weight management intervention and completion of follow-up assessments in the associated randomised controlled trial. I found evidence to suggest that intervention participants are less likely to attend intervention sessions, engage with intervention resources, and attend study follow-up visits if they report higher levels of depression or anxiety or lower scores for quality of life or satisfaction with life at baseline.

In Chapter Five, I conducted quantitative analyses to assess the long-term impact of behavioural weight management interventions on symptoms of depression and anxiety. I found no evidence of a difference between intervention and control groups for changes in depression and anxiety symptoms at 5 years from baseline. On average, participants across all randomised groups did not experience meaningful changes (defined by minimal important difference) in depression and anxiety from baseline to 5 years.

In Chapter Six, I conducted quantitative analyses to identify participant characteristics associated with changes in mental health during and after a behavioural weight management intervention. I found that those reporting higher baseline anxiety were likely to experience decreases in anxiety symptoms and increases in depression symptoms up to 5 years from baseline, whereas those reporting higher baseline depression were likely to experience decreases in depression symptoms and increases in anxiety symptoms up to 5 years from baseline.

In Chapter Seven, I explored participants' mental health experiences during a remote behavioural weight management intervention to support adults with overweight or obesity during the COVID-19 pandemic (SWiM-C). I conducted semi-structured interviews with twenty participants and used reflexive thematic analysis to identify patterns of meaning across the dataset relevant to mental health. Findings suggest that participants experienced multiple factors related to and external to the intervention that negatively impacted their mental health, yet aspects of the SWiM-C intervention appeared to support some participants to adaptively manage the decline in their mental health.

As a whole, this thesis offers three main contributions to the field. Firstly, thesis findings suggest that, on average, behavioural weight management interventions appear to have net positive or neutral impacts on mental health. However, a proportion of participants do experience a decline in their mental health, and these appear to be participants beginning the intervention with poorer mental health. Next, my findings suggest that there may be a bidirectional relationship between intervention attendance/engagement and participant mental health. Specifically, findings suggest that i) poorer mental health at baseline is associated with lower rates of intervention attendance and engagement, and that ii) managing competing demands can lead to reduced intervention engagement which subsequentially worsens mental health. Finally, thesis findings suggest that results from trials of behavioural weight management interventions may be biased to those who are most mentally healthy at the beginning of the trial.

The findings of this thesis contribute new insight into the role of mental health in adult behavioural weight management interventions. Thesis findings highlight a need for greater research into the role of mental health in behavioural weight management interventions; for example, greater research on i) the impact of interventions on mental health, ii) the mechanisms by which this impact may occur, iii) and approaches to better support participant mental health during weight management efforts would be of value.

## PUBLICATIONS AND RESEARCH DISSEMINATION

#### Publications resulting from this thesis

#### Published work

Jones RA, Mueller J, Sharp SJ, et al. (2022). 'Participant characteristics associated with changes in mental health in a trial of behavioural weight management programmes: Secondary analysis of the WRAP trial'. *Obesity Facts*, https://doi.org/10.1159/000522083 - (Chapter Six)

Jones RA, Mueller J, Sharp SJ, et al. (2021). The impact of participant mental health on attendance and engagement in a trial of behavioural weight management programmes: secondary analysis of the WRAP randomised controlled trial. *International Journal of Behavioral Nutrition and Physical Activity*, *18* (1) <u>https://doi.org/10.1186/s12966-021-01216-6</u> - (Chapter Four)

Jones RA, Lawlor ER, Birch JM, et al. (2020) The impact of adult behavioural weight management interventions on mental health: A systematic review and meta-analysis. *Obesity Reviews*. 2020; 1–18. https://doi.org/10.1111/obr.13150 - (Chapter Two)

Jones RA, Lawlor ER, Griffin SJ, et al. (2020) Impact of adult weight management interventions on mental health: a systematic review and meta-analysis protocol. *BMJ Open* 2020; 10: e031857. https://doi.org/10.1136/bmjopen-2019-031857 - (Chapter Two)

#### In preparation or under review

Jones RA, Richards R, Palat R, et al. (*Under review at International Journal of Qualitative Studies on Health & Wellbeing – Submitted Oct 2021*). 'Participants experiences of mental health during a COVID-19 tailored, web-based, guided self-help, ACT-based behavioural weight management intervention: a qualitative study.' - (Chapter Seven)

Jones RA, Mueller J, Sharp SJ, et al. (*Under review at Obesity*). 'Long term impact of a commercial behavioural weight management intervention on depression and anxiety: 5-year follow up of the WRAP trial' - (Chapter Five)

#### Research dissemination resulting from this thesis

#### Conference presentations

*European Congress on Obesity 2022:* Oral presentation of PhD thesis for EASO ECN Best Thesis Award Finalist Session & Poster presentation: 'Participants experiences of mental health during a COVID-19 tailored, web-based, guided self-help, ACT-based behavioural weight management intervention: a qualitative study.' (**Chapter Seven**).

<u>Obesity Week 2021, The Obesity Society</u>: Two poster presentations: 'Mental Health Experiences during a COVID19-Tailored Weight Management Programme: A Qualitative Study' (**Chapter Seven**) & 'Characteristics Associated with Mental Health Decline during Weight Management in the WRAP Trial' (**Chapter Six**).

<u>International Society of Behavioral Nutrition and Physical Activity (ISBNPA) Xchange Initiative</u> <u>2021:</u> Oral presentation: 'The impact of participant mental health on attendance and engagement in a trial of behavioural weight management programmes: Secondary analysis of the WRAP trial' (**Chapter Four**).

*European Congress on Obesity 2021:* Two poster presentations: 'The impact of participant mental health on attendance and engagement in a trial of behavioural weight management programmes: Secondary analysis of the WRAP trial' (**Chapter Four**) & 'Long-term impact of a commercial adult weight management programme on depression and anxiety: 5-year follow up of the WRAP trial' (**Chapter Five**).

*European and International Congress on Obesity (ECOICO) 2020:* Poster presentation: 'Impact of adult behavioural weight management programmes on mental health: A systematic review and meta-analysis' (**Chapter Two**).

<u>UK Congress on Obesity (UKCO) 2019</u>: Poster presentation: 'Impact of adult weight management interventions on mental health: a systematic review and meta-analysis protocol' (**Chapter Two**).

#### Other research dissemination

ASO National Webinar, September 2020: Oral presentation: 'Do weight management interventions help or hinder mental health? Findings from a recent systematic review' (Chapter Two).

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## ABBREVIATIONS

| %        | Percentage   |
|----------|--|
| >        | Less than  |
| <        | Greater than   |
| <u> </u> | Less than or equal to  |
| 2        | Greater than or equal to   |
| ACT      | Acceptance and Commitment Therapy                                  |
| ANCOVA   | ANalysis of COVariance   |
| APMS     | Adult Psychiatric Morbidity Surveys                                |
| ВСТ      | Behaviour Change Technique   |
| BI       | Brief Intervention   |
| ВМІ      | Body Mass Index  |
| Cl       | Confidence Intervals   |
| CONSORT  | Consolidated Standards of Reporting Trials                         |
| CP12     | 12-week Commercial Weight Loss Programme                           |
| CP52     | 52-week Commercial Weight Loss Programme                           |
| DSRQ     | Diet Self-Regulation Questionnaire                                 |
| E.g.,    | Exempli Gratia or 'for example'                                    |
| ESRQ     | Exercise Self-Regulation Questionnaire                             |
| HADS     | Hospital Anxiety and Depression Scale                              |
| l.e.,    | Id est or 'That is'  |
| IMD      | Index of Multiple Deprivation                                      |
| MCR      | Maladaptive Coping Response  |
| MID      | Minimal Important Difference                                       |
| N        | Number (indicating the number of participants)                     |
| NHS      | National Health Service  |
| NICE     | National Institute for Health and Care Excellence                  |
| NIHR     | National Institute for Health Research                             |
| Р        | p-value  |
| PPI      | Patient and Public Involvement                                     |
| PRISMA   | Preferred Reporting Items for Systematic Reviews and Meta-Analyses |

| PROSPERO | International Prospective Register of Systematic Reviews       |
|----------|--|
| RCT      | Randomised Controlled Trial                                    |
| RoB      | Risk of Bias tool  |
| SD       | Standard deviation   |
| SES      | Socioeconomic status   |
| SLQ      | Satisfaction with Life Questionnaire                           |
| SMD      | Standardised Mean Difference                                   |
| SRHI     | Self-Report Habit Index  |
| SWiM-C   | Supporting Weight Management during COVID-19                   |
| TFEQ     | Three-Factor Eating Questionnaire                              |
| TIDieR   | Cochrane Template for Intervention Description and Replication |
| TSRQ     | Treatment Self-Regulation Questionnaire                        |
| UK       | United Kingdom   |
| UKRI     | United Kingdom Research Institute                              |
| WHO      | World Health Organisation                                      |
| WRAP     | Weight loss Referrals for Adults in Primary care               |

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## **CHAPTER ONE: INTRODUCTION**

#### 1.1 Chapter overview

In this thesis, I aim to investigate the role of mental health in adult behavioural weight management interventions. This chapter outlines the relevant literature and research context, highlights the gaps in knowledge that shaped the research questions, and details the significance and value of the thesis for the broader research field and public health practice. There are further reviews of the relevant literature within each subsequent chapter.

To address the overall thesis aim, my thesis objectives are to (1) determine the short- and longterm impact of behavioural weight management interventions on participants' mental health, (2) determine how mental health is associated with intervention and trial attendance and engagement, (3) determine how participant characteristics are associated with changes in mental health during and after an intervention, and lastly, (4) explore participant experiences of a behavioural weight management intervention. In doing so, I seek to better understand how well behavioural weight management interventions support participant mental health, and how interventions could be adapted to provide more effective support.

#### 1.2 Overweight and obesity in adults

#### 1.2.1 Definition

Obesity is classified by the World Health Organisation (WHO) as "abnormal or excessive fat accumulation that presents a risk to health" (WHO, 2020),<sup>1</sup> whilst the European Association for the Study of Obesity describes obesity as an "adiposity-based chronic disease that is frequent, serious, complex, relapsing, and chronic" (Frühbeck et al., 2019: Page 1, EASO position statement).<sup>2</sup> The National Institute for Health and Care Excellence (NICE) defines a person's weight class based on their body mass index (BMI), as shown in Table 1.<sup>3</sup> In this thesis, overweight is classed as a BMI 25 kg/m<sup>2</sup> to 29.9 kg/m<sup>2</sup> and obesity as having a BMI of 30 kg/m<sup>2</sup> or greater, in line with NICE recommendations.<sup>3</sup>

| Weight class   | Body mass index (BMI)                            |
|----------------|--|
| Healthy weight | 18.5 kg/m <sup>2</sup> to 24.9 kg/m <sup>2</sup> |
| Overweight     | 25 kg/m <sup>2</sup> to 29.9 kg/m <sup>2</sup>   |
| Obesity        | 30 kg/m <sup>2</sup> or greater                  |

Table 1. Definition of weight classes based on body mass index.

#### 1.2.2 Prevalence and adverse health effects

Societal beliefs and attitudes commonly and mistakenly consider obesity to be solely due to individual choice and behaviour, causing devaluation and depreciation of those with obesity, consequentially resulting in stigma and discrimination.<sup>4,5</sup> However, many factors influence the development of obesity, including genetics, health inequalities, food availability, marketing and advertisements, inactive transport methods, psychology/cognition, the obesogenic environment, as well as health-related behaviours.<sup>6</sup> In 2016, more than 52% of the worldwide adult population had developed overweight or obesity.<sup>1</sup> In England in 2019, more than 64% of the adult population lived with overweight or obesity.<sup>7</sup> Research shows that the prevalence of obesity is patterned by known health inequalities, such as socioeconomic status and education.<sup>8–11</sup>

Living with obesity greatly increases the risk of life-altering and life-threatening consequences, such as the greater risk of all-cause mortality, cardiovascular disease, type 2 diabetes, stroke, and some cancers (including endometrial, oesophageal and kidney cancer).<sup>1,3,12–17</sup> In addition to the physical health effects of obesity, adults living with obesity are at greater risk of depression, binge eating disorder, mood disorders, psychological distress, poor self-esteem, and reduced health-related quality of life.<sup>14,18–20</sup> The growing prevalence of obesity and the harmful associated consequences highlight the need for effective and supportive treatments.

#### 1.3 Mental health

#### 1.3.1 Definition

The World Health Organisation (WHO) defines mental health as "a state of well-being in which the individual realises his or her own abilities, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to his or her community".<sup>21</sup> This definition is centred on positive functionality and feelings, whereas more often within society the term mental health is used as a synonym for mental illness.<sup>22</sup> When researching mental health, investigators are increasingly considering mental health as a symptom continuum that appreciates that individuals can experience one or more symptoms of mental illness without meeting diagnostic criteria.<sup>23,24</sup> For example, individuals may experience feelings of hopelessness, low self-esteem or irritability, yet not meet the full diagnostic criteria for clinical depression.<sup>25</sup> Considering mental health as a continuum is associated with reduced stigma and improved attitudes towards mental illness, highlighting the benefits of broadening the definition of mental health.<sup>24,26</sup> This thesis will embrace a symptom continuum-based definition of mental health.

#### 1.3.2 Prevalence

Worldwide, mental health problems are one of the main causes of the overall disease burden.<sup>5</sup> The most common mental health problems worldwide are depression and generalised anxiety;<sup>5</sup> Table 2 describes how these conditions are characterised. In 2017, 16.9% of the adult population in England had a common mental health disorder, with 10.7% of the population having a depression diagnosis.<sup>27,28</sup> Notably, however, the Adult Psychiatric Morbidity Surveys (APMS) in 2014 found that over a third of adults (36.2%) who self-identified as having a mental health problem in the 2014 APMS had never been diagnosed by a professional.<sup>27</sup> This suggests that prevalence statistics based on service provision may misrepresent the true level of mental health problems. The WHO recognises that, despite the high levels of mental health problems within England and worldwide, mental health has been neglected by most governments.<sup>5</sup>

Table 2. Description and characterisation of the most common mental health problems worldwide, depression and anxiety. (Source: National Health Service (NHS)<sup>29</sup>)

| Mental health problem | Description and characterisation   |
|-----------------------|--|
| Depression            | The NHS describes symptoms of depression to vary greatly and may         |
|                       | include: Lasting feelings of unhappiness and hopelessness, losing        |
|                       | interest in the things you used to enjoy, feeling very tearful,          |
|                       | constantly feeling tired, and poor-quality sleep. Symptoms can           |
|                       | range from mild to severe, with severe symptoms of depression            |
|                       | associated with feeling suicidal or that life is no longer worth living. |
| Generalised anxiety   | The NHS describes symptoms of anxiety to range from mild to              |
|                       | severe, and may include: Restlessness, feeling constantly 'on edge',     |
|                       | irritability, difficulty concentrating, a sense of dread, dizziness,     |
|                       | tiredness, heart palpitations (strong, fast, or irregular heartbeat),    |
|                       | trembling or shaking, excessive sweating, and difficulty falling or      |
|                       | staying asleep.  |

#### 1.4 Relationship between obesity and mental health

Numerous studies have documented a bidirectional relationship between obesity and mental health, with mental ill-health being both a cause and consequence of obesity.<sup>5,30–35</sup> There are many potential mechanisms underpinning the relationship bodyweight and mental health. These include biological (appetite dysregulation, evaluated stress reactions, immunological dysfunctions, inflammation, hormones, genetic drivers, medication side effects), psychosocial (reduced social support and networks, disordered eating behaviours, health and appearance concerns, societal pressures to have the 'ideal body'), and wider factors (e.g., social economic status, environmental, experiences of discrimination and stigma).<sup>18,36–38</sup>

Both obesity and mental ill-health are independently associated with experiencing stigma and discrimination, with stigma defined as a negative stereotype and discrimination as the resulting behaviour.<sup>4,5</sup> Stigma and discrimination are associated with damaging consequences for both mental and physical health, including psychological distress, social isolation and exclusion, weight gain, and avoidance of health-promoting activities (e.g., healthcare services, physical activity).<sup>4,39,40</sup> Adults living with both obesity and mental ill-health unfairly experience an exacerbated level of stigma and discrimination. This is often referred to as a 'double burden of stigma', yet researchers suggest that the combination of the stigma from two conditions may be multiplied rather than additive, intensifying the consequences on mental and physical health, and the associated double burden of stigma and discrimination, research investigating treatments for obesity often still lack sufficient focus on the role of mental health.

The importance of investigating the relationship between obesity and mental health is highlighted in the mental health research goals for 2020-2030 set by the Department of Health & Social Care (supported by the National Institute for Health Research (NIHR), United Kingdom Research Institute (UKRI), MQ: Transforming Mental Health, Mental Health Research UK, and Wellcome).<sup>42,43</sup> Specifically, Goal Two states that it is a priority to understand the links between physical and mental health, with the overall aim to reduce mortality and morbidity (Table 3).<sup>42,43</sup> This thesis speaks to this research goal by gathering and creating evidence to strengthen our understanding of the relationship between obesity and mental health. Table 3. Mental health research goals 2020-2030: Details of goal two. (Source: Wykes et al.  $(2021)^{43}$ )

| Goal Two  | "Research to improve understanding of the links between physical and mental   |
|-----------|---|
|           | health, and eliminate the mortality gap"                                      |
| Target 2A | "Research to strengthen our understanding of the co-morbidity of both mental  |
|           | and physical health problems. This research should address clusters of health |
|           | problems, underlying mechanisms and progression, and societal and             |
|           | individual risk and protective factors and in addition the implications for   |
|           | treatment and support."   |
| Target 2B | "Research to improve the efficacy and effectiveness of interventions for the  |
|           | prevention of mental ill-health and increase maintenance of good physical     |
|           | health for people living with mental health problems, or who are at risk of   |
|           | developing mental health problems. The aim is to reduce morbidity and excess  |
|           | mortality."   |

#### 1.5 Managing overweight and obesity

Overweight and obesity have great impacts on the health of an increasing proportion of the population, and effective treatments are essential. Behavioural weight management interventions are the most common form of weight management treatment in the United Kingdom and are recommended by national guidelines across the world.<sup>44</sup> Behavioural weight management interventions are typically multicomponent and target changes in diet and/or physical activity through behaviour change strategies, with the overarching aim of supporting adults with overweight and obesity to reduce excess weight, minimise health risks, and improve health outcomes.<sup>3</sup> These interventions are known as 'tier 2 multicomponent lifestyle interventions' in the United Kingdom (UK) and are provided as part of a four-tiered pathway (tier 1: universal services; tier 2: multicomponent lifestyle interventions; tier 3: specialist weight management services; and tier 4: bariatric surgery) for adults with overweight or obesity.<sup>3</sup> National Institute for Health and Care Excellence (NICE) guidance recommends that all behavioural weight management interventions (i.e., tier 2 multicomponent lifestyle interventions) include a psychological component, however, this is inconsistently provided and the impact of these interventions on psychological health is scarcely studied.<sup>35,45</sup>

These treatments are interchangeably referred to as either 'interventions' or 'programmes', whilst referring to the same form of treatment. In this thesis, I will refer to this form of obesity treatment as behavioural weight management *interventions* in line with the terminology used by NICE,<sup>46</sup> except when discussing published trials that explicitly refer to their trial intervention as a 'programme'.

Despite evidence of the relationship between obesity and mental health,<sup>30–34</sup> there is a scarcity of research investigating the role of mental health in behavioural weight management interventions. Research is required to inform the development and implementation of effective weight management treatments that support both physical and mental health concurrently.

#### 1.5.1 Behavioural weight management interventions and mental health

The role of mental health has been researched in behavioural interventions more widely, such as in interventions for smoking cessation and substance abuse. Researchers investigating smoking cessation interventions have explored the impact of tailored interventions on mental health, the effectiveness of interventions in those with poor mental health, and which particular strategies are most effective in those with poor mental health, and more.<sup>47–52</sup> Researchers investigating interventions to treat substance abuse have explored the impact of mental health and stigma on treatment, improving care and treatments for those with poor mental health, and impacts of substance abuse treatments on mental health.<sup>53–60</sup>

However, despite evidence highlighting the bidirectional relationship between obesity and mental health, there remains limited research exploring the role of mental health in behavioural weight management interventions. In the following sections, I describe the background and rationale for the thesis objectives which address the thesis aim: to investigate the role of participant mental health in behavioural weight management interventions.

#### 1.5.1.1 Impact of behavioural weight management interventions on mental health

There is a wealth of evidence reporting that behavioural weight management interventions benefit physical health,<sup>61–72</sup> including reductions to premature mortality,<sup>72</sup> prevention of type 2 diabetes,<sup>73–75</sup> and improvements in cardiovascular risk factors (e.g., blood pressure, cholesterol).<sup>76</sup> However, the impact on mental health remains unclear.

There is limited evidence with inconsistent findings investigating the impact of these interventions on mental health.<sup>33,77–88</sup> Several studies report mental health improvements from weight management interventions,<sup>78–80,87,88</sup> yet some studies report concerns that a focus on dietary restriction and weight control can exacerbate psychological distress and feelings of stigmatisation.<sup>77,89–91</sup> Previous systematic reviews have attempted to synthesise evidence on the impact of behavioural weight management interventions on various aspects of mental health, however, findings have been limited and conflicting.<sup>33,77,81–85</sup> For example, Warkentin et al.<sup>81</sup> found that weight loss may be associated with improved physical health but not mental health, Fabricatore et al.<sup>33</sup> reported reductions in depressive symptoms following behavioural weight-loss interventions, and Lasikiewicz et al.<sup>82</sup> concluded that weight management interventions are

associated with improvements in multiple mental health outcomes including self-esteem, body image, quality of life, and depression.

Previous systematic reviews have highlighted the breadth of mental health outcomes that may be affected by participating in a behavioural weight management intervention (e.g., quality of life, depression, self-esteem, body image, stress).<sup>33,77,81–85</sup> However, the majority of reviews have focused on a limited number of outcomes.<sup>33,77,81–85</sup> It is important to understand the impact of weight management interventions on a more comprehensive range of mental health outcomes as the benefits of improvements in one aspect of mental health may be undermined by negative impacts on another. Previous systematic reviews have also excluded participants with any concurrent physical or mental diagnosis to constrain the search or to exclude illnesses associated with unintentional weight changes (e.g., chronic obstructive pulmonary disease or cancer).<sup>77,86</sup> Overweight and obesity are associated with an increased risk of a wide range of comorbidities, and, therefore, the exclusion of these participants may limit the representativeness of findings.<sup>32</sup>

The limitations and inconsistent findings of previous reviews make it difficult to draw clear, reliable conclusions on the impact of behavioural weight management interventions on mental health. As such, an updated and more comprehensive review of the literature is required. Furthermore, the most effective combination of intervention components should be investigated to facilitate improved decision-making in intervention development, aiding the design of an effective and supportive 'whole person' intervention (i.e., effectively supporting both physical and mental health concurrently). Lee and colleagues recently sought to identify effective characteristics of behavioural weight management interventions for weight loss in people with serious mental illness.<sup>92</sup> However, to my knowledge, there lacks a review investigating the effective characteristics of behavioural weight management interventions for mental health changes in adults with overweight or obesity.

**Chapter Two** presents a systematic review investigating the effect of behavioural weight management interventions on a broad range of mental health outcomes in a representative sample of adults with overweight or obesity. The chapter also aims to investigate whether particular participant, intervention or study characteristics influence the effect of interventions on mental health.

# 1.5.1.2 Influence of participant mental health on attendance and engagement in trials of behavioural weight management interventions

The systematic review (**Chapter Two**) quantifies the average impact of behavioural weight management interventions on mental health in adults with overweight or obesity. It is known that attendance and engagement with these interventions are often low, yet the reasons for this are poorly understood.<sup>93,94</sup> Mental health may play an important role in attendance and engagement, particularly as poor mental health can exacerbate feelings of amotivation<sup>19,95,96</sup> and can increase the likelihood to socially withdraw and isolate.<sup>97–99</sup> However, there is currently limited evidence investigating this.

Low attendance and engagement can decrease the opportunity for participants to gain the skills, strategies, knowledge, and social support offered by weight management interventions.<sup>94</sup> Previous research has reported that low levels of attendance and engagement in behavioural weight management interventions are associated with a decreased likelihood of achieving clinically significant weight loss, consequently reducing the likelihood of gaining the associated health benefits.<sup>62,100,101</sup> This highlights the importance of better understanding the reasons for poor attendance and engagement. Previous research has sought to identify factors associated with attendance and engagement in behavioural weight management trials, but findings have been constrained by the limited diversity of potentially associated factors assessed. Demographic factors, such as age, education, and gender, have been commonly assessed for their association, with evidence suggesting better attendance and engagement among people who are older, more educated, and female.<sup>102–104</sup> However, previous research lacks sufficient investigation into how mental health may be associated with attendance and engagement.

Some researchers have suggested that mental health may play an important role in attendance and engagement of behavioural weight management interventions, and in attrition of trials evaluating these interventions.<sup>93</sup> Both obesity and poor mental health are associated with experiencing stigma and discrimination, which is in turn associated with the avoidance of healthpromoting activities (e.g., behavioural weight management interventions).<sup>4,39,40</sup> Furthermore, poor mental health can exacerbate feelings of amotivation<sup>19,95,96</sup> and can increase the likelihood to socially withdraw and isolate.<sup>97–99</sup> Thus, it is plausible that mental health may be associated with intervention attendance and engagement. However, previous research lacks sufficient investigation into the role of mental health in attendance at and engagement with behavioural weight management interventions.

The findings of the limited existing research are conflicting with some evidence reporting lower attendance and completion rates among weight management participants with higher levels of anxiety or depression,<sup>103,105,106</sup> with other research reporting mental health to not be associated with attendance and engagement.<sup>107</sup> A systematic review reported not finding any consistently associated psychological factors, though these findings were limited by the small number of studies assessing each factor.<sup>93</sup> The lack of previous research and conflicting evidence highlights a need for further research investigating the relationship between mental health and attendance at and engagement with behavioural weight management interventions.

It is also plausible that mental health may influence whether a participant attends study followup visits for trials of behavioural weight management interventions. This is important as, although on average mental health may improve following a behavioural weight management intervention, if baseline mental health is associated with attrition, then it is possible that this finding may be biased by unrepresentative participant samples. Participant samples may be biased to include the most mentally healthy participants, and this would minimise the generalisability of evidence produced from weight management trials, particularly when assessing the impact of weight management interventions on mental health. By investigating how participant mental health influences attendance at follow-up assessments for behavioural weight management trials, it can be determined whether participant samples accurately reflect the true range of mental health experiences.

**Chapter Four** presents a study investigating whether baseline mental health was associated with attendance at and engagement with a behavioural weight management intervention and completion of follow-up assessments in a randomised controlled trial. By better understanding the influence of baseline mental health on attendance and engagement, appropriate strategies may be implemented to support participation, minimise attrition, and subsequentially benefit health.
#### 1.5.1.3 Sustained impact of behavioural weight management interventions on mental health

The systematic review (**Chapter Two**) aims to evaluate the average effect of behavioural weight management interventions on mental health. The findings are limited, however, by a lack of trials measuring and reporting mental health measures, particularly for long-term follow-up timepoints. While many studies have investigated the long-term effects of behavioural weight management interventions on physical health,<sup>108</sup> there is very little evidence assessing the long-term impact on mental health.

The end of a behavioural weight management intervention is a pivotal point in a participant's weight management journey, with the potential for increased symptoms of stress, anxiety, and depression. Adults with obesity rarely receive formal support after completing a behavioural weight management intervention, and the absence of formal support can exacerbate feelings of psychological distress. In addition, research reports a high rate of weight regain upon completion of a behavioural weight management intervention, <sup>109</sup> potentially resulting in feelings of failure, blame, and shame. Furthermore, researchers have expressed some concerns that participating in a weight management intervention can have long-lasting detrimental effects on mental health, with some research highlighting a worsening in mental health for a proportion of participants after weight loss effects.<sup>87,110</sup> This may be related to an increased focus on dietary restrictions and body shape/image, and increased awareness of the risks of living with obesity. It is important to understand how interventions impact mental health in the long term to ensure appropriate care and treatment are provided to participants. This may be in the form of better preparing participants for the intervention to end, providing longer-term support, referring to external sources of long-term care, or through adaptations to provider training.

Weight management trials seldom measure mental health at timepoints greater than 12-months from baseline,<sup>45</sup> potentially due to lack of funding for long-term follow-up, high rates of study withdrawal, and concerns about participant burden. This limits our understanding of the long-term impacts on mental health and inhibits the further development of weight management interventions to effectively support the mental health of adults with obesity. Therefore, **Chapter Five** explores the impact of behavioural weight management interventions on symptoms of depression and anxiety at 5 years from baseline in a randomised controlled trial.

#### 1.5.1.4 Participant characteristics associated with changes in mental health

The systematic review (**Chapter Two**) and analysis of the long-term impact (**Chapter Four**) of behavioural weight management interventions aim to evaluate the *average* effect of behavioural weight management interventions on mental health. Although it is possible that, *on average*, mental health may improve following a behavioural weight management intervention, it is likely that this is not the case for all participants. It is important to identify the participants of a behavioural weight management intervention who are at risk of worsening mental health to provide more effective support for these people.<sup>45</sup>

By investigating how participant characteristics are associated with changes in mental health, I may better identify those at a greater risk of psychological harm during and after a behavioural weight management intervention. Various baseline participant characteristics may be associated with changes in mental health, including age, gender, education, habit strength, and self-regulation. Despite much research investigating how these characteristics may be associated with weight changes during behavioural weight management interventions,<sup>63,89,111–120</sup> there is a scarcity of research investigating the association with mental health changes.<sup>121–124</sup> Previous research has identified paid work, social support, and self-determination, among others, to be associated with quality of life and wellbeing during behavioural weight management treatments.<sup>121–123</sup> However, to my knowledge, no research has investigated the association of participant characteristics with changes in adverse mental health outcomes (e.g., depression, anxiety), therefore making it difficult to identify those at risk of detrimental impacts on mental health.

Some participant characteristics are considered to be modifiable by the behavioural intervention, such as habit strength, dietary restraint, and self-regulation. These are often targeted by behavioural weight management interventions to reduce risk factors of disease and improve health. Previous research has shown that early changes in modifiable participant characteristics during a behavioural intervention are associated with subsequent health behaviours (e.g., emotional eating, dietary adherence) and weight loss.<sup>116,125</sup> However it is unclear how early changes in participant characteristics are associated with changes in mental health. Investigating how changes to participant characteristics during the early stages of a behavioural weight management intervention relate to subsequent changes in mental health may inform the development of future interventions. For example, if decreases in dietary restraint are associated

with a deterioration in mental health, then interventions should be developed to mitigate this risk. This may involve adaptations to intervention content, provider training, or referrals to external support.

A small number of studies have explored how participant characteristics are associated with changes in mental health during behavioural interventions, however, studies have been limited by a focus on positive mental health outcomes.<sup>121–123</sup> Research was further limited by investigating a small number of participant characteristics in samples unrepresentative of the general population of adults with obesity (i.e., exclusively hospital patients or those with type 2 diabetes).<sup>121–123</sup> It is important to include a large range of participant characteristics potentially associated with mental health to broaden our understanding and increase the likelihood of identifying those at a greater risk of harm. In addition, previous research has lacked clarity and detail in the research methods used, resulting in difficulties in replicating study methods or comparing findings. Specifically, previous research has often not clearly stated the timepoint of the participant characteristics investigated (e.g., baseline or early changes), potentially due to limited journal word counts or human error/oversight.

Overall, I identified a scarcity of research investigating how participant characteristics are associated with changes in negative mental health (i.e., depression and anxiety) during and after behavioural weight management interventions. In **Chapter Six**, I investigate how baseline participant characteristics are associated with changes in mental health to identify those at most risk of worsening mental health during a trial of behavioural weight management interventions. **Chapter Six** also investigates the association of early changes in participant characteristics with changes in mental health to inform the development of future interventions.

# 1.5.1.5 Participants' experiences of mental health during a behavioural weight management intervention

In **Chapters Two**, **Four**, **Five** and **Six**, I quantify the average short- and long-term effect of interventions on mental health, quantify how attendance and engagement in interventions and trials are patterned by mental health, and identify the participant characteristics associated with changes in mental health during a behavioural weight management trial. These chapters provide necessary information to better understand the role of mental health in behavioural weight management interventions, yet they are unable to explore the underlying meaning, feelings, and

personal experiences of the intervention participants. Qualitative research methods enable researchers to gain a deeper understanding of people's experiences, thoughts, feelings, attitudes, behaviours, and motivations; they are well suited to investigating complex and sensitive issues, such as participants' experiences of mental health during behavioural weight management interventions.

Despite the well-evidenced relationship between obesity and mental health,<sup>5,30–34</sup> research investigating behavioural treatments for obesity often still lack sufficient focus on the role of mental health. Weight management requires a vast amount of mental and emotional investment, however previous research has found little or no mental health support within weight management services.<sup>126</sup> Thus, further research is needed to clarify whether these interventions sufficiently support mental health, and how they can be improved.

On 11<sup>th</sup> March 2020, the World Health Organisation (WHO) declared the novel coronavirus outbreak (COVID-19) to be a global pandemic.<sup>127</sup> The COVID-19 pandemic represents a unique period of heightened distress, with research showing those living with obesity experienced a detrimental impact on their mental health at a greater rate than those without pre-existing conditions (such as obesity).<sup>128–133</sup> The increased risk of poor mental health in adults with obesity during the pandemic amplifies the need for weight management services to provide adequate mental health support. However, the introduction of pandemic restrictions, such as social distancing and isolation measures, resulted in the suspension of many face-to-face weight management services.<sup>134</sup> Alternative methods of remotely providing weight management support were required.

Evidence suggests that behavioural weight management interventions based on acceptance and commitment therapy (ACT) may be more supportive of mental health for adults with overweight and obesity than standard behavioural treatment.<sup>135</sup> ACT is an action-based approach to behavioural therapy, with a core focus on accepting what is outside of personal control, and committing to changing that which is within personal control.<sup>136</sup> ACT-based interventions are increasingly being provided remotely as 'guided self-help' – these are interventions that are predominantly self-directed with periodic support from a trained practitioner.<sup>137–140</sup> Research shows that guided self-help interventions improve access to hard-to-reach and/or isolated populations and require fewer resources whilst producing similar effects to face-to-face treatment.<sup>137–140</sup> Despite growing evidence for ACT-based weight management interventions,

CHAPTER ONE: INTRODUCTION

there is currently limited evidence assessing how effectively these interventions support mental health, particularly when delivered remotely as 'guided self-help'.<sup>135,140</sup> Understanding the impact of these interventions on mental health, particularly during periods of heightened distress and reduced access to standard support, may inform the development of more psychologically supportive interventions for adults with overweight or obesity.

In response to the need for remote methods of providing psychological support for adults with overweight or obesity and the growing evidence for ACT-based interventions, the SWiM-C (Supporting Weight Management during COVID-19) intervention was developed. SWiM-C was a web-based, guided self-help, ACT-based intervention that aimed to support adults with overweight and obesity to prevent weight gain and manage their mental health during the COVID-19 pandemic. As the SWiM-C intervention was ACT-based, it centred on core concepts such as mindfulness, acceptance, and values clarification that ultimately aim to enhance psychological flexibility.<sup>136</sup> Psychological flexibility encourages self-compassion and tolerance towards unpleasant thoughts, feelings, and bodily sensations.<sup>136</sup> The SWiM-C intervention included strategies such as present-moment awareness, cognitive defusion, and urge-surfing to help to achieve this. Thus, SWiM-C may support participants to better manage the psychological demands of weight management efforts, particularly during the context of the COVID-19 pandemic.

In **Chapter Seven**, I aimed to broadly explore intervention participants' mental health experiences during the SWiM-C intervention, and how SWiM-C and other weight management interventions could be adapted to better support mental health. Findings from this study may inform the development of future weight management interventions, as well as informing how SWiM-C could be adapted and optimised for other contexts. While the pandemic represents a unique situation, the findings of this chapter may be generalisable to weight management interventions in other contexts of high stress, reduced access to support and resources, and high levels of social isolation.

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# 1.6 Aims and objectives

The overall aim of this thesis is to investigate the role of participant mental health in behavioural weight management interventions.

The thesis objectives are:

- Thesis Objective One: To determine the short- and long-term impact of behavioural weight management interventions on the mental health of adults with overweight and obesity.
- Thesis Objective Two: To identify how participant mental health is associated with attendance and engagement with a behavioural weight management intervention and trial.
- Thesis Objective Three: To identify participant characteristics associated with changes in mental health in adults with obesity during and after a behavioural weight management intervention.
- Thesis Objective Four: To explore participant experiences of a behavioural weight management intervention to better understand how well the intervention supports participant mental health, and how the intervention could be adapted to provide more effective support.

#### 1.7 Thesis structure

The thesis objectives have guided my doctoral research, and will be fulfilled through the following thesis chapters:

#### 1.7.1 Chapter Two

**Chapter Two** presents a systematic review and meta-analysis that assesses the impact of behavioural weight management interventions on mental health in adults with overweight and obesity, compared to minimal intervention, 'standard care', or inactive control groups.

The chapter objectives are to:

- Quantify the effect of behavioural weight management interventions on mental health in adults with overweight and obesity compared to minimal intervention, 'standard care', or inactive control groups.
- 2. Quantify whether particular study, intervention or participant characteristics influence the effect of interventions on mental health.

#### 1.7.2 Chapter Three

**Chapter Three** introduces the Weight loss Referrals for Adults in Primary care (WRAP) trial and includes details of the study design, participant eligibility criteria, outcome measures, study arms, and baseline results. Multiple thesis chapters (Chapters Four, Five and Six) use data from the WRAP trial. I was not involved in the design or implementation of the WRAP trial, however, I designed and conducted secondary analyses of WRAP data to answer my thesis objectives.

#### 1.7.3 Chapter Four

**Chapter Four** presents a secondary quantitative analysis using WRAP data which aims to identify how participant mental health is associated with attendance and engagement with a behavioural weight management intervention and trial.

The chapter objectives are to:

- 1. Identify whether participant mental health is associated with intervention attendance.
- 2. Identify whether participant mental health is associated with intervention engagement.
- 3. Identify whether participant mental health is associated with attendance at trial study visits.

#### 1.7.4 Chapter Five

**Chapter Five** presents a secondary quantitative analysis using WRAP data which aims to identify how referral to a behavioural weight management intervention impacted mental health-related outcomes at 5-years from baseline.

The chapter objectives are to:

- 1. Identify whether referral to a 52-week or 12-week weight management intervention results in greater improvements in mental health-related outcomes than brief intervention at 5-years from baseline.
- 2. Identify whether referral to a 52-week weight management intervention results in significantly greater improvements in mental health-related outcomes than the current practice of referral to a 12-week weight management intervention at 5-years from baseline.

#### 1.7.5 Chapter Six

**Chapter Six** presents a secondary quantitative analysis using WRAP data which aims to identify how baseline and early changes in participant characteristics are associated with changes in depression and anxiety in adults with obesity during and after a behavioural weight management intervention. The chapter objectives are to:

- 1. Identify whether baseline participant characteristics are associated with changes in depression and anxiety during and after a behavioural weight management intervention.
- 2. Identify whether early changes in individual characteristics are associated with changes in depression and anxiety during and after a commercial weight management intervention.

#### 1.7.6 Chapter Seven

**Chapter Seven** presents the findings from a qualitative interview study with participants of a behavioural weight management intervention during the COVID-19 pandemic (SWiM-C: Supporting Weight Management during COVID-19). The chapter broadly aims to explore mental health experiences during the intervention, and how the intervention could be adapted to better support participant mental health.

The chapter objectives are to:

- 1. Explore the mental health experiences of SWiM-C intervention participants.
- 2. Explore how well the intervention supports participant mental health.
- 3. Explore how the intervention could be adapted to better support participant mental health.

#### 1.7.7 Chapter Eight

**Chapter Eight** reviews the thesis aims and objectives, critically examines the thesis findings in comparison to previous relevant literature, and highlights the novel contributions made to the field. Strengths and limitations will be discussed, and implications for public health and research presented.

# CHAPTER TWO: THE IMPACT OF ADULT BEHAVIOURAL WEIGHT MANAGEMENT INTERVENTIONS ON MENTAL HEALTH: A SYSTEMATIC REVIEW AND META-ANALYSIS.

The work in this chapter has been published as:

Jones RA, Lawlor ER, Birch JM, et al. (2020) The impact of adult behavioural weight management interventions on mental health: A systematic review and meta-analysis. Obesity Reviews. 2020; 1–18. https://doi.org/10.1111/obr.13150

Jones RA, Lawlor ER, Griffin SJ, et al. (2020) Impact of adult weight management interventions on mental health: a systematic review and meta-analysis protocol. BMJ Open 2020; 10: e031857. <u>https://doi.org/10.1136/bmjopen-2019-031857</u>

This work was presented at the UK Congress on Obesity (UKCO) in 2019, the European and International Congress on Obesity (ECOICO) in 2020, and as part of the ASO National Webinar on Obesity and Mental Wellbeing (September 2020) with the talk titled 'Do weight management interventions help or hinder mental health? Findings from a recent systematic review'.

# 2.1 Chapter overview

As described in Chapter One (*Section 1.5.1.1*), there is a lack of evidence assessing the impact of behavioural weight management interventions on participant mental health. Previous systematic reviews have aimed to synthesise evidence for the impact of behavioural weight management interventions on various aspects of mental health.<sup>33,77,81–85</sup> However, findings have been limited and conflicting. In addition, previous systematic review findings were limited by focusing on a limited number of outcomes at once and the exclusion of participants with a concurrent medical diagnosis. The limitations of previous reviews and inconsistent findings make it difficult to draw clear, reliable conclusions on the impact of behavioural weight management interventions on mental health. A greater understanding of the impact of weight management intervention on mental health is necessary to inform the development of interventions to support both mental and physical health concurrently, optimising care and minimising the risk of harm.

In **Chapter Two**, I present a systematic review and meta-analysis that assessed the impact of behavioural weight management interventions on mental health in adults with overweight and obesity, compared to minimal intervention, 'standard care', or inactive control groups.

This chapter addresses **thesis Objective One**: To determine the short- and long-term impact of behavioural weight management interventions on the mental health of adults with overweight and obesity.

## 2.1.1 Aims and objectives

I aimed to assess the effectiveness of behavioural weight management interventions compared to minimal, inactive or 'standard care' control groups on mental health in adults with overweight and obesity.

The chapter objectives were to:

- Quantify the effect of behavioural weight management interventions on mental health in adults with overweight and obesity compared to minimal intervention, 'standard care', or inactive control groups.
- 2. Quantify whether particular study, intervention or participant characteristics influence the effect of interventions on mental health.

## 2.2 Methods

This systematic review was registered on the International Prospective Register of Systematic Reviews (PROSPERO: CRD42019131659) and adheres to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) reporting guidelines.<sup>141</sup>

The review protocol is shown in Chapter Two Appendices (A2.1). The protocol and results are published in peer-reviewed journals – BMJ Open (protocol) and Obesity Reviews (chapter results).<sup>45,142</sup>

## 2.2.1 Eligibility criteria

#### 2.2.1.1 Participants

Studies were eligible if participants were community-dwelling adults ( $\geq$  18 years old with no upper age limit applied) with overweight or obesity (body mass index (BMI)  $\geq$  25 kg/m<sup>2</sup>) at baseline. Studies that included participants both under and over the age of 18 years were to be included if the data for participants 18 years and older were reported separately. Participants must be seeking intentional weight loss through a behavioural programme. There were no restrictions to participant demographics. To increase the generalisability of the findings, I included studies that included participants with comorbidities but excluded papers that focused exclusively on populations with a physical or mental comorbidity (e.g., all participants had cancer), or pregnant women.

#### 2.2.1.2 Interventions

Studies were included if they evaluated a behavioural weight management intervention in community-based settings aiming to achieve weight loss through changes in diet and/or physical activity. No restrictions were placed on intervention delivery duration, delivery format or on who delivers the intervention. Studies with multiple intervention arms were included if at least one arm met the eligibility criteria and separate results were presented for eligible arms. Interventions aiming to treat eating disorders or involving surgical and/or pharmacological intervention were excluded.

#### 2.2.1.3 Comparators

Studies with an inactive/minimal intervention (e.g., information leaflet) or usual care met eligibility criteria.

#### 2.2.1.4 Outcomes

Included studies were required to include measures of one or more of the following mental health outcomes reported at intervention-end: Affect/mood; anxiety; binge-eating; body image; depression; emotional eating; quality of life; self-esteem; stress. I chose these *a-priori* defined outcomes as they were deemed to be the most relevant, were most frequently reported in the previous relevant literature, represented the most prevalent mental health conditions, and provided the most comprehensive insight to date into mental health impacts of behavioural weight management interventions. Outcomes reported at intervention-end and 12-months from baseline were extracted, regardless of intervention duration.

#### 2.2.1.5 Study designs

Original peer-reviewed primary research articles reporting individual or cluster randomised controlled trials (RCTs) were included. Non-English language publications were excluded. No restrictions were placed on the year of publication.

## 2.2.2 Information sources and search strategy

I searched seven databases (AMED, ASSIA, CINAHL, Cochrane database (CENTRAL), Embase, MEDLINE, and PsycINFO) from database inception to 7<sup>th</sup> May 2019. The search strategy was based on the concepts: (1) adults with overweight/obesity and (2) weight management interventions and (3) mental health outcomes and (4) study designs (Chapter Two Appendices: A2.2). The search was restricted to English-language papers, with no other restrictions applied.

To augment the results of the database search, I hand searched the reference lists of included studies and previous relevant reviews.<sup>33,64,77,81–86,143–146</sup>

#### 2.2.3 Data management and study selection

The search results were imported into Covidence systematic review software (Veritas Health Innovation, Melbourne, Australia), and duplicates were removed. Initially, another investigator and I pilot screened an identical 500 articles to ensure consistency. Any discrepancies in the interpretation of the eligibility criteria were discussed between investigators, with a third investigator assisting when necessary.

Upon completion of pilot screening, the remaining title and abstracts were independently screened in duplicate. The full text of articles identified as potentially relevant were obtained and screened in duplicate to ascertain studies to be included in the review. Eligibility was discussed for consensus between the investigators who conducted screening, with a third investigator resolving discrepancies when required. For each screening stage, I screened all of the articles, and duplicate screening was split between four further investigators.

Reasons for the exclusion of articles were recorded at the full-text screening stage. Investigators were not blinded to authors, institutions, or journals when screening articles. When studies were reported in more than one publication, all articles that met eligibility criteria were included and combined to make the best use of available data. Study authors (n=2) were contacted to resolve any uncertainties about eligibility.

#### 2.2.4 Data collection process

Studies meeting the eligibility criteria had pertinent data extracted using a data extraction form based on the Cochrane data extraction form (2011),<sup>147</sup> the Consolidated Standards of Reporting Trials (CONSORT) statement (2010),<sup>148</sup> and the Cochrane Template for Intervention Description and Replication (TIDieR)<sup>149</sup> to ensure sufficient breadth and detail was captured. Two investigators (myself and a further investigator) pilot tested the data extraction form; we completed data extraction for three studies in duplicate to identify missing or superfluous data items. I completed data extraction for all included studies, with one of four further investigators completing a full check of the extracted data. Discrepancies were resolved through discussion, with the use of a third investigator when necessary.

Study authors were contacted to request missing data (n=26), and authors were sent two email reminders if there was no response. Authors were given a minimum of 2 months to respond.

Authors of six studies did not respond, five responded that data was unavailable, and 15 responded with the data requested.

#### 2.2.4.1 Data items

Data extracted included:

- General information e.g., study authors, publication year, country, funding source.
- Study details e.g., study aim, study design, randomisation method, blinding and allocation concealment.
- Participant information e.g., demographics, sample size, co-morbidities.
- Attrition/adherence e.g., total number of participants at baseline and follow up measurements, differential attrition, attendance, study withdrawal, loss to follow-up.
- Intervention information e.g., setting, content, intervention duration and frequency, profession delivering the intervention, method of delivery, group or individual delivery.
- Comparator information e.g., setting, content, intervention duration and frequency, profession delivering the intervention, method of delivery, group or individual delivery.
- Outcomes e.g., mental health outcome(s) studied, whether self-reported or objectively measured, duration of follow-up, statistical analysis, intervention effect sizes.

## 2.2.5 Outcomes and prioritisation

When studies reported multiple measures for the same outcome, the measure deemed (in consultation with the review team) to be most valid and precise was prioritised and used. Prioritisation was given to units reported as raw data at baseline and intervention-end over data presented as 'mean change' or equivalent. When possible, data items were extracted at both study and group levels to permit analysis of overall and stratified data (e.g., extracting stratified data to analyse moderation by sex).

## 2.2.6 Risk of bias in individual studies

I completed risk of bias appraisal using the Cochrane 'Risk of bias' tool (RoB),<sup>150</sup> with full checking by one of four further investigators. Discrepancies were resolved through discussion, with a third investigator providing consultation if required. Included studies were given an overall rating of 'low', 'unclear', or 'high' risk of bias dependent on the ratings for individual domains. Individual domains were:

- Selection bias: sequence generation, allocation sequence concealment.
- Performance bias: blinding of participants and personnel.
- Detection bias: blinding of outcome assessment.
- Attrition bias: incomplete outcome data.
- Reporting bias: selective outcome reporting.
- Other potential sources of bias.

Ratings given to 'blinding of participants and personnel' and 'blinding of outcome assessment' were excluded from the overall assessment of the risk of bias because of the behavioural nature of the interventions and self-reported assessment of outcomes.

#### 2.2.7 Synthesis of results

Stata v.16 was used for all statistical analyses.<sup>151</sup> Unstandardised mean differences between the intervention and comparator groups and 95% confidence intervals (CI) were calculated for continuous outcomes, with standardised mean differences (Hedges' *g*) calculated if different measurement tools were reported in the individual studies. Effect sizes for each outcome were combined across studies using random effects meta-analysis (due to the presence of heterogeneity). When studies had multiple interventions meeting the eligibility criteria, each estimate of intervention versus comparator was included separately in the meta-analysis, and the comparator group was split between the different interventions to avoid the data in this group contributing more than once to the pooled result (i.e., unit-of-analysis error). Meta-analyses examined effectiveness at intervention-end and 12-months from baseline, regardless of intervention duration. These timepoints were selected to assess the immediate effect and longer-term impact of interventions on mental health outcomes. The potential influence of intervention duration was assessed by subgroup meta-analyses.

For meta-analyses combining unstandardised mean differences, effect sizes based either on postintervention (i.e., raw data at intervention-end) or change from baseline (i.e., mean change) results were combined in a single forest plot. Separate forest plots were produced for postintervention and change from baseline when standardised mean differences were used in the meta-analyses.<sup>150</sup>

Heterogeneity was assessed using the I<sup>2</sup> statistic and interpreted according to Cochrane recommendations: low (0%–30%), moderate (30%–60%), substantial (60%–90%) and considerable (90%–100%).<sup>150</sup> Contour-enhanced funnel plots of individual study effect sizes were produced for all outcomes to assess the risk of publication bias.

# 2.2.7.1 Additional analyses: Impact of risk of bias and study-level heterogeneity on effect estimates

Sensitivity analysis was conducted by removing studies judged to be at high risk of bias from pooled estimates to investigate the potential impact on effect estimates. Potential study-level sources of observed heterogeneity between studies in the effect estimates were explored using random effects meta-regression and stratified analyses. Study-level characteristics considered were intervention type (education-only, physical activity-only, education and physical activity), intervention duration (in weeks), intervention delivery mode (face-to-face, online, resources, telephone, combination), comparator type (inactive, minimal, usual care), comparator intensity (minimal vs intervention-intensity), and demographic characteristics (e.g., gender, age).

# 2.3 Results

## 2.3.1 Study selection

Following de-duplication, 31,390 articles were identified for the title and abstract screening, with 265 articles eligible for full-text screening. Five additional studies were identified through hand-searching. Forty-three articles, reporting on 42 studies, met eligibility criteria for inclusion in the review (Figure 1).<sup>61,152–193</sup> Three studies were excluded from the meta-analyses as data were incomplete or unable to be pooled.<sup>159,166,181</sup>



Figure 1. PRISMA Flow Diagram for the inclusion of studies.

#### 2.3.2 Study characteristics

Table 1 provides an overview of included studies, and the appendices (Chapter Two Appendices: A2.3) presents detailed characteristics for each study. Briefly, studies included a total of 9,385 participants, with the sample size ranging from 23<sup>154</sup> to 1,269<sup>61</sup>. Interventions were compared to no intervention, minimal intervention (e.g., information leaflet), or usual care (ranging from minimal intervention to delivery of an intervention). One study did not define what usual care entailed.<sup>185</sup>

Twenty-nine studies<sup>61,156,158,159,161,162,164–176,178–180,183,185,187,189,191–193</sup> provided interventions lasting between 2 to 11 months, whereas 12 studies provided interventions lasting greater than 12-months.<sup>61,152,153,155,157,160,175,177,181,182,186,188</sup> Three studies were less than 2 months in duration.<sup>154,163,184</sup> Studies contributing to the analysis of intervention effects at 12-months from baseline were between 1 week and 12-months in duration; 10 interventions were less than 6 months in duration,<sup>61,163,167,174,179,187</sup> and eight interventions were 12-months in duration.<sup>61,153,157,160,182,188</sup>

Seven outcomes were positively scaled, defined as measured on a numeric scale where a positive effect size represented the desired impact of the intervention (all measures of quality of life, self-efficacy and self-esteem). Seven outcomes were negatively scaled, defined as measured on a numeric scale where higher values represented higher levels of the trait, and hence, a negative effect size represented the desired impact of the intervention (anxiety, body image concerns, depression, emotional eating, negative affect, psychological distress, and stress). One outcome (obesity-related quality of life) was assessed on a variety of scales with higher values representing different concepts in different scales; hence, these were analysed separately.

Table 1. Overview of characteristics of 42 trials, reported in 43 studies, included in the systematic review of behavioural weight management interventions.

|                             | Number     | Citations   |  |  |
|-----------------------------|------------|---|--|--|
|                             | of studies |   |  |  |
| Study characteristics       |            |   |  |  |
| Study design                |            |   |  |  |
| RCTs                        | 43 (100%)  | 61,152–193  |  |  |
| Year of publication         | 1          |   |  |  |
| ≥2019                       | 1          | 191   |  |  |
| 2017-2018                   | 8          | 61,162,174,175,181,184,188,190                              |  |  |
| 2015-2016                   | 11         | 152,154,155,159,161,167,172,173,176,192,193                 |  |  |
| ≤2014                       | 23         | 153,156–158,160,163–166,168–171,177–180,182,183,185–187,189 |  |  |
| Overall risk of bias rating |            |   |  |  |
| Low risk of bias            | 10         | 156,160,161,166,167,170,174,175,187,191                     |  |  |
| Unclear risk of bias        | 15         | 142,153–155,158,159,162,163,178,180,181,186,190,192,193     |  |  |
| High risk of bias           | 18         | 152,157,164,165,168,169,171–173,176,177,179,182–185,188,189 |  |  |
| Study location              | 1          | ·   |  |  |
| USA                         | 15         | 152,153,155,159,160,164–166,173,177,178,180,185,189,193     |  |  |
| UK                          | 10         | 61,154,156,158,167,171,174,183,186,187                      |  |  |
| Australia                   | 8          | 162,163,168–170,181,186,191                                 |  |  |
| Portugal                    | 2          | 182,190   |  |  |
| Finland                     | 2          | 157,172   |  |  |
| Germany                     | 2          | 186,192   |  |  |
| Malaysia                    | 1          | 161   |  |  |
| Canada                      | 1          | 175   |  |  |
| Greece                      | 1          | 184   |  |  |
| India                       | 1          | 176   |  |  |
| New Zealand                 | 1          | 188   |  |  |
| Not reported                | 1          | 179   |  |  |
| Participant characteristics |            |   |  |  |
| Sample size                 |            |   |  |  |

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| ≤50 participants                | 3  | 154,158,173  |  |
|---------------------------------|----|--|--|
| 50-200                          | 25 | 156,157,159,162,163,165,166,168-172,175,176,178,180,183-       |  |
|                                 |    | 185,188–193  |  |
| ≥200                            | 15 | 61,152,153,155,160,161,164,167,174,177,179,181,182,186,187     |  |
| Mean age (years)                | 1  |  |  |
| 18-30                           | 2  | 155,189  |  |
| 31-50                           | 32 | 154,156–159,161,163–172,174–176,180–188,190–193                |  |
| 51-70                           | 9  | 61,152,153,160,162,173,177–179                                 |  |
| Proportion female               | 1  |  |  |
| 0% (All male)                   | 8  | 156,168–170,175,176,187,193                                    |  |
| 50-99%                          | 27 | 61,152,153,155,157–159,161–167,171,172,174,177,179–181,184–    |  |
|                                 |    | 186,188,190,191  |  |
| 100% (All female)               | 8  | 154,160,173,178,182,183,189,192                                |  |
| Participant BMI (kg/m²)         |    |  |  |
| 25-29.9                         | 2  | 154,155  |  |
| 30-34.9                         | 23 | 61,156,157,160–163,165,166,168–170,173,178–182,186,189,191–193 |  |
| 35-39.9                         | 13 | 152,153,159,167,171,172,174,175,177,183–185,187                |  |
| ≥40                             | 4  | 158,164,188,190  |  |
| Not reported                    | 1  | 176  |  |
| Intervention characteristics    |    |  |  |
| Intervention type               |    |  |  |
| Education-only                  | 33 | 61,153,155,157,159–169,171–175,177–186,188,191,193             |  |
| Physical activity-only          | 4  | 154,158,160,192  |  |
| Education and physical activity | 8  | 156,160,170,171,175,176,187,189                                |  |
| Delivery mode                   | 1  |  |  |
| Face-to-face                    | 23 | 61,152–154,156,158,161,163,167,171,172,174–176,178,182–        |  |
|                                 |    | 184,186,187,189,192  |  |
| Online                          | 6  | 162,165,166,173,180,191  |  |
| Resources                       | 4  | 162,170,179,191  |  |
| Telephone                       | 2  | 153,159  |  |
| Mixture of modes                | 11 | 155,157,160,164,168–170,177,185,188,193                        |  |

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| Delivery format                   |              |  |  |
|-----------------------------------|--------------|--|--|
| Individuals-only                  | 25           | 152,153,155,157,159,162–166,168–172,174,177,179–181,183–       |  |
|                                   |              | 185,190,191,193  |  |
| Groups-only                       | 16           | 61,153,154,156,158,161,163,167,175,176,178,182,186,187,189,192 |  |
| Groups and individuals            | 4            | 160,173,177,188  |  |
| Intervention duration             |              |  |  |
| ≤2 months                         | 3            | 154,163,184  |  |
| >2-6 months                       | 25           | 61,156,158,159,161,162,165–171,173–                            |  |
|                                   |              | 176,178,179,183,185,187,189,191,192                            |  |
| >6-11 months                      | 4            | 164,172,180,193  |  |
| >12-23-months                     | 9            | 61,153,157,160,175,181,182,186,188                             |  |
| >24-months                        | 3            | 152,155,177  |  |
| Comparator characteristics        |              |  |  |
| Type of control group             |              |  |  |
| No intervention                   | 16           | 154,157,160,165,168–170,175,179,180,183,187,189,191–193        |  |
| Minimal intervention              | 14           | 61,156,161–163,172,173,176–178,181,182,184,190                 |  |
| Usual care                        | 13           | 152,153,155,158,159,164,166,167,171,174,185,186,188            |  |
| Outcome characteristics           |              |  |  |
| Mental health outcomes reported   | at intervent | ion-end  |  |
| Anxiety                           | 6            | 61,158,160,162,171,191   |  |
| Binge eating                      | 0            | -  |  |
| Body image concerns               | 2            | 180,182  |  |
| Depression                        | 14           | 61,152,155,158,160,162,164,171,177,178,180,184,185,191         |  |
| Emotional eating                  | 4            | 167,172,182,186  |  |
| Negative affect                   | 4            | 156,161,175,187  |  |
| Psychological distress            | 1            | 188  |  |
| Quality of life (Global)          | 12           | 61,153,155,162,167,171,174,175,177,183,188,191                 |  |
| Quality of life (Mental health-   | 13           | 154,156,160,161,168–170,177,178,181,187,188,193                |  |
| related)                          |              |  |  |
| Quality of life (Obesity-related) | 4            | 165,174,186,190  |  |
| Satisfaction with life            | 2            | 61,153   |  |

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| Self-efficacy (General)  | 2           | 163,179                             |  |
|--|-------------|-------------------------------------|--|
| Self-efficacy (Diet-related)   | 9           | 153,157,159,161,166,173,182,189,193 |  |
| Self-efficacy (Exercise-related)   | 7           | 153,158,168,169,182,189,193         |  |
| Self-esteem  | 5           | 156,171,175,187,192                 |  |
| Stress   | 6           | 160,162,176,184,189,192             |  |
| Mental health outcomes reported  | at 12-month | hs from baseline                    |  |
| Anxiety  | 1           | 61                                  |  |
| Body image concerns  | 1           | 182                                 |  |
| Depression   | 2           | 61,160                              |  |
| Emotional eating   | 2           | 167,182                             |  |
| Negative affect  | 1           | 187                                 |  |
| Psychological distress   | 0           | -                                   |  |
| Quality of life (Global)   | 5           | 61,153,167,174,188                  |  |
| Quality of life (Mental health-  | 4           | 160,181,187,188                     |  |
| related)   |             |                                     |  |
| Quality of life (Obesity-related)  | 1           | 174                                 |  |
| Satisfaction with life   | 1           | 153                                 |  |
| Self-efficacy (General)  | 2           | 163,179                             |  |
| Self-efficacy (Diet-related)   | 3           | 153,157,182                         |  |
| Self-efficacy (Exercise-related)   | 2           | 153,182                             |  |
| Self-esteem  | 1           | 187                                 |  |
| Stress   | 0           | -                                   |  |
| Note: Number of studies per characteristic may sum greater than 43 due to studies contributing |             |                                     |  |
| multiple intervention arms   |             |                                     |  |

#### 2.3.3 Risk of bias

Forty-two percent of studies received an overall rating of high risk of bias, 152, 157, 164, 165, 168, 169, 171-173,176,177,179,182-185,188,189 of bias rating,<sup>142,153-</sup> 35% unclear received an risk 155,158,159,162,163,178,180,181,186,190,192,193 risk and 23% received low of bias а rating  $^{156,160,161,166,167,170,174,175,187,191}$  (Table 1). The appendices (Chapter Two Appendices: A2.4 – A2.5) report the domain ratings for all included studies and the summary of risk of bias domain ratings across studies.

#### 2.3.4 Intervention effects on mental health

#### 2.3.4.1 Anxiety

There was no evidence of a difference between intervention and comparator for anxiety at intervention-end [Post intervention: Standardised Mean Difference (SMD) -0.02 (95% CI -0.25, 0.21; n=11;  $I^2=61\%$ ); change from baseline: SMD -0.22 (95% CI -0.72, 0.29; n=2;  $I^2=0\%$ )] (Figure 2). After excluding studies deemed to be at high risk of bias (n=2),<sup>171</sup> there was still no evidence of a difference between groups at intervention-end (Chapter Two Appendices: A2.6). Only one study<sup>61</sup> reported results for anxiety at 12-months from baseline, so no meta-analysis was possible.

Meta-regression identified that the substantial heterogeneity at intervention-end was explained by one study<sup>162</sup> where the intervention consisted solely of provision of resources (Chapter Two Appendices: A2.9 - Table A4). After removal of this study, there was a suggestion of an effect in favour of the intervention [SMD -0.10 (95% CI -0.22, 0.02; n=10; l<sup>2</sup>=0%)] (Chapter Two Appendices: A2.10 - Figure A48).

#### 2.3.4.2 Binge-eating

Only one study<sup>180</sup> reported results for binge-eating, so this could not be included in the metaanalysis, despite being a pre-specified outcome. This study found no evidence of a difference between intervention and control in the likelihood of reporting any binge eating (odds ratio 3.9 [95% CI 0.9, 10.0], p = 0.079). No studies reported binge eating at 12-months from baseline, so no meta-analysis was possible.

#### 2.3.4.3 Body image concerns

The combined effect estimate favoured the intervention over comparator for body image concerns at intervention-end [SMD -0.54 (95% CI -0.90, -0.18; n=2; l<sup>2</sup>= 54%)], but there was moderate heterogeneity (Figure 2). Only one study reported body image concerns at 12-months from baseline (SMD -0.69 [-0.96, -0.42]),<sup>182</sup> so no meta-analysis was possible.

#### 2.3.4.4 Depression

There was some evidence of an effect in favour of interventions for depression at interventionend [Post intervention: SMD -0.19 (95% CI -0.29, -0.10; n=15; l<sup>2</sup>=2%); Change from baseline: SMD -0.41 (95% CI -1.06, 0.24; n=7; l<sup>2</sup>=1%)] (Figure 2) and at 12-months from baseline [Post intervention: SMD -0.19 (95% CI -0.34, -0.04; n=5; l<sup>2</sup>=0%)] (Chapter Two Appendices: A2.8 - Figure A40).

After removal of interventions from studies deemed to be high risk of bias (n=8),<sup>152,164,171,177,184,185</sup> an effect remained in favour of the intervention at the end of the intervention [Post intervention: SMD -0.23 (95% CI -0.34, -0.13; n=11; I<sup>2</sup>=0%); Change from baseline: SMD -0.17 (95% CI -0.51, 0.18; n=3; I<sup>2</sup>=19%)] (Chapter Two Appendices: A2.8 - Figure A41-42).

#### 2.3.4.5 Emotional eating

There was no evidence of a difference between intervention and comparator for emotional eating at intervention-end [Post intervention: SMD -0.12 (95% CI -0.30, 0.06; n=3; l<sup>2</sup>=21%)] (Figure 2). Only one study reported change from baseline results for emotional eating at intervention-end<sup>167</sup> (SMD 0.14 [95% CI -0.14, 0.43]) or at 12-months from baseline (post-intervention: SMD -0.28 [95%CI -0.54, -0.02]; mean change: SMD 0.14 [95% CI -0.13, 0.41]),<sup>71</sup> so no meta-analysis was possible.

#### 2.3.4.6 Negative affect

At intervention-end, there was no evidence of a difference between intervention and comparator for negative affect [Change from baseline: SMD -0.12 (95% CI -0.38, 0.15; n=3; l<sup>2</sup>=65%)] (Figure 2). Only one study reported post-intervention results for negative affect at the end of the intervention (SMD -0.22 [95% CI -0.66, 0.23]),<sup>156</sup> and one study reported results at 12-months from baseline (SMD -0.21 [95% CI -0.36, -0.06]),<sup>187</sup> so no meta-analysis was possible.

#### 2.3.4.7 Psychological distress

Only one study reported results for psychological distress at intervention-end (SMD –0.51 [95% CI –0.95, –0.07]),<sup>188</sup> and no studies reported psychological distress data at 12-months from baseline, so no meta-analysis was possible for this outcome.

## 2.3.4.8 Quality of life (Global)

There was no evidence of a difference between intervention and comparator for global quality of life at intervention-end [Post intervention: SMD -0.06 (95% CI -0.51, 0.40; n=11; l<sup>2</sup>=94%); Change from baseline: SMD 0.19 (95% CI -0.03, 0.40; n=8; l<sup>2</sup>=60%)] (Figure 3) or at 12-months from baseline [Post intervention: SMD 0.12 (95% CI -0.04, 0.28; n=4; l<sup>2</sup>=0%); Change from baseline: SMD 0.00 (95% CI -0.16, 0.16; n=3; l<sup>2</sup>=0%)] (Chapter Two Appendices: A2.8 - Figure A40). After excluding studies deemed to be at high risk of bias (n=7),<sup>171,177,183,188</sup> there was still no evidence of a difference between intervention and comparator for global quality of life at intervention-end (Chapter Two Appendices: A2.8 - Figure A43-44).

Meta-regression identified that the substantial heterogeneity at intervention-end was explained by three interventions<sup>162,183</sup> where 90-100% of intervention participants were women, or where the intervention consisted solely of provision of resources (Chapter Two Appendices: A2.9 - Table A5). After excluding the identified sources of heterogeneity, there was some evidence of an effect in favour of the intervention [SMD 0.06 (95% CI -0.06, 0.18; n=7; l<sup>2</sup>=0%)] (Chapter Two Appendices: A2.11 - Figure A49).

## 2.3.4.9 Quality of life (Mental health-related)

Interventions were associated with improvements in mental health-related quality of life at intervention-end [Post intervention: SMD 0.46 (95% CI 0.31, 0.61; n=10; l<sup>2</sup>=15%); Change from baseline: SMD 0.03 (95% CI -0.14, 0.20; n=5; l<sup>2</sup>=45%)] (Figure 3) and at 12-months from baseline [Post intervention: SMD 0.29 (95% CI 0.09, 0.50; n=4; l<sup>2</sup>=0%)] (Chapter Two Appendices: A2.8 - Figure A40). After excluding studies deemed to be at high risk of bias (n=4),<sup>168,169,177,188</sup> there was evidence of an effect in favour of the intervention for mental health-related quality of life at intervention-end [Post intervention: SMD 0.45 (95% CI 0.28, 0.61; n=8; l<sup>2</sup>=14%); Change from

baseline: SMD 0.15 (95% Cl 0.03, 0.28; n=3; l<sup>2</sup>=0%)] (Chapter Two Appendices: A2.8 - Figure A43-44).

Only one study reported change from baseline results for mental health-related quality of life at 12-months from baseline (SMD 0.04 [95% CI -0.11, 0.19]),<sup>187</sup> so meta-analysis was not possible.

#### 2.3.4.10 Quality of life (Obesity-related)

Only one study<sup>174</sup> measured obesity-related quality of life with a positively scaled measure at intervention-end (SMD 0.37 [95% CI 0.06, 0.68]) and at 12-months from baseline (SMD 0.16 [95% CI –0.12, 0.44]), so meta-analysis could not be conducted.

There was no evidence of a difference between intervention and comparator for negatively scaled obesity-related quality of life at intervention-end [Post intervention: SMD 0.03 (95% CI - 0.34, 0.28; n=3;  $I^2$ = 54%)] (Figure 2). After excluding studies deemed to be at high risk of bias (n=1),<sup>165</sup> there was some evidence of an effect in favour of the intervention for negatively scaled obesity-related quality of life at intervention-end [Post intervention: SMD -0.18 (95% CI -0.38, 0.01; n=2;  $I^2$ = 0%)] (Chapter Two Appendices: A2.8 - Figure A41-42). No studies reported negatively scaled obesity-related quality of life at 12-months from baseline, so meta-analysis was not possible.

#### 2.3.4.11 Satisfaction with life

There was no evidence of a difference between intervention and comparator in satisfaction with life at intervention-end [Post intervention: SMD 0.01 (95% CI -0.14, 0.16; n=2;  $I^2=0\%$ ); Change from baseline: SMD -0.12 (95% CI -0.32, 0.07; n=2;  $I^2=0\%$ )] (Figure 3). Effect estimates favoured the comparator for satisfaction with life at 12-months from baseline [Change from baseline: SMD -0.12 (95% CI -0.37, -0.18; n=2;  $I^2=0\%$ )] (Chapter Two Appendices: A2.8 - Figure A40). No studies measuring satisfaction with life were deemed to be at high risk of bias.

## 2.3.4.12 Self-efficacy (General)

Effect estimates favoured intervention groups for general self-efficacy at intervention-end [Post intervention: SMD 0.39 (95% CI 0.16, 0.61; n=6; l<sup>2</sup>=0%)] (Figure 3) and at 12-months from baseline [Post intervention: SMD 0.35 (95% CI 0.13, 0.57; n=6; l<sup>2</sup>=0%)] (Chapter Two Appendices: A2.8 - Figure A40).

After excluding studies deemed to be at high risk of bias (n=4),<sup>179</sup> there was some evidence of an effect in favour of the intervention for general self-efficacy at intervention-end [Post intervention: SMD 0.37 (95% CI -0.08, 0.83; n=2; I<sup>2</sup>=0%)] (Chapter Two Appendices: A2.8 - Figure A43-44).

## 2.3.4.13 Self-efficacy (Diet-related)

There was some evidence of an effect in favour of interventions for diet-related self-efficacy at intervention-end [Post intervention: SMD 0.19 (95% CI -0.06, 0.44; n=7; l<sup>2</sup>=65%)] (Figure 3) and at 12-months from baseline [Post intervention: SMD 0.26 (95% CI -0.04, 0.56; n=4; l<sup>2</sup>=71%)] (Chapter Two Appendices: A2.8 - Figure A40), but there was substantial heterogeneity. Findings were unchanged following exclusion of studies deemed to be at high risk of bias  $(n=5)^{157,173,182,189,193}$  (Chapter Two Appendices: A2.8 - Figure A40, Figure A43-44). There were insufficient studies to conduct meta-regression to identify sources of heterogeneity.

Only one study reported change from baseline results for diet-related self-efficacy at intervention-end (SMD 0.39 [95% CI 0.11, 0.68]),<sup>161</sup> so meta-analysis was not possible.

## 2.3.4.14 Self-efficacy (Exercise-related)

Effect estimates favoured the interventions for exercise-related self-efficacy at intervention-end [Post intervention: SMD 0.49 (95% CI 0.25, 0.74; n=8; l<sup>2</sup>=60%)] (Figure 3) and at 12-months from baseline [Post intervention: SMD 0.47 (95% CI 0.15, 0.79; n=3; l<sup>2</sup>=71%)], but there was substantial heterogeneity. Findings were unchanged after exclusion of studies deemed to be at high risk of bias (n=4).<sup>168,169,182,189,193</sup> There were insufficient studies to conduct meta-regression to identify sources of heterogeneity.

#### 2.3.4.15 Self-esteem

There was no evidence of a difference between intervention and comparator groups for selfesteem at intervention-end [MD 0.95 (95% CI -0.25, 2.15; n=6; l<sup>2</sup>=77%)] (Figure 4). Findings were unchanged following exclusion of studies deemed to be at high risk of bias  $(n=2)^{171}$  (Chapter Two Appendices: A2.8 - Figure A45). There were insufficient studies to conduct meta-regression to identify sources of heterogeneity. Only one study reported data for self-esteem at 12-months from baseline (SMD 0.57 [95% CI 0.41, 0.72]),<sup>187</sup> so meta-analysis was not possible.

#### 2.3.4.16 Stress

There was no evidence of a difference between intervention and comparator for stress at intervention-end [Post intervention: SMD -0.03 (95% CI -0.40, 0.35; n=8; I2=77%)] (Figure 2). Findings were unchanged following the exclusion of studies deemed to be at high risk of bias (n=2) (Chapter Two Appendices: A2.8 - Figure A41-42).<sup>176,189</sup> Only one study reported change from baseline results for stress at intervention-end (SMD -5.14 [95% CI -6.34, -3.93]),<sup>184</sup> and no studies reported stress at 12-months from baseline, so meta-analysis was not possible.

#### HEALTH: A SYSTEMATIC REVIEW AND META-ANALYSIS.

| Study  | Assessment tool       |     | Hedges's<br>with 95% ( | g<br>Cl |
|--|-----------------------|-----|------------------------|---------|
| Anxiety* [Change from baseline] (n=2)  |                       |     |                        |         |
| Cleo et al. (2019) [TTT]   | Bespoke questionnaire |     | 0.39 [-1.12,           | 0.33]   |
| Cleo et al. (2019) [DSD]   | Bespoke questionnaire |     | 0.05 [-0.75,           | 0.66]   |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$                   |                       |     | 0.22 [-0.72,           | 0.29]   |
| Test of $\theta_i = \theta_i$ : Q(1) = 0.45, p = 0.50                            |                       |     | _                      | _       |
|  |                       |     |                        |         |
| Anxiety* [Post intervention] (n=11)  |                       |     |                        |         |
| Ahern et al. (2017) [12-week BWLP]   | HADS                  |     | 0.12 [–0.32,           | 0.07]   |
| Ahern et al. (2017) [52-week BWLP)   | HADS                  |     | 0.02 [-0.19,           | 0.24]   |
| Herring et al. (2014) [Resistance Exercise]                                      | HADS                  |     | 0.04 [–1.13,           | 1.04]   |
| Herring et al. (2014) [Aerobic Exercise]   | HADS —                |     | 0.72 [–1.84,           | 0.40]   |
| Imayama et al. (2011) [Dietary]  | BSI-18                |     | 0.20 [-0.60,           | 0.21]   |
| Imayama et al. (2011) [Exercise]   | BSI-18                |     | 0.31 [–0.72,           | 0.09]   |
| Imayama et al. (2011) [Dietary+Exercise]   | BSI-18                |     | 0.26 [–0.66,           | 0.15]   |
| Jane et al. (2018) [PG]  | DASS                  |     | 1.83 [ 0.91,           | 2.76]   |
| Jane et al. (2018) [FB]  | DASS                  |     | 0.61 [–0.21,           | 1.42]   |
| Nanchahal et al. (2009) [SS]   | HADS                  | -   | 0.05 [-0.60,           | 0.71]   |
| Nanchahal et al. (2009) [SSP]  | HADS                  |     | 0.14 [–0.82,           | 0.53]   |
| Heterogeneity: $\tau^2 = 0.07$ , $I^2 = 61.23\%$ , $H^2 = 2.58$                  |                       | • - | 0.02 [–0.25,           | 0.21]   |
| Test of $\theta_i = \theta_j$ : Q(10) = 24.10, p = 0.01                          |                       |     |                        |         |
| Body image concerns* [Post intervention] (n=2)                                   |                       |     |                        |         |
| Teixeira et al. (2010)   | BSQ                   | -   | 0.69 [–0.96, –         | 0.42]   |
| Steinberg et al. (2014)  | BSQ                   |     | 0.31 [–0.73,           | 0.10]   |
| Heterogeneity: $\tau^2 = 0.04$ , $I^2 = 54.24\%$ , $H^2 = 2.19$                  |                       | • - | 0.54 [-0.90, -         | 0.18]   |
| Test of $\theta_i = \theta_j$ : Q(1) = 2.19, p = 0.14                            |                       | •   |                        |         |
|  |                       |     |                        |         |
| Depression* [Change from baseline] (n=7)   |                       |     |                        |         |
| Samuel-Hodge et al. (2009)   | CES-D                 | -   | 0.04 [–0.38,           | 0.31]   |
| Xenaki et al. (2018)   | BDI —                 | -   | 2.48 [–3.25, –         | 1.71]   |
| Cleo et al. (2019) [TTT]   | Bespoke questionnaire |     | 0.71 [–1.45,           | 0.03]   |
| Cleo et al. (2019) [DSD]   | Bespoke questionnaire |     | 0.03 [–0.74,           | 0.67]   |
| Rubin et al. (2013) [In-person support]  | PHQ-8                 | -   | 0.20 [-0.11,           | 0.52]   |
| Rubin et al. (2013) [Remote support only]  | PHQ-8                 | -   | 0.04 [–0.28,           | 0.35]   |
| Altaris et al. (2015)  | PHQ-8                 | -   | 0.16 [-0.40,           | 0.09]   |
| Heterogeneity: $\tau^{-} = 0.69$ , $\Gamma^{-} = 94.57\%$ , $H^{-} = 18.43$      |                       | -   | 0.41 [-1.06,           | 0.24]   |
| lest of $\theta_i = \theta_j$ : Q(6) = 43.88, p = 0.00                           |                       |     |                        |         |
| Depression* [Post intervention] (n=15)   |                       |     |                        |         |
| Ahern et al. (2017) [12-week BWLP]   | HADS                  | -   | 0.33 [–0.53, –         | 0.13]   |
| Ahern et al. (2017) [52-week BWLP)   | HADS                  | -   | 0.22 [-0.44, -         | 0.01]   |
| Barnes et al. (2014)   | BDI                   |     | 0.10 [–0.61,           | 0.41]   |
| Godino et al. (2016)   | CES-D                 | -   | 0.27 [-0.49, -         | 0.05]   |
| Herring et al. (2014) [Resistance Exercise]                                      | HADS                  |     | 0.02 [-1.06,           | 1.11]   |
| Herring et al. (2014) [Aerobic Exercise]   | HADS —                |     | 0.61 [–1.72,           | 0.50]   |
| Imayama et al. (2011) [Dietary]  | BSI-18                |     | 0.07 [–0.47,           | 0.34]   |
| Imayama et al. (2011) [Exercise]   | BSI-18                |     | 0.03 [–0.44,           | 0.37]   |
| Imayama et al. (2011) [Dietary+Exercise]   | BSI-18                |     | 0.26 [–0.66,           | 0.15]   |
| Jane et al. (2018) [PG]  | DASS                  |     | 0.06 [–0.73,           | 0.85]   |
| Jane et al. (2018) [FB]  | DASS                  |     | 0.06 [-0.86,           | 0.74]   |
| Kalarchian et al. (2013)   | BDI                   | -   | 0.09 [–0.21,           | 0.39]   |
| Nanchahal et al. (2009) [SS]   | HADS                  |     | 0.03 [-0.63,           | 0.68]   |
| Nanchahal et al. (2009) [SSP]  | HADS                  | -   | 0.26 [–0.93,           | 0.42]   |
| Steinberg et al. (2014)  | CES-D                 |     | 0.20 [–0.61,           | 0.22]   |
| Heterogeneity: $\tau^{\circ} = 0.00$ , $I^{\circ} = 1.54\%$ , $H^{\circ} = 1.02$ |                       | •   | 0.19 [–0.29, –         | 0.10]   |
| l est ot $\theta_i = \theta_j$ ; Q(14) = 8.63, p = 0.85                          |                       |     |                        |         |

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#### BEHAVIOURAL WEIGHT MANAGEMENT INTERVENTIONS

| Study   | Assessment too | DI                         | Hedges's g<br>with 95% Cl |
|---|----------------|----------------------------|---------------------------|
| Emotional eating* [Change from baseline] (n=1)                  |                |                            |                           |
| McRobbie et al. (2016)  | TFEQ           |                            | 0.14 [-0.14, 0.43]        |
|   |                |                            |                           |
|   |                |                            |                           |
| Emotional eating* [Post intervention] (n-3)                     |                |                            |                           |
| Nurkkala et al. (2015)  | TEEO           | _                          | 0 15 [-0 39 0 68]         |
| Teixeira et al. (2010)  | DEBO           |                            | -0.28[-0.54 -0.02]        |
| lebb et al. (2011)  | TEEQ           |                            | -0.07[-0.26 0.12]         |
| Heterogeneity: $\tau^2 = 0.01$ , $I^2 = 20.94\%$ , $H^2 = 1.26$ | La             | <b>T</b>                   | -0.12 [-0.30, 0.06]       |
| Test of $\theta_1 = \theta_2$ : Q(2) = 2.67, p = 0.26           |                |                            |                           |
| Negative affect* [Change from baseline] (n=3)                   |                |                            |                           |
| Petrella et al. (2017)  | PANAS          | -                          | 0.20[-0.23 0.64]          |
| Jamal et al. (2016)   | ATO            |                            | -0.08[-0.36 0.20]         |
| Hunt et al. (2014)  | PANAS          |                            | -0.30 [-0.45 -0.15]       |
| Heterogeneity: $\tau^2 = 0.03$ $I^2 = 64.96\%$ $H^2 = 2.85$     | 1740/0         |                            | -0.12[-0.38 0.15]         |
| Test of $A = A$ : $Q(2) = 5.63$ , $p = 0.06$                    |                |                            | 0.12[ 0.00, 0.10]         |
| 10000101 = 01.00000000000000000000000000                        |                |                            |                           |
| Negative affect* [Post intervention] (n=1)                      |                |                            |                           |
| Gray et al. (2013)  | PNAS           | -                          | -0.22 [-0.66, 0.23]       |
|   |                |                            |                           |
|   |                |                            |                           |
|   |                |                            |                           |
| Psychological distress* [Post intervention] (n=1)               | 1/10           |                            | 0.541.0.05.0.071          |
| Seliman et al. (2017)   | K10            |                            | -0.51 [-0.95, -0.07]      |
|   |                |                            |                           |
|   |                |                            |                           |
| Quality of life – Obesity-related* [Post intervention] (n=3)    |                |                            |                           |
| Camolas et al. (2017)   | ORWELL-R       |                            | -0.08 [-0.58, 0.42]       |
| Jebb et al. (2011)  | IWOQOL         |                            | -0.20 [-0.41, 0.01]       |
| Kraschnewski et al. (2011)                                      | IWOQOL         |                            | 0.30 [-0.12, 0.73]        |
| Heterogeneity: $\tau^2 = 0.04$ , $I^2 = 53.87\%$ , $H^2 = 2.17$ |                | •                          | -0.03 [-0.34, 0.28]       |
| Test of $\theta_i = \theta_j$ : Q(2) = 4.36, p = 0.11           |                |                            |                           |
|   |                |                            |                           |
| Stress* [Change from baseline] (n=1)                            |                |                            |                           |
| Xenaki et al. (2018)  | PSS            |                            | -5.14 [-6.34, -3.93]      |
|   |                |                            |                           |
|   |                |                            |                           |
| Stress* [Post intervention] (n=8)                               |                |                            |                           |
| Berry et al. (2011)   | HPLP II        | -                          | 0.30 [-0.22, 0.82]        |
| Cramer et al. (2016)  | PSS            | -=-                        | -0.78 [-1.33, -0.24]      |
| Imayama et al. (2011) [Dietary]                                 | PSS            | -                          | -0.14 [-0.55, 0.26]       |
| Imayama et al. (2011) [Exercise]                                | PSS            | -                          | -0.19 [-0.60, 0.22]       |
| Imayama et al. (2011) [Dietary+Exercise]                        | PSS            | -                          | -0.52 [-0.92, -0.11]      |
| Jane et al. (2018) [PG]   | DASS           |                            | - 1.00 [ 0.17, 1.84]      |
| Jane et al. (2018) [FB]   | DASS           | -                          | - 0.85 [ 0.02, 1.69]      |
| Rshikesan et al. (2016)   | PSS            |                            | -0.13 [-0.59, 0.32]       |
| Heterogeneity: $\tau^2 = 0.22$ , $I^2 = 77.10\%$ , $H^2 = 4.37$ |                | •                          | -0.03 [-0.40, 0.35]       |
| Test of $\theta_i = \theta_j$ : Q(7) = 24.10, p = 0.00          |                |                            |                           |
|   |                |                            |                           |
|   |                |                            |                           |
|   |                | Favours intervention Favou | urs comparator            |
|   |                |                            |                           |
|   |                | _6 _4 _2 0                 | <u>م</u>                  |
|   |                | -0 -4 -2 0                 | 2                         |

Figure 2. Changes in negatively scaled mental health outcomes comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using randomeffects pairwise meta-analysis. [Abbreviations: TTT: Ten Top Tips; DSD: Do Something Different; BWLP: Behavioural Weight Loss Programme; PG: Pamphlet Group; FB: Facebook Group; SS: Structured Support; SSP: Structured Support and Physical Activity; HADS: Hospital Anxiety and Depression Scale: BSI: Brief Symptom Inventory; DASS: Depression Anxiety Stress Scales; BSQ: Body Shape Questionnaire; CES-D: Center for Epidemiologic Studies Depression Scale; BDI: Beck Depression Inventory: PHQ: Patient Health Questionnaire; TFEQ: Three Factor Eating Questionnaire; DEBQ: Dutch Eating Behaviour Questionnaire; ORWELL-R: Obesity-Related Wellbeing Questionnaire; IWOQOL: Impact of Weight on Quality of. Life; PSS: Perceived Stress Scale; HPLP II: Health-Promoting Lifestyle Profile.]

#### THE ROLE OF MENTAL HEALTH IN ADULT

#### BEHAVIOURAL WEIGHT MANAGEMENT INTERVENTIONS

| Study  | Assessment tool       | Hedges's g<br>with 95% Cl |
|--|-----------------------|---------------------------|
| Quality of life – Global [Change from baseline] (n=8)            |                       |                           |
| Astbury et al. (2018)  | EQ5D-index            | 0.22 [-0.09, 0.53]        |
| Cleo et al. (2019) [TTT]   | Bespoke questionnaire | 0.96 [ 0.13, 1.78]        |
| Cleo et al. (2019) [DSD]   | Bespoke questionnaire | 0.90 [ 0.11, 1.69]        |
| Rubin et al. (2013) [In-person support]                          | EQ5D-VAS              | 0.05 [-0.39, 0.29]        |
| Rubin et al. (2013) [Remote support only]                        | EQ5D-VAS              | - 0.10 [-0.25, 0.45]      |
| Damschroder et al. (2014) [ASPIRE-Phone]                         | EQ5D-index            | 0.00 [-0.27, 0.27]        |
| Damschroder et al. (2014) [ASPIRE-Group]                         | EQ5D-index            | -0.12 [-0.40, 0.15]       |
| Petrella et al. (2017)   | EQ5D3L                | 0.58 [ 0.13, 1.02]        |
| Heterogeneity: $\tau^2 = 0.05$ , $I^2 = 60.21\%$ , $H^2 = 2.51$  |                       | 0.19 [-0.03, 0.40]        |
| Test of $\theta_i = \theta_j$ : Q(7) = 17.07, p = 0.02           |                       |                           |
| Quality of life – Global [Post intervention] (n=11)              |                       |                           |
| Ahern et al. (2017) [12-week BWLP]                               | EQ5D3L                | 0.08 [-0.12, 0.28]        |
| Ahern et al. (2017) [52-week BWLP)                               | EQ5D3L                | 0.11 [-0.11, 0.33]        |
| McRobbie et al. (2016)   | EQ5D5L                | 0.18 [-0.12, 0.49]        |
| Sellman et al. (2017)  | WHOQOL -              | 0.04 [-0.39, 0.47]        |
| Nanchahal et al. (2009) [SS]                                     | EQ5D-index            | -0.07 [-0.73, 0.59]       |
| Nanchahal et al. (2009) [SSP]                                    | EQ5D-index -          | -0.12 [-0.79, 0.56]       |
| Jane et al. (2018) [PG]  | WHOQOL                | -1.96 [-2.83, -1.09]      |
| Jane et al. (2018) [FB]  | WHOQOL                | -1.46 [-2.34, -0.57]      |
| White et al. (2010) [Group 1]                                    | Bespoke questionnaire |                           |
| White et al. (2010) [Group 2]                                    | Bespoke questionnaire | 0.76 [ 0.22, 1.30]        |
| Godino et al. (2016)   | QWS                   | 0.08 [-0.13, 0.30]        |
| Heterogeneity: $\tau^2 = 0.51$ , $I^2 = 94.00\%$ , $H^2 = 16.67$ |                       | -0.06 [-0.51, 0.40]       |
| Test of $\theta_i = \theta_j$ : Q(10) = 51.82, p = 0.00          |                       |                           |
| Quality of life – Mental health [Change from baseline] (n=5)     |                       |                           |
| Samuel-Hodge et al. (2009)                                       | SF-8 -                | - 0.01 [-0.33, 0.36]      |
| Rubin et al. (2013) [In-person support]                          | SF-12 -               | -0.14 [-0.49, 0.21]       |
| Rubin et al. (2013) [Remote support only]                        | SF-12 -               | -0.22 [-0.56, 0.13]       |
| Jamal et al. (2016)  | WHOQOL                | 0.07 [-0.22, 0.35]        |
| Hunt et al. (2014)   | SF-12                 | 0.21 [ 0.05, 0.36]        |
| Heterogeneity: $\tau^2 = 0.02$ , $I^2 = 44.77\%$ , $H^2 = 1.81$  |                       | 0.03 [-0.14, 0.20]        |
| Test of $\theta_i = \theta_j$ : Q(4) = 7.11, p = 0.13            |                       |                           |
| Quality of life – Mental health [Post intervention] (n=10)       |                       |                           |
| Morgan et al. (2013) [SHED-IT-Resources]                         | SF-12                 | 0.44 [-0.03, 0.91]        |
| Morgan et al. (2013) [SHED-IT-Online]                            | SF-12 -               | 0.15 [-0.31, 0.62]        |
| Morgan et al. (2011) & (2012)                                    | SF-12                 |                           |
| Cramer et al. (2016)   | SF-36                 |                           |
| Domene et al. (2016)   | SF-36                 | 0.83 [-0.05, 1.70]        |
| Imayama et al. (2011) [Dietary]                                  | SF-36 -               | 0.22 [-0.19, 0.62]        |
| Imayama et al. (2011) [Exercise]                                 | SF-36                 | 0.32 [-0.09, 0.72]        |
| Imayama et al. (2011) [Dietary+Exercise]                         | SF-36                 | 0.38 [-0.02, 0.79]        |
| Sellman et al. (2017)  | WHOQOL -              | 0.26 [-0.17, 0.69]        |
| Gray et al. (2013)   | SF-12                 |                           |
| Heterogeneity: $\tau^2 = 0.01$ , $I^2 = 15.02\%$ , $H^2 = 1.18$  |                       | 0.46 [ 0.31, 0.61]        |
| Test of $\theta_i = \theta_j$ : Q(9) = 10.36, p = 0.32           |                       |                           |
| Quality of life - Obesity-related [Change from baseline] (n=1)   |                       |                           |
| Astbury et al. (2018)  | OWL-QOL               |                           |
|  |                       |                           |

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| Study  | Assessment tool                         | Hedges's g<br>with 95% Cl |
|--|---|---------------------------|
| Satisfaction with life [Change from baseline] (n=2)                  |   |                           |
| Damschroder et al. (2014) [ASPIRE-Phone]                             | Deiner SWL                              | -0.16 [-0.43, 0.12]       |
| Damschroder et al. (2014) [ASPIRE-Group]                             | Deiner SWL                              | -0.09 [-0.37, 0.18]       |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$       |   | -0.12 [-0.32, 0.07]       |
| Test of $\theta_i = \theta_i$ : Q(1) = 0.10, p = 0.75                |   |                           |
|  |   |                           |
| Satisfaction with life [Post intervention] (n=2)                     |   |                           |
| Ahern et al. (2017) [12-week BWLP]                                   | SWL 📕                                   | -0.03 [-0.23, 0.17]       |
| Ahern et al. (2017) [52-week BWLP)                                   | SWL -                                   | 0.05 [-0.16, 0.27]        |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$       | •                                       | 0.01 [-0.14, 0.16]        |
| Test of $\theta_i = \theta_j$ : Q(1) = 0.30, p = 0.58                |   |                           |
|  |   |                           |
| Self efficacy – Diet [Change from baseline] (n=1)                    |   |                           |
| Jamal et al. (2016)  | WEL -                                   | 0.39 [ 0.11, 0.68]        |
|  |   |                           |
| Salf afficany - Diat [Post intervention] (n-7)                       |   |                           |
| Borny et al. (2011)  |   | 0.29 [ 0.90 0.24]         |
| Crane et al. (2016)  | WEL                                     | -0.20 [-0.00, 0.24]       |
| Damschroder et al. (2014) [ASPIRE_Phone]                             | SOCO                                    | 0.26[-0.06, 0.58]         |
| Damschroder et al. (2014) [ASPIRE_Group]                             | 5000                                    | 0.17 [-0.15, 0.48]        |
|  | Bespoke questionnaire                   | -0.13[-0.56, 0.31]        |
|  | WMEO                                    | -0.13 [-0.36, 0.90]       |
| O'Brien et al. (2016)  | WEL                                     | -0.22 [-1.05, 0.61]       |
| Heterogeneity: $\tau^2 = 0.07$ $I^2 = 64.60\%$ $H^2 = 2.82$          |   | 0.19[-0.06, 0.44]         |
| Test of $\theta_{-} = \theta_{-} O(\theta) = 16.83 \text{ n} = 0.01$ |   | 0.10 [-0.00, 0.44]        |
| $1031010_1 = 0_1$ . $a(0) = 10.00, p = 0.01$                         |   |                           |
| Self efficacy – Exercise [Post intervention] (n=8)                   |   |                           |
| Berry et al. (2011)  | ESES —                                  | 0.63 [ 0.10, 1.16]        |
| Crane et al. (2016)  | Bespoke questionnaire                   | 0.04 [-0.34, 0.41]        |
| Damschroder et al. (2014) [ASPIRE-Phone]                             | Bespoke questionnaire                   | 0.38 [ 0.06, 0.70]        |
| Damschroder et al. (2014) [ASPIRE-Group]                             | Bespoke questionnaire -                 | 0.23 [-0.09, 0.55]        |
| Herring et al. (2014) [Resistance Exercise]                          | SERPA                                   | — 1.79 [ 0.52, 3.06]      |
| Herring et al. (2014) [Aerobic Exercise]                             | SERPA                                   | 1.62 [ 0.38, 2.86]        |
| Morgan et al. (2011) & (2012)  | Bespoke questionnaire                   | 0.42 [ 0.04, 0.80]        |
| Teixeira et al. (2010)   | SEEB -                                  | 0.77 [ 0.50, 1.04]        |
| Heterogeneity: $\tau^2 = 0.06$ , $I^2 = 60.25\%$ , $H^2 = 2.52$      | •                                       | 0.49 [ 0.25, 0.74]        |
| Test of $\theta_i = \theta_j : Q(7) = 20.02,  p = 0.01$              |   |                           |
| Self efficacy [Post intervention] (n=6)                              |   |                           |
| Ash et al. (2006) [IDT]  | GSES —                                  | 0.50 [-0.13, 1.13]        |
| Ash et al. (2006) [FBI]  | GSES —                                  | 0.24 [-0.42, 0.89]        |
| Scholz et al. (2013) [PG1]   | Bespoke questionnaire                   | 0.56 [ 0.04, 1.08]        |
| Scholz et al. (2013) [PG3]   | Bespoke questionnaire                   | 0.37 [-0.15, 0.88]        |
| Scholz et al. (2013) [PG6]   | Bespoke questionnaire                   | 0.22 [-0.28, 0.73]        |
| Scholz et al. (2013) [PG9]   | Bespoke questionnaire                   | 0.42 [-0.09, 0.94]        |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$       | •                                       | 0.39 [ 0.16, 0.61]        |
| Test of $\theta_i=\theta_j;$ Q(5) = 1.18, p = 0.95                   |   |                           |
|  |   |                           |
|  | Favours comparator Favours intervention |                           |
|  |   |                           |
|  | -1 0 1 2                                | 3                         |

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Figure 3. Changes in positively scaled mental health outcomes comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using randomeffects pairwise meta-analysis. [Abbreviations: TTT: Ten Top Tips; DSD: Do Something Different; BWLP: Behavioural Weight Loss Programme; PG: Pamphlet Group; FB: Facebook Group; SS: Structured Support; SSP: Structured Support and Physical Activity; SHED-IT: Self-Help, Exercise, and Diet using Information Technology; IDT: Individualised dietetic treatment; FBI: Fat Boosters Incorporated; WHOQOL: World Health Organization Quality of Life; QWS: Quality of Well-being Scale; SF: Short Form; OWL-QOL: Obesity and Weight-Loss Quality of Life; SWL: Satisfaction with Life; WEL: Weight Efficacy Lifestyle Questionnaire; ESES: Exercise Self-Efficacy Scale; SOCQ: Stages of Change questionnaire; WMEQ: Weight Management Efficacy Questionnaire; SERPA: Self-Efficacy for Regulating Physical Activity; SEEB: Self-Efficacy for Exercise Behaviours; GSES: General Self-Efficacy Scale.]



Figure 4. Changes in [positively scaled] self-esteem comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis. [Abbreviations: SS: Structured Support; SSP: Structured Support and Physical Activity; RSES: Rosenberg self-esteem scale.]
## 2.3.5 Additional analyses

The appendices (Chapter Two Appendices: A2.11 - Figure A50-84) present the findings from stratified random-effects meta-analyses investigating the differential effects of prespecified study, intervention, and participant characteristics on pooled estimates for anxiety (post-intervention), depression (post-intervention), global quality of life (post-intervention/change from baseline), mental health-related quality of life (post-intervention) and exercise self-efficacy (post-intervention). There was no clear and consistent evidence that any of these characteristics explained heterogeneity in effect sizes. The remaining outcomes at intervention-end, and all outcomes at 12-month follow-up, did not have sufficient variability in any prespecified characteristics to enable stratified analyses.

Contour-enhanced funnel plots of individual study effect sizes show a high risk of publication bias across all outcomes (Chapter Two Appendices: A2.6 Figure A2-39).

### 2.4 Discussion

This comprehensive systematic review and meta-analysis found evidence suggesting that behavioural weight-loss interventions result in greater improvements for several mental health outcomes compared with a minimal/inactive comparison group. At the end of the intervention, there was evidence to suggest greater improvements for depression, mental health-related quality of life, body image concerns, self-efficacy, exercise self-efficacy and diet self-efficacy. At 12-months from baseline, evidence suggests improvements to depression, mental health-related quality of life, satisfaction with life, general self-efficacy, and exercise self-efficacy. Notably, this review found no evidence to suggest that interventions negatively impacted mental health relative to comparator groups. However, there was insufficient evidence to assess the impact on a large number of mental health domains at intervention-end (including binge eating and psychological distress) and 12-month follow up (including anxiety, binge eating, body image concerns, emotional eating, negative affect, psychological distress, obesity-related quality of life, self-esteem, and stress). Findings should be interpreted with caution given the RoB of many studies and the possibility of publication bias.

Improvements in depression in favour of the behavioural interventions aligned with the findings of Fabricatore et al.<sup>33</sup> and Peckmezian et al.<sup>77</sup> A previous review by Baillot et al.<sup>84</sup> found no evidence of an effect on depression following an exercise-only intervention, which is consistent with the stratified analysis in this review. Previous reviews assessing the impact of behavioural interventions on mental health-related quality of life found no effect for exercise-only behavioural interventions<sup>84</sup> and improvements in mental health-related quality of life for maleonly interventions.<sup>145</sup> I found evidence to suggest improvements in mental health-related quality of life at intervention-end and 12-months from baseline. Stratified analysis suggested that exercise-only interventions are beneficial for mental health-related quality of life, contrasting with the findings of Baillot et al.<sup>84</sup> Contrasting with previous evidence,<sup>84,86</sup> I found evidence of improvements in body image following a behavioural weight loss intervention. This may be due to key differences in study participants (i.e.,  $\geq$ 25 kg/m<sup>2</sup> vs.  $\geq$ 30 kg/m<sup>2</sup>), study designs (e.g., the inclusion of non-RCTs), or interventions studied (e.g., behavioural intervention vs. cognitive behaviour interventions). Consistent with previous reviews,<sup>84,86</sup> I found no evidence of an effect of interventions on anxiety. However, there was considerable heterogeneity for this outcome and after removal of a single study<sup>162</sup> identified as the source of heterogeneity, the behavioural interventions were associated with a reduction in anxiety. This highlights the potential influence 50

of study, intervention, or participant characteristics on anxiety; insights into the differential effects of these characteristics are limited, however, because of the low number of heterogeneous studies.

To my knowledge, this is the first review evaluating the impact of adult behavioural weight management interventions on mental health to apply stratification techniques to investigate if effect estimates were influenced by study, participant, or intervention characteristics. However, few outcomes had a sufficient number of contributing studies and variability in characteristics to permit these analyses to be conducted, and there were no clear and consistent findings. Suitably powered, high-quality trials are required to explore the differential effects of study, participant, or intervention characteristics.

Many studies included in this review were deemed to be at high or unclear risk of bias. Common reasons included selective reporting, allocation concealment, and incomplete data. Although sensitivity analyses showed the minimal impact of high risk of bias studies on pooled estimates, these recurring weaknesses should be addressed to strengthen the evidence base. Incomplete data, selective reporting, and biased publication increase the risk of review findings inheriting bias, consequently impacting the interpretation of findings and patient healthcare. In efforts to overcome this, study authors were contacted for missing data. Future studies should consistently adopt standards for trial reporting, such as the CONSORT recommendations,<sup>148</sup> to improve study validity and credibility.<sup>194</sup>

Substantial heterogeneity was present for many outcomes in this review, hypothesised to be due to diversity in intervention types, populations under study, and measurement tools. Whilst there was no evidence of a difference between intervention and comparator for anxiety or global quality of life (with substantial heterogeneity present), pooled estimates suggested evidence of an effect in favour of the interventions for both outcomes when adjusted for heterogeneity. This suggests that substantial heterogeneity may impact the magnitude and/or direction of effect estimates. Identifying and adjusting for heterogeneity is challenging when research lacks the necessary detail of information, further highlighting the need for adherence to trial reporting recommendations.<sup>148</sup>

Despite previous reviews highlighting a need for more research,<sup>33,77,81–84,86,145</sup> there remains a lack of high-quality behavioural weight loss intervention studies measuring and reporting mental health outcomes. Systematic reviews of the effectiveness of behavioural weight loss intervention

for weight change identified 58 RCTs<sup>195</sup> in 2014 and 89 RCTs<sup>64</sup> in 2018, whilst I identified only 42 trials that measured and reported mental health. It is essential to build a robust evidence base to comprehensively understand the impact of current interventions on mental health and to identify how services may better support participants in the future. Future RCTs should investigate the impact of behavioural weight-loss interventions on a broad variety of mental health outcomes, assessed repeatedly over longer durations, and compared to inactive comparison groups.

It is also important to note that in this review I assessed the average effect of interventions on mental health. Although evidence suggests that, on average, mental health outcomes improve following a behavioural intervention, it is likely that this is not the case for all participants. Future research should investigate whether the effect of interventions on mental health is different in different subgroups of participants and should seek to identify whether we can predict who might be at risk of adverse mental health effects.

#### 2.4.1 Strengths and limitations

To my knowledge, this is the most up-to-date, comprehensive review investigating the effect of weight management interventions on a broad range of mental health outcomes in a representative sample of adults with overweight or obesity. Additionally, this review is the first to investigate whether particular intervention or study characteristics are more supportive of mental health. The methodological approach of this systematic review was rigorous and comprehensive. This review was strengthened by exclusively including RCTs, assessing a broad variety of mental health outcomes, and including adults that were representative of the general population with obesity. This review is further strengthened by comparing behavioural weight management interventions to inactive comparator groups or usual care, allowing the review to assess if providing an intervention is more supportive of mental health than not intervening. The impact on mental health was at assessed the end of the intervention to understand the immediate effects, and additionally at 12-months from baseline to explore the sustained effects. Finally, this review aligns with key recommendations for open science and reproducibility of meta-analyses.<sup>196</sup> In particular, the review protocol was preregistered and published, data and methods are comprehensively reported, PRISMA reporting guidelines were adhered to,<sup>141</sup> a librarian was consulted in the search strategy development, and the authorship team included a statistician.

The review findings were limited by the scarcity of eligible evidence, and the high risk of bias in many included studies. Intervention trials rarely report mental health outcomes in title and abstracts; consequently, the screening process may not have identified all eligible studies. However, I conducted extensive hand-searching of reviews assessing other outcomes and study reference lists to maximise the inclusion of eligible studies. Review findings were further limited by poor reporting within studies, which made it difficult to conduct stratified analyses and meta-regression for many outcomes.

Despite the comprehensive and inclusive eligibility criteria, the findings of this review are limited to the populations studied in the individual trials. Included studies had a high proportion of female participants and were conducted in middle-high or high-income countries; this is common for weight management interventions.<sup>197,198</sup> Consequently, how interventions affect the mental health of male participants or adults with obesity in low-middle or low-income countries remains unclear, as does the impact of other characteristics not represented in the review.

## 2.5 Conclusion

This comprehensive and inclusive systematic review suggests that behavioural weight management interventions result in improvements in several mental health outcomes, including body image concerns, depression, mental health-related quality of life, self-efficacy, exercise self-efficacy and diet self-efficacy. This review found no evidence to suggest that interventions negatively impacted mental health; however, there was insufficient evidence to assess the impact on a large number of mental health outcomes at intervention-end and beyond. The review contributes to a growing field of research and makes recommendations to strengthen future intervention studies. Specifically, future RCTs should ensure the inclusion of a broad range of mental health outcomes, transparent reporting of findings, repeated measures over longer durations, and comparison with a suitable inactive comparator group. Larger, high-quality studies are required to provide sufficient statistical power to assess differential effects in participant subgroups and to investigate the influential components of interventions.

In this review, evidence suggests that behavioural weight management interventions produce small improvements in some aspects of mental health. A patient representative, when reviewing the associated publication, posed an important question as to whether the findings are representative of the full range of mental health experiences as those with worse mental health may not engage with the intervention or attend trial follow-up visits. I address this question in Chapter Four where I examine whether baseline mental health is associated with attendance and engagement in a trial of behavioural weight management interventions.

In this review, I identified a dearth of high-quality studies with long-term follow-up, which leaves uncertainty about the sustained impact of these interventions. I address this uncertainly in Chapter Five, where I examine the impact of behavioural weight management interventions on mental health at five years from baseline.

Although this review suggests that, on *average*, mental health outcomes improve following a behavioural intervention, it is likely that this is not the case for all participants. It is important to be able to identify intervention participants who may be at risk of a decline in their mental health so that appropriate support may be implemented. I address this in Chapter Six, where I investigate how we may identify the participants who are at most risk of a decline in their mental health during and after a behavioural weight management intervention.

## 2.6 Contributions

I designed this study in collaboration with Amy Ahern and Emma Lawlor. I developed the search strategy with advice from Eleanor Barker at the Medical Library of the University of Cambridge. I conducted the literature searches in all databases, exported search outputs, and uploaded articles to Covidence for screening. I conducted title, abstract, and full-text screening of all articles, with duplicate screening divided between Jack Birch, Manal Patel, Andre Werneck, and Erin Hoare. I carried out data extraction and quality assessments, which was checked by JB, MP, AW or EH. I conducted data synthesis via meta-analysis with advice from Stephen Sharp. I critically interpreted the findings with support from Amy Ahern. I drafted the full thesis Chapter and the associated manuscript for publication (all co-authors reviewed and approved the manuscript for publication). A panel of PPI representatives contributed to the development of the research questions, informed the acceptability of the research, and informed the interpretations of the findings.

## CHAPTER THREE: 'WEIGHT LOSS REFERRALS FOR ADULTS IN PRIMARY CARE' (WRAP) TRIAL: STUDY DESIGN AND BASELINE RESULTS

## 3.1 Chapter overview

In Chapter Two, a review of available evidence suggested that interventions benefit some aspects of mental health, and there was no evidence to suggest that interventions negatively impacted mental health relative to comparator groups. I concluded that high-quality, transparently reported RCTs measuring a range of mental health outcomes over longer durations are required to strengthen the evidence base.

The Weight loss Referrals for Adults in Primary care (WRAP) trial is an example of a high-quality RCT measuring mental health over a long duration of time (up to 5 years from baseline). This trial was included in the systematic review and meta-analysis (Chapter Two) and acted as the data source for Chapters Four, Five, and Six.

In **Chapter Three**, I present the WRAP trial protocol and baseline results, including participant characteristics, withdrawals and retention, and programme engagement information. In addition, I present the proportion of missing data for relevant outcomes at each assessment timepoint. I was not involved in the design or implementation of the WRAP trial; in this thesis, I have designed and conducted secondary analyses of data collected during the trial.

## 3.2 Methods

## 3.2.1 Study design and randomisation

The Weight loss Referrals for Adults in Primary care (WRAP) trial is an open-group, multi-arm, randomised controlled trial comparing three groups: (1) Brief intervention (BI), (2) 12-weeks commercial weight loss programme (CP12), (3) 52-weeks commercial weight loss programme (CP52). Participants who met eligibility criteria and gave informed consent were randomly assigned to an intervention arm on a 2:5:5 ratio (BI:CP12:CP52) with a block size of 12, stratified by the research centre and gender. An online database was used to randomise participants using a statistician-generated randomisation sequence that was unknown to research staff and participants. Due to the nature of the intervention and trial design, participants and research staff were not blinded to allocation after randomisation.

Ethical approval was received from NRES Committee East of England Cambridge East and local approvals from NRES Committee North West Liverpool Central and NRES Committee South Central Oxford. This trial was registered with Current Controlled Trials (ISRCTN82857232). More detailed trial methods are reported in the published trial protocol.<sup>199</sup>

## 3.2.2 Participants: Eligibility and recruitment

Adults with a body mass index of 28 kg/m<sup>2</sup> or greater, residing in the United Kingdom, were eligible for participation in the trial. Individuals were excluded from study participation if they met one or more of the following: planned or current pregnancy in the next two years, previous or planned bariatric surgery, currently following a weight-loss programme, non-English Speaking or communication needs that would preclude them from understanding the study materials and interventions, and GP-defined inappropriate for participation (e.g., patients who are violent/terminally ill/ have a history of an eating disorder/severe mental health problem or learning difficulty). Eligible participants were identified and recruited by 23 local primary care practices across England, and all study participants gave written informed consent. Recruitment ran from 18<sup>th</sup> October 2012 until 10<sup>th</sup> February 2014.

#### 3.2.3 Setting

Participants were identified and recruited by local primary care practices across England by three research centres (University of Cambridge [coordinating centre], University of Liverpool, and University of Oxford). The University of Cambridge recruited participants through local practices in Cambridgeshire and all measurements were conducted by trained staff at the research centre. The University of Liverpool recruited participants through local practices in Merseyside and all measurements were conducted by trained staff at the University of Oxford participants through local practices in Merseyside and all measurements were conducted by trained staff at the research centre. The University of Diverpool recruited participants through local practices in Merseyside and all measurements were conducted by trained staff at the research centre. The University of Oxford recruited participants through local practices across southern and eastern England and all measurements were conducted by trained health professionals in the practice.

#### 3.2.4 Study arms

#### *3.2.4.1 Commercial weight management programmes*

Participants randomly assigned to the 12- or 52 week-commercial weight loss programmes were provided with vouchers to attend a weekly local WW (formerly Weight Watchers) meeting for the duration of the intervention they were assigned to (12- or 52-weeks). WW meetings are group-based behavioural weight management programmes operating on a rolling basis and led by a non-specialist trained in weight loss and nutrition. Participants were provided with a unique code to access digital tools for the duration of their assigned intervention. The WW digital tools are an online service that includes access to support materials (e.g., recipes, videos, community area) and tracking tools. Participants randomised to the 12-week programme received vouchers to attend 12 WW sessions and a unique code to access the digital resources for 16 weeks. Participants randomised to the 52-week programme received vouchers to attend 52 WW sessions and a unique code to access for 52 weeks.

#### *3.2.4.2 Brief intervention*

Participants assigned to the brief intervention control group received a standardised brief intervention, involving a GP letter and basic written information. The GP letter provided problem recognition and study invitation, and the basic written information was a 32-page printed British Heart Foundation booklet containing self-help weight-management strategies.<sup>61</sup> Research staff read a scripted booklet introduction to the participant.

### 3.2.5 Outcomes

Trial participants attended assessment appointments at baseline and 3, 12, 24, and 60-months. The primary outcome of the trial was change in body weight at 12-months, and these results have been published in a peer-reviewed journal.<sup>61</sup> The following sections provide details on the outcomes that were used in analyses presented in thesis chapters four, five and six.

## 3.2.5.1 Participant demographics

Participant age, sex, ethnicity, education status, socioeconomic status, and antidepressant medication use were collected by self-report questionnaires. Participants self-reported their age in complete years. Socioeconomic status (SES) was estimated by calculating the Index of Multiple Deprivation (IMD), which is a measure of relative deprivation for small areas in England.<sup>200</sup> The IMD is ranked in deciles with '1' representing areas that are least deprived and '10' that are most deprived. The IMD rank is calculated by combining seven domains: (1) Income Deprivation, (2) Employment Deprivation, (3) Health Deprivation and Disability, (4) Education, Skills and Training deprivation, (5) Barriers to Housing and Services, (6) Crime, and (7) Living Environment Deprivation.<sup>200,201</sup> In the WRAP trial, the postcode for the participant's practice was used to calculate the IMD, using the English indices of deprivation 2010 as SES indicators.<sup>200,201</sup>

Response options for categorical demographic variables were:

- Gender was self-reported as (1) male or (2) female;
- Ethnicity was self-reported as (1) White or White British, (2) Asian or Asian British, (3) Black or Black British, (4) Mixed or multiple ethnic group, or (5) Other, missing, or prefer not to say;
- Education status was self-reported as (1) No qualifications, (2) GCSE or equivalent, (3) A-Level or equivalent, (4) Post-secondary study, (5) University degree or equivalent, or (6) Higher degree or equivalent;
- Antidepressant medication use was self-reported as (1) taking antidepressant medication or (2) not taking antidepressant medication.

#### 3.2.5.2 Psychological outcomes

#### 3.2.5.2.1 Anxiety and depression

Anxiety and depression were measured by the Hospital Anxiety and Depression Scale (HADS).<sup>202</sup> The HADS is a validated screening tool with 14 items (1:1 ratio for anxiety:depression) scored on a Likert scale from 0 to 3.<sup>202–204</sup> The scale produces symptom scores for anxiety and depression that each range from 0 to 21, with a score of equal to or greater than 11 represents moderate to severe symptoms of depression and/or anxiety.<sup>202–204</sup> The scale cannot provide a clinical diagnosis of anxiety or depression.<sup>202–204</sup>

Evidence shows that the HADS has validity, high internal consistency, and reliability for measuring depression and anxiety severity.<sup>203,205</sup> Bjelland and colleagues reported that HADS performed well in assessing symptom severity in somatic, psychiatric, and primary care patients, as well as in the general population.<sup>203</sup> For populations of adults with overweight and obesity participating in trials of behavioural adult weight management interventions, symptoms of anxiety and depression are recommended to be measured by HADS.<sup>206</sup> Furthermore, the HADS score is recommended to be included in the core outcome set for trials of behavioural weight management interventions.<sup>206</sup> The HADS score has been described as a "*quick and reliable*" measure of depression and anxiety, with the advantage of measuring these conditions simultaneously.<sup>205</sup>

Despite the strengths, there are a few limitations of the HADS score to consider. The cut-offs points for the HADS score have been criticised for lacking sensitivity, with recommendations for further research to validate the cut-offs.<sup>207</sup> However, the cut-offs were not relevant in this thesis as I adopted the symptom continuum definition of mental health. The HADS does not capture somatic symptoms of depression and anxiety (e.g., fatigue, insomnia, headache) as it was originally developed to identify emotional distress in those with a physical illness – it was rationalised that somatic symptoms may be present due to physical, rather than mental, illness.<sup>208</sup>

Additionally, a minimal important difference (MID) for change in the HADS score has not been determined in a population of adults with overweight and obesity. This makes it challenging to determine whether changes in HADS scores reflect a clinically meaningful or important difference. The minimal important difference in alternative populations (cancer, cardiovascular disease, bronchiectasis, and chronic obstructive pulmonary disease) has most commonly been defined as a change of 2 points.<sup>209–213</sup> Therefore, in Chapters where changes in depression/anxiety

were categorised, categories were: 'decrease in symptoms' ( $\leq$ -2 units in HADS score), 'no change in symptoms' (-1.99 to 1.99), or 'increase in symptoms' ( $\geq$ 2).

#### 3.2.5.2.2 Quality of life

The EQ5D-3L questionnaire was used to measure quality of life.<sup>214</sup> The questionnaire has 5 dimensions ([1] Mobility, [2] Self-care, [3] Usual activities, [4] Pain/discomfort, [5] Anxiety/depression) which are rated on 3 levels of severity (Level 1: No problem, Level 2: Some problems, Level 3: Extreme problems).<sup>214</sup> Scores for the individual dimensions are collated to create a single index score; the UK value set and algorithm was used to calculate the index scores used. Potential index scores range from -0.281 to 1, where an index score less than 0 represents a state worse than death.<sup>215</sup> In addition, the measure includes a visual analogue scale (VAS) which asks individuals to rate their health today on a scale of 0 (the worst health you can imagine) to 100 (the best health you can imagine).<sup>214</sup> The EQ5D-3L is a validated questionnaire and is a commonly used measure.<sup>214</sup>

The EQ5D-3L is strengthened by its brevity, evidence of validity, and cognitive simplicity.<sup>214,216–218</sup> There is a lack of evidence assessing the responsiveness of the measure in adults with obesity, yet Payakachat and colleagues showed that the EQ5D was responsive in similar populations, such as those with type 2 diabetes.<sup>218</sup> The measure is more responsive when the population has a more severe condition or when large treatment effects are observed, therefore the EQ-5D measure may not identify small changes in quality of life.<sup>218</sup> A further limitation of the EQ5D measure is that the questionnaire asks responders how they feel "*today*", thus the responses captured may not accurately account for participant experiences of quality of life over time.

#### 3.2.5.2.3 Satisfaction with life

Satisfaction with life was measured using the self-reported Satisfaction with Life Questionnaire (SLQ).<sup>219</sup> The questionnaire is a 5-item 7-point scale ([1] strongly disagree to [7] strongly agree) that measures an individual's perception of their satisfaction with their life as a whole, allowing the individual to combine and weight aspects of life satisfaction (e.g., health, finances, socialisation) according to their own criteria and judgement.<sup>220,221</sup> The SLQ score is calculated by adding the scores for each of the 5-items, with a higher total score representing a greater sense

of life satisfaction.<sup>219</sup> The SLQ is a valid and reliable scale, with suitability for a wide range of population groups.<sup>220,221</sup> Furthermore, research reports that the scale has sufficient sensitivity to potentially detect changes over time.<sup>221</sup>

#### 3.2.5.3 Psychosocial and behavioural outcomes

#### 3.2.5.3.1 Cognitive dietary restraint

The Flexible and Rigid subscales of the Eating Inventory (also known as the Three-Factor Eating Questionnaire [TFEQ]) were used to measure cognitive dietary restraint.<sup>222</sup> Cognitive dietary restraint is defined as an individuals' intent to restrict energy intake to control body weight, and can also be explained as the conscious cognitive control of eating behaviours, or *"restrained eating"*.<sup>222,223</sup> Cognitive dietary restraint has two heterogeneous subcomponents, (1) rigid dietary restraint and (2) flexible dietary restraint. Rigid dietary restraint reflects an 'all-or-nothing' approach, with a tendency to cycle between strict restriction and free consumption. Flexible dietary restraint, however, reflects a more moderate approach where foods are limited in quantity but are not eliminated from the diet entirely.<sup>223</sup> Higher scores indicate greater flexible or rigid dietary restraint.

The Eating Inventory<sup>222</sup> is a psychometrically valid measure shown to have good internal consistency and reliability, and research reporting the measure to be ideal for assessing disordered eating behaviours regardless of weight status.<sup>224–227</sup> The scale is reported to be particularly useful in large-scale studies, such as the WRAP trial, where patient burden and costs are contributing factors.<sup>225</sup>

#### 3.2.5.3.2 Self-regulation

Participants' motivation to participate in treatment, eat a healthy diet, or exercise was measured using the Treatment Self-Regulation Questionnaire (TSRQ), Diet Self-Regulation Questionnaire (DSRQ), and Exercise Self-Regulation Questionnaire (ESRQ).<sup>228</sup> The measures assessed whether an individual's motivation was autonomous or controlled, defined as motivated for personal reasons or by perceived external pressure. TSRQ is distinguished as (1) Autonomous self-control and (2) Controlled self-control, whilst the DSRQ and ESRQ are distinguished as 1) Autonomous self-control, (2) Controlled self-control and (3) Amotivation. Higher scores represent higher levels

of self-regulation. Research has found the measure to be valid and to be useful for assessing motivation in various settings and for various health behaviours.<sup>228</sup>

#### 3.2.5.3.3 Habit strength

In the WRAP trial, the Self-Report Habit Index (SRHI) was used to assess the extent to which (1) "*watching what I eat*" and (2) "*exercising regularly*" become automatic and a part of a participants' identity.<sup>229</sup> The SRHI measures three elements of habit strength, being (1) History of behavioural repetition, (2) Lack of control (Automaticity), and (3) Lack of awareness (Identity). History of behavioural repetition refers to the frequency of behavioural occurrence. Lack of control, or automaticity, refers to unintentional or uncontrollable behaviour; this occurs when the behaviour is no longer consciously performed and is an automatic habit. Lack of awareness, or identity, refers to when an individual considers a behaviour to be 'typically them' and reflective of who they are, the way they think of themselves, and the way they view the world (i.e., their identity).

The SRHI is a 12-item scale with a 7-point Likert scale from [1] strongly disagree to [7] strongly agree. Higher scores represent greater habit strength for the 3 dimensions (e.g., greater history of behavioural repetition, greater automaticity, and a greater sense of the behaviour being 'typically them'). Considering the measure as three-dimensional rather than as a total score (i.e., one-dimensional) is reported to be more accurate in the measurement of habit strength.<sup>230</sup> There is evidence of validity and reliability for the SRHI measure.<sup>231</sup>

#### 3.2.5.4 Attendance and engagement

#### 3.2.5.4.1 Programme attendance

Attendance at WW sessions (programme attendance) was defined as the number of weekly WW sessions attended in the first 3-months of the programme, with a possible range of 0 to 12. Programme attendance was calculated by data collected by WW at weekly meetings; participants were provided booklets of vouchers to attend meetings, and WW reported how many vouchers were used. Vouchers were not recorded for a short duration of time due to a computer system error. As the only difference between those with and without data was referral date, missing data was considered to be missing at random.

#### 3.2.5.4.2 Programme engagement

Programme engagement (i.e., engagement with digital tools) was defined as:

(1) Weekly frequency of use of the WW e-tools and online resources. The WW e-tools are an online service that includes access to support materials (e.g., recipes, videos, community area) and tracking tools.

(2) Weekly frequency of use of the WW mobile phone app.

Engagement with digital tools was self-reported at 3-months from baseline, and answers were multiple choice (coded [1] Daily/almost daily, [2] 3-5 times per week, [3] 1-2 times per week, [4] Never/almost never).

#### 3.2.5.4.3 Study visit attendance

Study attendance was defined as attendance at study assessment visits at baseline 3-, 12-, 24and 60-month. Study attendance was monitored by the research team and categorised as (1) did attend visit or (2) did not attend visit.

#### 3.2.5.5 Physiological outcomes

#### 3.2.5.1 Body mass index

Height was measured in centimetres (cm) using a stadiometer, with participants removing shoes prior to measurement. A Tanita segmental body composition analyser was used to measure weight in kilograms (kg), with participants removing heavy clothing prior to measurement. Body mass index (BMI) was calculated by dividing participant weight in kg by their height in metres (m) squared:

$$BMI = \frac{kg}{m^2}$$

Table 1 in Chapter One presents weight classes based on BMI score as recommended by NICE guidelines (Clinical guideline: CG189]).<sup>46</sup>

## 3.2.6 Statistical analysis

Stata (version 16) was used for all statistical analyses. The proportion of participants attending study visit assessments was presented by number and percentage. Reasons for withdrawal from the trial were calculated as the number of participants and percentage per reason and presented by randomised group. Descriptive summary statistics were calculated for baseline characteristics, with the number of participants, mean, and standard deviation presented for continuous variables and number and proportion of participants presented for categorical variables. The statistical analysis methods for Chapters Four, Five, and Six are presented within the individual chapters.

### 3.3 Results

#### 3.3.1 Recruitment and retention

Of the individuals assessed for eligibility (n=1954), 685 were deemed ineligible to take part according to the participant eligibility criteria (See: 3.2.2 Participants: Eligibility and recruitment). Between October 2012 and February 2014, 1267 eligible participants were randomised to one of three groups: brief intervention (BI: n=211), 12-week commercial weight management programme (CP12: n=528), or 52-week commercial weight management programme (CP52: n=528). The commercial weight management programmes were provided by WW (formerly Weight Watchers). Figure 1 shows the participant flow through the trial. The number of participants attending follow-up assessments was 1004 participants at 3-months (79%), 823 participants at 12-months (65%), 856 participants at 24-months (68%), and 643 at 60-months (51%). Reasons for withdrawal from the study are detailed in Table 1.

#### BEHAVIOURAL WEIGHT MANAGEMENT INTERVENTIONS





| Withdrawal reasons  |  |          |          |  |  |  |  |  |
|---|--|----------|----------|--|--|--|--|--|
| BI (n=58) CP12 (n=110) CP52 (n=100  |  |          |          |  |  |  |  |  |
| Changed mind about participating      12 (21%)      21 (19%)      28 (28%)            |  |          |          |  |  |  |  |  |
| Found another weight-loss method1 (2%)2 (2%)1 (1%)                                    |  |          |          |  |  |  |  |  |
| Health issues   | 5 (9%)                                     | 16 (15%) | 15 (15%) |  |  |  |  |  |
| Moved away  | 7 (12%)                                    | 17 (15%) | 13 (13%) |  |  |  |  |  |
| No reason given   | 6 (10%)                                    | 16 (15%) | 9 (9%)   |  |  |  |  |  |
| Personal reasons  | 7 (12%)                                    | 12 (11%) | 14 (14%) |  |  |  |  |  |
| Time/other commitments      6 (10%)      13 (12%)      9 (9%)                         |  |          |          |  |  |  |  |  |
| Trouble attending study visits03 (3%)1 (1%)   |  |          |          |  |  |  |  |  |
| Unable to attend WW      N/A      1 (1%)      2 (2%)                                  |  |          |          |  |  |  |  |  |
| Unhappy with study procedures   | Unhappy with study procedures02 (2%)2 (2%) |          |          |  |  |  |  |  |
| Unhappy with intervention      14 (24%)      7 (6%)      6 (6%)                       |  |          |          |  |  |  |  |  |
| Abbreviations: WW – formerly Weight Watchers, BI – Brief intervention, CP12 – 12-week |  |          |          |  |  |  |  |  |
| commercial weight management programme (WW), CP52 – 52-week commercial weight         |  |          |          |  |  |  |  |  |
| management programme (WW).  |  |          |          |  |  |  |  |  |

Table 1. Reasons for withdrawal from the study, presented by randomised group.

## 3.3.2 Participant characteristics

At baseline, across study arms, study participants had a mean BMI between 34.43 ( $\pm$  4.63) and 34.68 kg/m2 ( $\pm$  5.39), and 68% of all participants were female. A similar proportion of participants in each study arm self-reported taking antidepressant medication at baseline (between 19-23%). The majority of study participants were White or White British (between 86-91% across study arms). Further participant characteristics at baseline are detailed in Table 2.

|                  | Baseline characteristics              |               |               |               |  |  |  |
|------------------|---------------------------------------|---------------|---------------|---------------|--|--|--|
|                  |                                       | BI (n=211)    | CP12 (n=528)  | CP52 (n=528)  |  |  |  |
| Age (years) [mea | n ± SD]                               | 51.91 ± 14.07 | 53.63 ± 13.26 | 53.30 ± 13.96 |  |  |  |
| Female           |                                       | 143 (68%)     | 357 (68%)     | 359 (68%)     |  |  |  |
| Body mass index  | (BMI: kg/m <sup>2</sup> ) [mean ± SD] | 34.43 ± 4.63  | 34.68 ± 5.39  | 34.45 ± 5.05  |  |  |  |
| Self-reports     | taking antidepressant                 | 26 (19%)      | 81 (21%)      | 81 (23%)      |  |  |  |
| medication       |                                       |               |               |               |  |  |  |
| Anxiety [mean ±  | SD]                                   | 7.25 ± 4.29   | 6.89 ± 3.97   | 7.29 ± 4.09   |  |  |  |
| Depression [mea  | n ± SD]                               | 5.58 ± 3.77   | 5.24 ± 3.38   | 5.20 ± 3.64   |  |  |  |
| Ethnicity        | White or White                        | 181 (86%)     | 480 (91%)     | 475 (90%)     |  |  |  |
|                  | British                               |               |               |               |  |  |  |
|                  | Asian or Asian                        | 9 (4%)        | 11 (2%)       | 15 (3%)       |  |  |  |
|                  | British                               |               |               |               |  |  |  |
|                  | Black or Black                        | 5 (2%)        | 12 (2%)       | 6 (1%)        |  |  |  |
|                  | British                               |               |               |               |  |  |  |
|                  | Mixed or                              | 4 (2%)        | 4 (1%)        | 7 (1%)        |  |  |  |
|                  | multiple ethnic                       |               |               |               |  |  |  |
|                  | groups                                |               |               |               |  |  |  |
|                  | Other, missing,                       | 12 (6%)       | 21 (4%)       | 25 (4%)       |  |  |  |
|                  | or prefer not to                      |               |               |               |  |  |  |
|                  | say                                   |               |               |               |  |  |  |

Table 2. Participant characteristics at baseline, presented by study arm.

| Index of  | of      1 (least      16 (8%)      45 (9%)      44 (8%) |                |               |                |  |  |  |  |  |               |
|---|---|----------------|---------------|----------------|--|--|--|--|--|---------------|
| Multiple  | deprived)   |                |               |                |  |  |  |  |  |               |
| Deprivation   | 2   | 8 (4%)         | 16 (3%)       | 26 (5%)        |  |  |  |  |  |               |
| (IMD) deciles   | 3   | 12 (6%)        | 38 (7%)       | 32 (6%)        |  |  |  |  |  |               |
|   | 4   | 17 (8%)        | 37 (7%)       | 38 (8%)        |  |  |  |  |  |               |
|   | 5   | 31 (15%)       | 49 (9%)       | 50 (10%)       |  |  |  |  |  |               |
|   | 57 (11%)  |                |               |                |  |  |  |  |  |               |
| <b>7</b> 32 (15%) 67 (13%) 63   |   |                |               |                |  |  |  |  |  |               |
|   | 8   | 19 (9%)        | 69 (13%)      | 75 (14%)       |  |  |  |  |  |               |
|   | 9   | 12 (6%)        | 51 (10%)      | 47 (9%)        |  |  |  |  |  |               |
|   | 10 (most  | 45 (21%)       | 95 (18%)      | 94 (18%)       |  |  |  |  |  |               |
|   | deprived)   |                |               |                |  |  |  |  |  |               |
| Level of  | None  | 7 (4%)         | 25 (5%)       | 27 (6%)        |  |  |  |  |  |               |
| education   | GCSE or   | 55 (28%)       | 153 (32%)     | 155 (33%)      |  |  |  |  |  |               |
| equivalent  |   |                |               |                |  |  |  |  |  |               |
| A-Level or      53 (27%)      95 (20%)      110 (24)                                  |   |                |               |                |  |  |  |  |  |               |
|   | equivalent  |                |               |                |  |  |  |  |  |               |
| Post-secondary      10 (5%)      14 (3%)      10 (29)                                 |   |                |               |                |  |  |  |  |  |               |
|   | study   |                |               |                |  |  |  |  |  |               |
|   | University  | 48 (24%)       | 108 (23%)     | 97 (21%)       |  |  |  |  |  |               |
| degree or<br>equivalent   |   |                |               |                |  |  |  |  |  |               |
|   |   |                |               |                |  |  |  |  |  | Higher degree |
| or equivalent   |   |                |               |                |  |  |  |  |  |               |
| Abbreviations: WW – formerly Weight Watchers, BI – Brief intervention, CP12 – 12-week |   |                |               |                |  |  |  |  |  |               |
| commercial weig   | ght management program                                  | nme (WW), CP52 | – 52-week com | mercial weight |  |  |  |  |  |               |
| management programme (WW), SD – Standard deviation, BMI – Body mass index.            |   |                |               |                |  |  |  |  |  |               |

A proportion of participants experienced a decrease, no change, or increase in symptoms of depression and anxiety at all timepoints (Table 3).

Table 3. Proportion of participants experiencing a decrease, no change, or increase in depressionand anxiety symptoms at all timepoints.

|   |           | Number and    | percentage of   | participants by  |  |  |  |
|---|-----------|---------------|-----------------|------------------|--|--|--|
|   |           | categorised   | change in an    | xiety/depression |  |  |  |
|   |           | symptoms (HA  | DS score)       |                  |  |  |  |
|   |           | Decrease (≤2) | No change       | Increase (≥2)    |  |  |  |
|   |           |               | (-1.99 to 1.99) |                  |  |  |  |
| Depression  | 3-months  | 282 (30%)     | 473 (51%)       | 180 (19%)        |  |  |  |
|   | 12-months | 221 (29%)     | 372 (49%)       | 163 (22%)        |  |  |  |
|   | 24-months | 201 (27%)     | 375 (50%)       | 178 (24%)        |  |  |  |
|   | 60-months | 140 (30%)     | 205 (43%)       | 129 (27%)        |  |  |  |
| Anxiety   | 3-months  | 305 (33%)     | 446 (48%)       | 184 (20%)        |  |  |  |
|   | 12-months | 234 (31%)     | 336 (44%)       | 186 (25%)        |  |  |  |
|   | 24-months | 212 (28%)     | 344 (46%)       | 198 (26%)        |  |  |  |
|   | 60-months | 155 (33%)     | 193 (41%)       | 126 (27%)        |  |  |  |
| Abbreviations: HADS – Hospital Anxiety and Depression Scale |           |               |                 |                  |  |  |  |

## 3.3.2 Attendance and engagement

On average, participants attended approximately 10 out of 12 WW sessions during the first 3months of the study (12-week programme:  $9.63 \pm 3.44$  sessions (80%); 52-week programme: 9.73  $\pm$  3.41 sessions (81%)) (Table 3). Fifty-six percent of the 12-week programme participants and 50% of the 52-week programme participants never or almost never used the WW e-tools or online research (Table 5). A high proportion of the study participants never or almost never used the WW mobile phone app (12-week programme: 80%; 52-week programme: 73%) (Table 3).

|                           |                           | CP12        | CP52        |
|---------------------------|---------------------------|-------------|-------------|
| Attendance at WW sessions | Mean number of sessions   | 9.63 ± 3.44 | 9.73 ± 3.41 |
| in first 3-months         | attended (± SD)           |             |             |
| CP12 (n=272)              | Low attendance (n %)      | 35 (13%)    | 55 (15%)    |
| CP52 (n=360)              | (≤4 sessions)             |             |             |
|                           | Moderate attendance (n %) | 33 (12%)    | 29 (8%)     |
|                           | (>4 & ≤8 sessions)        |             |             |
|                           | High attendance (n %)     | 204 (75%)   | 276 (77%)   |
|                           | (>8 & ≤12 sessions)       |             |             |
| Frequency of using WW e-  | Daily/Almost daily        | 62 (17%)    | 91 (23%)    |
| tools/online resources    | 3-5 times per week        | 30 (8%)     | 40 (10%)    |
| CP12 (n=355)              | 1-2 times per week        | 63 (18%)    | 67 (17%)    |
| CP52 (n=400)              | Never/Almost never        | 200 (56%)   | 202 (51%)   |
| Frequency of using the WW | Daily/Almost daily        | 35 (10%)    | 60 (15%)    |
| mobile phone app          | 3-5 times per week        | 15 (4%)     | 15 (4%)     |
| CP12 (n=356)              | 1-2 times per week        | 22 (6%)     | 32 (8%)     |
| CP52 (n=401)              | Never/Almost never        | 284 (80%)   | 294 (73%)   |

Table 4. Attendance and engagement with WW interventions, presented by randomised group.

Abbreviations: WW – formerly Weight Watchers, SD – Standard Deviation, CP12 – 12-week commercial weight management programme (WW), CP52 – 52-week commercial weight management programme (WW).

## 3.3.3 Proportion of missing data

Table 4 reports the total number and percentage of missing data for each variable contributing to study analyses, as well as the number and percentage of missing data by intervention arm. Missing data was assumed to be missing at random.

|--|

| Participant characteristics |             | Number (and percentage) of missing data |          |          |            |
|-----------------------------|-------------|---|----------|----------|------------|
|                             |             | BI (n=211)                              | CP12     | CP52     | Total      |
|                             |             |   | (n=528)  | (n=528)  | (n=1267)   |
| Age (years)                 | At baseline | 0                                       | 0        | 0        | 0          |
| Sex                         | At baseline | 0                                       | 0        | 0        | 0          |
| Education                   | At baseline | 15 (7%)                                 | 54 (10%) | 61 (12%) | 130 (10 %) |
| Socioeconomic status        | At baseline | 0                                       | 0        | 2 (0%)   | 2 (0 %)    |
| Depression                  | At baseline | 7 (3%)                                  | 12 (2%)  | 11 (3%)  | 30 (2%)    |
|                             | 3-months    | 79 (37%)                                | 149      | 94 (18%) | 322 (25%)  |
|                             |             |   | (28%)    |          |            |
|                             | 12-months   | 103 (49%)                               | 208      | 191      | 502 (40%)  |
|                             |             |   | (39%)    | (36%)    |            |
|                             | 24-months   | 96 (46%)                                | 210      | 200      | 506 (40%)  |
|                             |             |   | (40%)    | (38%)    |            |
|                             | 60-months   | 145 (69%)                               | 320      | 324      | 789 (62%)  |
|                             |             |   | (61%)    | (61%)    |            |
| Anxiety                     | At baseline | 7 (3%)                                  | 12 (2%)  | 11 (3%)  | 30 (2%)    |
|                             | 3-months    | 79 (37%)                                | 149      | 94 (18%) | 322 (25%)  |
|                             |             |   | (28%)    |          |            |
|                             | 12-months   | 103 (49%)                               | 208      | 191      | 502 (40%)  |
|                             |             |   | (40%)    | (36%)    |            |
|                             | 24-months   | 96 (45%)                                | 210      | 200      | 506 (40%)  |
|                             |             |   | (40%)    | (38%)    |            |

|                 |               | 60-months   | 145 (69%) | 320     | 324      | 789 (62%) |
|-----------------|---------------|-------------|-----------|---------|----------|-----------|
|                 |               |             |           | (61%)   | (61%)    |           |
| Body mass       | index [BMI]   | At baseline | 0         | 0       | 0        | 0         |
| (kg/m²)         |               | At 3-months | 67 (32%)  | 123     | 73 (14%) | 263 (21%) |
|                 |               |             |           | (23%)   |          |           |
| Quality of life | 9             | At baseline | 14 (7%)   | 20 (4%) | 24 (5%)  | 58 (5%)   |
|                 |               | At 3-months | 82 (39%)  | 159     | 106      | 347 (27%) |
|                 |               |             |           | (30%)   | (20%)    |           |
| Satisfaction    | with life     | At baseline | 9 (4%)    | 14 (3%) | 17 (3%)  | 40 (3%)   |
|                 |               | At 3-months | 80 (38%)  | 152     | 100      | 332 (26%) |
|                 |               |             |           | (29%)   | (19%)    |           |
| Total dietary   | restraint     | At baseline | 7 (3%)    | 12 (2%) | 12 (2 %) | 31 (2%)   |
|                 |               | At 3-months | 80 (38%)  | 148     | 93       | 321 (25%) |
|                 |               |             |           | (28%)   | (181%)   |           |
| Flexible dieta  | ary restraint | At baseline | 7 (3%)    | 12 (2%) | 12 (2%)  | 31 (2%)   |
|                 |               | At 3-months | 80 (38%)  | 148     | 93 (18%) | 321 (25%) |
|                 |               |             |           | (28%)   |          |           |
| Rigid dietary   | restraint     | At baseline | 7 (3%)    | 12 (2%) | 12 (2%)  | 31 (2%)   |
|                 |               | At 3-months | 80 (38%)  | 148     | 93 (18%) | 321 (25%) |
|                 |               |             |           | (28%)   |          |           |
| Entering        | Autonomous    | At baseline | 7 (3%)    | 10 (2%) | 12 (2%)  | 29 (2%)   |
| treatment       | regulation    | At 3-months | 91 (43)   | 177     | 131      | 399 (31%) |
| self-           | score         |             |           | (34%)   | (25%)    |           |
| regulation:     | Controlled    | At baseline | 9 (4%)    | 13 (2%) | 14 (3%)  | 36 (3%)   |
|                 | regulation    | At 3-months | 91 (43%)  | 177     | 131      | 399 (31%) |
|                 | score         |             |           | (34%)   | (25%)    |           |
| Diet self-      | Autonomous    | At baseline | 7 (3%)    | 12 (2%) | 13 (2%)  | 32 (3%)   |
| regulation:     | self-control  | At 3-months | 81 (38%)  | 153     | 102      | 336 (27%) |
|                 | score         |             |           | (29%)   | (19%)    |           |
|                 |               | At baseline | 7 (3%)    | 13 (2%) | 14 (3%)  | 34 (3%)   |

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|             | Controlled   | At 3-months | 82 (39%)  | 153     | 102     | 337 (27%) |
|-------------|--------------|-------------|-----------|---------|---------|-----------|
|             | self-control |             |           | (29%)   | (19%)   |           |
|             | score        |             |           |         |         |           |
|             | Amotivation  | At baseline | 7 (3%)    | 14 (3%) | 16 (3%) | 37 (3%)   |
|             | score        | At 3-months | 82 (39%)  | 154     | 102     | 338 (27%) |
|             |              |             |           | (29%)   | (19%)   |           |
| Exercise    | Autonomous   | At baseline | 10 (5%)   | 15 (3%) | 16 (3%) | 41 (3%)   |
| self-       | self-control | At 3-months | 86 (41%)  | 163     | 107     | 356 (28%) |
| regulation: | score        |             |           | (31%)   | (20%)   |           |
|             | Controlled   | At baseline | 10 (5%)   | 17 (3%) | 19 (4%) | 46 (4%)   |
|             | self-control | At 3-months | 87 (41%)  | 163     | 107     | 357 (28%) |
|             | score        |             |           | (31%)   | (20%)   |           |
|             | Amotivation  | At baseline | 10 (5%)   | 18 (3%) | 22 (4%) | 50 (4%)   |
|             | score        | At 3-months | 87 (41%)  | 164     | 108     | 359 (28%) |
|             |              |             |           | (31%)   | (20%)   |           |
| Self-       | History of   | At baseline | 9 (4%)    | 18 (3%) | 12 (2%) | 39 (3%)   |
| reported    | behavioural  | At 3-months | 81 (38%)  | 153     | 106     | 340 (27%) |
| dietary     | repetition   |             |           | (29%)   | (20%)   |           |
| habits:     | Lack of      | At baseline | 9 (4%)    | 19 (4%) | 17 (3%) | 45 (4%)   |
|             | control      | At 3-months | 82 (39%)  | 157     | 107     | 346 (27%) |
|             |              |             |           | (30%)   | (20%)   |           |
|             | Lack of      | At baseline | 11 (5%)   | 22 (4%) | 22 (4%) | 55(4%)    |
|             | awareness    | At 3-months | 83 (39%)  | 159     | 113     | 355 (28%) |
|             |              |             |           | (30%)   | (21%)   |           |
| Self-       | History of   | At baseline | 9 (4%)    | 18 (3%) | 14 (3%) | 41 (3%)   |
| reported    | behavioural  | At 3-months | 82 (39 %) | 155     | 108 (20 | 345 (27%) |
| exercise    | repetition   |             |           | (29%)   | %)      |           |
| habits:     | Lack of      | At baseline | 9 (4%)    | 25 (5%) | 20 (4%) | 54 (4%)   |
|             | control      | At 3-months | 84 (40%)  | 158     | 111     | 353 (28%) |
|             |              |             |           | (30%)   | (21%)   |           |
|             |              | At baseline | 11 (5%)   | 26 (5%) | 21 (4%) | 58 (5%)   |

|  | Lack of         | At 3-months | 85 (4%)   | 159   | 114        | 358 (28%) |
|--|-----------------|-------------|-----------|-------|------------|-----------|
|  | awareness       |             |           | (30%) | (22%)      |           |
| Total number of Weight Watchers sessions   |                 |             | 256 (48%) | 168   | 424/1056 ( | (40%)     |
| attended in t  | he first 3-mont | าร          |           | (32%) |            |           |
| Weekly use of WW e-tools/online  |                 |             | 173 (33%) | 128   | 301/1056 ( | (29%)     |
| resources (24%)  |                 |             |           |       |            |           |
| Weekly use of WW mobile app      172 (33%)      127      299/1050                      |                 |             |           |       |            | (28%)     |
| (24%)  |                 |             |           |       |            |           |
| Abbreviations: BI - Brief Intervention, CWMP - Commercial Weight Management Programme, |                 |             |           |       |            |           |
| WW – Weight Watchers   |                 |             |           |       |            |           |

#### 3.4 Discussion

The WRAP trial has a number of strengths that make it an excellent dataset with which answer my research questions for Chapters Four, Five and Six. Firstly, the WRAP trial collected data on multiple aspects of mental health for 5 years from baseline using validated measurement tools. As highlighted in Chapter 2, trials of behavioural weight management interventions rarely measure mental health, especially in the longer term. Secondly, despite high missingness at longer term follow-ups, the follow-up rate for WRAP trial was above average when compared to similar trials.<sup>93,94,232</sup> A further reason for the WRAP dataset being an excellent fit to analysis to address my research question was that it was a high quality trial with a large, representative sample investigating the impact of a commercially available intervention. This means that findings from analyses of this dataset are broadly generalisable to adults attending one of the WRAP dataset for use in my thesis included data availability and accessibility. My PhD supervisor, Dr Amy Ahern, is the principal investigator of the WRAP trial which eased access to the dataset and benefited my understanding of the trial nuances (e.g., I was able to more easily ask Dr Ahern detailed and specific questions about the trial).

However, there are a number of limitations that should be considered. Firstly, some aspects of mental health in people living with obesity that I considered to be important were not measured (e.g., stress and weight stigma). I recognise, however, that trials are unable to measure everything that they might like to because they have to consider participant burden and resource limitations. Furthermore, the primary focus of the WRAP trial was the impact of the interventions on weight, and as such the trial was powered to detect changes in weight.<sup>199</sup> Consequently, this can limit the level of statistical power for secondary analyses, like those presented in this thesis. Post-hoc power estimations have previously been performed when conducting secondary data analyses, however they are generally considered to be bad practice. Dziak and colleagues state that post-hoc power estimates are "logically invalid and practically misleading". As such, rather than conducting these problematic analyses, I recommend taking consideration of this when interpreting chapter findings.

In Chapter Two, I synthesised trials of behavioural weight management interventions that measured and reported mental health outcomes in the short and longer term. I identified no other trial that had measured multiple mental health outcomes in a large representative

population over as long of a duration of follow-up as the WRAP trial. In addition, the WRAP trial had received better risk of bias ratings in the systematic review analyses than many other trials. It was, therefore, highly advantageous to analyse the WRAP trial dataset to address my research questions.

More generally, there are numerous strengths associated with conducting secondary data analyses. Firstly, secondary datasets are a low cost, easily accessible way to conduct analyses. They are commonly prepared and cleaned prior to the researcher receiving the dataset, and existing analyses using the data provides contextual insight that can strengthen research findings.<sup>235,236</sup> However, when conducting secondary data analyses, you inherit the measurement decisions made by others. For example, my analyses were limited by the measures available in the dataset. Secondary data analyses can also be limited by the potential for researcher bias, as discussed by Baldwin and colleagues in their recent essay on how to mitigate against researcher bias in secondary data analyses.<sup>237</sup> I implemented many of practices to protect against researcher bias recommended by the Baldwin and colleagues. These included i) minimising prior knowledge of the data by not accessing the data until the statistical analysis plan was finalised and approved, and iii) being transparent about any deviations from planned analyses when plans are no longer appropriate for the data after receipt.

## 3.5 Conclusion

The WRAP trial randomised 1267 participants to one of three study arms. The trial studied commercially provided behavioural weight management interventions of varying lengths compared to brief intervention. Participants of the WRAP trial were followed for 5 years from baseline, with assessments including multiple mental health measures at each timepoint.<sup>199</sup> Despite a reduction in participant retention at long term follow-up assessments, the trial had above-average participant retention when compared to other similar trials.<sup>93,94,232</sup> For these reasons, the WRAP trial was an excellent source of data to analyse to address the following thesis objectives:

- Thesis Objective One: To determine the short- and long-term impact of behavioural weight management interventions on the mental health of adults with overweight and obesity (*Chapter Five*).
- Thesis Objective Two: To identify how participant mental health is associated with attendance and engagement with a behavioural weight management intervention and trial (*Chapter Four*).
- Thesis Objective Three: To identify participant characteristics associated with changes in mental health in adults with obesity during and after a behavioural weight management intervention (*Chapter Six*).

## 3.6 Contributions

I was not involved in the design or conduct of the WRAP trial which was a data source in this thesis. Within this chapter, I planned and conducted the analyses for the baseline trial results presented.

# CHAPTER FOUR: THE IMPACT OF PARTICIPANT MENTAL HEALTH ON ATTENDANCE AND ENGAGEMENT IN A TRIAL OF A BEHAVIOURAL WEIGHT MANAGEMENT PROGRAMMES: SECONDARY ANALYSIS OF THE WRAP TRIAL.

The work in this chapter has been published as:

**Jones RA**, Mueller J, Vincent A, et al. (2021). The impact of participant mental health on attendance and engagement in a trial of behavioural weight management programmes: Secondary analysis of the WRAP randomised controlled trial. *IJBNPA*.

This work was presented at the International Society of Behavioural Nutrition and Physical Activity (ISBNPA) Xchange Initiative in 2021 and at the European Congress on Obesity 2021.

## 4.1 Chapter overview

In Chapter Two, I found evidence to suggest that behavioural weight management interventions produce small benefits for some aspects of mental health at the end of an intervention and 12-months from baseline. In addition, I found no evidence to suggest interventions worsened any aspect of mental health.<sup>45</sup> However, as described in Chapter One (*Section 1.5.1.2*), low attendance at and engagement with behavioural interventions are common, and the reasons for this are poorly understood.<sup>93,94</sup> Previous research exploring this association is limited with inconsistent findings, and there is a particular dearth of evidence investigating the potential role of mental health in intervention attendance and engagement.<sup>93,103,105–107</sup>

Furthermore, as described in Chapter One (*Section 1.5.1.2*), it is plausible that mental health may influence participant attendance at study follow-up visits for trials of behavioural weight management interventions. Investigating how participant mental health may influence attendance at follow-up assessments for behavioural weight management trials allows us to better understand whether participant samples accurately reflect the true range of mental health experiences.

In **Chapter Four**, I present a secondary quantitative analysis using Weight loss Referrals for Adults in Primary care (WRAP) data which aims to identify how participant mental health is associated with attendance and engagement with a behavioural weight management intervention and trial.

This chapter addresses **thesis Objective Two**: To identify how participant mental health is associated with attendance and engagement with a behavioural weight management intervention and trial.

## 4.1.1 Aims and objectives

I aimed to investigate whether mental health at baseline (anxiety, depression, quality of life, satisfaction with life) was associated with attendance and engagement with a behavioural weight management intervention and completion of follow-up assessments in a randomised controlled trial.

The chapter objectives were to:

- 1. Identify whether participant mental health is associated with intervention attendance.
- 2. Identify whether participant mental health is associated with intervention engagement.
- 3. Identify whether participant mental health is associated with attendance at trial study visits.

## 4.2 Methods

This chapter is a secondary data analysis of the Weight loss Referrals for Adults in Primary care (WRAP) trial; trial design and baseline results are presented in Chapter Three.

An *a-priori* statistical plan for Chapter Four can be found in Chapter Four Appendices (A4.1). The publication associated with this chapter is published in the International Journal for Behavioural Nutrition and Physical Activity.<sup>238</sup>

## 4.2.1 Outcomes

Study participants completed outcome assessments at baseline, 3-, 12-, 24- and 60-months. The outcomes of interest in this chapter were:

- Attendance at WW sessions (i.e., programme attendance): Number of weekly WW sessions attended in the first 3-months of the programme. Attendance at WW sessions was treated as an ordered count variable with a possible range of 0 to 12. Attendance at WW sessions was categorised as low (<4 sessions), moderate (>4 and<8 sessions), or high (>8 and<12 sessions) attendance.</li>
- Engagement with WW digital tools (i.e., programme engagement): Weekly frequency of use of the WW e-tools and online resources, and weekly frequency of use of the WW mobile phone app. Responses were multiple choice and coded as [1] Daily/almost daily,
  [2] 3-5 times per week, [3] 1-2 times per week, [4] Never/almost never.
- Attendance at study follow-up visits at 3-, 12-, 24- and 60-months. Study attendance was categorised as (1) did attend visit or (2) did not attend visit.

Exposure variables were baseline measures of quality of life,<sup>214</sup> satisfaction with life,<sup>219</sup> depression,<sup>202</sup> and anxiety.<sup>202</sup> Exposure variables were treated as continuous variables. Further information on outcomes can be found in Chapter Three (*Section 3.2.5*).
## 4.2.2 Statistical analysis

Stata (version 16)<sup>151</sup> was used for all statistical analyses.

#### 2.5.1 Association of mental health with programme attendance and engagement

Negative binomial regression was used to estimate the effect of participant mental health on programme attendance, controlling for the randomised group. Ordered logistic regression was used to estimate the effect on engagement with digital tools, controlling for the randomised group. In the ordered logistic regression models, engagement response options were categorised as (1) Daily/Almost daily, (2) 3-5 times per week, (3) 1-2 times per week, and (4) Never/Almost never. Therefore, results were interpreted as the reduction in engagement associated with every unit change in mental health outcome. Analyses were performed using data from the intervention groups only (CP12 and CP52), and robust standard errors were calculated in all models to allow for clustering by general practice.

## 2.5.2 Association of mental health with study visit attendance

Logistic regression was used to estimate the association between baseline participant mental health and attendance at study follow-up visits (at 3-, 12-, 24-, and 60-months), controlling for randomised group and with robust standard errors to allow for clustering by general practice. Baseline mental health variables whose p-value for association with study visit attendance was <0.05 were included in mutually adjusted models. Analyses were conducted using data from both intervention and control groups.

## 4.3 Results

## 4.3.2 Association of mental health with programme attendance and engagement

#### 4.3.2 Association of mental health with programme attendance

Baseline scores for global quality of life (Incidence rate ratio (IRR) 1.06; 95% confidence interval (CI) 0.96, 1.17; n=608), anxiety (IRR 1.00; 95% CI 0.99, 1.01; n=625) and satisfaction with life (IRR 1.00; 95% CI 0.999, 1.01; n=620) were not associated with attendance at WW sessions in the first 3-months (Table 1). Every one unit of baseline depression score was associated with a 1% relative reduction in the rate of session attendance (IRR 0.99; 95% CI 0.98, 0.999; n=625) (Table 1).

Table 1. Association of baseline mental health with attendance at WW sessions in first 3-months: Results are presented from negative binomial regression models, controlled for randomised group and with robust standard errors to allow for clustering by general practice.

| Attendance at WW sessions in first 3-months                            |                               |                        |  |
|--|-------------------------------|------------------------|--|
| Mental health at baseline:   | Incidence rate ratio (95% CI) | Number of participants |  |
| Model 1: Global quality of life  | 1.06 (0.96, 1.17)             | 608                    |  |
| Model 2: Satisfaction with life  | 1.00 (0.999, 1.01)            | 620                    |  |
| Model 3: Anxiety   | 1.00 (0.99, 1.01)             | 625                    |  |
| Model 4: Depression  | 0.99 (0.98, 0.999)            | 625                    |  |
| Abbreviations: WW – formerly Weight Watchers, CI – Confidence interval |                               |                        |  |

### 4.3.3 Association of mental health with programme engagement

#### 4.3.3.1 Association of mental health with engagement with WW e-tools and online resources

Baseline scores for global quality of life (Odds Ratio (OR) 0.65; 95% CI 0.39, 1.09; n=728), satisfaction with life (OR 1.01; 95% CI 0.99, 1.03; n=743), and depression (OR 1.00; 95% CI 0.97, 1.04; n=747) were not associated with weekly frequency of using WW e-tools/online resource (Table 2). Participants' baseline score for anxiety was associated with self-reported engagement with the WW e-tools and online resources; every one unit of baseline anxiety was associated with 4% lower odds of reporting high levels of engagement with the WW e-tools and online resources (OR 0.96; 95% CI 0.94, 0.99; n=747) (Table 2).

## 4.3.3.1 Association of mental health with engagement with WW mobile phone app

Anxiety (OR 0.98; 95% CI 0.95, 1.02; n=749), depression (OR 1.00; 95% CI 0.96, 1.05; n=749) and satisfaction with life (OR 1.02; 95% CI 0.996, 1.04; n=745) at baseline were not associated with weekly frequency of using the WW mobile phone app (Table 2). Every one unit of baseline global quality of life was associated with 69% lower odds of reporting high levels of weekly engagement with the WW mobile phone app (OR 0.31; 95% CI 0.15, 0.64; n=730) (Table 2).

Table 2. Association of baseline mental health with weekly use of WW digital resources in first 3months: Results are presented from negative binomial regression models, controlled for randomised group and with robust standard errors to allow for clustering by general practice.

| Weekly frequency of using WW e-tools/online resources (reported at 3-months)  |  |  |  |
|---|--|--|--|
| Mental health at baseline:  | Odds Ratio (95% CI)  | Number of participants   |  |
| Model 1: Global quality of life   | 0.65 (0.39, 1.09)  | 728  |  |
| Model 2: Satisfaction with life   | 1.01 (0.99, 1.03)  | 743  |  |
| Model 3: Anxiety  | 0.96 (0.94, 0.99)  | 747  |  |
| Model 4: Depression   | 1.00 (0.97, 1.04)  | 747  |  |
| Weekly frequency of using the WW mobile phone app (reported at 3-months)  |  |  |  |
|   |  |  |  |
| Mental health at baseline:  | Odds Ratio (95% CI)  | Number of participants   |  |
| Mental health at baseline:<br>Model 1: Global quality of life   | Odds Ratio (95% CI) 0.31 (0.15, 0.64)  | Number of participants       730   |  |
| Mental health at baseline:<br>Model 1: Global quality of life<br>Model 2: Satisfaction with life  | Odds Ratio (95% Cl) 0.31 (0.15, 0.64) 1.02 (0.996, 1.04)   | Number of participants         730         745                                 |  |
| Mental health at baseline:<br>Model 1: Global quality of life<br>Model 2: Satisfaction with life<br>Model 3: Anxiety                        | Odds Ratio (95% Cl)           0.31 (0.15, 0.64)           1.02 (0.996, 1.04)           0.98 (0.95, 1.02)                     | Number of participants730745749  |  |
| Mental health at baseline:<br>Model 1: Global quality of life<br>Model 2: Satisfaction with life<br>Model 3: Anxiety<br>Model 4: Depression | Odds Ratio (95% Cl)         0.31 (0.15, 0.64)         1.02 (0.996, 1.04)         0.98 (0.95, 1.02)         1.00 (0.96, 1.05) | Number of participants           730           745           749           749 |  |

#### 4.3 Association of mental health with study visit attendance

#### 4.3.1 Attendance at 3-month study visit

Every one unit of baseline global quality of life (OR 1.95; 95% CI 1.20, 3.17; n=1209) and baseline satisfaction with life (OR 1.02; 95% CI 1.00, 1.04; n=1209) were associated with 95% and 2% higher odds of attending the 3-month study visit respectively. Conversely, every one unit of baseline anxiety (OR 0.95; 95% CI 0.92, 0.98; n=1209) and baseline depression (OR 0.93; 95% CI 0.89, 0.97; n=1209) were associated with 5% and 7% lower odds of attending the 3-month study visit (Table 3).

Baseline quality of life, satisfaction with life, anxiety, and depression were not associated with attendance at the 3-month study visit in the mutually adjusted model (Table 3).

#### 4.3.2 Attendance at 12-month study visit

Baseline global quality of life was not associated with attendance at the 12-months study visit (OR 1.48; 95% CI 0.93, 2.37; n=1227). A unit higher baseline satisfaction with life score was associated with 2% higher odds of attending the 12-month study visit (OR 1.02; 95% CI 1.00, 1.04; n=1227). A unit higher anxiety (OR 0.94; 95% CI 0.91, 0.97; n=1227) and baseline depression (OR 0.94; 95% CI 0.91, 0.97; n=1227) and baseline depression (OR 0.94; 95% CI 0.91, 0.91, 0.98; n=1227) score at baseline were associated with 6% lower odds of attending the 12-month study visit (Table 3).

Baseline satisfaction with life, anxiety, and depression were not associated with attendance at the 12-month study visit in the mutually adjusted model (Table 3).

#### 4.3.3 Attendance at 24-month study visit

Baseline global quality of life was not associated with attendance at the 24-months study visit (OR 1.61; 95% CI 0.97, 2.66; n=1237). A unit higher baseline satisfaction with life score was associated with a 3% increase in odds of attending the 24-month study visit (OR 1.03; 95% CI 1.00, 1.05; n=1237). A unit higher baseline anxiety (OR 0.94; 95% CI 0.91, 0.97; n=1237) and depression (OR 0.95; 95% CI 0.91, 0.997; n=1237) scores were associated with 6% and 5% lower odds of attending the 24-month study visit (Table 3).

Baseline satisfaction with life and baseline depression did not remain associated with attendance at the 24-month study visit when adjusted for baseline anxiety and depression in the mutually adjusted model (Table 3). When adjusted for baseline satisfaction with life and depression in the mutually adjusted model, a unit in baseline anxiety was associated with a 5% decrease in odds of attending the 24-month visit (OR 0.95; 95% CI 0.91, 0.98); n=1196).

#### 4.3.4 Attendance at 60-month study visit

A unit higher baseline global quality of life (OR 2.02; 95% CI 1.27, 3.23; n=1237) and satisfaction with life (OR 1.03; 95% CI 1.00, 1.05; n=1237) scores were associated with a 102% and 3% increase in odds of attending the 60-month study visit. Conversely, a unit higher baseline anxiety (OR 0.95; 95% CI 0.92, 0.98; n=1237) and depression (OR 0.94; 95% CI 0.91, 0.97; n=1237) scores were associated with 5% and 6% decrease in odds of attending the 60-month study visit.

Baseline quality of life, satisfaction with life, anxiety, and depression were not associated with attendance at the 60-month study visit in the mutually adjusted model (Table 3).

Table 3. Association of baseline mental health with attendance at study follow-up visits: Results are presented from unadjusted and mutually adjusted logistic regression models. Mutually adjusted models are adjusted for baseline mental health variables that were statistically significant in unadjusted models. Baseline mental health variables that were not statistically significant in unadjusted models were not adjusted for in mutually adjusted models. All models were controlled for randomised group and clustering by general practice.

| Mental health at baseline: | Attendance at 3-month study visit (Odds ratio (95% CI)) |                     |  |
|----------------------------|---|---------------------|--|
|                            | Unadjusted logistic regression Mutually adjusted        |                     |  |
|                            | (n=1209)  | regression (n=1196) |  |
| Global quality of life     | 1.95 (1.20, 3.17)                                       | 1.25 (0.67, 2.30)   |  |
| Satisfaction with life     | 1.02 (1.00, 1.04)                                       | 0.99 (0.97, 1.02)   |  |
| Anxiety                    | 0.95 (0.92, 0.98)                                       | 0.99 (0.94, 1.04)   |  |
| Depression                 | 0.93 (0.89, 0.97)                                       | 0.94 (0.87, 1.01)   |  |

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| Mental health at baseline:                            | Attendance at 12-month study visit (Odds ratio (95% CI)) |                             |  |
|---|--|-----------------------------|--|
|   | Unadjusted logistic regression                           | Mutually adjusted logistic  |  |
|   | (n=1227)   | regression (n=1224)         |  |
| Global quality of life                                | 1.48 (0.93, 2.37)  | ٨٨                          |  |
| Satisfaction with life                                | 1.02 (1.00, 1.04)  | 1.01 (0.98, 1.03)           |  |
| Anxiety   | 0.94 (0.91, 0.97)  | 0.96 (0.92, 1.00)           |  |
| Depression  | 0.94 (0.91, 0.98)  | 0.97 (0.93, 1.02)           |  |
| Mental health at baseline:                            | Attendance at 24-month study                             | visit (Odds ratio (95% Cl)) |  |
|   | Unadjusted logistic regression                           | Mutually adjusted logistic  |  |
|   | (n=1237)   | regression (n=1224)         |  |
| Global quality of life                                | 1.61 (0.97, 2.66)  | ٨٨                          |  |
| Satisfaction with life                                | 1.03 (1.00, 1.05)  | 1.01 (0.99, 1.04)           |  |
| Anxiety   | 0.94 (0.91, 0.97)  | 0.95 (0.91, 0.98)           |  |
| Depression  | 0.95 (0.91, 1.00)  | 1.00 (0.95, 1.06)           |  |
| Mental health at baseline:                            | Attendance at 60-month study visit (Odds ratio (95% CI)) |                             |  |
|   | Unadjusted logistic regression                           | Mutually adjusted logistic  |  |
|   | (n=1237)   | regression (n=1196)         |  |
| Global quality of life                                | 2.02 (1.27, 3.23)  | 1.41 (0.83, 2.38)           |  |
| Satisfaction with life                                | 1.03 (1.00, 1.05)  | 1.01 (0.98, 1.04)           |  |
| Anxiety   | 0.95 (0.92, 0.98)  | 0.98 (0.95, 1.02)           |  |
| Depression  | 0.94 (0.91, 0.97)  | 0.97 (0.92, 1.03)           |  |
| Note: ^^ not included in the mutually adjusted model. |  |                             |  |
| Abbreviations: CI – Confidence                        | interval   |                             |  |

## 4.4 Discussion

In this chapter, I investigated whether participants' mental health was associated with the rate of attendance and engagement with a behavioural weight management programme (WW) and trial (WRAP). Lower levels of depression symptoms and higher scores for satisfaction with life at baseline were associated with higher rates of attendance at WW sessions (i.e., higher rates of programme attendance). Similarly, adults with obesity who reported experiencing fewer symptoms of depression and anxiety and higher satisfaction with life at baseline were more likely to report higher engagement with the programme resources (WW e-tools and mobile phone app). I also found that those reporting greater quality of life at baseline were likely to have lower engagement with the WW mobile phone app than those with poorer quality of life, however, this association was not consistent across analyses. Higher scores for quality of life and satisfaction with life and fewer symptoms of depression and anxiety were also associated with higher attendance at all study visits up to 5 years follow-up.

Overall, I found that adults with obesity who self-reported being more mentally healthy at baseline were more likely to attend programme sessions, engage with programme resources, and attend study follow-up assessments. Previous research has reported that low levels of attendance and engagement in behavioural weight management trials are associated with decreased likelihood of achieving clinically significant weight loss, consequently reducing the likelihood of gaining the associated health benefits.<sup>62,100,101</sup> These findings highlight an emerging research priority to explore how to maximise the engagement and retention of people experiencing poorer mental health.

It is important to note, however, that the chapter findings should be interpreted with consideration to the loss of significance in mutually adjusted models and the magnitude of the effect sizes presented. Many significant associations in univariable models became non-significant when mutually adjusted, potentially due to the mental health-related exposure variables being moderately correlated (Chapter Four Appendices: A4.2). Cross-correlation of exposure variables found correlations to range between small and large, with measures of anxiety and depression most highly correlated. Future research may consider the use of a composite indicator by combining individual measures into a single index, therefore reducing the impact of multicollinearity. The effect sizes of the associations between mental health and attendance and engagement were considered to be small, suggesting a small increase in the risk of reporting

lower attendance and engagement when reporting poor mental health at baseline.<sup>239</sup> However, these changes may still have a meaningful effect on the effectiveness of the behavioural weight management programme and trial completeness. More research is needed to confirm the size of the effect and investigate the potential impact on programme effectiveness and health outcomes.

Previous systematic review evidence has found no consistent psychological factors to be associated with attendance and engagement and recommended further research into this area.93 In the current study, I found poorer rates of attendance and engagement in those with poor mental health scores at baseline, aligning with the findings of McLean and colleagues who reported lower attendance among participants with higher levels of anxiety or depression.<sup>105</sup> Furthermore, current findings also align with previous research reporting those with higher levels of anxiety or depression are more likely to report worse attendance and engagement with the weight management trial.<sup>103,106</sup> Some previous research, however, has reported finding mental health to not be associated with attendance and engagement, <sup>104,107</sup> contrasting with the findings of the current study. This may be due to the different classifications of mental health within different studies. For example, Funderburk and colleagues defined mental health as diagnosed versus non-diagnosed with mental illness,<sup>107</sup> whereas I considered mental health as a symptomcontinuum that appreciates that participants can experience one or more symptoms of mental illness without meeting diagnostic criteria.<sup>23,24</sup> This approach was selected as it is associated with reduced stigma and enables the investigation of a broader range of mental health outcomes.<sup>23,24,26</sup>

There are many reasons why mental health might influence attendance and engagement with a behavioural weight management programme. Having poor mental health can make participation and engagement difficult and, in particular, can make it difficult to engage in things that may interfere with self-soothing coping strategies (e.g., emotional eating).<sup>240</sup> Many adults with obesity seek social support and socialisation from WW groups.<sup>241</sup> For those living with poor mental health, forming connections with others can be impeded by an increased likelihood to withdraw/isolate, be less vulnerable with others when forming connections, and be more likely to perceive others to judge them poorly (i.e., self-conscious/lacking self-esteem).<sup>241</sup> In turn, those living with obesity and mental ill-health are likely to experience greater difficulties to connect with peers at the WW group than those who are mentally healthy, thus reducing the likelihood of programme

attendance as their hopes and expectations of social support are not met. Previous negative experiences with healthcare providers (e.g., experiencing blame, shame, and discrimination for weight and/or mental health) may have reduced trust in services and healthcare staff, resulting in reduced engagement with services.<sup>240,242</sup> Participants may also find that lack of immediate weight changes emphasises feelings of failure and shame, reduces their confidence in services' effectiveness, <sup>126,243–245</sup> and results in feelings of disappointment with the intervention content.<sup>126</sup> Understandably, these feelings may decrease their motivation to attend the programme sessions. Future research could use qualitative approaches to explore the mechanisms underpinning why those with poor mental health are less likely to attend and engage with behavioural weight management programmes. The mechanisms influencing programme attendance and engagement may be individual-level, societal-level, or operate across multiple levels. Understanding these mechanisms would enable the development of approaches to combat this issue. Furthermore, future research might explore whether tailoring programmes for those with obesity and poor mental health may result in improved programme attendance and engagement. For example, the RAINBOW trial provided a tailored weight management programme for persons with obesity and depression, finding modest improvements in both weight and depression symptoms.<sup>246</sup> It remains unclear, however, whether the tailored programme resulted in greater attendance and engagement rates than similar individuals attending a standard behavioural weight management programme.

The findings of this chapter suggest that follow-up participant samples are less likely to include people with poorer mental health at baseline. Potential explanations may be higher levels of anxiety regarding clinical assessments (e.g., blood-sampling), lack of confidence in trial effectiveness (e.g., lack of immediate results), discomfort answering personal questionnaires (e.g., psychological assessments), and perceived participant burden (e.g., unhappy with the length of questionnaires about mental health).<sup>247–249</sup> Previous evidence from behavioural weight management trials should not be discarded, however, caution should be taken when interpreting findings, particularly those relating to mental health. In future trials, researchers should consider implementing a participant retention strategy that supports those with poorer mental health at baseline.

#### 4.1 Strengths and limitations

It is uncommon for behavioural weight management trials to measure and report mental health outcomes.<sup>45</sup> This secondary analysis of the WRAP trial benefited from the inclusion of multiple mental health outcomes at each assessment. Chapter findings were limited to those mental health measures implemented in the WRAP trial, the primary focus of which was the impact of the interventions on weight and related outcomes.<sup>199</sup> Mental health measures not collected in this trial may further explain participant attendance and engagement rates, such as social support, stress, loneliness, self-esteem, and self-efficacy. Future research should aim to measure a wide range of mental health outcomes, but this must be balanced against participant burden.

A limitation was the large proportion of missing data, specifically for attendance at WW sessions and engagement with the WW resources. I had pre-specified a sensitivity analysis using multiple imputation, but also pre-specified that this would not be appropriate if the level of missingness were 25% or more (as it was for the programme attendance and engagement analyses), and would not be necessary if the level of missingness were less than 5% (as it was for the analysis of study attendance).

In addition, it is worth noting that engagement with WW digital resources and the mobile phone app was assessed using a self-report questionnaire and is therefore subject to potential error and bias, such as recall error and social desirability bias. To increase the accuracy of engagement data going forward, I recommend the use of objective measures either in replacement or in combination with self-report measures.

Despite these limitations, this chapter contributes new evidence to the field by seeking to understand the factors impacting attendance and engagement in behavioural weight management trials. To my knowledge, this chapter is one of the first studies to explicitly focus on the impact of mental health on programme and study attendance and engagement. I investigated the impact of participant mental health on numerous attendance and engagement factors and found relatively consistent evidence across factors. The aims of this secondary analysis were determined *a priori*, with a comprehensive statistical analysis plan determined prior to obtaining the trial data. The WRAP trial benefits from the randomised controlled trial design and minimal eligibility criteria that increase the representative nature of the baseline participant sample relative to the general population of adults with obesity in the UK.

## 4.5 Conclusions

This chapter shows that adults with obesity attending a behavioural weight management programme are less likely to attend programme sessions, engage with programme resources, and attend study follow-up visits if they report higher levels of depression and anxiety, and lower scores for quality of life and satisfaction with life at baseline. The small effect sizes reported suggest a small increase in odds of low attendance and engagement in those experiencing poor mental health at baseline, however, the changes may still have a meaningful effect on programme effectiveness and trial completion. Lower attendance and engagement are associated with a reduced likelihood of achieving clinically significant weight loss and the associated health benefits, highlighting the importance of maximising participant attendance and engagement in behavioural weight management programmes. Future research should explore the effectiveness of targeted strategies to maximise attendance and engagement in those reporting poorer mental health upon entering a behavioural weight management programme or trial. Additionally, researchers should ensure to apply appropriate caution when interpreting trial findings and consider the potential for bias due to mental health when conducting trial analyses.

# 4.6 Contributions

I designed this study in collaboration with Amy Ahern. I devised the statistical analysis plan with support from Julia Mueller and Stephen Sharp. I independently conducted the statistical analyses. I interpreted the results with support from Amy Ahern, Julia Mueller, and Stephen Sharp. Ann Vincent provided PPI input, informing the acceptability of the research, and contributing to the interpretation of the findings. I drafted the full thesis Chapter and the associated manuscript for publication (all co-authors reviewed and approved the manuscript for publication).

# CHAPTER FIVE: THE LONG-TERM IMPACT OF A BEHAVIOURAL WEIGHT MANAGEMENT INTERVENTION ON DEPRESSION AND ANXIETY: 5-YEAR FOLLOW UP OF THE WRAP TRIAL.

The work in this chapter is under review as:

Jones RA, Mueller J, Sharp SJ, et al. (Under review). 'Long term impact of a commercial behavioural weight management intervention on depression and anxiety: 5-year follow up of the WRAP trial'. *Obesity* 

This work was presented at the European Congress on Obesity 2021.

# 5.1 Chapter overview

In Chapter Two, I found evidence to suggest that behavioural weight management interventions produce small benefits for some aspects of mental health at the end of an intervention and 12-months from baseline. In addition, I found no evidence to suggest interventions worsened any aspect of mental health.<sup>45</sup> I identified a particular lack of research assessing the longer-term impacts of behavioural interventions on mental health. As described in Chapter One (*Section 1.5.1.3*), this limits our understanding of the sustained impacts on mental health and inhibits the further development of weight management interventions to effectively support the mental health of adults with obesity.

In **Chapter Five**, I present a secondary quantitative analysis using WRAP data (Chapter Three) which aims to identify how referral to a behavioural weight management intervention impacted mental health-related outcomes at 5-years from baseline. This chapter contributes to understanding the longer-term impacts of the intervention on mental health.

This chapter addresses **thesis Objective One**: To determine the short- and long-term impact of behavioural weight management interventions on the mental health of adults with overweight and obesity.

# 5.1.1 Aims and objectives

I aimed to investigate the impact of commercial behavioural weight management programmes on symptoms of depression and anxiety at 5-years from baseline using data from the WRAP trial.

The chapter objectives were to:

- Identify whether referral to a 52-week or 12-week weight management intervention results in greater improvements in mental health-related outcomes than brief intervention at 5-years from baseline.
- 2. Identify whether referral to a 52-week weight management intervention results in significantly greater improvements in mental health-related outcomes than the current practice of referral to a 12-week weight management intervention at 5-years from baseline.

## 5.2 Methods

This chapter is a secondary data analysis of the Weight loss Referrals for Adults in Primary care (WRAP) trial; trial design and baseline results are presented in Chapter Three.

An *a-priori* statistical plan for Chapter Five can be found in Chapter Five Appendices (A5.1). The publication associated with this chapter is under review at Obesity.

## 5.2.1 Outcomes

Outcomes of interest were change from baseline to 5-years in depression and anxiety symptoms, measured by the Hospital Anxiety and Depression Scale (HADS).<sup>202</sup> In this thesis, the minimal important difference (MID) was defined as a change of  $\pm 2$  points in HADS score for depression or anxiety symptoms. Further information on the outcomes can be found in Chapter Three.

## 5.2.2 Statistical analysis

Stata (version 16) was used for statistical analysis. The number of participants and percentage of participants with an 'increase' ( $\geq$  +2 units of HADS), 'decrease' ( $\leq$  -2 units of HADS), or 'no change' (-1.99 to 1.99 of HADS) in depression and anxiety symptoms from baseline to 5-years were calculated using descriptive statistics and presented by intervention arm.

The primary analysis used linear regression to, separately, compare the 5-year change in depression and anxiety between the three randomised groups, adjusting for baseline depression and anxiety, as well as the randomisation stratifiers (gender and research centre), i.e., analysis of covariance (ANCOVA). The null hypothesis of no difference between the three groups was tested using an F-test. Estimates and 95% confidence intervals of differences comparing 52-week programme vs. brief intervention, 52-week programme vs. 12-week programme, and 12-week programme vs. brief intervention group were obtained from the model. As no significant difference was found between the randomised groups, per the pre-specified statistical analysis plan, a secondary analysis was conducted to compare the 52-week programme and the other groups (12-week programme and brief intervention) combined. In all analyses, participants were included in the group to which they were randomised, based on the intention-to-treat principle.

# 5.3 Results

## 5.3.1 Impact on depression symptoms at 60-months (i.e., 5-years)

Mean change in depression scores at 60-months were -0.08 ( $\pm$  3.29) after the brief intervention, 0.02 ( $\pm$  3.01) in the 12-week programme, and -0.09 ( $\pm$  3.41) in the 52-week programme (Table 1). On average, changes in depression at 60-months were less than the minimal important difference of 2 and, therefore, did not represent meaningful change. Histograms (Chapter Five Appendices: A5.2 - Figure A1-8) highlighting the distribution of changes in depression from baseline to 3-, 12, 24-, and 60-months show that, at all timepoints, some people in all groups experienced an improvement or decline in their mental health. A proportion of participants in each group experienced a meaningful change in mental health; 22 BI participants (33%), 62 CP12 participants (30%), and 56 CP52 participants (28%) experienced a meaningful decrease in symptoms of depression at 60-months, whilst 11 BI participants (17%), 37 CP12 participants (18%), and 42 CP52 participants (21%) experienced a meaningful increase in symptoms of depression at 60-months (Table 2).

I conducted ANCOVA analyses to determine the difference between brief intervention, 12-week behavioural programme, and 52-week behavioural programme on the change in depression symptoms between baseline and 60-months, controlling for baseline depression and anxiety, gender, and research centre. There was no evidence of a difference between randomised groups in change in depression (F(2)=0.10, p=0.91; n=474).

Pairwise comparisons showed no difference between brief intervention and 12-week (0.07; 95% CI -0.76, 0.89) or 52-week programme (-0.06; 95% CI -0.89, 0.77), or between the 12-week and 52-week programme (-0.13; 95% CI -0.71, 0.45). Participants in the 52-week behavioural programme did not differ from the participants in the other groups (brief intervention and 12-week behavioural programme) combined in changes to depression symptoms from baseline to 60-months (-0.11; 95% CI -0.65, 0.43) (Table 1).

## 5.3.1 Impact on anxiety symptoms at 60-months (i.e., 5-years)

Mean change in anxiety scores at 60-months were 0.16 ( $\pm$  3.50) after the brief intervention, -0.05 ( $\pm$  3.55) in the 12-week programme, and -0.66 ( $\pm$  3.59) in the 52-week programme (Table 1). On average, changes in anxiety at 60-months were less than the minimal important difference of 2 and, therefore, did not represent meaningful change. Histograms (Chapter Five Appendices: A5.2 - Figure A1-8) highlighting the distribution of changes in anxiety from baseline to 3-, 12, 24-, and 60-months show that, at all timepoints, some people in all groups experienced an improvement or decline in their mental health. A proportion of participants in each group experienced a meaningful change in mental health; 19 Bl participants (29%), 63 CP12 participants (31%), and 73 CP52 participants (36%) experienced a meaningful decrease in symptoms of anxiety at 60-months, whilst 16 Bl participants (24%), 41 CP12 participants (20%), and 24 CP52 participants (12%) experienced a meaningful increase in symptoms of anxiety at 60-months (Table 2).

I conducted ANCOVA analyses to determine the difference between brief intervention, 12-week behavioural programme, and 52-week behavioural programme on the change in anxiety symptoms between baseline and 60-months, controlling for baseline depression and anxiety, gender, and research centre. There was no evidence of a difference between randomised groups in change in anxiety (F(2)=1.55; p=0.21; n=474).

Pairwise comparisons showed no difference between brief intervention and 12-week (-0.07; 95% CI -0.98, 0.85) or 52-week programme (-0.59; 95% CI -1.51, 0.33), or between the 12-week and 52-week programme (-0.52; 95% CI -1.16, 0.12). Participants in the 52-week behavioural programme did not significantly differ from the participants in the other groups (brief intervention and 12-week behavioural programme) combined in changes to anxiety symptoms from baseline to 60-months (-0.54; 95% CI -1.14, 0.06) (Table 1).

|   | Mean change in mental health |          | Estimated differences between groups |         |         |         |           |
|---|------------------------------|----------|--------------------------------------|---------|---------|---------|-----------|
|   | from baseline to 60-months   |          | (95% CI)                             |         |         |         |           |
|   | (± SD)                       |          |                                      |         |         |         |           |
|   | BI                           | CP12     | CP52                                 | CP12 vs | CP52    | CP52 vs | BI & CP12 |
|   |                              |          |                                      | Ы       | vs Bl   | CP12    | vs CP52   |
| Depression  | -0.08                        | 0.02     | -0.09                                | 0.07    | -0.06   | -0.13   | -0.11     |
| symptoms  | (± 3.29)                     | (± 3.01) | (± 3.41)                             | (-0.76, | (-0.89, | (-0.71, | (-0.65,   |
|   |                              |          |                                      | 0.89)   | 0.77)   | 0.45)   | 0.43)     |
| Anxiety   | 0.16                         | -0.05    | -0.66                                | 0.07    | -0.59   | -0.52   | -0.54     |
| symptoms  | (± 3.50)                     | (± 3.55) | (± 3.59)                             | (-0.98, | (-1.51, | (-1.16, | (-1.14,   |
|   |                              |          |                                      | 0.85)   | 0.33)   | 0.12)   | 0.06)     |
| Analyses were adjusted for baseline mental health, gender, and research centre. |                              |          |                                      |         |         |         |           |

Table 1. Changes in symptoms of depression and anxiety from baseline to 60-months.

Analyses were adjusted for baseline mental health, gender, and research centre. Abbreviations: BI- Brief intervention, CP12 – 12-week commercial weight management programme, CP52 – 52-week commercial weight management programme, SD – Standard deviation, CI – Confidence interval.

| Change in symptoms of depression or anxiety  |                                 | Number of participants (%) |           |                 |
|--|---------------------------------|----------------------------|-----------|-----------------|
| at 60-months from baseline   |                                 | BI (n=66)                  | CP12      | CP52            |
|  |                                 |                            | (n=206)   | (Depression:    |
|  |                                 |                            |           | n=202,          |
|  |                                 |                            |           | Anxiety: n=206) |
| Depression   | Decrease (≤ -2 units)           | 22 (33%)                   | 62 (30%)  | 56 (28%)        |
| symptoms   | No change (-1.99 to 1.99 units) | 33 (50%)                   | 107 (52%) | 104 (51%)       |
|  | Increase (≥ +2 units)           | 11 (17%)                   | 37 (18%)  | 42 (21%)        |
| Anxiety  | Decrease (≤ -2 units)           | 19 (29%)                   | 63 (31%)  | 62 (30%)        |
| symptoms   | No change (-1.99 to 1.99 units) | 31 (47%)                   | 102 (50%) | 107 (52%)       |
|  | Increase (≥ +2 units)           | 16 (24%)                   | 41 (20%)  | 37 (18%)        |
| Abbreviations: BI- Brief intervention, CP12 – 12-week commercial weight management |                                 |                            |           |                 |
| programme, CP52 – 52-week commercial weight management programme.                  |                                 |                            |           |                 |

Table 2. Proportion of participants by randomised group experiencing a decrease, no change, or increase in symptoms of depression or anxiety at 60-months from baseline.

## 5.4 Discussion

In this chapter, I aimed to assess the impact of commercial behavioural weight management programmes on symptoms of depression and anxiety at 5 years (i.e., 60-months) from baseline. I found no evidence to suggest that, on average, attending a commercial weight management programme had greater benefits for depression and anxiety symptoms compared to brief intervention. Importantly, I also found no evidence that, on average, attending a commercial weight management programme had worse impacts on long-term depression or anxiety symptoms than brief intervention.

A recent systematic review reported small benefits for some aspects of mental health at the end of a behavioural weight management programme and highlighted the lack of evidence reporting the impacts on mental health in the longer term.<sup>45</sup> In the current analyses I found that, on average, participants across all randomised groups did not experience meaningful changes (as defined by minimal important difference) in depression and anxiety symptoms from baseline to 5-years. However, these findings are average effects and may not represent the experiences of all participants. I found that a proportion of participants in all randomised groups experienced a meaningful increase or decrease in depression and anxiety symptoms. Future research should look to identify those experiencing an increase in depression or anxiety symptoms and consider the support that may be most effective to minimise this risk. This may be achieved by identifying the programme components most and least supportive of participant mental health to inform the design of future weight management programmes.

The primary aim of a behavioural weight management programme is to produce a meaningful reduction in body weight, with any changes in mental health considered secondary impacts or unintended benefits/consequences. As these programmes are not designed to produce long-term improvements in mental health, it is perhaps unsurprising that I found no difference between randomised groups for changes in symptoms of depression and anxiety at 5-years from baseline. However, previous research has found that both adults with obesity and healthcare providers believe that weight management services do not sufficiently support mental health, <sup>126</sup> suggesting that programmes may benefit from adapting the development process to intentionally support mental health.

Strong evidence shows that weight gain/regain is common after a weight management programme ends, and this can result in a decline in mental health with participants reporting

feelings of failure, blame, and shame.<sup>109</sup> I found that, on average, this behavioural weight management programme did not cause long-term increases in depression and anxiety, despite weight regain. This may provide reassurance to both participants and providers that engaging with a behavioural weight management programme is unlikely to have negative long-term impacts on mental health.

## 5.4.1 Strengths and limitations

To my knowledge, this chapter is the first to investigate the impact of commercial behavioural weight management programmes on symptoms of depression and anxiety at 5-years from baseline. The strengths of this study include the minimal exclusion criteria in the parent trial, maximising the generalisability of the study population at baseline. The trial had a reasonable rate of participant follow-up, which is above average when compared to similar trials.<sup>93,94,232</sup>

This analysis was limited by high levels of missing data, which meant it was not possible to perform subgroup analyses to assess if the impact of the interventions was different across particular groups, such as gender, education, or ethnicity. Despite pre-specifying a sensitivity analysis using multiple imputation, I also pre-specified that this would not be appropriate if the level of missingness were 25% or more, and would not be necessary if the level of missingness were less than 5%. Future research should investigate the reasons for data missingness and seek to implement strategies to improve data completion.

This analysis was further limited by the mental health measures included in the WRAP trial; HADS only measures symptoms of anxiety and depression and a wider range of mental health measures such as distress, loneliness, disordered eating, and body image concerns would enable a broader understanding of the impact of these programmes on mental health. It is important to understand the impact of weight management programmes on a range of mental health ealth outcomes as benefits in one domain may not be reflected in another; for example, the long-term effects on anxiety and depression symptoms do not inform of the effect on stress and self-esteem.

There is evidence that the HADS has validity, high internal consistency, and is reliable for measuring depression and anxiety severity.<sup>203,205</sup> The measure is recommended to be included in the core outcome set for trials of behavioural weight management interventions.<sup>206</sup> However, the measure has been criticised as it does not capture somatic symptoms of depression and anxiety (e.g., fatigue, insomnia, headache).<sup>208</sup> Despite this limitation, has been described as a "*quick and reliable*" measure of depression and anxiety.<sup>205</sup> Section 3.2.5.2.1 provides a more in-depth critique of this measure.

# 5.5 Conclusion

On average, there was no evidence of a difference between the 12-week weight management programme, 52-week weight management programme or brief intervention for changes in depression and anxiety at 5-years from baseline. Furthermore, there was no evidence that behavioural weight management programmes cause harm to long-term mental health. However, it is important to note that these are average effects and do not rule out the long-term impacts of these programmes on some people or other aspects of mental health. It is important that we can identify those at a greater risk of psychological harm during and after a behavioural weight management intervention to implement appropriate and timely support. In Chapter Six, I aim to investigate how we may identify the participants who are at most risk of a decline in their mental health during and after a behavioural weight management intervention.

# 5.6 Contributions

I designed this study in collaboration with Amy Ahern. I devised the statistical analysis plan with support from Julia Mueller and Stephen Sharp. I independently conducted the statistical analyses and interpreted the results with support from Amy Ahern, Julia Mueller, and Stephen Sharp. A PPI representative (Ken Clare) informed the acceptability of the research and the interpretation of the study findings. I drafted the full thesis Chapter and the associated manuscript for publication (all co-authors reviewed and approved the manuscript for publication).

# CHAPTER SIX: PARTICIPANT CHARACTERISTICS ASSOCIATED WITH CHANGES IN MENTAL HEALTH DURING A TRIAL OF BEHAVIOURAL WEIGHT MANAGEMENT PROGRAMMES: SECONDARY ANALYSIS OF THE WRAP TRIAL.

The work in this chapter has been published as:

**Jones RA**, Mueller J, Sharp SJ, et al. (2022). 'Participant characteristics associated with changes in mental health in a trial of behavioural weight management programmes: Secondary analysis of the WRAP trial'. *Obesity Facts* 

This work was presented at the Obesity Week 2021, The Obesity Society.

## 6.1 Chapter overview

In Chapter Two, I found evidence to suggest that behavioural weight management interventions produce small benefits for some aspects of mental health at the end of an intervention and 12-months from baseline.<sup>45</sup> In Chapter Five, I found no evidence of a difference between the behavioural weight management interventions and control group for changes in depression and anxiety at 5 years from baseline. In both chapters, there was no evidence that behavioural weight management interventions cause harm to long-term mental health. However, these findings represent *average* effects, and it is likely that this is not the case for all participants. As described in Chapter One (*Section 1.5.1.4*), by investigating how participant characteristics are associated with changes in mental health, we may better identify those at a greater risk of psychological harm during and after a behavioural weight management intervention.

In **Chapter Six**, I present a secondary quantitative analysis using WRAP data which aims to identify how baseline and early changes in participant characteristics are associated with changes in depression and anxiety in adults with obesity during and after a behavioural weight management intervention.

This chapter addresses **thesis Objective Three**: To identify participant characteristics associated with changes in mental health in adults with obesity during and after a behavioural weight management intervention.

## 6.1.1 Aims and objectives

I aimed to assess how participant characteristics were associated with changes in mental health during and after a behavioural weight management intervention. I did not have specific, directional hypotheses relating to which participant characteristics may be associated with changes in mental health due to the lack of existing literature to inform such hypotheses. As such, this secondary data analysis is an exploratory study.

The chapter objectives were to:

- 1. Identify whether baseline participant characteristics are associated with changes in depression and anxiety during and after a behavioural weight management intervention.
- 2. Identify whether early changes in individual characteristics are associated with changes in depression and anxiety during and after a commercial weight management intervention.

## 6.2 Methods

This chapter is a secondary data analysis of the Weight loss Referrals for Adults in Primary care (WRAP) trial; trial design and baseline results are presented in Chapter Three.

An *a-priori* statistical plan for Chapter Six can be found in Chapter Six Appendices (A6.1). The publication associated with this chapter has been published at Obesity Facts.

## 6.2.1 Outcomes

Outcomes of interest were changes in symptoms of depression and anxiety from baseline to follow-up visits at 3-, 12-, 24-, and 60-months.

Baseline participant characteristics were assessed for their association with changes in depression and anxiety symptoms from baseline to 3-, 12-, 24-, and 60-months.

Early changes (from baseline to 3-months) in participant characteristics were assessed for their association with changes in symptoms of depression and anxiety from (i) baseline to 3-months, and (ii) from 3-months to 12-, 24-, and 60-months.

Due to the lack of relevant literature to inform the selection of exposure variables to investigate, I determined exposure variables using investigator expertise (i.e., through consultation with the co-authors of the associated manuscript) with the aim of assessing a broad range of potentially associated characteristics. Exposure variables, and justification for the chosen variables, are shown below:

• Demographics (age, sex, BMI, education, socioeconomic status<sup>201</sup>).

*Rationale for inclusion*: Inclusion of demographic variables allows exploration of nonmodifiable factors that might influence changes in mental health during and after the intervention. Demographic variables are generally included in these forms of analyses, and they can be relevant to disease and condition development and changes. For example, those with low socioeconomic status are more vulnerable to developing mental ill-health.<sup>250</sup> As such, those with lower socioeconomical status may be more vulnerable to greater declines in their mental health during and after a behavioural weight management intervention.

- Psychological factors (baseline depression and anxiety,<sup>202</sup> quality of life by EQ5D summary score,<sup>214</sup> satisfaction with life,<sup>219</sup> cognitive dietary restraint,<sup>222</sup> self-regulation,<sup>228</sup> habit strength<sup>229</sup>).
- Rationale for inclusion: Psychological factors have generally been linked to a wide range
  of negative mental and emotional effects.Intervention attendance and engagement:
  Programme attendance in the first 3-months of WW sessions (objectively measured by
  data collected by WW at weekly meetings). Self-reported weekly engagement with WW
  digital resources.

*Rationale for inclusion*: Poor intervention attendance and engagement is common in behavioural weight management interventions, and individuals can blame themselves rather than attribute this to a lack of intervention effectiveness. This internalised blame can negatively impact an individual's mental health and, as such, it is important to investigate the role that attendance and engagement may play in changes in mental health during and after a behavioural weight management intervention.

Further details on outcomes can be found in Chapter Three.

#### 6.2.2 Statistical analysis

Stata (version 16) was used for all statistical analyses.<sup>151</sup>

#### 6.2.2.1 Analysis methods

Analyses of the association between changes in depression/anxiety and (1) baseline participant characteristics and (2) early changes in participant characteristics were conducted and presented separately, with findings discussed and critiqued simultaneously for integrated interpretation.

# 6.2.2.1.1 The association between baseline participant characteristics and changes in depression and anxiety symptoms

Linear regression was used to estimate the association between participant characteristics at baseline and changes in symptoms of depression and anxiety between baseline and 3-, 12-, 24-, and 60-months, controlling for the randomised group. Baseline participant characteristics whose

p-value for association with changes in symptoms of depression/anxiety was <0.05 were included in mutually adjusted models. Robust standard errors were calculated in all models to allow for clustering by general practice.

# 6.2.2.1.2 The association between early changes in participant characteristics and changes in depression and anxiety symptoms

Linear regression was used to estimate the association between early changes (i.e., from baseline and 3-months) in participant characteristics and changes in symptoms of depression and anxiety from baseline to 3-months, and from 3- to 12-, 24- and 60-months, controlling for the randomised group. Early changes in participant characteristics whose p-value for association with changes in symptoms of depression/anxiety was <0.05 were included in mutually adjusted models. Robust standard errors were calculated in all models to allow for clustering by general practice.

#### 6.2.2.1.3 Sensitivity analyses: Imputation of missing data to assess the impact of missingness

Participants with missing values were excluded (i.e., complete-case analysis), assuming data are missing at random conditional on covariates in the model. A sensitivity analysis was performed using multiple imputation by chained equations (MICE), which also assumes data are missing at random but provides increased precision compared with complete-case analysis. For sensitivity analyses, I imputed data for variables with  $\geq$ 5% missing data by MICE; variables with  $\geq$ 25% missing data were excluded from sensitivity analyses.

#### 6.2.2.1.4 Additional analyses not included in the original statistical analysis plan (SAP)

Changes in depression/anxiety were continuous outcomes in the primary analyses. Since changes can be positive or negative, the precise nature of any exposure/outcome association may not be obvious using this approach. Therefore, I also fitted multinomial regression models to further illuminate the interpretation of the results of the primary analysis. I fitted these models for the primary analysis showing consistent associations across all timepoints (i.e., baseline participant characteristics), and did not fit these models where they were no consistent associations to be

interpreted (i.e., early changes in participant characteristics). Estimates from the multinomial regression models were reported as relative risk ratio (RRR) and 95% Confidence Interval (CI).

A minimal important difference (MID) for change in the HADS score has not been determined in a population of adults with overweight and obesity. The minimal important difference in alternative populations (cancer, cardiovascular disease, bronchiectasis, and chronic obstructive pulmonary disease) has most commonly been defined as a change of 2 points.<sup>209–213</sup> Therefore, I categorised change in depression/anxiety as 'decrease in symptoms' ( $\leq$ -2), 'no change in symptoms' (-1.99 to 1.99), or 'increase in symptoms' ( $\geq$ 2) in the multinomial regression models. As in the primary analysis, these models were adjusted for the randomised group, and robust standard errors were calculated to allow for clustering by general practice.

#### 6.3 Results

# 6.3.1 The association between baseline participant characteristics and changes in depression and anxiety

Baselines scores for 'entering treatment self-regulation' (amotivation and autonomous selfcontrol domains), age, BMI, gender, socioeconomic status, attendance at WW sessions, and exercise self-regulation (amotivation domain) were associated with changes in mental health; however, changes were smaller than the minimal important difference (MID: 2), associations were not consistent across timepoints, and associations were not evident for both depression and anxiety (Table 1).

Baseline depression and anxiety were the only characteristics consistently associated with changes in depression and anxiety from baseline to 3-, 12-, 24-, and 60-months (Chapter Six Appendices: A6.2 -Table A1) and remained associated after mutual adjustment (Table 1). Changes in depression and anxiety were smaller than the minimal important difference (MID: 2) across all timepoints. When considered alongside the associations with categorised changes in depression/anxiety (Chapter Six Appendices: A6.2 - Table A2 [A. Depression, B. Anxiety]), higher levels of anxiety at baseline were associated with decreases in anxiety symptoms and increases in depression symptoms from baseline to follow-up visits. Similarly, higher levels of depression at baseline were associated with decreases in depression symptoms and increases in anxiety symptoms and increases in anxiety symptoms from baseline to follow-up visits.

#### 6.3.1.1 Sensitivity analyses: Imputation of missing data to assess the impact of missingness

I pre-specified that a sensitivity analysis using multiple imputation would not be deemed appropriate if the level of missingness were 25% or more (as it was for changes in depression and anxiety from baseline to 12-, 24- and 60-months).

Sensitivity analyses using multiple imputation for change in depression and anxiety outcomes from baseline to 3-months found comparable results to primary analyses (i.e., complete-case analyses) (Chapter Six Appendices: A6.3 - Table A3-4). Higher levels of depression and lower levels of anxiety at baseline were associated with an increase in anxiety symptoms from baseline to 3months (Chapter Six Appendices: A6.3 - Table A3-4). Additionally, lower levels of depression and lower history of dietary behavioural repetition scores at baseline were associated with increases in depression symptoms from baseline to 3-months (Chapter Six Appendices: A6.3 - Table A3-4).

Table 1. Association of baseline participant characteristics with changes in symptoms of depression and anxiety – controlled for study arm and clustering by GP practice, and mutually adjusted for covariates in the model.

| Estimated association of changes in depression with outcome per 1 unit of baseline |   |  |  |
|--|---|--|--|
| characteristic, unless otherwise indicated (Unstandardised coefficient, 95% CI)    |   |  |  |
|  | Change in depression from baseline to 3-  |  |  |
| Participant characteristic at baseline   | months                                    |  |  |
|  | (n=904)                                   |  |  |
| Age (years)  | 0.01 (-0.00, 0.02)                        |  |  |
| Baseline anxiety   | 0.11 (0.05, 0.17)                         |  |  |
| Baseline depression  | -0.29 (-0.36, -0.23)                      |  |  |
| Total dietary restraint  | 0.01 (-0.05, 0.08)                        |  |  |
| Entering treatment self-regulation: Autonomous                                     | -0.03(-0.18, 0.11)                        |  |  |
| regulation score   | -0.03 (-0.18, 0.11)                       |  |  |
| Entering treatment self-regulation: Amotivation                                    | 0 18 (0 06 0 31)                          |  |  |
| score  | 0.16 (0.00, 0.31)                         |  |  |
| Self-reported dietary habits: History of   | -0.18 (-0.50, 0.14)                       |  |  |
| behavioural repetition   | 0.10 ( 0.00, 0.17)                        |  |  |
| Self-reported dietary habits: Lack of awareness                                    | 0.16 (-0.16, 0.48)                        |  |  |
|  | Change in depression from baseline to 12- |  |  |
| Participant characteristic at baseline   | months                                    |  |  |
|  | (n=371)                                   |  |  |
| Baseline depression  | -0.20 (-0.28, -0.12)                      |  |  |
| Weekly use of WW e-tools/online resources  |   |  |  |
| (never as the reference group): 3-5 times per                                      | -0.48 (-1.22, 0.27)                       |  |  |
| week   |   |  |  |
| Socioeconomic status   | -0.10 (-0.18, -0.03)                      |  |  |

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| Total number of WW sessions attended in the    |   |
|--|---|
| first 3-months                                 | -0.07 (-0.17, 0.03)                       |
|  | Change in depression from baseline to 24- |
| Participant characteristic at baseline         | months                                    |
|  | (n=374)                                   |
| Education (none as reference group): Post-     | -0.42 (-1.61.0.77)                        |
| secondary study                                |   |
| Baseline depression                            | -0.26 (-0.36, -0.16)                      |
| Baseline anxiety                               | 0.06 (-0.03, 0.16)                        |
| Total number of WW sessions attended in the    | 0.15 ( 0.27 . 0.02)                       |
| first 3-months                                 | -0.15 (-0.27, -0.05)                      |
| Weekly use of WW e-tools/online resources      |   |
| (never as the reference group): Daily/Almost   | 0.32 (-0.31, 0.94)                        |
| daily  |   |
| Male gender (female as the reference group)    | 0.72 (0.18, 1.26)                         |
| Self-reported exercise habits: Lack of control | 0.04 (-0.13, 0.22)                        |
|  | Change in depression from baseline to 60- |
| Participant characteristic at baseline         | months                                    |
|  | (n=466)                                   |
| Exercise self-regulation: Amotivation score    | 0.35 (0.09, 0.61)                         |
| Baseline depression                            | -0.40 (-0.50, -0.30)                      |
| Baseline anxiety                               | 0.10 (0.04, 0.15)                         |
|  |   |

Estimated association of changes in anxiety with outcome per 1 unit of baseline characteristic, unless otherwise indicated (Unstandardised coefficient, 95% CI)

|  | Change in anxiety from baseline to 3- |
|--|---------------------------------------|
| Participant characteristic at baseline         | months (Model 1)                      |
|  | (n=862)                               |
| Education (none as the reference group): Post- | 0 10 ( 0 47 0 26)                     |
| secondary study                                | -0.10 (-0.47, 0.20)                   |
| Baseline depression                            | 0.09 (0.04, 0.14)                     |
| Baseline anxiety                               | -0.24 (-0.30, -0.17)                  |

|   | Change in anxiety from baseline to 3-  |  |
|---|--|--|
| Participant characteristic at baseline          | months (Model 2)                       |  |
|   | (n=862)                                |  |
| Education (no formal education as the reference | 0.10/0.56.0.18)                        |  |
| group): GCSE or equivalent                      | -0.19 (-0.30, 0.18)                    |  |
| Baseline depression                             | 0.09 (0.04, 0.14)                      |  |
| Baseline anxiety                                | -0.24 (-0.30, -0.17)                   |  |
|   | Change in anxiety from baseline to 12- |  |
| Participant characteristic at baseline          | months                                 |  |
|   | (n=373)                                |  |
| Baseline depression                             | 0.05 (-0.05, 0.15)                     |  |
| Baseline anxiety                                | -0.18 (-0.28, -0.08)                   |  |
| Weekly use of WW mobile phone app (never as     | 0.96 (0.00, 1.92)                      |  |
| the reference group): Daily/Almost daily        |  |  |
| Total number of WW sessions attended in the     | -0.04 (-0.16, 0.07)                    |  |
| first 3-months                                  | 0.0+(0.10, 0.07)                       |  |
|   | Change in anxiety from baseline to 24- |  |
| Participant characteristic at baseline          | months                                 |  |
|   | (n=754)                                |  |
| Baseline anxiety                                | -0.36 (-0.46, -0.27)                   |  |
| Baseline depression                             | 0.16 (0.04, 0.28)                      |  |
|   | Change in anxiety from baseline to 60- |  |
| Participant characteristic at baseline          | months                                 |  |
|   | (n=468)                                |  |
| Baseline anxiety                                | -0.32 (-0.42, -0.23)                   |  |
| Total restraint                                 | -0.03 (-0.27, 0.21)                    |  |
| Rigid dietary restraint                         | 0.01 (-0.30, 0.32)                     |  |
| Exercise self-regulation: Autonomous self-      |  |  |
| control score                                   | 0.52 (-0.02, -0.05)                    |  |
| Age (years)                                     | -0.05 (-0.07, -0.03)                   |  |
| BMI (kg/m <sup>2</sup> )                        | 0.07 (0.02, 0.12)                      |  |

# 6.3.2 The association between early changes in participant characteristics and changes in depression and anxiety

For every unit of early changes in global quality of life and satisfaction with life, changes in both depression and anxiety reduced from baseline to 3-months; the estimated association of early changes in quality of life with changes in depression and anxiety from baseline to 3-months (*b* - 2.57, 95% CI -4.18, -0.95) exceeded the minimal important difference of two units of change (Chapter Six Appendices: A6.4 - Table A5). The estimated association of early changes in satisfaction with life with changes in depression and anxiety from baseline to 3-months (*b* -0.09, 95% CI -0.13, -0.05) did not meet minimal important difference to represent meaningful change. Notably, there were no early changes in characteristics consistently associated with changes in depression and anxiety across all timepoints (Table 2) (Chapter Six Appendices: A6.4 - Table A5).

#### 6.3.2.1 Sensitivity analyses: Imputation of missing data to assess the impact of missingness

I pre-specified that sensitivity analysis using multiple imputation would not be appropriate if the level of missingness were 25% or more (as it was for change in depression and anxiety from baseline to 12-, 24- and 60-months, and numerous early changes in participant characteristics (Chapter Six Appendices: A6.5 – Table A6).

Table 2. Association of early changes in participant characteristics with changes in symptoms of depression and anxiety – controlled for study arm and clustering by GP practice, and mutually adjusted for covariates in the model.

|  | Estimated association with outcome per 1      |  |  |
|--|---|--|--|
|  | unit of change in participant characteristic, |  |  |
|  | unless otherwise indicated                    |  |  |
|  | (Unstandardised coefficient, 95% CI)          |  |  |
| Change from baseline to 3-months in              | Change in depression from baseline to 3-      |  |  |
|  | months (n=772)                                |  |  |
| BMI (kg/m <sup>2</sup> )                         | 0.24 (0.07, 0.42)                             |  |  |
| Global quality of life                           | -2.57 (-4.18, -0.95)                          |  |  |
| Satisfaction with life                           | -0.09 (-0.13, -0.05)                          |  |  |
| Total dietary restraint                          | -0.07 (-0.17, 0.03)                           |  |  |
| Flexible dietary restraint                       | [omitted because of collinearity]             |  |  |
| Rigid dietary restraint                          | 0.01 (-0.14, 0.17)                            |  |  |
| Treatment self-regulation: Autonomous            | -0.02 (-0.14, 0.10)                           |  |  |
| regulation score                                 |   |  |  |
| Self-reported dietary habits: History of         | 0 12 (-0 09 0 34)                             |  |  |
| behavioural repetition                           | 0.12 ( 0.05, 0.5 l)                           |  |  |
| Self-reported dietary habits: Lack of control    | -0.11 (-0.21, -0.02)                          |  |  |
| Self-reported dietary habits: Lack of awareness  | 0.14 (-0.07, 0.35)                            |  |  |
| Self-reported exercise habits: History of        | 0.04 (-0.18, 0.26)                            |  |  |
| behavioural repetition                           | 0.04 (*0.10, 0.20)                            |  |  |
| Self-reported exercise habits: Lack of control   | 0.04 (-0.10, 0.18)                            |  |  |
| Self-reported exercise habits: Lack of awareness | -0.05 (-0.30, 0.20)                           |  |  |
| Change from haseline to 3-months in              | Change in depression from 3- to 24-months     |  |  |
|  | (n=620)                                       |  |  |
| Satisfaction with life                           | 0.05 (0.00, 0.10)                             |  |  |
| Rigid dietary restraint                          | 0.18 (0.02, 0.35)                             |  |  |
| Treatment self-regulation: Autonomous            | 0.14 (-0.05, 0.32)                            |  |  |
| regulation score                                 |   |  |  |

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| Change from baseline to 2 menths in                 | Change in depression from 3- to 60-months |  |  |
|---|---|--|--|
| Change from basenne to 5-months m                   | (n=684)                                   |  |  |
| Total dietary restraint                             | 0.16 (-0.01, 0.33)                        |  |  |
| Flexible dietary restraint                          | 0.00 (-0.10, 0.11)                        |  |  |
| BMI (kg/m <sup>2</sup> )                            | -0.07 (-0.27, 0.12)                       |  |  |
| Change from baseline to 3-months in                 | Change in anxiety from baseline to 3-     |  |  |
|   | months (n=753)                            |  |  |
| Global quality of life                              | -1.95 (-3.36, -0.55)                      |  |  |
| Satisfaction with life                              | -0.08 (-0.12, -0.03)                      |  |  |
| Treatment self-regulation: Controlled regulation    | 0.04 ( 0.15, 0.23)                        |  |  |
| score   | 0.04 (-0.13, 0.23)                        |  |  |
| Diet self-regulation: Controlled self-control score | 0.17 (-0.05, 0.39)                        |  |  |
| Diet self-regulation: Amotivation score             | 0.08 (-0.08, 0.25)                        |  |  |
| Exercise self-regulation: Autonomous self-          | -0.17 (-0.33, -0.01)                      |  |  |
| control score                                       |   |  |  |
| Self-reported exercise habits: History of           | -0.01 (-0.27, 0.24)                       |  |  |
| behavioural repetition                              | -0.01 (-0.27, 0.24)                       |  |  |
| Self-reported exercise habits: Lack of control      | 0.10 (-0.04, 0.24)                        |  |  |
| Self-reported exercise habits: Lack of awareness    | 0.00 (-0.19, 0.20)                        |  |  |
| Change from baseline to 3-months in                 | Change in anxiety from 3- to 60-months    |  |  |
|   | (n=390)                                   |  |  |
| Treatment self-regulation: Controlled regulation    | -0.32 (-0.68, 0.05)                       |  |  |
| score   | 0.02 ( 0.00, 0.00)                        |  |  |
| Diet self-regulation: Autonomous self-control       | -0.26 (-0.69, 0.18)                       |  |  |
| score   | 0.20 ( 0.05, 0.10)                        |  |  |
| Diet self-regulation: Controlled self-control score | -0.11 (-0.42, 0.20)                       |  |  |
| Exercise self-regulation: Autonomous self-          | -0.17 (-0.44, 0.09)                       |  |  |
| control score                                       | 0.17 (0.17, 0.00)                         |  |  |
## 6.4 Discussion

I aimed to identify whether participant characteristics at baseline, or early changes in characteristics, were associated with changes in symptoms of depression and anxiety during and after a commercial weight management programme. I found that those reporting higher baseline anxiety were likely to experience decreases in anxiety symptoms and increases in depression symptoms up to five years from baseline, whereas those reporting higher baseline depression were likely to experience decreases in depression symptoms and increases in anxiety symptoms up to five years from baseline. No further characteristics were consistently associated with changes in mental health.

Study findings should be interpreted with consideration to the distinct difference between statistical significance and clinical significance. Statistically, baseline depression and anxiety were associated with very small changes in depression and anxiety up to five years from baseline, though these changes were smaller than the minimal important difference (MID). The MID represents the smallest change that is perceived by participants to be important, suggesting that the associations found may not represent a meaningful change to those attending the weight management programme.

Findings suggest that baseline depression and anxiety may indicate future mental health needs; in particular, those reporting high baseline depression or anxiety symptoms may benefit from ongoing monitoring so that deteriorations in mental health may be identified early. However, I am unsure of the mechanisms underpinning these findings. For example, I am uncertain why those with high baseline anxiety would experience reductions in anxiety yet increases in depression symptoms. I suggest that qualitative research may help to better understand why participants appear to simultaneously experience an improvement in one aspect of mental health, whilst experiencing a decline in another aspect of mental health. It is also possible that the findings may be explained by regression to the mean, which is a common phenomenon in which individuals reporting a score at the extreme end of a scale are likely to show a change towards the centre of the scale. The high proportion of missing data in this chapter increases the likelihood that regression to the mean may influence chapter findings as the sample may not represent the true population distribution.<sup>251,252</sup> Future research may wish to explore the patterning between anxiety and depression to better understand this relationship, and qualitative research may help to elicit a better understanding of why these changes occur by exploring the

potential factors that influence mental health. In addition, the large number of analyses increases the risk of type 1 error, so it would be important to replicate the associations we have reported in other studies.

Previous research has sought to identify factors associated with changes in positive mental health outcomes during weight management interventions (e.g., quality of life and wellbeing<sup>121-124</sup>), yet to my knowledge, this is the first study investigating the factors associated with negative aspects of mental health (i.e., depression and anxiety). In previous research, factors found to be associated with quality of life and wellbeing included paid work, social support, self-determination, small weight loss, and an active lifestyle.<sup>121-124</sup> The findings of this chapter differ from this earlier research, with symptoms of depression and anxiety at baseline found to be the only characteristics consistently associated with changes in depression and anxiety during and after WW. Comparisons of the chapter findings with previous research must be considered with caution due to differing study eligibility criteria, interventions, outcomes of interest, and exposures assessed for association. For example, the participant eligibility criteria of previous research greatly differ due to studies focusing on those at risk of type 2 diabetes,<sup>123</sup> women only,<sup>121</sup> those with obesity waiting for bariatric surgery<sup>122</sup>, and excluding participants with psychological conditions.<sup>124</sup>

More research is needed to assess how participant characteristics are related to changes in depression and anxiety in a range of different participants, with trials including large samples with broad diversity in characteristics to enable these investigations. Whilst I recognise that the current findings are not conclusive and more research is required, I suggest a cautious approach to minimise the risk of possible harm to the mental health of programme participants. Therefore, trialists and healthcare practitioners may consider measuring depression and anxiety more regularly to implement preventive care if a decline in symptoms is identified; any changes in measurement frequency should involve consultation with patient and public involvement (PPI) representatives to ensure that participant burden is considered and that the proposed changes are deemed acceptable.

## 6.4.1 Strengths and limitations

This chapter assessed a broad range of potentially associated participant characteristics at baseline as well as early changes in characteristics. A formal SAP for the *a-priori* aims was developed and approved by all authors of the associated manuscript before commencing analyses, minimising the potential of being influenced to seek significant findings, rather than guided by the pre-determined research aims and rationale. I conducted an additional analysis to inform the interpretation of the results, which strengthened the meaningfulness of the conclusions (*See: 6.2.2.1.4 Additional analyses not included in the original statistical analysis plan*).

The chapter was limited by the proportion of missing data, particularly at longer-term follow-up visits (Chapter Six Appendices: A6.5 – Table A6). Despite this, the WRAP trial reports a smaller attrition rate than is common in weight-loss trials,<sup>93,94,232</sup> and best efforts were made to transparently and clearly report missingness. A high proportion of missing data increases the risk of sample bias and may reduce the generalisability of findings. For example, if those with missing data experience poorer mental health than the study sample, then I may be underestimating the associations found in this chapter. Where possible, I investigated the impact of missing data on the results using multiple imputation. In future trials, engagement strategies should be considered to improve participant retention at study follow-up visits. Furthermore, the sample had limited variability in some characteristics, such as ethnicity, meaning that I could not investigate their potential association with changes in mental health.

## 6.5 Conclusion

Evidence suggests that baseline depression and anxiety may be indicative of how symptoms of depression and anxiety change during and after a commercial weight management programme. Specifically, higher levels of anxiety at baseline were associated with decreases in anxiety and increases in depression symptoms up to 5 years from baseline, whilst higher levels of depression at baseline were associated with decreases in depression and increases in anxiety symptoms. I did not identify any further characteristics to be consistently associated with changes in depression and anxiety. Measurement of depression and anxiety at the start of a behavioural weight management programme and subsequent monitoring may facilitate timely psychological support if a deterioration in mental health is identified. Further research in large and diverse participant samples is required to clarify the findings and determine the underpinning mechanisms.

## 6.6 Contributions

I designed this study in collaboration with Amy Ahern. I devised the statistical analysis plan with support from Julia Mueller and Stephen Sharp. I independently conducted the statistical analyses and interpreted the results with support from Amy Ahern, Julia Mueller, and Stephen Sharp. A PPI representative (Mike Willis) informed the acceptability of the research and the interpretation of the study findings. I drafted the full thesis Chapter and the associated manuscript for publication (all co-authors reviewed and approved the manuscript for publication).

# CHAPTER SEVEN: PARTICIPANTS' EXPERIENCES OF MENTAL HEALTH DURING A COVID-19 TAILORED, WEB-BASED, GUIDED SELF-HELP, ACT-BASED BEHAVIOURAL WEIGHT MANAGEMENT INTERVENTION: A QUALITATIVE STUDY.

The work in this chapter is under review as:

Jones RA, Richards R, Palat R, et al. (Under review – Submitted Oct 2021). 'Participants experiences of mental health during a COVID-19 tailored, web-based, guided self-help, ACT-based behavioural weight management intervention: a qualitative study.' *International Journal of Qualitative Studies on Health and Wellbeing* - (Chapter Seven)

This work was presented at the Obesity Week 2021, The Obesity Society, and the European Congress on Obesity 2022.

## 7.1 Chapter overview

In previous chapters, I used quantitative methods to address multiple thesis objectives: Objectives One: To determine the short- and long-term impact of behavioural weight management interventions on the mental health of adults with overweight and obesity; Objective Two: To identify how participant mental health is associated with attendance and engagement with a behavioural weight management intervention and trial; and, Objective Three: To identify participant characteristics associated with changes in mental health in adults with obesity during and after a behavioural weight management intervention.

As described in Chapter One (*Section 1.5.1.5*), these chapters (Chapters Two, Four, Five, and Six) provide necessary information to better understand the role of mental health in behavioural weight management interventions, yet they do not provide insight into the underlying meaning, feelings, and personal experiences of the intervention participants. Qualitative research methods are well suited to exploring people's experiences, thoughts, feelings, attitudes, behaviours, and motivations, particularly when investigating complex and sensitive issues (e.g., participants' experiences of mental health during behavioural weight management interventions). In addition, qualitative research findings can support a deeper understanding of quantitative findings. For example, whilst Chapters Two and Five can quantify the impact of interventions on mental health, qualitative research may explore the deeper reasons as to why their mental health may have been impacted in this way.

In **Chapter Seven**, I present an interview-based qualitative study where I explored the mental health experiences of participants from the 'Supporting Weight Management During COVID-19' trial. The chapter broadly aims to explore mental health experiences during the intervention and, in particular, aims to explore how the intervention could be adapted to better support participant mental health.

This chapter addresses **thesis Objective Four**: To explore participant experiences of a behavioural weight management intervention to better understand how well the intervention supports participant mental health, and how the intervention could be adapted to provide more effective support.

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## 7.1.1 Aims and objectives

I aimed to broadly explore intervention participants' mental health experiences during the SWiM-C (Supporting Weight Management during COVID-19) intervention, and how SWiM-C and other weight management interventions could be adapted to better support mental health.

The chapter objectives were to:

- 1. Explore the mental health experiences of SWiM-C intervention participants.
- 2. Explore how well the intervention supports participant mental health.
- 3. Explore how the intervention could be adapted to better support participant mental health.

## 7.2 Methods

This study was an embedded qualitative study in the Supporting Weight Management during COVID-19 (SWiM-C) randomised controlled trial. As such, the protocol is included in the main trial protocol as shown in Chapter Seven Appendices (A7.1).

The publication associated with this chapter has been submitted to the International Journal of Qualitative Studies on Health and Wellbeing and is under review.

## 7.2.1 Design and setting

## 7.2.1.1 Study design and setting

This qualitative study was embedded in the SWiM-C (Supporting Weight Management during COVID-19) randomised controlled trial (Clinical trial registration: ISRCTN12107048). Ethical approval was obtained from the Cambridge Psychology Research Ethics Committee (Application No: PRE.2020.049) on 24/04/2020, and the study was conducted according to the Declaration of Helsinki. All participants gave written, informed consent (Chapter Seven Appendices: A7.2). Participants were randomised to either the SWIM-C intervention or to a standard advice waitlist control with 1:1 allocation. Standard advice was provided in the format of a leaflet with information on diet, physical activity, and mood during the pandemic. Outcome assessments were completed online at baseline and 4-months from baseline. Information was collected on height, weight, demographics, eating behaviour, physical activity, quality of life/wellbeing, and intervention engagement.

## 7.2.1.2 SWiM-C Intervention

SWIM-C was a web-based, guided self-help intervention that aimed to support adults with overweight and obesity with weight management, health behaviours, and emotional wellbeing during the Covid-19 pandemic. The intervention was based on ACT and included 12 weekly sessions delivered online. Sessions covered topics such as control and acceptance, willingness, overcoming obstacles, stress management, and urges and cravings; this list is not exhaustive. Each session consisted of psychoeducation, reflective exercises, and behavioural experiments. The 'guided' element of the self-help programme was provided by trained non-specialists ('SWIM

Coaches'). SWiM coaches had a 20-minute phone call with each participant following the completion of session four and sent a tailored email to the same participant following their completion of session 10. Further information is reported elsewhere.<sup>253</sup>

## 7.2.2 Participant recruitment and sampling

## 7.2.2.1 Eligibility criteria

Participants were adults with overweight or obesity ( $\geq$ 18 years,  $\geq$ 25 kg/m<sup>2</sup>) who had a good understanding of written English and owned a set of bodyweight scales. Participants were excluded from taking part if they had undergone bariatric surgery in the last two years. Participants were not excluded based on mental health diagnosis. To be eligible for participation in the embedded qualitative study, participants were required to provide informed consent to be contacted and invited to interview.

## 7.2.2.3 Sampling

Twenty SWiM-C intervention participants were purposively sampled for maximum variation in broad demographic data (age, sex, education, ethnicity, occupation). The sample was heterogenous in demographic characteristics to ensure the group was broadly representative of the wider population participating in or eligible for the SWiM-C trial, yet the sample was a homogenous group as they were all SWiM-C intervention participants: people living with obesity who wanted to manage their weight and all had experience of the SWiM C intervention." The sample size was estimated to be sufficient based on previous relevant studies and the pragmatic restraints of the COVID-19 pandemic.<sup>243,254–257</sup> Interview participants were given a minimum of 48 hours to read the participant information sheet and multiple opportunities to ask questions. Written informed consent was obtained prior to any study activities. Participants received a £20 gift voucher as an honorarium after completing the interview.

## 7.2.3 Data collection

Dr Rebecca Richards (RR) and I conducted the interviews. I am a female PhD researcher with a background in public health and weight management, and RR is a female postdoctoral researcher with a background in health psychology and weight management. We both have experience and training in qualitative research. Neither researcher were not known to the participants prior to undertaking the study. Twenty individual semi-structured interviews were conducted at the end of the SWiM-C intervention by telephone. The interview schedule (Chapter Seven Appendices: A7.3) was developed from previous literature, investigator expertise, and with experts from relevant fields of obesity, psychology, and qualitative research. Interview schedules explored participants' experiences of the intervention, intervention acceptability (including benefits and disadvantages), and experiences of mental health during SWiM-C. The interview schedule did not explicitly ask pandemic-related questions. I piloted the interview schedule with two patient representatives and revised it accordingly prior to study commencement. Interviews were digitally audio-recorded with participants' permission and were on average 48 minutes in duration (range: 22 minutes - 64 minutes). Recordings were transcribed by an experienced external agency and I checked each transcript for accuracy.

### 7.2.4 Data analysis

Data analysis and management was supported by using NVivo qualitative data analysis software (v11, QSR International Pty Ltd). Data analysis was conducted by interviewers (myself and RR) and a female medical student (Roshni Palat (RP)) with experience in psychology research and a background in clinical medicine. Analysis was conducted using a blend of inductive and deductive approaches as although I was guided by the broad research questions, I searched for patterns and themes arising directly from the raw data without *a-priori* expectations or assumptions of the data.<sup>258,259</sup>

I led the data analysis, with two researchers (RR and RP) coding a subset of transcripts in duplicate (n=10/20). Duplicate coding helped to maintain reflexivity and reflect on how data was coded, challenge any assumptions made during coding, and identify aspects that may have been missed or overlooked. Researchers remained conscious of their positionality and how this may influence data interpretation. For example, I have lived experience of obesity and mental health diagnoses and have previous experience delivering behavioural weight management interventions. Any

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## CHAPTER SEVEN: PARTICIPANTS' EXPERIENCES OF MENTAL HEALTH DURING A COVID-19 TAILORED, WEB-BASED, GUIDED SELF-HELP, ACT-BASED BEHAVIOURAL WEIGHT MANAGEMENT INTERVENTION: A QUALITATIVE STUDY.

inconsistencies between coders were resolved through discussion. I developed the coding framework and refined it with the support of the wider research team. The wider research team had a background and expertise in psychology, social science, mental health, obesity medicine, and weight management. Researchers involved in data analysis and the wider research team regularly discussed the findings as part of the iterative analysis process.

I used reflexive thematic analysis to explore patterns of meaning across the data by familiarisation, coding, theme development, and revision. Reflexive thematic analysis is ideal for analysing data pertinent to individual experiences and/or behaviours, reasons why individuals think or feel or behave in such a way, and the factors underpinning and shaping these experiences.<sup>260–262</sup> The flexible application of thematic analysis allowed for a more inductively oriented analysis that could identify latent and sematic meanings across the dataset, whilst being flexible and iterative in the process of addressing a broad research question.<sup>263</sup> I followed the six phases of analysis as described by Braun and Clarke, with flexibility for iterative movement back and forth between phases: 1) Familiarisation with the data, 2) Coding, 3) Generating initial themes, 4) Developing and reviewing themes, 5) Refining, defining, and naming themes, and 6) Writing up.<sup>260–266</sup> Table 1 describes my analytic process in greater detail.

Mental health terms, such as anxiety, are both medical terms and part of lay language. I was conscious to use the terms used by participants to describe their experiences, therefore avoiding misidentifying a participant's mental health. For example, when a participant described symptoms of anxiety (e.g., worry, panic) but did not use the term 'anxiety', I was conscious to not refer to the participant as having anxiety. I used medical terms such as 'anxiety' only when a participant stated this.

| Table 1. The analytic proces | s related to the six phases | of reflexive thematic | analysis. |
|------------------------------|-----------------------------|-----------------------|-----------|
|------------------------------|-----------------------------|-----------------------|-----------|

| Phase           |      | What this looked like   |
|-----------------|------|---|
| Phase           | one: | I achieved deep familiarity with the content of the data by immersing     |
| Familiarisation | with | myself in the dataset. This involved listening to each of the             |
| the data        |      | transcripts from start to finish and, separately, reading all transcripts |

| from | start  | to  | finish. | Whilst    | liste | ning/re | eading | g, I | made  | e h | and-   | written |
|------|--------|-----|---------|-----------|-------|---------|--------|------|-------|-----|--------|---------|
| dood | les an | d s | cribble | s relatir | ng to | things  | that s | stru | ick m | e o | r stoo | od out. |

During and after listening/reading each transcript, I practiced reflexivity by reflecting and asking myself deeper questions about the data. Reflexivity is defined as "*the practice of critical reflection on your role as researcher, and your research practice and process*" (Braun and Clarke 2021: Page 5).<sup>263</sup> Examples of questions I asked myself were: Would I feel similar to the participant if experiencing similar things (and why might this be similar/different)? What am I feeling, and why might I be reacting in this way? Why might I be interpreting the data in this way, and what other ways could this be interpreted?

During this phase, I noted particularly interesting or intriguing elements that stood out to me and identified multiple points of potential analytic interest (e.g., the impact of SWiM-C on participants mood). Although the process of familiarisation was benefited from my rich understanding of the topic based on my previous research of the topic, professional experience working as an intervention provider, and personal experience as a person living with obesity, critical self-inquiry (i.e., practicing reflexivity) aided me to inspect the influence of my positionality on my interpretations.

Phase two: CodingEach coder (myself, RR, and RP) reviewed each interview transcript<br/>and applied code labels to segments of data related to mental health.All data related to mental health were coded as the research<br/>question was broad and exploratory. Some data were not coded as<br/>they were not related to the broad research interest, being mental<br/>health. A few hundred codes were initially produced. On the<br/>spectrum of sematic (i.e., explicit and surface meanings) to latent<br/>(i.e., interpretative), the codes applied were of more latent<br/>orientation as I sought to interpret, rather than simply describe, the

|            |         | data. Sematic elements were maintained when participants used                     |  |  |
|------------|---------|---|--|--|
|            |         | mental health language (e.g., anxiety) to avoid misdiagnosing or                  |  |  |
|            |         | misrepresenting the participants' experience.                                     |  |  |
|            |         |   |  |  |
|            |         | All data coders made an active effort to resist thinking about theme              |  |  |
|            |         | during this stage as this can result in cherry-picking and foreclosing            |  |  |
|            |         | analysis (i.e., ceasing analysis after only superficial engagement w              |  |  |
|            |         | the data).  |  |  |
|            |         |   |  |  |
|            |         | I coded four transcripts before meeting with the second coders to                 |  |  |
|            |         | compare and discuss code labels. We had in-depth discussions about                |  |  |
|            |         | how we interpreted the data, why we had made particular decisions,                |  |  |
|            |         | and how our positionality may have influenced our interpretations.                |  |  |
|            |         | We did not aim for consensus, rather used this process with the aim               |  |  |
|            |         | of "developing richer and more complex insights" (Braun and Clarke,               |  |  |
|            |         | 2021: Page 55). <sup>263</sup> This process supported me to critically reflect on |  |  |
|            |         | my positionality may have influenced my assumptions and                           |  |  |
|            |         | interpretations of the data (i.e., practicing reflexivity).                       |  |  |
| Phase      | three:  | Each coder (myself, RR, and RP) engaged with the data codes to                    |  |  |
| Generating | initial | explore clusters and patterns of meaning across the dataset. Each                 |  |  |
| themes     |         | coder independently developed an early thematic map that                          |  |  |
|            |         | represented proposed candidate themes (i.e., potential broad                      |  |  |
|            |         | patterns of meaning). I initially clustered codes into six candidate              |  |  |
|            |         | themes related to: Previous weight-related experiences, beliefs of                |  |  |
|            |         | the role of mental health, mood and influencing factors, impacts of               |  |  |
|            |         | mood, what did and did not work in SWiM-C, and suggested                          |  |  |
|            |         | intervention adaptations.   |  |  |
|            |         |   |  |  |
|            |         | I met with the second coders to compare early thematic maps. We                   |  |  |
|            |         | critically discussed our maps and questioned each other on why we                 |  |  |
|            |         | had made particular decisions, how we had interpreted the data, and               |  |  |
|            |         | what may have influenced our interpretations. This process of                     |  |  |

|                        | challenging one another's assumptions and interpretations                       |  |  |  |
|------------------------|---|--|--|--|
|                        | supported my practice of reflexivity as I was able to critically reflect        |  |  |  |
|                        | on the potential influence of my positionality. As before, the aim of           |  |  |  |
|                        | this process was not to determine consensus. Instead, this process              |  |  |  |
|                        | helped to make sense of the different ways that the data could be               |  |  |  |
|                        | clustered, allowing for the development of "richer and more complex             |  |  |  |
|                        | insights" (Braun and Clarke, 2021: Page 55). <sup>263</sup> My thematic map was |  |  |  |
|                        | revised based on these conversations.   |  |  |  |
| Phase four: Developing | This phase aimed to review the viability of the themes and refine               |  |  |  |
| and reviewing themes   | them accordingly. I reengaged with the coded data extracts related              |  |  |  |
|                        | to each theme and asked questions about the codes, coded data, and              |  |  |  |
|                        | themes. For example:  |  |  |  |
|                        | • Does the theme have a central concept and include multiple                    |  |  |  |
|                        | dimensions of that idea?  |  |  |  |
|                        | • Does the theme have clear boundaries (what should and                         |  |  |  |
|                        | should not be included)?  |  |  |  |
|                        | • Is there enough supporting data and is it meaningful enough                   |  |  |  |
|                        | to support the theme?   |  |  |  |
|                        | • Is the theme coherent, or is the data too diverse and wide-                   |  |  |  |
|                        | ranging?  |  |  |  |
|                        | • Does the theme communicate something important,                               |  |  |  |
|                        | meaningful, and relevant to the overall question?                               |  |  |  |
|                        |   |  |  |  |
|                        | I also reengaged with the entire dataset by reviewing each interview            |  |  |  |
|                        | transcript again from start to finish to further refine the code labels         |  |  |  |
|                        | and apply new code labels to any data that was overlooked/missed                |  |  |  |
|                        | during phase two (coding). It was important to return to the entire             |  |  |  |
|                        | dataset at this point in the analysis as it is possible to become distant       |  |  |  |
|                        | and a few steps removed from the data during theme development,                 |  |  |  |
|                        | and reengagement with the data reduces the likelihood of                        |  |  |  |
|                        | misrepresenting the dataset. I remained flexible with the thematic              |  |  |  |

|                       | map during this stage, allowing for further refinement of themes and     |  |  |  |
|-----------------------|--|--|--|--|
|                       | code labels.   |  |  |  |
|                       |  |  |  |  |
|                       | Reengagement with the coded extracts and entire dataset allowed          |  |  |  |
|                       | me to develop, review, and refine the themes. The refined themes         |  |  |  |
|                       | (and associated code labels) were circulated with the wider group of     |  |  |  |
|                       | researchers to discuss their relevancy to the broad question,            |  |  |  |
|                       | legitimacy and meaningfulness as themes, and the over                    |  |  |  |
|                       | flow/narrative. This process supported me to critically reflect on ho    |  |  |  |
|                       | my views and position may affect the research process (i.e.,             |  |  |  |
|                       | practicing reflexivity).   |  |  |  |
| Phase five: Refining, | I explored the dataset for contradictions within transcripts and         |  |  |  |
| defining, and naming  | across the dataset. I defined and named the themes with a short          |  |  |  |
| themes                | phrase that captured the central concept.                                |  |  |  |
|                       |  |  |  |  |
|                       | I circulated the refined thematic map (and associated code labels) to    |  |  |  |
|                       | the wider research groups for feedback and discussion. I described       |  |  |  |
|                       | the thematic map (themes and overall narrative) to multiple people       |  |  |  |
|                       | outside of my research group to test whether the scope, boundaries,      |  |  |  |
|                       | and core concepts of the themes were sufficiently developed, and         |  |  |  |
|                       | whether the overall narrative had a logical and meaningful flow.         |  |  |  |
|                       |  |  |  |  |
|                       | There was back and forth movement between phases three, four,            |  |  |  |
|                       | and five until there was a final set of themes and related coded         |  |  |  |
|                       | extracts. At this stage, there were five themes related to: Pre-existing |  |  |  |
|                       | beliefs about the links between mental health and weight                 |  |  |  |
|                       | management, changes in mental health associated with the SWiM-C          |  |  |  |
|                       | intervention, factors external to the intervention that negatively       |  |  |  |
|                       | impacted mental health and intervention engagement, the use and          |  |  |  |
|                       | impact of maladaptive coping responses, and preferences for              |  |  |  |
|                       | intervention components based on psychological needs and the             |  |  |  |
|                       | desire for intervention personalisation.                                 |  |  |  |

| Phase six: Writing up | I began writing up the analysis presented in this chapter. The write-   |
|-----------------------|---|
|                       | up provided a final opportunity for refinement of the themes - for  |
|                       | example, during the write-up it became clear that the theme relating  |
|                       | to pre-existing beliefs about the links between mental health and   |
|                       | weight management did not fit well with the other themes. It  |
|                       | seemed to add little value whilst confusing the clear narrative   |
|                       | between the other themes. As a consequence, this theme was  |
|                       | removed.  |
|                       |   |
|                       | I selected data extracts to be used as quotes in the chapter results  |
|                       | (and associated publication). I sought quotes from across the dataset   |
|                       | that provided vivid, clear, concise examples that supported the   |
|                       | analytic claims. I edited out unnecessary details from the quotes and   |
|                       | included text before/after the quotes to add clarity and context  |
|                       | where necessary.  |
|                       |   |
|                       |   |
|                       | After writing up the analysis, I again reflected on the logical flow of   |
|                       | After writing up the analysis, I again reflected on the logical flow of<br>the narrative and the ordering of the themes. I took a short break   |
|                       | After writing up the analysis, I again reflected on the logical flow of<br>the narrative and the ordering of the themes. I took a short break<br>from the analysis and write-up to 'step away' from the themes – this   |
|                       | After writing up the analysis, I again reflected on the logical flow of<br>the narrative and the ordering of the themes. I took a short break<br>from the analysis and write-up to 'step away' from the themes – this<br>allowed me to return to the results with a 'fresh mind' to assess the  |
|                       | After writing up the analysis, I again reflected on the logical flow of<br>the narrative and the ordering of the themes. I took a short break<br>from the analysis and write-up to 'step away' from the themes – this<br>allowed me to return to the results with a 'fresh mind' to assess the<br>story across the themes. From doing so, I drew initial conclusions  |
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|                       | After writing up the analysis, I again reflected on the logical flow of<br>the narrative and the ordering of the themes. I took a short break<br>from the analysis and write-up to 'step away' from the themes – this<br>allowed me to return to the results with a 'fresh mind' to assess the<br>story across the themes. From doing so, I drew initial conclusions<br>about the data and analysis, existing knowledge in the field, and the<br>wider context.   |
|                       | After writing up the analysis, I again reflected on the logical flow of<br>the narrative and the ordering of the themes. I took a short break<br>from the analysis and write-up to 'step away' from the themes – this<br>allowed me to return to the results with a 'fresh mind' to assess the<br>story across the themes. From doing so, I drew initial conclusions<br>about the data and analysis, existing knowledge in the field, and the<br>wider context.   |
|                       | After writing up the analysis, I again reflected on the logical flow of<br>the narrative and the ordering of the themes. I took a short break<br>from the analysis and write-up to 'step away' from the themes – this<br>allowed me to return to the results with a 'fresh mind' to assess the<br>story across the themes. From doing so, I drew initial conclusions<br>about the data and analysis, existing knowledge in the field, and the<br>wider context.<br>This phase involved many rounds of edits, with feedback and  |
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|                       | After writing up the analysis, I again reflected on the logical flow of<br>the narrative and the ordering of the themes. I took a short break<br>from the analysis and write-up to 'step away' from the themes – this<br>allowed me to return to the results with a 'fresh mind' to assess the<br>story across the themes. From doing so, I drew initial conclusions<br>about the data and analysis, existing knowledge in the field, and the<br>wider context.<br>This phase involved many rounds of edits, with feedback and<br>suggestions from the researchers co-authoring the publication<br>associated with this chapter. The aim was not to achieve consensus,  |
|                       | After writing up the analysis, I again reflected on the logical flow of<br>the narrative and the ordering of the themes. I took a short break<br>from the analysis and write-up to 'step away' from the themes – this<br>allowed me to return to the results with a 'fresh mind' to assess the<br>story across the themes. From doing so, I drew initial conclusions<br>about the data and analysis, existing knowledge in the field, and the<br>wider context.<br>This phase involved many rounds of edits, with feedback and<br>suggestions from the researchers co-authoring the publication<br>associated with this chapter. The aim was not to achieve consensus,<br>but the aim instead was to achieve rich, meaningful, and impactful  |
|                       | After writing up the analysis, I again reflected on the logical flow of<br>the narrative and the ordering of the themes. I took a short break<br>from the analysis and write-up to 'step away' from the themes – this<br>allowed me to return to the results with a 'fresh mind' to assess the<br>story across the themes. From doing so, I drew initial conclusions<br>about the data and analysis, existing knowledge in the field, and the<br>wider context.<br>This phase involved many rounds of edits, with feedback and<br>suggestions from the researchers co-authoring the publication<br>associated with this chapter. The aim was not to achieve consensus,<br>but the aim instead was to achieve rich, meaningful, and impactful<br>conclusions that were well supported by the themes (and associated  |
|                       | After writing up the analysis, I again reflected on the logical flow of<br>the narrative and the ordering of the themes. I took a short break<br>from the analysis and write-up to 'step away' from the themes – this<br>allowed me to return to the results with a 'fresh mind' to assess the<br>story across the themes. From doing so, I drew initial conclusions<br>about the data and analysis, existing knowledge in the field, and the<br>wider context.<br>This phase involved many rounds of edits, with feedback and<br>suggestions from the researchers co-authoring the publication<br>associated with this chapter. The aim was not to achieve consensus,<br>but the aim instead was to achieve rich, meaningful, and impactful<br>conclusions that were well supported by the themes (and associated<br>coded extracts). My overall aim of writing-up was to present a critical |

| mental health during the SWiM-C intervention, whilst respecting and |
|---|
| appropriately representing the participant voice.                   |

## 7.2.5 Patient and Public Involvement (PPI)

Representatives from an established Patient and Public Involvement (PPI) panel were involved in informing the trial design and the acceptability of the research questions, interpretation of the results, and dissemination of study findings. The PPI panel included representatives with experience of obesity and weight management. A further PPI representative (AV) actively contributed to data analysis, data interpretation, and critical appraisal of the manuscript, resulting in authorship.

## 7.3 Results

Figure 1 shows the participant flow through the trial. Participant baseline characteristics are described in Table 2.

Figure 1. Participant flow diagram.



| Characteristic                       |                                       | Number and percentage   |
|--------------------------------------|---------------------------------------|-------------------------|
|                                      |                                       | of participants (unless |
|                                      |                                       | otherwise stated)       |
| Age (years)                          |                                       | 52.04 ± 16.48           |
| (mean ± standard deviation           | on [min – max])                       | (25-84)                 |
| Gender                               | Male                                  | 6 (30%)                 |
|                                      | Female                                | 14 (70%)                |
| Marital status                       | Single                                | 7 (35%)                 |
|                                      | Married/Civil partnership             | 9 (45%)                 |
|                                      | Co-habiting                           | 2 (10%)                 |
|                                      | Widowed                               | 1 (5%)                  |
|                                      | Separated/Divorced                    | 1 (5%)                  |
| Ethnicity                            | White                                 | 14 (70%)                |
|                                      | Mixed                                 | 2 (10%)                 |
|                                      | Black                                 | 1 (5%)                  |
|                                      | Asian                                 | 1 (5%)                  |
| Education status                     | No formal qualification               | 1 (5%)                  |
|                                      | GCSE or equivalent                    | 3 (15%)                 |
|                                      | A-Level or equivalent                 | 6 (30%)                 |
|                                      | Post-secondary education              | 3 (15%)                 |
|                                      | University degree or equivalent       | 4 (20%)                 |
|                                      | Higher degree or equivalent           | 3 (15%)                 |
| Occupation status                    | Employed in a full-time job           | 6 (30%)                 |
|                                      | Employed in a part-time job           | 4 (20%)                 |
|                                      | Self-employed full or part-time       | 3 (15%)                 |
|                                      | Full-time education at school/college | 1 (5%)                  |
|                                      | Unemployed and available for work     | 1 (5%)                  |
|                                      | Wholly retired from work              | 5 (25%)                 |
| Body mass index (kg/m <sup>2</sup> ) | 1                                     | 33.34 ± 5.76            |
| (mean ± standard deviation           | on [minimum – maximum])               | (25.31–52.13)           |

Table 2. Baseline characteristics of interview study participants (n=20).

| Self-reported change in                         | Lost weight                           | 7 (35%)  |  |
|---|---------------------------------------|----------|--|
| weight from baseline to                         | Gained weight                         | 10 (50%) |  |
| 4 months  | Don't know                            | 3 (15%)  |  |
| Symptoms of depression                          | None to mild (score of 0 - ≤9)        | 12 (60%) |  |
| (by PHQ-8) <sup>267,268</sup>                   | Moderate to severe (score of 10 - 24) | 8 (40%)  |  |
|   |                                       |          |  |
| Symptoms of anxiety                             | None to mild (score of 0 - ≤9)        | 14 (70%) |  |
| (by GAD-7) <sup>269</sup>                       | Moderate to severe (score of 10 - 21) | 6 (30%)  |  |
| Perceived stress (higher se                     | 6.55 ± 2.09 (3 – 10)                  |          |  |
| (by PSS-4) <sup>270</sup>                       |                                       |          |  |
| (mean ± standard deviation [minimum – maximum]) |                                       |          |  |
| Number of sessions comp                         | 9.3 ± 3.5 (2.5 – 12)                  |          |  |
| (mean ± standard deviation [minimum – maximum]) |                                       |          |  |

Four themes were conceptualised from the analysis of the data that address the research questions. Participants are identified with 'P' followed by an identification number and their age, gender, and ethnicity (e.g., P1: 36yrs, Female, White).

## 7.3.1 Theme 1: Changes in mental health associated with the SWiM-C intervention

## 7.3.1.1 Mental health improvements associated with the SWiM-C intervention

Some participants expressed how being involved with the SWiM-C intervention improved their mental health, for example by lifting their mood.

"I felt really happy and positive doing the 12 weeks and I think it sort of... You just sort of... It just put me into a really sort of happy, positive mindset and feel that I was doing something for myself and sort of achieving something for myself" (P20: 26y, Female, Black).

These participants identified that the strategies in the SWiM-C intervention were helpful for their mental health, such as how to manage food cravings, practice willingness, reframe thoughts, and practice breathing techniques.

"It's hard to find positive and motivation when you're in that sort of low mood and feel like everything's defeating you but when I, you know I sat there sort of 'wheeer' and like when I got to the strategies that just, it gave me a little bit of a boost, a little bit of positivity you know, a little bit of light on what negative I was feeling, so yes again it comes down to those strategies I guess" (P1: 36yrs, Female, White).

Many participants characterised the intervention content and coach as compassionate and as providing a level of support that made them feel less alone in the weight management process.

"It's like sitting in a room, it felt for me, like sitting in the room with somebody else who was encouraging you to address your weight issues, yeah. Not forcing you, but encouraging you. So it was always like there was someone there." (P17: 61y, Female, Mixed).

A few participants also described how, despite the difficult circumstances of the COVID-19 pandemic, their symptoms of poor mental health reduced since beginning the SWiM-C intervention.

"My anxiety levels have been sort of up and down, but I would definitely say, since doing the programme [SWiM-C], they've definitely been lower and I'm not as anxious." (P20: 26y, Female, Black). For participants who experienced weight loss, many described this as contributing to improved confidence and mood whilst giving them a sense of achievement. In addition, participants directly associated making behavioural changes (such as to their diet and/or exercise) with general improvements in their mental health.

"I mean, it's always nice to lose weight, I mean, people will, you know, compliment you and that will put you in a good mood" ... "I feel good, I feel lighter, my clothing fits better, yeah, I feel more confident in myself, so it's been a definite improvement" (P4: 33y, Male, White).

"I can just go and walk the whole circumference of this park, which takes me approximately an hour. So that's an hour out of my day where I'm breathing fresh air, I see the trees, and I've lovely views. And I come home and I feel so much better" ... "because I work shifts, I mean, with the time, sometimes I'm away from home for two days, and I miss them. So the first thing that I do when I get home is I do that, just for my own mental health and wellbeing." (P19: 47y, Female, White).

## 1.2 Mental health deterioration associated with the SWiM-C intervention

Some participants felt that they were not doing the SWiM-C intervention justice by not doing 'enough' or engaging sufficiently (e.g., P5: 63y, Female, White), and that they had personal responsibility for lack of results, rather than a limitation with intervention effectiveness. This led to self-blame and negative self-talk.

"I didn't seem to be losing weight so then I thought, well I'm not doing what I should be doing, again it's being down on myself, like I'm not listening enough or I'm not spending enough time... As I say, it's very much an emotional thing with me so it was kind of stressful in that way" (P5: 63y, Female, White).

Others shared their disappointments in the programme, such as finding the content obvious and *"infantilising"* (P12: 25y, Female, Mixed) resulting in feeling this was another attempt to improve their health and wellbeing that was not going to work.

"When the obvious is pointed you know, you know you're really struggling and it gets you down because you can't get on top of it and control it, then if you read that it just makes you feel like you're hitting another brick wall, it just makes you feel like you're not, you know there's no hope! You just lose heart in it more I think if those things are pushed at you, the things that you know" (P1: 36yrs, Female, White).

Many participants described having to make decisions between competing demands, being the SWIM-C intervention and the other priorities in their lives. Some of these participants shared that the SWIM-C intervention became "too much" in combination with the other priorities in their lives, and other demands on their "mental energy" (P4: 33y, Male, White). Study participants also described the competing demands on their mental energy to lead to deteriorations in their mental health. For example, one participant described increased symptoms of "anxiety" and "stress" (e.g., P5: 63y, Female, White).

"If you're going about your day and you're busy and you're trying to sort of focus on losing weight, fine, and you're incorporating one thing into your life, and it takes mental energy to try and remember one thing, for instance, one little change, to kind of stick to that. And to then every week have to add something on top of that and to think differently and to incorporate something new, it was just too much work. Er... one or two things, you know, where you can get into a routine would be okay, but to try and get everything in was too much" (P4: 33y, Male, White). 7.3.2 Theme 2: Factors external to the intervention that negatively impacted mental health and intervention engagement.

## 7.3.2.1 Factors external to the intervention that negatively impacted mental health.

Participants described experiencing motivational conflicts between SWiM-C and external factors in their lives, as described in Theme 1.2. Many participants shared how the external factors in their lives negatively impacted their mental health. For many participants, the various ways that the COVID-19 pandemic impacted their lives resulted in a decline in their mental health. For example, government restrictions (including 'stay at home' and shielding orders) resulted in feelings of loneliness. This was exacerbated for those living alone.

"I live alone as well and I think during, you know, the Covid period, you know, peoples" mental health goes down because you are alone" (P17: 61y, Female, Mixed)

Other COVID-19 related issues that impacted participants' mental health included work-related stress (e.g., furloughing, job loss, lack of workplace support, increased workload) and health-related concerns (e.g., worries for self and others risk of contracting COVID-19).

Some participants expressed feeling "stressed" (e.g., P14: 51y, Female, Asian or Asian British) and "depressed" (e.g., P17: 61y, Female, Mixed) by the media reports about the pandemic, especially when the media reported on the links between COVID-19 and obesity. In addition, government decisions around restrictions caused stress, frustration, upset, and anger. It appeared that participants' negative psychological responses to the pandemic and related restrictions commonly stemmed from fear of illness, disagreement with governmental decision making, and feeling that the COVID-19 reporting was "constant" (P17: 61y, Female, Mixed).

"I felt stress because all the media and kind of reports were saying that if you're obese then you're much more likely to have a bad reaction to Covid" (P14: 51y, Female, Asian or Asian British).

"It's just so short-sighted for people to just like think it's okay to get together... it's just like crazy and he [Boris Johnson, UK Prime Minister] should say nobody can mix. But he won't... I'm angry. At the moment I'm angry. I get angry really quickly, I'm quite short-tempered which upsets me because I don't like being like that, but yeah. I do feel like I'm snapping really quickly" (P3: 55y, Female, White). Additional external factors that negatively impacted participant mental health included feeling unsupported by family members (e.g., disregarding dietary wishes/goals), experiencing health concerns (e.g., arthritis, spinal problems, cancer scares), and experiencing the loss of a family member (e.g., the recent loss of their father).

## 7.3.2.2 Factors external to the intervention that negatively impacted intervention engagement and, consequentially, mental health.

Most of the participants who described experiencing motivational conflicts between the SWiM-C intervention and other demands in their lives reported that SWiM-C became the lesser priority. These participants described feeling that they should have made more of an effort to engage with the SWiM-C intervention (e.g., by finding more time), but that the intervention "*was an extra thing to try and fit in around everything else*" (P5: 63y, Female, White) and did not seem important in comparison with their competing priorities.

"I was in the midst of all the stress, and I had to make time for it [SWiM-C], but then that is life. In the list of priorities of things, it [SWiM-C] didn't seem very important at that time" (P15: 56y, Female, Asian or Asian British).

When these participants experienced motivational conflicts and SWiM-C became the lesser priority, they described subsequent reductions in their intervention engagement. The perceived decline in intervention engagement resulted in feelings such as guilt, blame, shame, disappointment, and annoyance at oneself.

"I think I started okay and then it started building up, the anxiety about it a little bit and because I was so tired, I couldn't focus enough as well as I wanted to" (P5: 63y, Female, White).

## 7.3.3 Theme 3: Use and impact of coping responses

## 7.3.3.1 Maladaptive coping responses (MCR) and the resulting impact on mental health

Participants described experiencing poor mental health due to a multitude of factors, including those relating to the intervention (see Theme 1: e.g., obvious and infantilising content) and external to the intervention (see Theme 2: e.g., family death, work-related stress). Many participants also described experiencing motivational conflicts between the SWiM-C intervention and external factors in their lives, resulting in a decline in their mental health (see Themes 1 and 2).

Numerous participants reported using maladaptive coping responses (MCRs) to manage this deterioration in their mental health. The MCRs described included the use of food to cope, such as comfort eating, binge eating, and eating foods that they perceived to be unhealthy.

"I think the more stressed I am the worse my diet is. I do tend to binge on sort of sweet things... I do find that when I'm stressed I do binge on sweet things, on chocolate... So, yeah, my mood, or my eating is affected by my mood" (P4: 33y, Male, White).

Conversely, one participant described eating less in response to anxiety or anxiety-like symptoms.

"I'm not a comfort eater, in fact I stop eating if I'm anxious or frightened or anything like that" (P18: 58y, Female, White).

Several participants also described being more sedentary in response to negative emotions (e.g., low mood, stress). For some, this was instead of using a food-based MCR, whilst for others food-based MCRs co-occurred with increased sedentary behaviours and reduced physical activity. Some participants described having a lack of *"mental energy"* (P4: 33y, Male, White) to exercise when experiencing negative emotions.

"I'd be much more inclined to just sit and watch television or something, rather than actually go tuck into food if my mood is down" (P3: 55y, Female, White).

"I think the more stressed I am the worse my diet is"... "that [exercise] can also be affected where, if I'm just not in the head space and if I am stressed, then I don't have the mental energy to exercise and go to the gym, so that is also affected, yeah." (P4: 33y, Male, White). Some participants expressed that they used MCRs to compensate for negative emotions, intending to improve their immediate mood. However, using MCRs often made them feel worse overall, thus acting like a 'vicious circle'. For example, after occasions of using food to cope with negative moods, some participants described being self-critical.

"If you are in a low mood for quite some time you get out of being good and eating well, and also when you're not eating well you don't feel good. So it's a bit like a knock-on effect. It's a bit of a vicious circle that if you get into that mood and your eating's not good, you don't feel good, you don't feel, you don't feel energised, you don't feel, you look back and you think "well why did I eat that whole Cadbury's Cream Egg?" or "why did I...?" and knock yourself down a little bit then. It is a vicious circle." (P16: 67y, Female, White).

In contrast, one participant did not believe their use of food-based MCRs acted like a vicious cycle. They explained that although they snacked more due to work-related stress, they did not further eat to compensate for the weight gain due to the stress-snacking.

"I do tend to snack more... it's definitely gone up a bit since Covid but as I say that's just from work stress, but it's not a feedback spiral, i.e., I'm not snacking more seeing myself gain weight and therefore snack more in order to compensate the stress from that, you know, so it's linear and not exponential" (P2: 45y, Male, White).

## 7.3.3.2 Using adaptive, rather than maladaptive, coping responses to manage poor mental health

For many participants, aspects of the SWIM-C intervention supported them to manage the deterioration in their mental health in an adaptive (i.e., productive to coping), rather than maladaptive (i.e., counterproductive to coping), manner. For example, the intervention strategies and content were reported to help manage their responses to difficult emotions or moods in a more adaptive manner.

"It [SWiM-C] certainly, with the mood it does help when you're, on the days that you're feeling bleurgh, that you've got the strategies to cheer yourself up for want of a better phrase and get yourself to a more positive frame of mind. Whereas in the old days I'd just go and have a six pack of crisps or whatever, it gives me another alternative to say right okay, let's not do this, let's look at what else I can do instead, you know"... "it's more the avoiding the behaviours and how you replace them with other behaviours which are not as destructive to your weight loss regime" (P7: 52y, Male, White).

Many participants identified strategies/content that they found helpful to avoid using maladaptive coping strategies. These included content on overcoming obstacles, creating an emotional responses plan of alternative responses, reframing their thoughts, practising willingness, breathing techniques, and techniques to manage cravings. Content and strategies related to managing cravings, such as urge surfing, were considered particularly useful.

"You know you feel the urge coming, and think of it as a wave, and actually that, I found that really useful because it reminded me of when I was in labour with my children and thinking that the end would come, although it doesn't feel like it's going to now"... " when I was thinking of the urge of something, you know, it was building up, I was going, 'here we go, here we go'"... "what I was reading, you know, I was following it, and then I was thinking, 'right the wave's going to crash down and disappear now', and that did help" (P1: 36yrs, Female, White)

In addition, several participants found approaches derived externally to the intervention also helped to respond to difficult thoughts and feelings more adaptively. These included making use of exercise to improve their mood and pass time whilst experiencing hunger cravings, focusing on little things that brought them joy, and making use of GP-prescribed sleep medication. 7.3.4 Theme 4: Preferences for intervention components based on psychological needs, and the desire for intervention personalisation

### 7.3.4.1 Preferences for intervention components based on psychological needs

Participants who described feeling that their weight management problems were emotionally derived and those who experienced fluctuations in their mental health reported finding the psychological content that focused on thoughts and emotions more useful than other content, such as addressing dietary behaviours.

"It was more the mental side of things. It was more the psychological side of things that was more use to me. So, I know a lot of it dealt with that and the behaviours and the reinforcing and so on and so forth, and the mental workarounds, that bit was helpful" (P7: 52y, Male, White).

Many of these participants specifically noted that SWiM sessions on weight stigma, selfacceptance, and reframing thoughts were most useful, alongside the strategies (e.g., urge surfing) that were included in much of the psychological content. Many of these participants also expressed a wish for more in-depth psychological content on emotional responses to food and how mood impacts diet, exercise, and sleep.

"Just the emotional side of it [was most helpful]... yeah I think it could be more in-depth on that side of it" ... "I think they could do a lot more on that side of it. Just more support on like stress and how it affects your eating, your sleeping, your activeness of doing active things to keep the weight off" ... "More support, in a psychologically, sort of why you do it and why, more than the basics. And ways of sort of helping you emotionally cope better with food." (P11: 44y, Female, White)

Similarly, a large proportion of participants who believed that their weight management problems were emotionally derived described wanting more regular contact with the SWiM coach. Participants wanted different things from this contact, including counselling-like support, a general check-in, or a safety/welfare check. They felt that additional contact with the coach would help them by having personal human contact, an opportunity to ask nuanced questions, and support to stay engaged during emotionally difficult times.

"You can tell people what to eat but you, we know, it's like telling an alcoholic isn't it, don't drink, but, and I think it's more... we know what we should be eating but there's a problem, emotional around food. So I think there needs to be more counselling, psychological to help and support for the individual who's struggling" (P11: 44y, Female, White)

"To be honest I know it would be more work, but I would even perhaps throw extra calls in, so rather than just the one call maybe two or three spread throughout the course. Because then if I had hit a buffer for example, because of my dad dying I hadn't done it for a couple of weeks, I would have been able to be picked-up a little bit quicker than I was, and maybe alternative arrangements made at that point" (P7: 52y, Male, White)

Participants who described not experiencing mood fluctuations or poor mental health noted that they did not find the psychological content useful as it was not relevant or applicable to their needs. These participants saw little benefit from the content on stress, self-acceptance, emotional eating, weight stigma, and depression.

"I was more interested in the steps and strategies than the emotional wellbeing sides of it because I don't really think... I think I'm more half-full than half-empty as a general thing and I don't think, I know some people struggled through this last year, I don't think I'm one of those. So I don't think low mood is a particular feature for me, or anxiety or anything like that" (P8: 63y, Female, White)

#### 7.3.4.2 The desire for intervention personalisation, and awareness of the limitations and risks

Some participants felt that the intervention was too restrictive and that it "penalised" (P16: 67y, Female, White) them by having to complete a session before unlocking the next, meaning the participant was unable to skip sessions they were not interested in. As a result, participants expressed an interest in the intervention being tailored to their individual psychological needs, with a potential needs-assessment call or questionnaire at the beginning of the intervention to determine the type of session content, and the frequency and regularity of coach contact, that they may require. This could allow participants to select more or less psychological content dependent on their perceived individual psychological needs.

"It was asking all sorts of things, "Are you stressed with this, are you stressed with that? Do you have family stresses?" I don't. I mean, you know, I was sort of going through it, I mean, it was just all, all no, no, no, no, no for me. I mean, I understand that everyone's different. Erm... it's, I suppose at the start you've got to just assess what sort of type of course they've got to be on" (P6: 68y, Male, White)

Participants suggested that intervention personalisation could be achieved by ordering the sessions in different ways, adding or removing particular sessions, and changing the amount of SWiM coach contact.

"I think it's quite helpful for people to think about where they are, and why they are there at the beginning maybe... Because I think then what you could do is you could direct people, I mean but you could say, you know, you might help, find it helpful to do things in this order perhaps" (P18: 58y, Female, White)

Participants were aware of the potential limitations and risks of intervention personalisation, recognising that an intervention cannot suit everyone's needs and that there will always be intervention component(s) that are less relevant to some. Participants were aware that intervention personalisation depended on resource limitations, such as SWiM coach capacity, and recognised that it may be challenging to personalise an intervention based on psychological needs, as these can change regularly. Finally, participants were also aware that intervention personalisation risked a participant choosing to not complete a session due to failure to recognise the relevance of this content for them.

"I mean obviously you don't want it to be creating the opportunity to put somebody to be in denial and skip something which really is for them" (P18: 58y, Female, White)

## 7.4 Discussion

The purpose of this qualitative study was to broadly explore participants' mental health experiences during the SWiM-C intervention, with the aim of understanding how SWiM-C and other weight management interventions could be adapted to better support mental health. I found that participants were exposed to a range of experiences related to (see Theme 1) and external to (see Theme 2) the SWiM-C intervention that impacted their mental health. Many participants shared that they experienced improvements in their mental health during the intervention. However, some felt that the intervention was mentally draining and increased their stress. A recent systematic review (Chapter Two) found that behavioural weight management interventions, on average, result in small benefits for mental health. This highlights that although the average effect may be positive, a proportion of participants do experience a decline in their mental health that they attribute at least in part to participation in the intervention.

Previous research reported that weight management efforts require a vast amount of mental and emotional investment;<sup>126</sup> the authors did not define 'investment'. I infer that this suggests weight management efforts can be draining, aligning with the findings of the current study. Participants perceived to make trade-offs between the SWiM-C intervention and the external factors in their lives, including work-related stressors, negative impacts of the pandemic, and life crises (e.g., grief). Study findings show that participants perceive trade-offs between the competing demands as feeling "too much" and taking "mental energy" (e.g., P4). This may link to the psychological theory of motivational conflicts and ego depletion, which view self-regulatory capacity as a limited resource. This literature describes competing demands on mental energy as 'motivational conflicts', and the resultant draining of mental energy and feelings of overwhelm as 'ego depletion'.<sup>271–273</sup> When in a state of ego depletion, it may be harder to make choices in line with our goals and values.<sup>271–273</sup> The participants of this study described that they often experienced the SWiM-C intervention as of lesser importance when faced with competing priorities, thus making a choice that was not in line with their weight management goals and values (see Theme 2). Participants described the resultant decline in intervention engagement to lead to feeling selfblame, shame, guilt, and disappointment in themselves (see Theme 2), which might further deplete mental energy.

## CHAPTER SEVEN: PARTICIPANTS' EXPERIENCES OF MENTAL HEALTH DURING A COVID-19 TAILORED, WEB-BASED, GUIDED SELF-HELP, ACT-BASED BEHAVIOURAL WEIGHT MANAGEMENT INTERVENTION: A QUALITATIVE STUDY.

The findings of this chapter have suggested that participants may experience motivational conflicts between the SWiM-C intervention and the external demands in their lives, leading to diminished mental energy and a state of ego depletion (i.e., the resultant draining of mental energy and feelings of overwhelm as a result of managing competing demands<sup>271–273</sup>). Research shows that ego depletion is associated with a decline in mental wellbeing and an increased likelihood of using maladaptive coping responses (MCRs), with the use of MCRs further worsening mental health.<sup>271–273</sup> My study findings align with this literature; I found that participants described using maladaptive coping responses to manage the negative consequences from balancing the competing demands on their mental energy. My findings highlighted that both managing the competing demands and the demands themselves negatively impacted their mental health. Participants described how they hoped these coping responses would improve their mood, but that often their mental health was further damaged via feelings of regret, selfblame, and shame (see Theme 3). This is consistent with literature reporting that the use of MCR in adults with overweight or obesity was associated with poorer psychological wellbeing.<sup>271</sup> This further supports the study findings that the use of MCR exacerbates the decline in participants' mental health, rather than mitigating the existing decline.

Reducing the likelihood that participants manage worsening mental health with MCRs is important to minimise any further psychological harm. Previous research has suggested that positive affect and mental rest can counteract the effects of 'ego depletion' (i.e., worsening in mental wellbeing and use of MCRs).<sup>271,272</sup> In this chapter, I found that aspects of the SWiM-C intervention appeared to help participants to respond adaptively, rather than maladaptively (see Theme 3). For example, participants felt the compassion of their coach and the supportiveness of the intervention content improved their mental health, whilst intervention strategies, such as reframing thoughts and breathing techniques, helped to avoid using MCRs. Similarly, Frayn et al. found that participants endorsed the use of alternative stress reduction and coping strategies (e.g., targeting emotional regulation) to mitigate the effects of using food-based MCRs, such as emotional eating, aligning with the findings of this study.<sup>274</sup> It is possible that the SWiM-C intervention counteracted the effects of ego depletion via improvements in positive affect and mental rest, however further research is required to explore this hypothesis. Future trials of weight management interventions may consider including more strategies that target emotional regulation to investigate whether a potential reduction in the use of MCRs occurs.

In this chapter, participants also shared how they believed the current intervention could be adapted to better attend to their psychological needs (see Theme 4). Those who experienced poor mental health expressed a preference for more in-depth psychological content (e.g., content on emotional eating or stress management) and a greater amount of coach contact. Conversely, those who felt they did not experience fluctuations in mood were happy with the frequency of coach contact and expressed a preference to opt-out of psychological content. Participants suggested this could be achieved through intervention personalisation, however, they recognised that this may risk participants opting out of a session that could benefit them. A recent systematic review synthesised evidence on tailored eHealth interventions for weight loss and found only six digital weight-loss interventions to be personalised according to participant characteristics.<sup>275</sup> The study findings, alongside this lack of evidence, suggests that researchers may consider incorporating personalisation into future trials of weight management interventions. Researchers may achieve this by making all intervention content available at baseline, rather than participants having to complete a session before 'unlocking' the next. This would allow participants the flexibility to navigate through the content in an order and pace appealing to their individual wants and needs.

A recent systematic review by Lawlor and colleagues found behavioural weight management interventions based on acceptance and commitment therapy (ACT) to be effective for weight loss, with evidence to suggest that these interventions may be more supportive of mental health than standard behavioural treatment.<sup>135</sup> The findings of this qualitative study align with those of Lawlor and colleagues as I highlight the potential of ACT-based interventions to psychologically support adults with obesity during weight management. Specifically, I identified that intervention strategies with an ACT focus (e.g., reframing of thoughts, cognitive defusion, and urge surfing) were beneficial for mental health in some participants. In addition, these ACT-based strategies supported many participants to respond to declining mental health adaptively (e.g., visually the urge, using an emotional response plan) when they previously responded maladaptively (e.g., binge or comfort eating). The findings of this chapter add to the evidence base and strengthen our understanding of how ACT-based weight management interventions can support mental health.

The findings of this qualitative study represent an important contribution to understanding the role of mental health in behavioural weight management interventions for adults with overweight

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or obesity. This is of particular value due to the limited number of studies focusing on participants' mental health experiences during weight management interventions. There are several implications to be considered. Firstly, I suggest that intervention developers should consult with patient representatives to minimise participant burden, especially as the findings suggest that participants manage many competing demands that are experienced as draining their mental energy, making them feel overwhelmed, and may thereby negatively impact mental health. Intervention developers may wish to consider including strategies/content on emotional regulation to support participants to respond adaptively, rather than maladaptively, when experiencing poor mental health during weight management interventions. Further, intervention developers may wish to consider integrating personalisation within scalable behavioural interventions to support participants to tailor the content according to their individual psychological needs. Finally, healthcare practitioners providing services may consider talking with a participant about the concurrent demands in their life that may impact their mental energy and mental health. By doing so, the participant and practitioner may jointly reflect on whether this is an appropriate time to begin the intervention as it will result in further demands in their lives. The recently published guidance for healthcare practitioners on conversations about obesity may support these interactions to be non-stigmatising.<sup>276,277</sup>

## 7.4.1 Limitations of the study

It is possible that study participants were subjected to more demands that required mental energy and impacted their mental health more than usual due to the circumstances of the pandemic. As a consequence, the intervention may have been a lesser priority during the study period than it may have been outside of the circumstances of a pandemic. Although the pandemic represents a unique set of circumstances, findings may be transferable to other contexts of heightened stress and distress. Future research may wish to assess whether the intervention is differentially prioritised during times of increased and decreased stress and distress. This understanding may inform the design of intervention recruitment and engagement strategies in the future.

A concern in qualitative research, particularly when addressing potentially sensitive topics such as mental health, is participants feeling vulnerable sharing their experiences. I made conscious efforts to support participants to feel safe to share their experiences, including use of a 155 compassionately grounded interview style (e.g., offering reassurance when appropriate), contacting the participant before the interview to increase familiarity, and clearly communicating their rights to withdraw as well as the terms of confidentiality.<sup>278</sup>

I also recognise that assigning data to themes requires assessment of interpretation and meaning and, as with all qualitative research, researcher positionalities can influence the assessment of data and the development of study findings. The potential bias due to the subjective nature of qualitative research was minimised by regular discussion between authors (including a patient representative who participated in SWiM-C intervention), second coding of interview transcripts, and iterative development of the framework.

Furthermore, I acknowledge that interpretation of language can differ greatly, particularly as mental health terms exist in both medical practice and lay language. For example, the term 'mental health' can be defined and interpreted in multiple ways. I was conscious to appropriately represent participants' mental health by using their language, therefore minimising the risk of misdiagnosing or misrepresenting a participant's mental health.

In this study, I recruited participants for the maximum variation in demographic characteristics, strengthening the transferability of findings. However, I appreciate that the findings may not apply to all adults with overweight or obesity engaged with an online behavioural weight management intervention. Specifically, the sample reflects the population of the parent trial, which was largely made up of white, highly educated, females. Future research should consider exploring the mental health experiences of more specific participant groups (e.g., by age, gender, presence of mental health/disordered eating diagnosis) to compare findings.
# 7.5 Conclusion

In this chapter, I provide an in-depth examination of participants' mental health experiences during a web-based, guided self-help, ACT-based intervention during the COVID-19 pandemic. I found that many SWiM-C participants were exposed to a range of experiences, both related to and external to the intervention, that negatively impacted their mental health. I found participants used MCRs intending to manage these challenges and improve their mood, however, the MCRs more often resulted in further decline in psychological wellbeing. Notably, aspects of the SWiM-C intervention (e.g., intervention strategies, such as reframing thoughts and breathing techniques) appeared to support some participants to manage their mental health more adaptively. Intervention personalisation based on psychological needs was suggested to better support participant mental health. The findings can be used to inform the development of future weight management interventions.

# 7.6 Contributions

I was co-investigator for the SWIM-C trial; I contributed to the development of the intervention and design of the SWiM-C trial. I led the development of the embedded qualitative study protocol in collaboration with Amy Ahern and Robbie Duschinsky. I obtained funding from Clare Hall (University of Cambridge) for intervention transcription and participant honorariums. I developed the interview schedules with advice from Amy Ahern, Robbie Duschinsky, and Rebecca Richards. I sampled eligible participants from the trial to be invited to participate in the interview study, and Jenny Woolston and Marie Stubbings supported me to invite those sampled to participate. I conducted participant interviews with support from Rebecca Richards. Interviews were transcribed by a professional transcriber; I conducted quality assurance of transcriptions with support from Rebecca Richards. I carried out all coding and theme development, with sub-sample coding by Rebecca Richards and Roshni Palat. Robbie Duschinsky, Rebecca Richards, Roshni Palat, Ann Vincent, Carly Hughes, and Andy Hill contributed to the refinement and naming of the themes. A PPI representative (Ann Vincent) informed the acceptability of the research, theme refinement, and the interpretation of the study findings. I drafted the full thesis Chapter and the associated manuscript for publication (all co-authors reviewed and approved the manuscript for publication).

# 8.1 Overview of the thesis

My thesis aimed to examine the role of mental health in behavioural weight management interventions for adults with overweight or obesity, with a view to elucidating steps that could be taken to better support participants with their mental health during these interventions.

The thesis objectives were:

- **Objective One**: To determine the short- and long-term impact of behavioural weight management interventions on the mental health of adults with overweight and obesity (*Chapter Two, Chapter Five, Chapter Seven*).
- **Objective Two**: To identify how participant mental health is associated with attendance and engagement with a behavioural weight management intervention and trial (*Chapter Four, Chapter Seven*).
- **Objective Three**: To identify participant characteristics associated with changes in mental health in adults with obesity during and after a behavioural weight management intervention (*Chapter Six*).
- **Objective Four**: To explore participant experiences of a behavioural weight management intervention to better understand how well the intervention supports participant mental health, and how the intervention could be adapted to provide more effective support (*Chapter Seven*).

In the following sections, I will

- i) Discuss the key contributions of my thesis: I will consider how these compare to the existing relevant literature and examine the implications for research and public health practice (*Section 8.2*).
- ii) Detail the thesis strengths and limitations including methodological considerations (*Section 8.2*).
- iii) Provide concluding remarks (*Section 8.4*).

# 8.2 Key contributions of the thesis

In response to my thesis aims and objectives, I firstly conducted a systematic review and metaanalysis that assessed the impact of behavioural weight management interventions on mental health. Using data from the Weight loss referrals for adults in primary care (WRAP) trial, I then conducted secondary data analyses that assessed i) how participant mental health is associated with attendance and engagement with a behavioural weight management intervention and trial, ii) how referral to a behavioural weight management intervention impacted mental healthrelated outcomes at 5-years from baseline, and iii) how baseline and early changes in participant characteristics are associated with changes in depression and anxiety in adults with obesity during and after a behavioural weight management intervention. Finally, I conducted a qualitative interview study to broadly explore the mental health experiences of behavioural weight management intervention participants during the COVID-19 pandemic.

This thesis offers three main contributions to the wider literature:

• **Contribution One**: The impact of behavioural weight management interventions on mental health – who are most likely to benefit? *(Section 8.2.1.)* 

On average, behavioural weight management interventions appear to have net positive or neutral impacts on mental health in the short- and long-term (*Chapter Two and Five*). However, a proportion of participants do experience a decline in their mental health (*Chapter Five*). Some intervention participants attributed their mental health decline, at least in part, to aspects of the intervention, whereas others found the intervention was supportive of their mental health (*Chapter Seven*). Participants who experienced a decline in their mental health appear to be those beginning the intervention with poorer mental health (*Chapter Six*).

• **Contribution Two**: The importance of intervention attendance/engagement in the relationship between behavioural weight management interventions and mental health. *(Section 8.2.2)* 

Intervention attendance and engagement appear to be key areas where the relationship between mental health and behavioural weight management interventions interact. Participants who have poorer mental health at the beginning of a behavioural weight management intervention are less likely to attend intervention sessions or engage with intervention resources (*Chapter Four*). In addition, those who have reduced intervention attendance/engagement due to competing demands in their life outside of the weight management intervention may experience a particular worsening in their mental health (*Chapter Seven*). In this way, my findings point to a potential bidirectional relationship between intervention attendance/engagement and mental health, where diminishment in one exacerbates the decline in the other.

• **Contribution Three**: Bias towards the mentally healthy within behavioural weight management trials. *(Section 8.2.3)* 

Results from trials of behavioural weight management interventions may be biased to those who are most mentally healthy at the beginning of the trial. Those with poorer mental health at baseline have lower attendance at trial follow-up visits, resulting in study results that may not represent those with poorer baseline mental health. (*Chapter Four*)

The links between Chapters, Contributions, and Objectives are visually displayed in Figure 1. The figure shows how the findings from Chapters informed the thesis Contributions, which addressed the thesis Objectives.

In the following sections, I summarise my key contributions before discussing methodological considerations and reflections about the doctoral research process, before concluding with research implications and recommendations.





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# 8.2.1 Contribution One: The impact of behavioural weight management interventions on

# mental health - who are most likely to benefit?

In Chapter Two, I synthesised existing literature to assess the impact of behavioural weight management interventions on a broad array of mental health outcomes at the end of the intervention and 12-months after beginning the intervention. I identified that behavioural weight management interventions appear to have small benefits for some aspects of mental health at the end of the intervention and 12-months from baseline. Notably, I found no evidence to suggest that interventions resulted in a worsening in any aspect of mental health.

In Chapter Five, I examined the impact of behavioural weight management interventions in the longer term. Specifically, I evaluated the impact of a commercial behavioural weight management intervention on depression and anxiety at 5 years from baseline. I found that the interventions appeared to have a net neutral effect at 5 years from baseline – the interventions did not benefit or worsen mental health differentially to the control group. This is consistent with the systematic review findings on shorter-term effects on mental health.

It is important to acknowledge, however, that the findings from Chapters Two and Five represent *average* effects. Despite the average effects on mental health appearing promising, there are a proportion of participants that experience a worsening in their mental health during and after a behavioural weight management intervention. In Chapter Seven, I identified that a proportion of participants experienced a decline in their mental health that they attributed at least partly to participation in the intervention. Similarly, a proportion of participants perceived their participation in the intervention to, at least in part, be attributable for the improvements in their mental health.

In Chapter Six, I identified that those with poorer mental health at baseline were most likely to experience a decline in an aspect of their mental health. Specifically, those with higher levels of anxiety at baseline were associated with decreases in anxiety but increases in depression symptoms, whilst those with higher levels of depression at baseline were associated with decreases in depression but increases in anxiety symptoms. Thus, those beginning the intervention with heightened anxiety or depression are likely to reduce symptoms of their existing mental health concern, yet concurrently experience a decline in an alternative aspect of mental health.

Contribution One responds to two overarching thesis objectives. Firstly, this contribution adds evidence to determining the short- and long-term impact of behavioural weight management interventions on the mental health of adults with overweight and obesity (Objective One). Secondly, this contribution adds to identifying participant characteristics associated with changes in mental health in adults with obesity during and after a behavioural weight management intervention (Objective Three). In this way, Chapters Two, Five, Six, and Seven informed Contribution One, which in turn addressed thesis Objectives One and Three (Figure 1 and 2).

# Figure 2. The Chapter and Objective links for Contribution One.

#### Chapter Two:

The impact of adult behavioural weight management interventions on mental health: a systematic review and meta-analysis.

#### **Chapter Five:**

Long-term impact of a behavioural weight management intervention on depression and anxiety: 5-year follow up of the WRAP trial.

#### **Chapter Six:**

Participant characteristics associated with changes in mental health during a trial of behavioural weight management programmes: Secondary analysis of the WRAP trial.

#### **Chapter Seven:**

Participants' experiences of mental health during a COVID-19 tailored, web-based, guided self-help, ACT-based behavioural weight management intervention: a qualitative study.

#### Contribution One:

The impact of behavioural weight management interventions on mental health – who is most likely to benefit?

#### **Objective One:**

To determine the short- and long-term impact of behavioural weight management interventions on the mental health of adults with overweight and obesity.

#### **Objective Three:**

To identify participant characteristics associated with changes in mental health in adults with obesity during and after a behavioural weight management intervention.

# 8.2.1.1 How this contribution fits with what was already known

When comparing my findings with existing literature, I reflected on the scarcity of relevant research in this field. In Chapters One and Two, I identified that there is a clear dearth of evidence investigating the impact of behavioural weight management interventions on mental health in adults with overweight and obesity. Previous relevant reviews have also noted that there is a distinct lack of literature investigating the impact of behavioural weight management interventions on mental health.<sup>33,77,81,84–86,145</sup>

In Chapters Two and Five, I found that behavioural weight management interventions, on average, have a net positive or neutral effect on mental health in the short- and long-term. I found no evidence of a negative impact on any aspect of mental health in the short- or long-term. Comparing these findings to the existing literature is challenging not only due to the dearth of evidence, but also due to differing study criteria and/or focuses. For example, Drew et al. focused on male-only weight management interventions,<sup>145</sup> Jacob et al. focused on cognitive behavioural therapy-based weight-loss interventions,<sup>86</sup> and Baillot et al. focused on exercise-only weight management interventions and did not include those with a BMI between 25-30kg/m<sup>2.84</sup> Furthermore, four relevant reviews assessed the impact of all forms of weight loss treatments (including pharmacological and surgical) on mental health.<sup>33,77,81,85</sup> Despite these differences, all previous relevant reviews found no evidence of a negative impact on mental health, aligning with the thesis findings. Many reviews also found improvements in aspects of mental health, supporting the findings of Chapters Two and Five. For example, Fabricatore et al.<sup>33</sup> and Peckmezian et al.<sup>77</sup> also found small reductions in depression symptoms in favour of the behavioural interventions, whilst Jacob et al. found modest improvements in emotional eating, and Lasikiewicz et al. found medium to large improvements in self-esteem, depression, body image, and quality of life.

In Chapter Seven, I identified that participants had varied experiences of the impacts of the intervention on mental health. Numerous participants perceived to have experienced improvements in their mental health, yet many perceived to have experienced a decline in their mental health. Both groups attributed the changes in their mental health at least in part to their participation in the intervention. Using WRAP data (as described in Chapter Three), Heath and colleagues assessed the effect of a WW (formerly Weight Watchers) programme compared to brief intervention at two years from baseline and found, on average, no difference between

groups and no evidence of harm to depression or anxiety symptoms as a result of attending the intervention.<sup>279</sup> Of note, Heath et al. conducted additional analyses and concluded that the changes in participant mental health were not attributable to the intervention.<sup>279</sup> It is important to note, however, that these analyses had a high level of data missingness which may have impacted the detection of an effect (e.g., analyses may have been impacted by a type II error). This conflicts with the findings of Chapter Seven as participants perceived the intervention to be at least partly attributable for the changes in their mental health. Comparison with these findings is difficult, however, due to differences in the intervention (e.g., in-person and group-based, versus online and individual-based), timepoint under study (e.g., 2 years from baseline, versus the end of intervention), and analyses conducted (e.g., quantitative versus qualitative). The lack of existing similar research makes it difficult to assess the relative alignment of Chapter Seven's findings with previous literature. Therefore, although it is possible that changes in mental health may be at least partly attributable to the intervention, further research is required to clarify and confirm this.

In Chapter Six, I found that those beginning the intervention with poorer mental health were most likely to experience a decline in their mental health during or after a behavioural weight management intervention. Similar to Chapters Two and Five, it is challenging to compare the Chapter Six findings to the existing literature as there is a distinct lack of studies investigating the factors associated with changes in mental health during or after a behavioural weight management intervention. In addition, the limited existing research has focused efforts on identifying factors associated with changes in positive mental health outcomes (e.g., psychological wellbeing and quality of life), and has not yet explored factors associated with measures of poorer mental health (e.g., depression and anxiety). Studies assessing the factors associated with positive mental health also differ substantially in terms of participant criteria and study design, further complicating comparisons with existing literature. For example, Lerdal et al. included those with 'morbid obesity' only,<sup>117</sup> Nilsen et al. included adults at risk of type 2 diabetes,<sup>123</sup> Vilhena et al. conducted a cross-sectional study of hospital patients with obesity,<sup>124</sup> and Vieira et al. focused the research on middle-aged women with overweight or obesity.<sup>121</sup> Existing research has been conducted in Finland, Norway, and Portugal; the differences in healthcare settings and services made it challenging to compare research findings.

Despite the distinct differences with existing literature, numerous studies also found baseline mental health to be the strongest factor associated with changes in mental health in those living with obesity. For example, Lerdal et al. found higher self-esteem at baseline was associated with a greater quality of life at follow-up,<sup>117</sup> whilst Vilhena et al. found that those with lower negative affect, higher positive affect, and lower perception of stigma reported having a greater quality of life.<sup>124</sup> Other studies found non-psychological factors to be related to changes in mental health, such as paid work and social support,<sup>122</sup> or small weight loss combined with aerobic capacity.<sup>123</sup> These findings align with my own in identifying mental health at baseline to be a relevant factor associated with changes during and after a behavioural weight management intervention. Further comparisons between the evidence adding to this thesis contribution and previous literature are detailed in Chapters Two, Five, Six, and Seven.

# 8.2.1.2 Implications for research and public health practice

#### 8.2.1.2.1 Implications for research: Further unanswered research questions

When reflecting upon the strength and consistency of the evidence contributing to Contribution One, it is important to acknowledge that the findings are suggestive rather than conclusive. Thus, future research is needed to explore the differences between those who experience improvements versus declines in their mental health during and after a behavioural weight management intervention. Specifically, future research should further examine how mental health at baseline influences whether participants experience improvements or declines in their mental health, with a particular focus on mechanisms of change (i.e., the processes by which the changes occur).

Firstly, further research investigating the relationship between mental health at baseline and changes in mental health during and after the intervention is required. Future research may make use of regression analyses (as demonstrated in this thesis) or may consider conducting structural equation modelling such as cross-lagged panel analysis. Cross-lagged panel analyses are useful for assessing the relationships between variables over time and allow the assessment of potentially predictive relationships.<sup>280</sup> In this thesis, the research questions were most suited to regression analyses as I was assessing unidirectional relationships to determine potential predictors of how mental health changes. The use of cross-lagged panel analysis would build upon

the knowledge developed from this thesis in greater detail. Once a greater volume of research investigating this relationship has been achieved, the synthesis of this literature should be considered.

In addition to studying this quantitatively, researchers may consider exploring the differences in how participants' mental health changes over time by their mental health at baseline using qualitative methods. I suggest conducting an interview-based study and sampling participants by their mental health at baseline to investigate similarities and differences in the experiences of the groups. Researchers may use interviewing skills to collect more detailed and rich information on participants mental health experiences. For example, using deep probing and prompting to explore complex behaviours, thoughts, and emotions in a rich manner. In this way, the interviews can seek greater detail and understanding on a more narrowly focussed topic. As the role of mental health in behavioural weight management interventions is greatly understudied, the use of broadly focussed semi-structured interviews in this thesis (Chapter Seven) was the appropriate choice of interviewing method as this allowed me to explore the topic more generally, gaining an understanding of which more focused topics could be explored in the future.

Further deployment of quantitative and qualitative research methods would permit a more comprehensive investigation into how changes in mental health over time may differ by mental health status upon beginning an intervention. Qualitative research can capture rich meanings which can be missing in quantitative research, whilst quantitative research is suited to examine the strength and directionality of relationships to inform causal inference.

#### 8.2.1.2.2 Implications for public health practice

As noted, I recognise that the conclusions that can be drawn from the findings of my thesis are suggestive rather than conclusive. However, the suggestive evidence still prompts the question – 'Are we supporting those who need it the most the least?'. Those living with overweight or obesity and poor mental health unfairly experience a higher level of stigma and discrimination, as described in Chapter One (*Section 1.4*).<sup>4,5</sup> Consequentially, adults with overweight or obesity and poor mental health are at a greater risk of the damaging consequences of stigma and discrimination including psychological distress, social isolation and exclusion, weight gain, and

avoidance of health-promoting activities. <sup>4,39–41</sup> Thus, adults with overweight or obesity and poor mental health are a disadvantaged group.

With this considered, Contribution One suggests that behavioural weight management interventions may psychologically benefit those in this disadvantaged group the least and could possibly result in a worsening in mental health. In this way, behavioural weight management interventions may be exacerbating health inequities. Health inequities are *"unfair, avoidable differences arising from poor governance, corruption or cultural exclusion"* (quote from Global Health Europe: 'Inequity and Inequality in Health'<sup>281</sup>), and a key goal identified at the 74<sup>th</sup> World Health Assembly in 2021 was to reduce health inequities.<sup>282</sup> This highlights the importance of taking action to minimise the differential impacts of obesity treatments, such as differential impacts dependent on mental health status.

In the short term, public health professionals may consider measuring the mental health of participants upon beginning an intervention to identify those who may benefit from additional support. Healthcare professionals may wish to make use of signposting and referrals to external organisations providing mental health support to support their psychological health during the weight management intervention. In the longer-term, public health professionals may wish to evaluate the intervention delivered by their service to assess whether a greater amount of psychologically informed content could be integrated. As scientific evidence is generated, this may be used to inform this process. To allow this process to be efficient and effective, strong networks are needed between researchers and practitioners to support prompt sharing and implementation of relevant research findings.

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# 8.2.2 Contribution Two: The importance of intervention attendance/engagement in the relationship between behavioural weight management interventions and mental health

In Chapter Four, I investigated whether participant mental health at baseline was related to intervention attendance and engagement. I found that those with poorer mental health at baseline were less likely to attend intervention sessions or engage with intervention resources.

In Chapter Seven, I conducted a qualitative study of participants' mental health experiences during a behavioural weight management intervention. I found that participants experienced a multitude of demands on their mental energy and that the intervention was often deemed the lesser priority, resulting in reduced intervention engagement. Consequentially, participants described experiencing a decline in their mental health via feelings such as shame, guilt, self-blame, and disappointment and annoyance in oneself.

Reflecting on the findings of Chapters Four and Seven, this evidence suggests that intervention attendance and engagement appear to play an important role in the relationship between mental health and behavioural weight management interventions. There appears to be a bidirectional relationship between intervention attendance/engagement and mental health where diminishment in one exacerbates the decline in the other. Specifically, i) poorer mental health at baseline is associated with subsequentially lower rates of attendance and engagement, and ii) managing competing demands can lead to reduced intervention engagement which subsequentially worsens mental health.

Contribution Two responds to two overarching thesis objectives. Firstly, this contribution adds evidence addressing how participant mental health is associated with attendance and engagement with a behavioural weight management intervention (Objective Two). Secondly, this contribution adds knowledge around participant experiences of these interventions to better understand how well the intervention supports participant mental health, and how the intervention could be adapted to provide more effective support (Objective 4). In this way, Chapters Four and Seven informed Contribution Two, which in turn addressed thesis Objectives Two and Four (Figure 1 and 3).

# Figure 3. The Chapter and Objective links for Contribution Two.

#### **Chapter Four:**

The impact of participant mental health on attendance and engagement in a trial of a behavioural weight management programmes: Secondary analysis of the WRAP trial.

#### **Chapter Seven:**

Participants' experiences of mental health during a COVID-19 tailored, web-based, guided self-help, ACT-based behavioural weight management intervention: a qualitative study.

#### **Contribution Two:**

The importance of intervention attendance/engagement in the relationship between behavioural weight management interventions and mental health.

#### **Objective Two:**

To identify how participant mental health is associated with attendance and engagement with a behavioural weight management intervention and trial.

#### **Objective Four:**

To explore participant experiences of a behavioural weight management intervention to better understand how well the intervention supports participant mental health, and how the intervention could be adapted to provide more effective support.

# 8.2.2.1 How this contribution fits with what was already known

Appraising agreement between my findings and available literature related to Contribution Two is challenging as, again, there is a distinct lack of relevant research. Specifically, there is a lack of evidence assessing the relationship between mental health and engagement within behavioural weight management interventions.

The impact of mental health on attendance and engagement with a behavioural weight management intervention is understudied. A systematic review investigating factors associated with adherence rates found just one study that assessed the impact of depression on adherence.<sup>283</sup> A later review assessed the factors associated with adherence to lifestyle modification programmes for weight management (i.e., behavioural weight management interventions) and identified four studies assessing the influence of depression on intervention adherence, and three studies that assessed the influence of stress.<sup>103</sup> Furthermore, there was great heterogeneity within the limited evidence identified; for example, one study focused on adults with metabolic syndrome, another included women only, and a further study provided a family-based intervention.<sup>103</sup> Despite substantial differences across the highly limited evidence identified, the reviews (and identified studies) found greater symptoms of depression and stress to predict poorer intervention adherence and non-completion of the intervention.<sup>103,283</sup> The reviews may have missed some relevant literature as there are a multitude of terms often used

to refer to engagement, such as dropout, attrition, and adherence.<sup>284</sup> I identified two studies that found contrasting evidence to the reviews discussed;<sup>104,107</sup> these studies found mental health to not be associated with attendance and engagement, contrasting with the evidence produced in this thesis. More recently published evidence aligned with the thesis findings.<sup>285,286</sup> Mitchell and colleagues (February 2021) found multiple aspects of mental health (e.g., quality of life, depression, anxiety) to be associated with intervention engagement,<sup>285</sup> whilst Goessl and colleagues (June 2021) found those with an active affective disorder reported reduced intervention engagement compared to those without an active affective disorder.<sup>286</sup> Authors defined affective disorder as under treatment (e.g., counselling, therapy, medication) for depression, anxiety, adjustment issues, or nerves.<sup>286</sup> As described in Chapter Four, the conflicting findings may be due to differences in mental health definitions used. For example, Funderburk and colleagues defined mental health as diagnosed versus non-diagnosed, 107 and Goessl and colleagues defined mental health as having an affective disorder versus without an affective disorder.<sup>286</sup> This differs from the definition I adopted in this thesis (i.e., mental health as a symptom continuum which appreciates that participants can experience one or more symptoms of mental illness without meeting diagnostic criteria<sup>23,24</sup>). Most recently, Jakob and colleagues (preprint published December 2021) found that depression symptoms and negative emotions related to self-monitoring of weight negatively impacted adherence to weight loss and multicomponent lifestyle intervention apps. These findings align with those of Chapter Four, despite the differences in intervention types.<sup>287</sup> The evidence informing Contribution Two corroborates with the majority of previous research and builds upon the current dearth of literature, yet further research is required to strengthen understanding of this relationship.

In Chapter Seven, I provided qualitative evidence that suggests reduced intervention attendance and engagement can lead to worsening in mental health (informing Contribution Two). There is little evidence to compare this finding to as, to the best of my knowledge, there is a lack of literature assessing the effects of poor attendance and/or engagement on mental health. The majority of literature examining attendance and/or engagement in behavioural weight management interventions has focused on intervention-level effectiveness, being the impact on body weight (i.e., assessing if greater attendance results in greater weight loss).<sup>62,100,101,288–291</sup> Research on intervention attendance and/or engagement in trials of behavioural weight management interventions has also focused on methods to improve engagement.<sup>94,292–294</sup> For example, Holdsworth and colleagues conducted a qualitative study of participant engagement with a weight loss intervention where they explored how to improve engagement.<sup>295</sup> The impact of low intervention attendance and engagement on participant mental health has, to the best of my knowledge, not been examined.

Despite the lack of comparable research, it is plausible that reduced intervention engagement may result in a decline in mental health. There is a pervasive societal belief that overweight and obesity are the result of an individual fault, including lack of motivation and poor behavioural choices.<sup>4,5</sup> Thus, when an individual living with overweight or obesity has poor engagement with an obesity treatment, it is then possible that they believe this is due to a personal fault rather than a limitation of the intervention. This was indicated by the findings of Chapter Seven as participants described feeling that their lack of results (e.g., weight loss) was due to personal fault rather than a lack of intervention effectiveness, leading to self-blame and negative self-talk. Previous research also reports that a lack of immediate weight changes was associated with feelings of failure and shame.<sup>126,243–245</sup> Additionally, participants of the interview study reported in Chapter Seven described feelings of self-blame, shame, disappointment and annoyance with themselves, and guilt due to reduced intervention engagement. This aligns with the hypothesis presented that poor intervention engagement may be perceived as intervention fault, resulting in a worsening in mental health.

Further comparisons between the evidence adding to this thesis contribution and previous literature are detailed in Chapters Four and Seven.

#### 8.2.2.2 Implications for research and public health practice

#### 8.2.2.2.1 Implications for research: Further unanswered research questions

The evidence from Chapters Four and Seven provided suggestive evidence that there may be a bidirectional relationship between intervention engagement and participant mental health. However, the lack of previous similar research means that any proposals must be tentative. Nevertheless, there are plausible arguments for why this bidirectional relationship may exist. Further research assessing the influence of intervention engagement on mental health, and vice versa, is required to understand what effect each has on the other. This is important to strengthen the evidence base so that consistency across studies can be assessed. Additionally, future research should focus on identifying possible mechanisms of action to better understand *how* 

each concept may be influencing the other. This is important as it may inform the development and implementation of strategies to improve intervention attendance/engagement. Before conducting quantitative research to assess *what* effect is produced in both directions and *how* the effects are produced, additional exploratory qualitative research may be useful to inform the design of these studies. For example, through qualitative research we may better understand which aspects of mental health are most relevant, which can help identify pertinent variables for quantitative models.

It is also worth considering how the findings relevant to Contributions One and Two may interact. Contribution One found that those with poor mental health at baseline are more likely to experience a decline in mental health, whilst Contribution Two found that those with poor mental health are likely to have poorer intervention engagement, and reduced intervention engagement can result in worsening in mental health. Thus, it may be possible that those with poor mental health at baseline engage poorly with the intervention, resulting in further decline in mental health. In Chapter Four, I assessed whether the rate of intervention attendance *moderated* the effect of baseline mental health on changes in mental health during and after the behavioural intervention, finding no evidence of an effect. Reflecting on Contributions One and Two, further research may wish to explore whether intervention attendance and/or engagement instead *mediates* this relationship.

In addition to generating greater knowledge of the relationship between mental health and intervention attendance/engagement, research should concurrently seek to understand how to improve intervention attendance and engagement rates in those with poorer mental health at baseline. For example, researchers may assess whether integrating engagement strategies with the intervention may improve rates. Alternatively, researchers may evaluate whether a tailored intervention for those with poor mental health may benefit intervention/engagement. For example, the RAINBOW trial provided a tailored weight management programme for persons with obesity and depression, finding modest improvements in both weight and depression symptoms.<sup>246</sup> It is still unknown, however, if the tailored programme resulted in greater attendance and engagement rates than similar individuals attending a standard behavioural weight management intervention.

# 8.2.2.2.2 Implications for public health practice

Though caution is needed when drawing conclusions from thesis findings, particularly due to the relative weakness of existing relevant research, some implications can nonetheless be identified. In the short term, healthcare practitioners may consider discussing concurrent demands with participants to jointly assess whether it is the right time to begin an intervention. Chapter Seven found that when participants found the demands on their mental energy became 'too much', their intervention engagement reduced and mental health worsened. Thus, by assessing the demands on their energy at the start, participants may reflect on whether adding the demands of the intervention to their lives will be manageable or possibly 'too much'. Through these conversations, participants and practitioners might also identify concurrent demands on their mental energy where external support could be obtained, e.g., via signposting or referring to other services/organisations. The recently published guidance for healthcare practitioners on conversations about obesity may support these interactions to be non-stigmatising.<sup>276,277</sup>

Additionally, in the short term, healthcare practitioners may wish to take a more flexible and cautious approach to discharging participants when intervention engagement has reduced. Practitioners may consider making repeated efforts via differing means (e.g., email, text message, phone-call) to contact participants to assess whether a determinant of reduced engagement is mental health. If so, the addition of greater mental health support may aid the participant to reengage and improve their adherence to the intervention (e.g., referrals to psychological services, information signposting).

In the longer term, once a stronger evidence base has been produced, healthcare services may wish to integrate evidence-based strategies to encourage intervention attendance and engagement. These could include adaptations to the intervention or providers (e.g., changes in session duration, intervention content, increased training). Alternatively, services may wish to provide a tailored behavioural weight management intervention for those with poor mental health with the aim of greater attendance and engagement outcomes.

# 8.2.3 Contribution Three: Bias towards the mentally healthy within behavioural weight management trials

In Chapter Four, I investigated whether participant mental health at baseline was related to attendance at study follow-up visits for data collection. I found that those with poorer mental health at baseline were less likely to attend study follow-up visits. Reflecting on the findings of Chapters Four, the evidence suggests follow-up samples and study findings that may not represent those reporting poorer mental health at baseline.

Contribution Three responds to one overarching thesis objective: Objective Two. This contribution adds evidence to determining how participant mental health is associated with attendance and engagement with a trial providing a behavioural weight management intervention. In this way, Chapter Four informed Contribution Three, which in turn addressed thesis Objective Two (Figure 1 and 4).

# Figure 4. The Chapter and Objective links for Contribution Three.



**Contribution Three:** Bias towards the mentally healthy within behavioural weight management trials.

#### **Objective Two:**

To identify how participant mental health is associated with attendance and engagement with a behavioural weight management intervention and trial

# 8.2.3.1 How this contribution fits with what was already known

Before addressing how the findings relevant to Contribution Three compare to existing literature, it is important to clarify the difference between trial attrition (i.e., loss of participants from the trial) and attendance at trial study visits. In this thesis, I examined the association between participant mental health and attendance at trial study visits where participants completed outcome assessments. In this way, participants could have attended the 3-month and 24-month follow-up visits, yet not have attended the 12-month follow-up visit. There is likely an overlap between these concepts which results in marginal differences to research implications, however,

this difference is more pertinent to consider when comparing findings to existing literature (e.g., to be conscious of key differences in the studies).

Existing literature has examined the association between participant mental health and trial attrition, yet, to my knowledge, no studies have assessed the association between participant mental health and attendance at trial study visits. In wider fields (i.e., non-obesity healthcare research), there is increasing evidence that those with poorer mental health are more likely to withdraw from the trial (i.e., trial attrition). This was evident in trials investigating treatments for patients with cancer,<sup>296</sup> with psychological diagnoses,<sup>297–301</sup> with osteoarthritis,<sup>302</sup> with HIV-positive diagnosis and neuropathic pain,<sup>303</sup> or with type 1 or 2 diabetes.<sup>304</sup> Despite distinct differences, the findings from the wider literature align with those of Chapter Four.

In the field of obesity treatments, a systematic review published in 2011 reported finding no consistent psychological factors to predict trial dropout and recommended further research into this area.<sup>93</sup> It is possible, though, that this review did not include all relevant literature: for example, a study by Grave et al. (published in 2006, before the review search) assessed the factors associated with attrition in weight loss was not captured in the review.<sup>305</sup> More recent research has shown poorer scores for depression, stress, self-confidence, and binge-eating predicted attrition.<sup>306,307</sup> These findings align with the findings of Chapter Four, which informed Contribution Three. It appears there may be a link between participant mental health and trial attrition, suggesting that this relationship may extend to the relationship between participant mental health and trial study visits. This Contribution should be considered as suggestive as the limited available evidence makes it difficult to conduct a sufficient assessment of the strength and consistency of the findings.

A relationship between participant mental health and attendance at trial study visits is plausible. Participants may experience high levels of anxiety regarding clinical assessments (e.g., bloodsampling), discomfort answering personal questionnaires (e.g., psychological assessments), or perceived participant burden (e.g., study visits may feel 'too much' alongside other commits).<sup>247–</sup>

Further comparisons between the evidence adding to this thesis contribution and previous literature are detailed in Chapter Four.

# 8.2.3.2 Implications for research and public health practice

# 8.2.3.2.1 Implications for research: Further unanswered research questions

A greater quantity of high-quality studies investigating the relationship between participant mental health and attendance at trial study follow-up visits is required to strengthen the evidence base. This would allow the synthesis of findings using meta-analysis methods to better understand how participant mental health impacts how representative trial follow-up samples are.

Future research does not particularly need to embrace complex methods and study designs, rather the focus should be on building a larger evidence-base so that strength of evidence and consistency across findings could be assessed. Researchers could use regression analyses, as used in this thesis, in large participant samples with varied characteristics. This would provide greater statistical power to investigate whether the effects are differential by, for example, age, gender, or presence of mental health or disordered eating diagnosis. This would aid our understanding as to whether the effect may differ according to particular participant characteristics. Additionally, I suggest trials to be conducted in varied locations (e.g., rural vs. urban, high- vs. low-socioeconomic status) to build our knowledge of how the effect may differ according to key geographical characteristics. In the dissemination of findings from future trials, I encourage researchers to transparently report recruitment and retention strategies used. This would allow future synthesis efforts to assess whether the inclusion of these strategies results in greater attendance at study follow-up visits in those reporting poorer mental health at baseline.

Alongside developing a stronger evidence base for the correlation between participant mental health and attendance at study follow-up visits, research should aim to understand the moderators, mediators, and mechanisms of behaviour change in this relationship. This would inform and enhance the development of effective strategies to increase participant retention/attendance at study follow-up visits. For example, by better understanding the moderators, mediators, and mechanisms of action, the most relevant Behaviour Change Techniques (BCTs) can be identified to support the development of these strategies.<sup>308,309</sup> BCTs are the active ingredients in interventions; they have been described by Michie and colleagues as "observable, replicable and irreducible component of an intervention designed to alter or redirect causal processes that regulate behaviour".<sup>310</sup> In this way, by better understanding the moderators, mediators, and mechanisms of action, the most relevant BCTs can be identified, and 178

thus, more effective retention strategies developed. Previous research has applied BCTs to the development of retention strategies,<sup>311,312</sup> however this has not yet been conducted with the aim to increase engagement specifically in those with poorer mental health.

It is standard practice in trial research to examine whether there are significant differences between groups at baseline. It is less common that researchers assess differences between samples at baseline and follow-up (i.e., intervention group at baseline vs. follow-up, and control group at baseline vs. follow-up). This is important to assess if there are differences between groups at baseline and follow-up to identify whether particular groups may not be represented in follow-up samples (e.g., those with poorer mental health). Although this is pertinent for mental health (due to the evidence presented), this may extend to other variables (e.g., socioeconomic status, age, sexual orientation). Researchers may consider pre-planning these analyses in statistical analysis protocols, with the findings transparently reported.

The evidence from my thesis informing Contribution Three suggests that follow-up participant samples in trials of behavioural weight management intervention may not represent the true range of mental health experiences, specifically those experiencing poorer mental health at baseline. Previous evidence from behavioural weight management trials should by no means be discarded, but caution should be taken when interpreting findings. Table 1 presents the amended versions of the thesis Chapter key findings when taking Contribution Three into consideration – the table includes the quantitative findings only as the qualitative chapter (Chapter Seven) did not include the complete follow-up sample, instead I sampled 20 of the 174 participants who completed the follow-up assessments. It is pertinent to understand to increase the attendance of those with poorer mental health at study follow-ups visits to improve the reliability and generalisability of trial findings.

|   | Original Key Finding(s)                 | Amended* Key Finding(s)                      |  |  |  |
|---|---|--|--|--|--|
| Chapter   | On average, behavioural weight          | In a sample of participants biased towards   |  |  |  |
| Two:  | management interventions produce        | those with better mental health at           |  |  |  |
|   | small benefits for some aspects of      | baseline, participants appear to             |  |  |  |
|   | mental health. Interventions do not,    | experience small benefits and no negative    |  |  |  |
|   | on average, appear to result in a       | effects for mental health after a            |  |  |  |
|   | decline in any aspect of mental health. | behavioural weight management                |  |  |  |
|   |   | intervention.                                |  |  |  |
| Chapter   | Participants with poorer mental health  | In a sample of participants biased towards   |  |  |  |
| Four:   | at baseline were less likely to attend  | those with better mental health at           |  |  |  |
|   | intervention sessions and engage with   | baseline, those on the poorer end of the     |  |  |  |
|   | intervention resources.                 | spectrum were less likely to attend          |  |  |  |
|   |   | intervention sessions and engage with        |  |  |  |
|   |   | intervention resources.                      |  |  |  |
| Chapter   | There were no differences between       | In a sample of participants biased towards   |  |  |  |
| Five:   | intervention and control in the impact  | those with better mental health at           |  |  |  |
|   | on depression and anxiety at 5-years    | baseline, participants appear to             |  |  |  |
|   | from baseline. The long-term impact     | experience no negative effects for mental    |  |  |  |
|   | appeared to be neutral (i.e.,           | health in the long term after a behavioural  |  |  |  |
|   | depression/anxiety symptoms did not     | weight management intervention.              |  |  |  |
|   | improve or decline).                    |  |  |  |  |
| Chapter   | Participants were most likely to        | In a sample of participants biased towards   |  |  |  |
| Six:  | experience a small decline in an aspect | those with better mental health at           |  |  |  |
|   | of their mental health during and after | baseline, those on the poorer end of the     |  |  |  |
|   | the intervention if they began the      | spectrum were most likely to experience      |  |  |  |
|   | intervention with poorer mental         | a small decline in an aspect of their mental |  |  |  |
|   | health.                                 | health during and after the intervention.    |  |  |  |
| *Amended to take thesis Contribution Three into consideration |   |  |  |  |  |

| Table 1. The impact o | f Contribution | Three on the | Thesis Chapters' | ' key findings. |
|-----------------------|----------------|--------------|------------------|-----------------|
|-----------------------|----------------|--------------|------------------|-----------------|

# 8.2.3.2.2 Implications for public health practice

The implications of Contribution Three more heavily influence research rather than public health practice, however, decisions in public health practice are based upon research findings (i.e., evidence-based practice). Therefore, if research findings are biased or unrepresentative then there is the potential for public health practice to echo these biases. As such, if research findings from behavioural weight management interventions do not sufficiently represent those with poorer mental health at baseline, then we cannot ascertain how the implications of the findings of the research will impact this group. This is by no means a reason for decisions in public health practice to not be based on scientific evidence, particularly as all evidence has limitations. Instead, I would encourage public health practice to be aware of the limitations of evidence during decision making.

# 8.3 Methodological considerations, strengths, and limitations

The methodological considerations, strengths, and limitations specific to each analysis are detailed within each Chapter. Instead, in the following sections, I will then discuss the cross-cutting methodological considerations, strengths, and limitations of the thesis as a whole.

# 8.3.1 Defining mental health

In this thesis, I embraced a symptom continuum-based definition of mental health which appreciates that individuals can experience one or more symptoms of mental illness without meeting diagnostic criteria.<sup>23,24</sup> This definition moves away from categorising mental health in a binary form as 'good' (i.e., mental wellness) or 'bad' (i.e., mental illness). Some researchers do adopt a definition of mental health which classifies mental health as with versus without a mental illness diagnosis; this binary classification has advantages when the research aims to understand the differences between those with and without a medical diagnosis. However, embracing a broader definition suited the thesis aims as it allowed a more comprehensive investigation of the full range of mental health experiences. It was sometimes challenging to appraise the agreement between my findings and existing literature due to the differing definitions of mental health most appropriate to the research aims. Furthermore, considering mental health as a continuum is associated with reduced stigma and improved attitudes towards mental illness, highlighting the benefits of adopting this definition.<sup>24,26</sup>

In addition to defining mental health, it was important to acknowledge that mental health-related terms (e.g., anxiety, depression) are part of medical and lay language, and can differ in their definitions and connotations. Recognition of this was particularly important when conducting the qualitative study in Chapter Seven. To overcome the potential error of misrepresenting or misdiagnosing participants, I was conscious to use the terms used by the participants to describe their experiences. For example, when a participant described potential symptoms of anxiety (e.g., worry, panic) but did not use the term 'anxiety', I was conscious to not refer to the participant as having anxiety. I only used medical terms such as anxiety only when a participant had stated this themselves. In this way, I represented the participant experiences as authentically as possible.

Despite the challenges associated with researching at the intersection of two fields (obesity and mental health), I have contributed evidence to an understudied area of research. This topic is of high research priority, as highlighted by the recently published research goals for 2020-2030 (set by the Department of Health & Social Care, United Kingdom) which stated that it is a priority to understand the links between physical health (including obesity) and mental health.<sup>42,43</sup>

# 8.3.2 Integration of research using multiple methods

In this thesis, I have used a combination of quantitative (Chapters Two, Four, Five, and Six) and qualitative methods (Chapter Seven). The use of both quantitative and qualitative methods provides multiple advantages to employing either method in isolation, including the flexibility to study a particular topic from multiple perspectives. For example, quantitative methods are suited to closed-ended questions with numeric outcomes such as: (i) What is the impact of interventions on mental health?, (ii) What is the impact of mental health on attendance and engagement?, and (iii) What is the impact of participant characteristics on changes in mental health?. Alternatively, qualitative methods are suited to open-ended questions with the aim of rich, deep insights on thoughts, feelings, and meanings associated with complex topics. As such, qualitative methods suited the exploration of participants' experiences of mental health during a behavioural weight management intervention.

Due to the unique advantages of each method, using both quantitative and qualitative methods in this thesis allowed a more comprehensive investigation into the role of mental health in adult behavioural weight management interventions. However, I recognise that integrating the findings of quantitative and qualitative methods can involve challenges. Whilst further considerations relevant to the use of each approach are considered within each Chapter, in this section I will instead consider the factors associated with the integration of the findings produced from using multiple methods.

Firstly, it is important to distinguish the difference between 'multiple methods' and 'mixed methods' research.<sup>313</sup> In this thesis, I conducted multiple methods research where quantitative and qualitative research were conducted and reported independently. Once the studies are completed, with multiple methods a researcher then considers how the findings of each study inform one another. This is often also referred to as 'triangulation'. As an example, in thesis Contribution Two, the findings from quantitative and qualitative chapters (Chapters Four and 183

Seven, respectively) informed one another. Alternatively, in mixed methods research, quantitative and qualitative research is, at least in part, conducted and reported together. Integration exists at multiple stages throughout the study, including design, data collection, and data analysis. Although integration of findings can be more challenging for multiple methods research, researchers suggest that this approach holds *"promise for greater discovery"* (Kidder and Fine)<sup>314</sup> through a more comprehensive investigation of the issue.

I aimed to generate new inferences from assessing the findings concurrently. To do so, I began by extracting the key findings from each chapter to then identify where findings in one chapter informed those in another. Specifically, I searched for convergence (agreement between findings), complementarity (complementary findings), and dissonance (contradictory findings).<sup>315</sup> By doing so, I moved from viewing the chapter findings independently to exploring potential 'meta-themes' across the thesis findings.<sup>315</sup> To blend the quantitative and qualitative results and identify potential 'meta-themes', I created an integrated results table which is a form of 'joint display'. Joint displays are a collection of useful and effective tools to help researchers to compare close-ended quantitative and open-ended qualitative findings to explore possible cross-cutting findings and identify possible points of convergence, complementarity, and dissonance.<sup>316,317</sup> Joint displays can take many forms, such as figures, graphs, and matrixes. In this thesis, I adopted the table form of the joint display as it allowed me more easily view the results side-by-side in one panel to iteratively compare the chapter findings. This is the most common form of joint display as it enhances the presentation of findings.<sup>316</sup> I placed the qualitative findings in the central panel of the table to further aid the comparison between the quantitative and qualitative findings; this approach has been used previously and was a suggested strategy for joint displays in a recent methods article by McCrudden and colleagues.<sup>316,318</sup> Chapter Eight Appendices (A8.1) present the joint display by integrated results table – in practice, I drew this on a large scale whiteboard so that I could use different colours to draw and erase comments and arrows where there may be potential links. For example, viewing the chapter findings in the large-scale joint display allowed me to see the links more easily between the qualitative findings in Chapter Seven and quantitative findings in Chapter Four in relation to intervention engagement. This ultimately led to the thesis Contribution Two, as described earlier in Chapter Eight (Section 8.2.2).

The use of joint displays is noted to enhance the rigour of mixed/multiple methods research.<sup>316,319</sup> However, alternative methods of integration, such as 'following a thread' and the 'mixed method

matrix', are also valid approaches. I deemed this to be the most suitable approach for my thesis as the studies in each chapter were conducted, analysed, and reported in parallel and independently to produce five sets of findings (i.e., Chapters Two, Four, Five, Six, and Seven). This aligns with the suggestion of McCrudden and colleagues who stated that joint displays that present findings side-by-side can be effective for studies with concurrent timing.<sup>316</sup> As chapters were independent and did not directly sequentially build on one another, sequential integration was not appropriate as it is suited to 'following a thread' integration.<sup>315</sup> Different data sources (e.g., WRAP, SWiM-C) were used to produce the thesis chapter findings, thus the 'mixed method matrix' was not appropriate as it is suited to integrating studies during analysis where quantitative and qualitative data is from the same data source.<sup>315</sup>

Joint displays can be effective and useful tools for the integration of findings from studies using multiple methods, yet they are not without their challenges. In particular, I found it challenging to find ample resources discussing the expectations, use, and considerations for joint displays. A recently published methods article by McCrudden et al. stated that "emerging use of joint displays for psychological mixed methods research may mean that it can be challenging for students and researchers to find examples in the existing literature or style manuals to guide their own work". They also expressed those students using emerging methods "may be more likely to stimulate innovation in their research fields of choice".<sup>316</sup> I regarded the joint display table to meet my needs for integration of research using multiple methods, and found the recent works on McCrudden and colleagues to be sufficient to guide my use of this approach.<sup>316</sup>

When reflecting on the methods used in my thesis, I believe that employing both quantitative and qualitative methods has resulted in benefits for both my research and development as a researcher. For example, I was able to generate more substantial inferences from my results than possible from a single methodological approach. Thus, I was able to provide a more comprehensive description of the role of mental health in adult behavioural weight management interventions. This benefitted my research as I could answer my research questions more fully. As a researcher, the use of multiple methods has advanced my skills in quantitative and qualitative methods as well as the integration of findings from these methods. This directly benefited my development and advancement as a researcher.

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### 8.3.3 Practicing reflexivity

Mauthner and Doucet state that "there is an assumption built into many data analysis methods that the researcher, the method and the data are separate entities rather than reflexively interdependent and interconnected".<sup>320</sup> Later, they describe that this is not the case as research methods "carry the epistemological, ontological and theoretical assumptions of the researchers who developed them", and when used, we (the researcher) impose our own assumptions to the process.<sup>320</sup> Practicing reflexivity is defined as the critical reflection on the research progress and the positionality of the researcher within the process.<sup>260</sup> Specifically, we can have *insider* and outside positions, and we should reflect upon both.<sup>260</sup> An insider position exists when we have a shared identity with the participant group being researched. For example, I have lived experience of obesity and mental health diagnoses during adulthood, and I have conducted my doctoral research on the role of mental health in the behavioural treatment of adult obesity. An outsider position exists when we do not have a shared identity with the participant group being researched. For example, I have delivered but not attended a behavioural weight management intervention, whereas the participants of my research are all participants of these interventions. Thus, to be reflexive, it has been important that I reflect on how my positionality may influence my research through aspects such as the development of research questions, assumptions of the data, and analysis and interpretation of findings. For example, my interpretation of results in Chapter Five benefited from my work of reflexivity. Initially, I felt slight disappointment as I interpreted that the intervention did not result in any improvements to participant mental health and did not initially acknowledge that it was a positive outcome that the intervention also did not cause harm to mental health. My work of reflexivity allowed me to acknowledge that my previous experience delivering interventions had influenced my interpretation of the findings; I then spent time conversing with colleagues and engaging with patient representatives to challenge the assumptions I had made and interpret the findings more completely.

I have adopted a number of practices to critically reflect on my role as the researcher in producing the evidence in this thesis. A practice that I found to be one of the most useful began in collaboration with my supervisor, Dr Amy Ahern. During the early stages of the PhD, Dr Ahern encouraged me to take several minutes to talk in free flow about the topic related to the project I was designing. Talking about the topic in this way, without pause and reflection, made inspection of my related assumptions easier. During later stages of the PhD, I completed this task independently by setting a timer and writing, without editing or deleting, my thoughts relating to 186

the topic under study. By regularly completing this task, I created space and time for in-depth reflection on how my background and experiences may influence my research. By doing this exercise, I recognised that I am a pragmatically driven researcher; I instinctively search for possible practical implications of the research from the earliest stage of study ideation. This influenced the formation of research questions and the design of research methods in my thesis.

Another practice that helped me to reflect on how my position influences my research involved building a team around me who have differing backgrounds, experiences, opinions, views, and perspectives. I regularly had one-on-one and group meetings with these colleagues and patient representatives where I actively invited others to challenge any assumptions I made. This was extremely useful to understand why I may make particular decisions and how I may interpret research findings. In particular, my meetings with patient representatives were exceptionally useful as they allowed me to hear alternative explanations and different experiences to my own, especially experiences that are so closely related to my work. For example, patient representations challenged my assumption of the format of behavioural weight management interventions. Specifically, my previous experience informed my generalisation of these interventions to be group-based, face-to-face meetings. Patient representations challenged their experiences of online interventions. This was particularly useful as it informed the ideation and design of Chapter Seven where I explored participants experiences of a web-based behavioural intervention.

Although I have made active efforts to practice reflexivity, there are always limits to how reflexive we can be. Grosz et al. stated that *"the author's intentions, emotions, psyche, and interiority are not only inaccessible to readers, they are likely to be inaccessible to the author herself*".<sup>321</sup> Mauthner and Doucet reflect on this by highlighting that there are degrees of reflexivity.<sup>260</sup> My degrees of reflexivity have increased throughout the duration of my doctoral research. The growth in reflexivity made research ideation and protocol development a richer and clearer process which directly benefited the interpretation of study findings as I was actively more open to differing perspectives. Supervisions with Dr Ahern, meetings with patient representatives, and reading literature by researchers with differing perspectives were fundamental to more fully practising reflexivity throughout the research process. This may be, in part, be due to beginning my doctoral research process by conducting quantitative research (Chapter Two). Although reflexivity practices are common in qualitative research, reflexivity is less commonly discussed

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within quantitative research.<sup>260</sup> I am grateful that my early PhD experiences showed me the importance of reflexivity, though, as reflexivity then became a substantial practice for me in producing this thesis, regardless as to whether research used quantitative or qualitative methods.

# 8.3.4 Generalisability and transferability

Generalisability refers to the extent to which results produced from a representative sample can be applied to the wider population.<sup>322</sup> In this thesis, for example, I reflected on whether the quantitative findings produced using data from the WRAP trial is generalisable to the wider population of adults with overweight or obesity attending behavioural weight management interventions. Whereas generalisability is often the aim in quantitative research, it is less commonly the aim of qualitative work. Instead, the aim of qualitative work is often to achieve rich and deep insights that may transfer to other contexts.<sup>323–325</sup> Transferability refers to the extent to which results from a particular population and/or context to a different, yet similar, population and/or context.<sup>324</sup> In this thesis, for example, I reflected on whether the qualitative findings reporting experiences during the COVID-19 pandemic is transferable to other similar, yet different, contexts.

Sampling is a core contributing factor to achieving generalisability.<sup>322</sup> The degree of generalisability for the quantitative findings in this thesis are strengthened by the inclusion of large representative participant samples. In Chapters Four, Five, and Six, I conducted secondary data analyses using data from the WRAP trial which included a large, representative sample of participants, further strengthening the generalisability of my research findings. However, generalisability in Chapters Four, Five, and Six was limited by the high level of missing data in these studies. Whilst I used statistical approaches (e.g., Multiple Imputation by Chained Equations) to mitigate the impact of missingness where possible, this must be taken into consideration when assessing generalisability. The generalisability of Chapters Four, Five, and Six were further limited by the investigation of one type of behavioural weight management intervention – specifically, WW (formerly Weight Watchers). The WW intervention shares many similarities with other commercial and publicly funded interventions (e.g., group-based, rolling-programme, community-based)<sup>199</sup> which improves the generalisability of the findings. Despite the many similarities between WW and other behavioural weight management interventions, consideration should be taken when interpreting the findings of these chapters. Generalisability

was also limited as individuals were excluded from taking part in the WRAP trial if GP-defined as inappropriate for participation, with one of many reasons including diagnosis of a severe mental health problem. This limits the generalisability of the thesis findings as those with severe mental illness diagnoses were screened out, resulting in findings that likely do not reflect the true range of mental health experiences.

Systematic reviews typically aim to determine the effectiveness of the intervention rather than examining whether the findings would apply to other contexts (i.e., generalisability).<sup>326</sup> As such, it is not common for systematic reviews to provide a critique of the generalisability of the findings. Avellar and colleagues state that assessing the generalisability of review findings "*may be subjective or even arbitrary*".<sup>326</sup> As assessments of generalisability may be subjective, I made efforts within Chapter Two to transparently report information in a detailed manner to support the reader to make their assessment as to whether the findings may apply to their context of interest. There was moderate to high heterogeneity across the included studies in the review; readers should consider this when making subjective assessments of generalisability as they may be unsure as to whether the effects may differ when applied to the setting or conditions of interest.

The degree of transferability for the qualitative findings in this thesis is strengthened by the participant sample included. As previously stated, sampling is an important component when considering generalisability and transferability. The participant sample in Chapter Seven was representative of the large trial sample, and the trial sample was representative of the general population of adults with overweight or obesity attending behavioural weight management interventions. Sandelowski stated that, ultimately, the responsibility is on the reader to make a subjective assessment of the transferability of the findings to the context of interest to them.<sup>327</sup> To support the reader to make this assessment, I have provided rich descriptions and included many quotes. In this way, I hope to improve resonance for the reader to support their subjective assessments of transferability.<sup>328,329</sup> Resonance is defined as a "posture of openness and receptivity toward potential meanings embedded in text".<sup>330</sup> Efforts to increase the degree of transferability were particularly pertinent for the research in this thesis as the qualitative study was conducted during the COVID-19 pandemic. Although the pandemic represents a unique set of circumstances, I believe the findings are transferable to other contexts of high stress and/or reduced access to standard face-to-face resources.

# 8.3.5 Reproducible science

The overarching aim of reproducible science is to progress scientific discovery through greater reliability, credibility, and efficiency of scientific research. This is particularly important in understudied areas to encourage and support further research in the field. Munafò and colleagues published a 'manifesto for reproducible science' in 2017 to support researchers and scientists to improve the reproducibility of their work.<sup>331</sup> The manifesto describes measures, organised by themes, that can be implemented when performing research. The findings in this thesis are strengthened by the implementation of multiple of the manifesto measures.

Firstly, I have minimised the impact of cognitive biases in my research by pre-registering study protocols and producing statistical analysis plans *a-priori*. This is highlighted as a highly effective way to be blinded as the raw data and outcomes are not yet known to you, and thus, cannot influence your decision-making. To improve my methodological training, I have completed rigorous training in statistics and research methods, and I work closely with the department's lead statistician (Stephen Sharp) which has aided my ongoing education in statistics and methods. Working closely with Stephen Sharp, as well as many other experienced researchers, has enabled me to implement the manifesto measure 'involving independent methodological support'. I have sought methodological support from a senior statistician outside of my core team (Stephen Sharp), and input on numerous projects from researchers outside of my institute, such as Dr Carly Hughes (a GP-academic) and Dr Andrew Hill (a psychologist-academic). Furthermore, collaborating with academics external to the University of Cambridge allowed me to implement the manifesto measure 'collaboration and team science'.

To improve the reproducibility of my research, I pre-registered my systematic review protocol on PROSPERO and internally shared the protocols for my quantitative and qualitative studies. I made use of relevant checklists (e.g., PRISMA(-P) for systematic reviews (and review protocols)) to improve the reporting in study protocols and published studies. Additionally, I was transparent in the disclosure of conflicts of interest within this thesis and relevant publications associated with my doctoral research.

The reproducibility of the thesis findings is limited as the data used in chapters has not been openly shared. This is due to the ongoing use of the data by other researchers in the department and ethical approvals not allowing data to be shared without consent. However, it is made known on associated publications that the data source (e.g., WRAP) is available from the trial's principal investigator (Dr Amy Ahern) upon reasonable request.

# 8.3.6 Outcome measurement

In this thesis, I embraced the symptom continuum definition of mental health which appreciates that people can experience one or more symptoms of a mental illness without meeting diagnosis criteria.<sup>23,24</sup> This definition moves away from categorising mental health as a binary entity (e.g., with versus without diagnosed mental illness). This continuum-based definition is associated with reduced stigma and improved attitudes towards mental illness, highlighting the benefits of broadening the definition of mental health.<sup>24,26</sup> This definition also permits the investigation of a larger number of mental health outcomes with greater diversity; for example, symptoms of depression, body image concerns, and stress. Adopting this definition is a key strength of my thesis.

Despite adopting a broad and inclusive definition of mental health, the findings in this thesis are limited by the availability of data on these mental health outcomes. The findings of my systematic review (Chapter Two) highlighted that trials more commonly capture data on mental illness (e.g., depression) than broader mental health outcomes (e.g., stress). This limited my ability to understand how behavioural interventions may impact the different aspects of mental health. This is particularly important as without sufficient data to investigate a comprehensive range of outcomes we cannot be sure as to whether improvements in one domain may be undermined by negative impacts on another. This limitation was echoed in Chapters Four, Five, and Six as the analyses were limited to the mental health outcomes included in the WRAP trial (acting as the data source), where the primary focus was weight change. Participant burden is an important concern when considering adding additional measures to a trial, therefore it is reasonable for the trial to not include a large number of measures. Nevertheless, it is uncommon for behavioural weight management trials to measure and report mental health outcomes. Hence, this thesis is strengthened by the use of a data source with long-term data on multiple mental health measures.

I acknowledge that mental health measures are often self-reported and subjective. Therefore, these measures are subject to potential error and bias, such as recall error and social desirability bias. Additionally, a minimal important difference has not been determined for many of these 191 measures (e.g., HADS). The minimal important difference, also known as the 'clinical relevance of treatment effects', refers to the smallest difference in the outcome that participants perceive to be important and to lead to valuable changes.<sup>213</sup> Despite these limitations, the findings in this thesis are strengthened by the use of valid and reliable scales. For example, the Hospital Anxiety and Depression Scale (HADS)<sup>202</sup> and the EQ5D measure of quality of life.<sup>214</sup> The recent core outcome set for trials of behavioural adult weight management recommends the inclusion of these measures to strengthen the consistency of reporting across trials, highlighting the strength of their inclusion in this thesis.<sup>206</sup>

# 8.3.7 Correlation, causation, and confounding

# 8.3.7.1 Correlation versus causation

Whilst causation refers to one factor causing another, correlation simply refers to a relationship between the factors. In the process of determining causal inference, consistent evidence of an association across a wealth of research must be established.<sup>332,333</sup> Thus, research to identify correlations must precede any attempts to establish causal inferences. As there is currently little existing evidence related to my thesis topic, I did not anticipate establishing definitive evidence of causal relationships. Moreover, I aimed to create evidence to support the establishment of causal relationships in the future.

# 8.3.7.2 Confounding

Confounding refers to factors that are associated with both the outcome and exposures, yet not the causal pathway. The presence of confounding, if not sufficiently uncontrolled, can influence study findings and lead to misleading conclusions.<sup>334–336</sup> The potential impact of confounders can be controlled in study design through randomisation and by using statistical methods.<sup>335</sup>

Randomisation minimises the potential impact of confounders as the randomised groups are comparable for both known and unknown factors. The findings in this thesis are strengthened by the restriction to including data from randomised controlled trials (RCTs) in all quantitative chapters. For example, in Chapter Two, systematic review criteria limited eligible studies to RCTs only, and in Chapters Four, Five, and Six, data from the WRAP randomised controlled trial was used.
Across all quantitative analyses (Chapters Four, Five, and Six), each model has been controlled for known potential confounders. Additionally, where possible, I used mutually adjusted models to allow for the controlling of multiple variables simultaneously. This is a key strength of my thesis as it reduces the likelihood that I drew inaccurate conclusions from my analyses. However, I was restricted by the variables available to control for. In an ideal world, I may have adjusted analyses for weight stigma, however, this outcome was not measured in the original trials. It is important to acknowledge, though, that it is likely not possible to control for all confounders as some will be unknown and/or not possible to measure.<sup>336</sup>

#### 8.3.8 Involvement of patient representatives

The findings in this thesis were greatly strengthened by the involvement of patient representatives throughout various stages of the research process. Patient representatives were directly involved in each Chapter as well as the overall thesis. The importance of patient involvement was recently highlighted in a publication by four self-defined "*fat activists*" where patient involvement was highlighted as an ethical obligation for researchers.<sup>337</sup> The involvement of patient representatives supports research to be patient-centred, ensuring that findings are of most relevance to those at the central focus of the work.<sup>277</sup>

In this thesis, patient representatives were engaged with my research before, during, and after the studies. The involvement of patient representatives in multiple research phases helps to achieve greater partnership working and representation.<sup>338</sup> Before beginning each study, one or more patient representatives informed the relevance of the research aims, as well as informing the design of the research (e.g., suggesting sub-group analyses of importance). For example, the research question addressed in Chapter Four was informed by a patient representative when discussing the findings of Chapter Two. A representative questioned if the systematic review findings (Chapter Two) were reliable if participants did not attend the intervention or study visits due to their mental health, and as a result, Chapter Four was designed to explore this. Patient representatives were involved in the data analysis for one study (Chapter Seven) and in the data interpretation for all studies. For example, a patient representative shared their perspectives on why mental health may influence intervention attendance, which informed my interpretation of Chapter Four's findings. After the study, representatives informed the research dissemination plans and advised on the research implications. For example, patient representations reviewed public-facing materials and advised where text could be difficult to understand. The involvement of patient representatives has resulted in the co-authorship of two papers (Chapters Four and Seven). Working with patient representatives has been a key factor in my development as a researcher and in the production of meaningful research within this thesis. I believe that the involvement of patient representations is a key strength of this thesis.

#### 8.3.9 Thesis adaptations in response to the pandemic

My original thesis plans involved a large-scale multilevel qualitative study that aimed to evaluate participant and providers experiences of community weight management interventions. I planned this project for approximately 10 months, leading to a meeting with the NHS ethics board on 16<sup>th</sup> March 2020 to discuss ethical approval for the study. The study was to form three major chapters of my thesis and relied on the usual delivery of weight management services in the community. However, the COVID-19 pandemic resulted in a national lockdown beginning on 16<sup>th</sup> March 2020, approximately 1 hour after the NHS ethics meeting. The national lockdown resulted in the closure or suspension of weight management services, and the lack of services meant it was no longer possible to conduct this study. The resultant loss of this project had a large impact on my PhD progress.

I made substantial efforts to adjust and adapt my thesis plans to mitigate the impact of the pandemic on my research. I have made use of existing data to conduct secondary data analyses (Chapters Three, Four, Five, and Six), reducing the risk of data loss due to the pandemic. I also contributed to the development and implementation of a COVID-19 tailored behavioural weight management intervention (SWiM-C) and planned a replacement thesis chapter that qualitatively evaluated this intervention (Chapter Seven). Despite adapting my thesis plans, I experienced a large amount of research loss due to the pandemic. This included valuable time conducting research, but also applied to the study documents I had created that could no longer be used (e.g., study rationale and methods, invite letters, interview schedules, support documents, marketing materials, budgeting plans, etc). I had also received approval for funding to support this study; as the study could no longer be conducted, I then wrote and submitted an amendment application to request to have funding transferred to an alternative study (i.e., Chapter Seven). I completed a substantial amount of work to mitigate the impact, resulting in a thesis that has made original contributions to the field of obesity.

### 8.4 Concluding remarks

Through the employment of review-, quantitative-, and qualitative methods, I investigated the role of participant mental health in behavioural weight management interventions. My thesis findings have made three main contributions towards understanding the role of mental health in behavioural weight management interventions.

Firstly, my thesis findings suggest that, on average, behavioural weight management interventions appear to have a positive impact or no impact on mental. However, a proportion of participants do experience a decline in their mental health, and these appear to be those beginning the intervention with poorer mental health. Secondly, my thesis findings suggest that there may be a bidirectional relationship between intervention attendance/engagement and participant mental health, where diminishment in one exacerbates the decline in the other. Finally, thesis findings suggest that results from trials of behavioural weight management interventions may be biased to those who are most mentally healthy at the beginning of the trial.

I have made contributions towards the limited existing literature exploring how behavioural weight management interventions may impact participant mental health, and the potential mechanisms of action. The thesis findings demonstrate a need for greater research into the role of mental health in behavioural weight management interventions. Specifically, greater research on i) the impact of interventions on mental health, ii) the mechanisms by which this impact may occur, iii) and approaches to better support participant mental health during weight management efforts would be of value.

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## **APPENDICES**

### A2. Appendices for Chapter Two

### A2.1 Systematic review protocol

Impact of adult weight management interventions on mental health: a systematic review and meta-analysis protocol

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### Abstract

Introduction: The effects of interventions targeting weight loss on physical health are well described, yet the evidence for mental health is less clear. It is essential to better understand the impact of weight management interventions on mental health to optimise care and minimise risk of harm. We will assess the effect of behavioural weight management interventions on mental health in adults with overweight and obesity.

Methods and analysis: The systematic review will follow the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidance. We will include behavioural weight management interventions with a diet and/or physical activity component focusing on weight loss for adults with a body mass index  $\geq$ 25 kg/m<sup>2</sup>. Randomised controlled trials (RCTs) and cluster RCTs will be the only eligible study designs. Outcomes of interest will be related to mental health. The following databases were searched from inception to 07 May 2019: MEDLINE, Embase, Cochrane database (CENTRAL), PsycINFO, ASSIA, AMED and CINAHL. The search strategy was based on four concepts: (1) adults, defined as  $\geq$ 18 years, with overweight/obesity, defined as BMI  $\geq$ 25kg/m<sup>2</sup>, (2) weight management interventions, (3) mental health outcomes and (4) study design. The search was restricted to English-language published papers, with no other restrictions
applied. Two stage screening for eligibility will be completed by two independent reviewers, with two independent reviewers completing data extraction and risk of bias assessment. Data permitting, a random-effects meta-analysis of outcomes, subgroup analyses and meta-regression will be conducted. If not appropriate, narrative synthesis and 'levels of evidence' assessment will be completed.

Ethics and dissemination: Ethical approval is not required as primary data will not be collected. The completed systematic review will be disseminated in a peer-reviewed journal, at conferences and contribute towards the lead author's PhD thesis.

PROSPERO registration number CRD42019131659.

### Strengths and limitations of this study

- The systematic review and meta-analysis will include only randomised controlled trials, offering the highest level of evidence.
- A broad array of mental health outcomes, including mood, stress and depression, will be included in the review.
- A comprehensive search strategy will be used in a large number of databases to maximise the identification of all eligible studies.
- Data permitting, subgroup analysis will be conducted to identify intervention or participant characteristics associated with increased effectiveness.
- High heterogeneity is anticipated across studies, which may increase the difficulties in interpreting a meta-analysis.

## Introduction

### <u>Rationale</u>

Overweight and obesity are strongly associated with reduced physical health, including a greater risk of cardiovascular disease, type 2 diabetes, stroke and some cancers (including endometrial, oesophageal and kidney cancer).<sup>1-3</sup> Consequently, individuals with overweight and obesity

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experience greater all-cause mortality and reduced health-related quality of life.<sup>4.5</sup> Research reports a bidirectional association between obesity and mental health, with those with overweight and obese more likely to have poor mental health and those with mental ill health at greater risk of weight gain, and consequently, obesity.<sup>6-10</sup> Many researchers have reported improvements in mental health outcomes with weight loss,<sup>11-15</sup> however, there has been concern expressed that weight management interventions advocating dietary restriction may contribute to disordered eating and worsen mental health.<sup>1617</sup> It is essential to better understand the impact of weight management interventions on mental health to optimise care and minimise risk of harm.

Research investigating the relationship between obesity and mental health is increasingly considering mental health as a symptom continuum. The symptom continuum appreciates that individuals can experience one or more symptoms of mental illness without meeting diagnostic criteria for mental illness.<sup>18 19</sup> Considering mental health as a continuum is associated with reduced stigma and improved attitudes towards mental health, highlighting the benefits of broadening the definition of mental health.<sup>19 20</sup> This review will embrace a continuum-based definition of mental health allowing the investigation of a broader range of outcomes from stress, self-esteem and affect, to symptoms of clinically diagnosed disorders, such as depression and anxiety.

While there is clear evidence that weight loss interventions improve physical health, the evidence that they enhance mental health is less clear. Some studies suggest that a focus on weight control can increase stigma and exacerbate symptoms of psychological distress,<sup>21</sup> particularly if goals are not met or if other aspects of life do not change with weight loss.<sup>22</sup> Qualitative research has suggested that there is inadequate support for mental health in obesity management interventions,<sup>23</sup> and a systematic review published in 2014 concluded that weight loss may be associated with improved physical health, but not mental health.<sup>24</sup> Conversely, Fabricatore et al's review found statistically significant reductions in depressive symptoms with intentional weight loss trials, although it reported no relationship between weight change and depression,<sup>9</sup> and Lasikiewicz et al's review reported weight management interventions to be associated with improvements in multiple mental health outcomes including self-esteem, body image, quality of life and depressive symptoms.<sup>25</sup>

Previous reviews highlight the breadth of mental health outcomes that could be affected by participation in weight management programmes. However, the majority of reviews focus on a limited range of outcomes, <sup>9 16 24–28</sup> and the direction of effects is inconsistent across different outcomes and reviews. It is important to generate a comprehensive understanding of the impact of weight management programmes on mental health as the benefits of improvements in one domain may be undermined by negative impacts on other domains. Previous reviews have also excluded participants with any concurrent disease or clinical psychopathology to constrain the search or to exclude illnesses associated with unintentional weight changes.<sup>16 29</sup> However, it is uncommon for an individual with overweight or obesity to be without any concurrent disease or clinical psychopathology due to the greatly increased risk of a wide range of comorbidities,<sup>8</sup> therefore, exclusion of these participants with comorbid conditions where possible to maximise the generalisability of review findings.

To our knowledge, there is no up-to-date, comprehensive review investigating the effect of weight management interventions on a broad range of mental health outcomes in a representative sample of adults with overweight and obesity. Furthermore, no review has investigated the intervention components most supportive of mental health improvements. Understanding whether specific intervention components, such as psychological support, can attenuate the possible adverse effects to mental health is important for the development of future interventions. If data allows, this systematic review will apply subgroup analyses and meta-regression techniques to explore the differential effects of intervention or participant characteristics on mental health.

The conflicting findings of previous research and the absence of an up-to-date evaluation of the impact of weight loss interventions on mental health make it difficult to draw clear, reliable conclusions. A comprehensive updated review should increase understanding of the impact of weight management interventions on mental health. The most effective combination of intervention components should be investigated to facilitate improved decision making in intervention development, aiding the creation of an effective and supportive 'whole-person' intervention.

### **Objectives**

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To assess the effectiveness of behavioural weight management interventions compared with minimal, inactive or 'standard care' control groups on mental health in adults with overweight and obesity.

Primary objective: (1) Quantify the effect of behavioural weight management interventions on mental health in adults with overweight and obesity.

Secondary objective: (2) Quantify if particular intervention or participant characteristics influence the effect of interventions on mental health.

# Methods and analysis

This systematic review protocol adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols (PRISMA-P). <sup>30</sup>

# Eligibility criteria

Studies will be selected according to the criteria outlined below:

*Study designs:* Original peer-reviewed primary research articles reporting randomised controlled trials (RCTs) or cluster RCTs will be included. No restrictions will be placed on year of publication.

*Participants:* Participants will be included if they are community-dwelling adults ( $\geq$ 18 years old with no upper age limit applied) with overweight or obesity (body mass index  $\geq$ 25 kg/m<sup>2</sup>) at baseline. Studies that include participants both under and over the age of 18 years will only be included if the data for participants 18 years and older is reported separately. Participants must be seeking intentional weight loss through a behavioural programme. No restrictions will be made on participant demographics. To increase the generalisability of the findings to the general population with overweight and obesity, we will include studies that include people with comorbidities, but we will exclude papers that focus exclusively on populations with a physical or mental comorbidity (e.g., all participants have cancer), or pregnant women.

*Interventions:* Studies will be included if they evaluated a behavioural weight management intervention that aims to achieve weight loss through changes in diet and/or physical activity. No restriction will be placed on intervention delivery duration, delivery format or on who delivers

the intervention. Any study with multiple intervention arms will be included if at least one arm meets the inclusion criteria and separate results are presented for this arm. Interventions aiming to treat eating disorders or involving surgical and/or pharmacological intervention will be excluded.

Comparators: Studies with a minimal/inactive/standard care control group will be included.

*Outcomes:* Included studies are required to have measures of one or more of the following outcomes: quality of life; mood/affect; stress; self-esteem; body image; emotional eating; binge eating; depression; anxiety. These a priori defined outcomes were chosen as they were deemed to be the most relevant and frequently used in previous relevant literature.

*Timing:* Defined outcomes must be measured and reported at preintervention and at minimum one follow-up point to be eligible for inclusion. The follow-up measurements closest to the time of intervention completion will be extracted for analysis to focus on the immediate intervention effects.

Settings: Only studies involving participants living in community-based settings will be included.

*Language:* Studies published in English language will be included. Non-English language publications will be excluded.

## Information sources and search strategy

The following databases were searched from inception to 7 May 2019:

- AMED.
- ASSIA.
- CINAHL.
- Cochrane database (CENTRAL).
- Embase.
- MEDLINE.
- PsycINFO.

Detailed search strategies for each electronic database were developed by RAJ, who has previous experience of conducting systematic reviews, with input from ERL, ALA and a medical librarian. The search strategy contains relevant key words and headings based on previous review articles<sup>25</sup> 31-34 and is based on the concepts: (1) adults with overweight/obesity AND (2) weight management interventions AND (3) mental health outcomes AND (4) study designs. Terms were adapted from the MEDLINE search accordingly for each database (<u>online supplementary B</u>). The search was restricted to English-language papers, with no other restrictions applied. The search strategy was validated through consultation with the systematic review team.

## Other resource searches

To augment the results of the database search, the reference lists of included studies and previous relevant reviews will be searched.<sup>9 16 24–27 29</sup>

## Study records

### Data management and selection process

The search results were imported into Covidence systematic review software (Veritas Health Innovation, Melbourne, Australia), and duplications removed. Two researchers initially pilot screened an identical 500 articles to ensure consistency. Any discrepancies in the interpretation of the eligibility criteria were discussed between investigators, with a third reviewer assisting where necessary. On completion of pilot screening, the remaining title and abstracts will be independently screened for inclusion by two authors. The full text of articles identified as potentially relevant will be obtained and dually screened according to the eligibility criteria to ascertain the studies to be included in the review. Eligibility will be discussed for consensus between the two investigators, with a third investigator resolving discrepancies when required. Where necessary, we will seek additional information from study authors to resolve any questions about eligibility. Reasons for exclusion of articles at the full-text screening stage will be recorded. Reviewers will not be blinded to authors, institution or journal when screening articles. Where studies are reported in more than one publication, all articles will be included and combined to make best use of the data. A PRISMA flow chart will be reported to show the process of study selection.<sup>30</sup>

### Data collection process

Studies meeting the inclusion criteria will have pertinent data extracted using a data extraction form. The data extraction form will be based on the Cochrane data extraction form (2011),<sup>35</sup> the Consolidated Standards of Reporting Trials statement (2010)<sup>36</sup> and the Cochrane Template for Intervention Description and Replication<sup>37</sup> to ensure breadth and detail will be captured. The data extraction form will be pilot tested by two investigators on three studies to identify missing or superfluous data items. Independent data extraction will be completed by one investigator with full checking by a minimum of one further investigator. Discrepancies will be resolved through discussion, with use of a third investigator where necessary.

### Data items

Data to be extracted will include:

- General information (e.g., study authors, publication year, country, funding source).
- Study details (e.g., study aim, study design, randomisation method, blinding and allocation concealment).
- Participant information (e.g., demographics, recruitment methods, sample size, comorbidities).
- Attrition/adherence (e.g., total number of participants at baseline and follow-up measurements, differential attrition, attendance, study withdrawal, lost to follow-up).
- Intervention information (e.g., setting, content, intervention duration and frequency, profession delivering the intervention, method of delivery, group or individual delivery).
- Comparator information (e.g., setting, content, intervention duration and frequency, profession delivering the intervention, method of delivery, group or individual delivery).

• Outcomes (e.g., mental health outcome(s) studied, whether self-reported or objectively measured, duration of follow-up, statistical analysis, intervention effect sizes).

If a study has multiple arms, data from any arm meeting the inclusion criteria will be extracted where possible. Study authors will be contacted if there are uncertainties regarding the study or missing data.

# Outcomes and prioritisation

For all outcomes, prioritisation will be given to units reported as raw data at baseline and postintervention over data presented as 'mean change' or equivalent. Where possible, data items will be extracted at both study and group level to permit analysis of overall and stratified data (e.g., extracting stratified data to analyse moderation by sex). Study authors will be contacted to request any data required that is not available.

# Risk of bias in individual studies

Risk of bias (RoB) will be independently appraised by a minimum of two review authors. Discrepancies will be discussed between authors for a consensus and a third investigator will be consulted where required.

The Cochrane 'RoB' tool will be used to assess the RoB in the included studies.<sup>38</sup> The tool assesses the following study features as 'low risk', 'high risk' or 'unclear': (1) random sequence generation, (2) allocation concealment, (3) blinding of participants and personnel, (4) blinding of outcome assessment, (5) incomplete outcome data and (6) selective reporting.

Other potential sources of bias not covered by the tool will be noted by review authors. Review authors will not be blinded to the included study's information (author names, journal of publication, affiliated institute). A RoB graph and summary table will be presented.

## Data synthesis

When the data permits, outcome data will be synthesised using a random-effects meta-analysis (Review Manager V.5.3, Cochrane Collaboration) due to the predicted diverse range of population and intervention types. Meta-analysis will be conducted on the outcome measures reported closest to the time of intervention completion, regardless of intervention duration, to focus analysis on the immediate intervention effects.

As it is likely a range of outcome measures will be identified, standardised mean difference (SMD) will be calculated. SMD will be categorised using thresholds as small (0.2), medium (0.5) and large (0.8).<sup>39</sup> Where possible, mean differences (for continuous data) and OR (for categorical data) and their 95% CIs will be calculated and reported.

## Sensitivity analysis

If considered useful after consultation with the review team, sensitivity analysis will be conducted to investigate the potential impact of RoB and participant characteristics on the effect estimates. The analysis will be restricted to different RoB levels to assess if study quality influences the effect estimates.

## Assessment of heterogeneity and reporting bias

Heterogeneity will be assessed using the  $I^2$  statistic (and 95% CI). Heterogeneity will be categorised as low (0%–30%), moderate (30%–60%), substantial (60%–90%) and considerable (90%–100%).<sup>40</sup> In accordance with Cochrane recommendations, a funnel plot will be reported to assess the presence of publication bias.

# Analysis of subgroups or subsets

In the presence of sufficient data, subgroup analysis will compare:

- Population characteristics (e.g., existing comorbidities, age, gender, degree of excess weight (overweight vs obese)).
- Intervention type (e.g., diet vs exercise vs diet and exercise combination, including vs excluding psychological therapies).

- Intervention duration (e.g., 1 day, 12 weeks, 52 weeks).
- Intervention delivery format (e.g., face to face vs remote, individual vs group-based).
- Comparator type (e.g., intensities of comparator (minimal/inactive/standard care)).

If considered useful after consultation with the review team and in the presence of sufficient data on important covariates, meta-regression techniques will be applied to identify and/or adjust for potential sources of heterogeneity.

# Narrative synthesis

Meta-analysis will be deemed inappropriate if significant heterogeneity is present or if we are unable to pool the outcomes. If meta-analysis is not possible, narrative synthesis and 'levels of evidence' assessment will be completed. This will be provided in the text and in a table format.

A ratings system, 'levels of evidence', will be used to draw conclusions of effectiveness. This will assess confidence in cumulative evidence at an outcome level. This is based on the methods applied by a previous review paper,<sup>41</sup> and is modified for the synthesis of RCTs only (<u>online supplementary C</u>). Included studies will be assessed on the level of evidence according to study quality and sample size. There are five possible levels of evidence ratings that can be achieved— strong, moderate, limited, inconclusive and no evidence for effect. Consistent positive findings in at least two thirds of studies is required to achieve 'strong', 'moderate' or 'limited' levels of evidence. In stratified analysis, we will assess study's levels of evidence according to intervention, participant or study characteristics. If meta-analysis is deemed inappropriate, we will graphically summarise the findings using harvest plots of extracted data.<sup>42</sup>

# Patient and public involvement

A lay summary of the proposed plan for the systematic review was shared with an established patient and public involvement (PPI) panel. The PPI panel gave feedback on the usefulness and relevance of the review aims and included outcomes. On review completion, the PPI panel will provide input on the lay summary of review findings and dissemination of findings.

**Ethics and dissemination:** This systematic review will follow the PRISMA checklist. The completed systematic review will be disseminated in a peer-reviewed journal, at conferences and contribute towards the lead author's PhD thesis. The findings of the review will be of interest to participants of interventions, healthcare practitioners, policy-makers and researchers.

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**Contributors** RAJ conceived the study, designed the study, developed the initial search strategy and was responsible for drafting the manuscript. ALA conceived the study, participated in study design, development of the search strategy and reviewed drafts of the manuscript. ERL participated in study design, development of the search strategy and reviewed drafts of the manuscript. EMFvS and SJG contributed to the design of the study and reviewed drafts of the manuscript. All authors critically reviewed the manuscript and approved the final version submitted for publication.

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Competing interests None declared.

Patient consent for publication Not required.

Ethics approval Ethical approval is not required as primary data will not be collected.

Provenance and peer review Not commissioned; externally peer reviewed.

# A2.2 Search strategy

Table A1. Search strategy (Medline)

| (1)          | exp Overweight/ or exp Obesity/ or (adipos* or obes* or over?weight).tw          |
|--------------|--|
| Participants |  |
| (2)          | exp Body Weight/ or exp Life Style/ or exp Physical Activity/ or exp Obesity     |
| Weight       | Management/ or exp Diet Therapy/ or exp Exercise/ or exp Diet/ or exp            |
| management   | Behavior Therapy/ or exp Health Education/ or ((weight adj3 (body or chang*      |
| intervention | or los* or maint* or manage* or control* or reduc*)) or (body?mass?index or      |
|              | bmi) or (body adj3 mass) or life?style or (diet* or nutrition*) or (physic* adj3 |
|              | (activ* or fit*)) or exercis* or (obes* adj3 (intervention or program* or camp*  |
|              | or treat*)) or (behavio?r* or psych*)).tw  |
| (3)          | exp Behavioral Symptoms/ or exp Emotions/ or exp Mental Disorders/ or exp        |
| Mental       | Adaptation, Psychological/ or exp Mental Health/ or exp Quality of Life/ or exp  |
| health       | Self Concept/ OR (depress* or anxiet* or well?being or (quality?of?life or qol   |
| outcomes     | or health?status) or (affect* or mood*) or (health?related?quality?of?life or    |
|              | hrqol) or emotion* or (mental adj3 (health or well?being)) or (psych* adj3       |
|              | (well?being or health)) or self?esteem or self?image or body?image or stress*    |
|              | or (emot* adj3 eating) or binge?eating).tw                                       |
| (4)          | exp Randomized Controlled Trials as Topic/ or randomized controlled trial.pt     |
| Study design | or controlled clinical trial.mp or randomi?ed.mp or randomly.mp or trial.mp      |
| (5)          | 1 AND 2 AND 3 AND 4  |
|              | Limited to English-language results  |

# A2.3 Characteristics of included studies

# Table A2. Characteristics of included studies

| Study        | Methods                    | Participant characteristics             | Relevant intervention and           | Relevant outcomes and           |
|--------------|----------------------------|---|-------------------------------------|---------------------------------|
| reference    |                            |   | comparators                         | timepoints                      |
| Ahern et al. | Study design:              | Intervention group(s):                  | Intervention groups:                | Outcome definition:             |
| (2017)       | RCT                        | 12-week behavioural weight-loss         | 12-week behavioural weight-loss     | • Quality of life: EuroQol 5-   |
|              |                            | programme (n=530)                       | programme                           | dimension 3-level questionnaire |
|              | <u>Country (locality):</u> | Age: mean 53.6 years (±13.3)            | 12-weekly group-based, face-to-     | (EQ5D-3L)                       |
|              | United Kingdom             | BMI: mean 34.7 kg/m <sup>2</sup> (±5.4) | face WW meetings with digital tools | • Satisfaction with life:       |
|              | (UK)                       | Sex/gender: 68% female.                 | to supplement, with non-specialist  | Satisfaction with Life          |
|              |                            | Race/ethnicity: 2%Asian or Asian        | providers.                          | Questionnaire (SLQ)             |
|              | <u>Setting:</u>            | British, 2% Black or black British,     |                                     | • Depression and anxiety:       |
|              | Recruited from 23          | 1% Mixed or multiple ethnic             | 52-week behavioural weight-loss     | Hospital Anxiety and Depression |
|              | primary care               | group, 91% White or white British,      | programme                           | Scale (HADS)                    |
|              | practices in               | 1% Other, 3% Missing or prefer          | 52-weekly group-based, face-to-     |                                 |
|              | England into a             | not to say.                             | face WW meetings with digital tools | Relevant timepoints:            |
|              | community based            |   | to supplement, with non-specialist  | Baseline, 3-months, 12-months.  |
|              | commercial                 |   | providers.                          |                                 |

| programme        | 52-week behavioural weight-loss         |                                  |  |
|------------------|---|----------------------------------|--|
| (Weight Watchers | programme (n=528)                       | <u>Control group:</u>            |  |
| (WW)).           | Age: mean 53.3 years (±14.1)            | Brief intervention               |  |
|                  | BMI: mean 34.5 kg/m <sup>2</sup> (±5.1) | Provided 32-page printed booklet |  |
|                  | Sex/gender: 68% female.                 | on self-help weight management   |  |
|                  | Race/ethnicity: 3%Asian or Asian        | strategies.                      |  |
|                  | British, 1% Black or black British,     |                                  |  |
|                  | 1% Mixed or multiple ethnic             |                                  |  |
|                  | group, 90% White or white British,      |                                  |  |
|                  | 1% Other, 3% Missing or prefer          |                                  |  |
|                  | not to say.                             |                                  |  |
|                  |   |                                  |  |
|                  | <u>Control group:</u>                   |                                  |  |
|                  | Brief intervention (n=211)              |                                  |  |
|                  | Age: mean 51.9 years (±14.1)            |                                  |  |
|                  | BMI: mean 34.4 kg/m <sup>2</sup> (±4.1) |                                  |  |
|                  | Sex/gender: 68% female.                 |                                  |  |
|                  | Race/ethnicity: 4% Asian or Asian       |                                  |  |
|                  | British, 2% Black or black British,     |                                  |  |
|                  | 2% Mixed or multiple ethnic             |                                  |  |

|                |                            | group, 86% White or white British,      |  |                              |
|----------------|----------------------------|---|--|------------------------------|
|                |                            | 1% Other, 5% Missing or prefer          |  |                              |
|                |                            | not to say.                             |  |                              |
| Alfaris et al. | Study design:              | Intervention group:                     | Intervention group:                    | Outcome definition:          |
| (2015)         | RCT                        | Brief Lifestyle Counselling (n=131)     | Brief Lifestyle Counselling            | • Depression: Patient Health |
|                |                            | Age: mean 52 years (±12.2)              | 24-month individual, face-to-face      | Questionnaire (PHQ-8)        |
|                | <u>Country (locality):</u> | BMI: mean 38.5 kg/m <sup>2</sup> (±4.6) | intervention with quarterly visits     |                              |
|                | United States of           | Sex/gender: 84% female.                 | with primary care provider to review   | Relevant timepoints:         |
|                | America (USA)              | Race/ethnicity: 57.3% White,            | health status. Given pedometer,        | Baseline, 24-months.         |
|                |                            | 39.7% African American, 3.1%            | calorie counting book, and             |                              |
|                | <u>Setting:</u>            | more than one race.                     | educational handouts. Monthly          |                              |
|                | 6 primary care             | 95.4% self-reported Hispanic.           | visits with lifestyle coach for        |                              |
|                | practices in the           |   | behavioural counselling following      |                              |
|                | University of              | Control group:                          | abbreviated lessons from Diabetes      |                              |
|                | Pennsylvania               | Usual care (n=130)                      | Prevention Programme (DPP). All        |                              |
|                | Health System,             | Age: mean 51.7 years (±12.1)            | participants were prescribed the       |                              |
|                | owned by Penn              | BMI: mean 39 kg/m² (±4.8)               | same diet and physical activity goals. |                              |
|                | Medicine - 3 urban         | Sex/gender: 75.4% female.               |  |                              |
|                | sites and 3                |   |  |                              |
|                | suburban sites             |   | <u>Control group:</u>                  |                              |

|            | serving racially and       | Race/ethnicity: 62.3% White,            | Usual care                           |                                    |
|------------|----------------------------|---|--------------------------------------|------------------------------------|
|            | economically               | 35.4% African American., 1.5%           | 24-month individual, face-to-face    |                                    |
|            | diverse                    | Asian, 0.8% more than one race.         | intervention with brief quarterly    |                                    |
|            | populations.               | 95.4% self-reported Hispanic.           | visits with primary care provider to |                                    |
|            |                            |   | review health status. Given          |                                    |
|            |                            |   | pedometer, calorie counting book,    |                                    |
|            |                            |   | and educational handouts.            |                                    |
| Ash et al. | Study design:              | Intervention group:                     | Intervention group:                  | Outcome definition:                |
| (2006)     | RCT                        | Fat Boosters Incorporated (FBI)         | Fat Boosters Incorporated (FBI)      | • Satisfaction with life:          |
|            |                            | (n=62)                                  | 8-week group-based, face-to-face     | Satisfaction with Life Scale (SWL) |
|            | <u>Country (locality):</u> | Age: mean 49 years (±13)                | intervention with weekly 1.5-hour    | • Self efficacy: General Self-     |
|            | Australia.                 | BMI: mean 33.7 kg/m² (±4.6)             | sessions for 6 weeks, with a follow- | Efficacy Scale (GSES)              |
|            |                            | Sex/gender: 66.7% female.               | up session at week 8. Sessions were  |                                    |
|            | <u>Setting:</u>            | Race/ethnicity: NR.                     | conducted by dieticians and          | Relevant follow-up timepoints:     |
|            | Hospital outpatient        |   | nutrition staff and focused on       | Baseline, 6 months.                |
|            | service at two             | Individualised dietetic treatment       | knowledge and skill development,     |                                    |
|            | tertiary hospitals         | (IDT) (n=66)                            | cognitive behavioural therapy, and   |                                    |
|            | (public and                | Age: mean 48 years (±13)                | relapse prevention. Monthly follow-  |                                    |
|            | private).                  | BMI: mean 34.2 kg/m <sup>2</sup> (±5.9) | up visits from week 8 to 6 months.   |                                    |
|            |                            | Sex/gender: 75.4% female.               | Participants purchased nutrition     |                                    |

| Race/ethnicity: NR.          | resource booklet based on cognitive |  |
|------------------------------|-------------------------------------|--|
|                              | behaviour therapy principles.       |  |
| <u>Control group:</u>        |                                     |  |
| Information booklet only (B) | Individualised dietetic treatment   |  |
| (n=63)                       | (IDT)                               |  |
| Age: mean 47 years (±14)     | 8-week face-to-face intervention    |  |
| BMI: mean 35.8 kg/m² (±6.2)  | with individualised weekly contact  |  |
| Sex/gender: 77.8% female.    | with dietician for dietary and      |  |
| Race/ethnicity: NR.          | exercise prescription. Attended     |  |
|                              | monthly follow-up visits from week  |  |
|                              | 8 to 6 months. Participants         |  |
|                              | purchased nutrition resource        |  |
|                              | booklet based on cognitive          |  |
|                              | behaviour therapy principles.       |  |
|                              |                                     |  |
|                              | <u>Control group:</u>               |  |
|                              | Information booklet only            |  |
|                              | Participants purchased nutrition    |  |
|                              | resource booklet based on cognitive |  |
|                              | behaviour therapy principles.       |  |

| Astbury et al. | Study design:              | Intervention group:                     | Intervention group:                  | Outcome definition:                  |
|----------------|----------------------------|---|--------------------------------------|--------------------------------------|
| (2018)         | RCT                        | Total Diet Replacement (TDR)            | Total Diet Replacement (TDR)         | Quality of life: EuroQol 5-          |
|                |                            | (n=138)                                 | 12-weekly individual, face-to-face   | dimension (EQ5D) questionnaire       |
|                | <u>Country (locality):</u> | Age: mean 48.2 years (±11.5)            | counsellor support to follow a total | • Quality of life – Obesity-related: |
|                | United Kingdom             | BMI: mean 37.6 kg/m² (±5.7)             | diet replacement, with 8 weeks of    | Obesity and Weight Loss Quality      |
|                | (UK)                       | Sex/gender: 60.5% female.               | TDR and 4 weeks of food re-          | of Life (OWL-QOL)                    |
|                |                            | Race/ethnicity: 90% White British,      | introduction, followed by monthly    |                                      |
|                | <u>Setting:</u>            | 10% Non-white British.                  | counsellor appointments up until 24  | Relevant follow-up timepoints:       |
|                | 10 primary care            |   | weeks. Intervention providers were   | Baseline, 6 months.                  |
|                | practices,                 | Control group:                          | Cambridge Weight Plan UK local       |                                      |
|                | Oxfordshire.               | Usual care (n=140)                      | counsellors.                         |                                      |
|                |                            | Age: mean 47.4 years (±12.8)            |                                      |                                      |
|                |                            | BMI: mean 36.8 kg/m <sup>2</sup> (±5.1) | Control group:                       |                                      |
|                |                            | Sex/gender: 60% female.                 | Usual care                           |                                      |
|                |                            | Race/ethnicity: 86% White British,      | Weight loss booklet and series of    |                                      |
|                |                            | 14% Non-white British.                  | individual, face-to-face             |                                      |
|                |                            |   | appointments with practice nurse     |                                      |
|                |                            |   | for weight management advice.        |                                      |
|                |                            |   | Timing of appointments was           |                                      |

|               |                            |   | dependent each practice's usual       |                                |
|---------------|----------------------------|---|---------------------------------------|--------------------------------|
|               |                            |   | protocol.                             |                                |
| Barnes et al. | Study design:              | Intervention group:                       | Intervention group:                   | Outcome definition:            |
| (2014)        | RCT                        | Motivational Interviewing and             | Motivational Interviewing and         | Depression: Beck Depression    |
|               |                            | Internet Condition (MIC) (n=30)           | Internet Condition (MIC)              | Inventory (BDI)                |
|               | <u>Country (locality):</u> | Age: mean 47.07 years (±9.97)             | 12-week intervention with 5           |                                |
|               | United States of           | BMI: mean 34.65 kg/m <sup>2</sup> (±7.06) | manualised, individual, face-to-      | Relevant follow-up timepoints: |
|               | America (USA)              | Sex/gender: 80% female.                   | face/telephone motivational           | Baseline, 12 weeks.            |
|               |                            | Race/ethnicity: 63% White, not            | interviewing (MI) sessions focusing   |                                |
|               | <u>Setting:</u>            | Hispanic; 27% African American;           | on weight loss. Participants used     |                                |
|               | Primary care               | 3% Bi-/multiracial; 7% Bi-                | Livestrong website to track food,     |                                |
|               | services at an urban       | /multiracial, Hispanic.                   | exercise and weight, with             |                                |
|               | university-based           |   | personalised feedback at sessions     |                                |
|               | medical healthcare         | Control groups:                           | based on inputted data. MI sessions   |                                |
|               | centre.                    | Nutrition Psychoeducation and             | provided by Medical Assistant         |                                |
|               |                            | Internet Condition (NPC) (n=29)           | Clinicians, who received training and |                                |
|               |                            | Age: mean 48.93 years (±11.95)            | supervision.                          |                                |
|               |                            | BMI: mean 35.07 kg/m <sup>2</sup> (±7.52) |                                       |                                |
|               |                            | Sex/gender: 69% female.                   | Control groups:                       |                                |
|               |                            |   | Usual care                            |                                |

|              |                            | Race/ethnicity: 69% White, not     | Asked to continue usual care with     |                                    |
|--------------|----------------------------|------------------------------------|---------------------------------------|------------------------------------|
|              |                            | Hispanic; 7% Hispanic; 10% African | primary care provider. No             |                                    |
|              |                            | American; 10% Bi-/multiracial; 3%  | intervention given.                   |                                    |
|              |                            | Bi-/multiracial, Hispanic.         |                                       |                                    |
|              |                            |                                    |                                       |                                    |
|              |                            | Usual care (n=30)                  |                                       |                                    |
|              |                            | Age: mean 47.77 years (±10.05)     |                                       |                                    |
|              |                            | BMI: mean 36.08 kg/m² (±6.44)      |                                       |                                    |
|              |                            | Sex/gender: 80% female.            |                                       |                                    |
|              |                            | Race/ethnicity: 63% White, not     |                                       |                                    |
|              |                            | Hispanic; 7% Hispanic; 23% African |                                       |                                    |
|              |                            | American; 3% Bi-/multiracial; 3%   |                                       |                                    |
|              |                            | Bi-/multiracial, Hispanic.         |                                       |                                    |
| Berry et al. | Study design:              | Intervention group:                | Intervention group:                   | Outcome definition:                |
| (2011)       | RCT                        | Experimental group (n=28)          | Experimental group                    | Stress: Health Promoting           |
|              |                            | Age: NR.                           | 12-weekly group-based, face-to-       | Lifestyle Profile II (HPLP II)     |
|              | <u>Country (locality):</u> | BMI: mean 32 kg/m² (±6.9)          | face 1hr sessions teaching nutrition, | subscale                           |
|              | United States of           | Sex/gender: NR.                    | exercise and coping skills, followed  | • Exercise self-efficacy: Exercise |
|              | America (USA)              | Race/ethnicity: NR.                | by 45-minute exercise class.          | Self-Efficacy Scale                |
|              |                            |                                    | Participants received a pedometer     |                                    |

|                | Setting:                   | Control group:                        | and were encouraged to walk most      | • Diet self-efficacy: Eating Self-   |
|----------------|----------------------------|---------------------------------------|---------------------------------------|--------------------------------------|
|                | Community centres          | Wait-list control (n=28)              | days a week and record steps in a     | Efficacy Scale                       |
|                | and churches               | Age: NR.                              | logbook. Providers were research      |                                      |
|                | serving Mexican            | BMI: mean 32 kg/m <sup>2</sup> (±5.2) | assistants and Spanish community      | Relevant follow-up timepoints:       |
|                | communities in             | Sex/gender: NR.                       | health educators.                     | Baseline, 9 months (3-months         |
|                | North Carolina.            | Race/ethnicity: NR.                   |                                       | post-intervention).                  |
|                |                            |                                       | Control group:                        |                                      |
|                |                            | Paper does not provide a              | Wait-list control                     |                                      |
|                |                            | complete description of each          | [No details provided].                |                                      |
|                |                            | group. Overall, participants were     |                                       |                                      |
|                |                            | all female Mexicans (as per           |                                       |                                      |
|                |                            | eligibility criteria) with a mean age |                                       |                                      |
|                |                            | of 29.7 years (±5.3).                 |                                       |                                      |
| Camolas et al. | Study design:              | Intervention group:                   | Intervention group:                   | Outcome definition:                  |
| (2017)         | RCT                        | INDIVIDUO (n=68 randomised, 45        | INDIVIDUO                             | • Quality of life – Obesity-related: |
|                |                            | at baseline)                          | Individual, face-to-face lifestyle-   | Obesity-Related Quality of Life      |
|                | <u>Country (locality):</u> | Age: mean 46.31 years (±13.65)        | focused nutritional counselling       | (ORWELL-R)                           |
|                | Portugal                   | BMI: mean 42.81 kg/m² (±4.96)         | sessions every 2 months, resulting in |                                      |
|                |                            | Sex/gender: 82.2% female.             | 4 sessions over the 6-month           | Relevant follow-up timepoints:       |
|                | <u>Setting:</u>            | Race/ethnicity: NR.                   |                                       | Baseline, 6 months.                  |

|             | Obesity Treatment          |   | intervention duration. Counselling  |                                 |
|-------------|----------------------------|---|-------------------------------------|---------------------------------|
|             | Unit (outpatient           | <u>Control group:</u>                     | provided by clinical nutritionists. |                                 |
|             | clinic) of a               | Control (n=79 randomised, 49 at           |                                     |                                 |
|             | Portuguese                 | baseline)                                 | Control group:                      |                                 |
|             | hospital.                  | Age: mean 43.53 years (±13.92)            | Control                             |                                 |
|             |                            | BMI: mean 43.45 kg/m <sup>2</sup> (±7.04) | Given and discussed a weight        |                                 |
|             |                            | Sex/gender: 79.6% female.                 | reduction advice leaflet and hypo-  |                                 |
|             |                            | Race/ethnicity: NR.                       | calorific diet leaflet. Usual       |                                 |
|             |                            |   | appointment schedule of 2           |                                 |
|             |                            |   | appointments (baseline, 6 months).  |                                 |
| Cleo et al. | Study design:              | Intervention group:                       | Intervention groups:                | Outcome definition:             |
| (2019)      | RCT                        | Ten Top Tips (TTT) (n=25)                 | Ten Top Tips (TTT)                  | Quality of life: Bespoke 8 item |
|             |                            | Age: mean 48.2 years (±11.3)              | 12-week self-guided, leaflet-based, | questionnaire                   |
|             | <u>Country (locality):</u> | BMI: mean 34.6 kg/m <sup>2</sup> (±5.2)   | individual intervention focusing on | • Depression: Bespoke 4 item    |
|             | Australia                  | Sex/gender: 80% female.                   | habit formation. Logbook provided   | questionnaire                   |
|             |                            | Race/ethnicity: NR.                       | for recording tip adherence and     | • Anxiety: Bespoke 4 item       |
|             | <u>Setting:</u>            |   | weekly weight.                      | questionnaire                   |
|             | Bond University,           | Do Something Different (DSD)              |                                     |                                 |
|             | Institute of Health        | (n=25)                                    | Do Something Different (DSD)        | Relevant follow-up timepoints:  |
|             |                            | Age: mean 51.3 years (±10.0)              |                                     | Baseline, 12 weeks.             |

| and Sport in Gold | BMI: mean 35.2 kg/m <sup>2</sup> (±7.4) | 9-week online, individual             |  |
|-------------------|---|---------------------------------------|--|
| Coast.            | Sex/gender: 76% female.                 | intervention requiring participants   |  |
|                   | Race/ethnicity: NR.                     | to do something different each day    |  |
|                   |   | to build behavioural flexibility and  |  |
|                   | Control group:                          | break unhealthy habits. Online        |  |
|                   | Attention-control waitlist (n=25)       | software provides 3-4 tasks per       |  |
|                   | Age: mean 52.0 years (±12.3)            | week, tracks compliance and allows    |  |
|                   | BMI: mean 33.6 kg/m <sup>2</sup> (±6.1) | comments to be added. Participants    |  |
|                   | Sex/gender: 80% female.                 | receive weekly accountability         |  |
|                   | Race/ethnicity: NR.                     | phone-call. Lead investigator, who is |  |
|                   |   | a dietician, delivered the            |  |
|                   |   | intervention.                         |  |
|                   |   |                                       |  |
|                   |   | Control group:                        |  |
|                   |   | Attention-control waitlist            |  |
|                   |   | Received no weight loss advice but    |  |
|                   |   | received weekly phone-call for 12     |  |
|                   |   | weeks then offered TTT or DSD.        |  |
|                   |   | Instructed to continue as normal in   |  |
|                   |   | interim.                              |  |

### THE ROLE OF MENTAL HEALTH IN ADULT

| Cramer et al. | Study design:              | Intervention group:             | Intervention group:                  | Outcome definition:                |
|---------------|----------------------------|---------------------------------|--------------------------------------|------------------------------------|
| (2016)        | RCT                        | Yoga intervention (n=40)        | Yoga intervention                    | • Quality of life – Mental health: |
|               |                            | Age: mean 48.5 years (±7.9)     | 12-week yoga intervention            | Short Form-36 Health Survey (SF-   |
|               | <u>Country (locality):</u> | BMI: mean 32.9 kg/m2 (±4.1)     | delivered face-to-face in groups. An | 36)                                |
|               | Germany.                   | Sex/gender: 100% female (as per | initial full day workshop was        | • Self-esteem: Rosenberg's self-   |
|               |                            | eligibility criteria).          | followed by 2 weekly 90-minute       | esteem scale                       |
|               | <u>Setting:</u>            | Race/ethnicity: 95% German; 5%  | classes. Encouraged to practice at   | Stress: German perceived           |
|               | NR                         | Other.                          | home and log in a diary. Sessions    | stress scale                       |
|               |                            |                                 | were delivered by a certified hatha  |                                    |
|               |                            | <u>Control group:</u>           | yoga teacher.                        | Relevant follow-up timepoints:     |
|               |                            | Waiting list (n=20)             |                                      | Baseline, 12 weeks.                |
|               |                            | Age: mean 46.4 years (±8.9)     | Control group:                       |                                    |
|               |                            | BMI: mean 36.9 kg/m2 (±6.6)     | Waiting list                         |                                    |
|               |                            | Sex/gender: 100% female (as per | Offered yoga intervention at the end |                                    |
|               |                            | eligibility criteria).          | of the 12 <sup>th</sup> week.        |                                    |
|               |                            | Race/ethnicity: 95% German; 5%  |                                      |                                    |
|               |                            | Other.                          |                                      |                                    |
| Crane et al.  | Study design:              | Intervention group:             | Intervention group:                  | Outcome definition:                |
| (2016)        | RCT                        | Rethinking Eating and FITness   | Rethinking Eating and FITness        |                                    |
|               |                            | (REFIT) (n=53)                  | (REFIT)                              |                                    |

| Country (locality): | Age: mean 44.7 years (±11.3)            | 6-month men-only, internet-            | • Diet self-efficacy: Weight      |
|---------------------|---|--|-----------------------------------|
| United States of    | BMI: mean 31.4 kg/m <sup>2</sup> (±3.9) | delivered weight loss intervention     | Efficacy Lifestyle (WEL)          |
| America (USA)       | Sex/gender: 100% male (as per           | focused on diet recommendations,       | questionnaire                     |
|                     | eligibility criteria).                  | physical activity and self-monitoring. | • Exercise self-efficacy: Bespoke |
| Setting:            | Race/ethnicity: 83% White, 9%           | 2 initial group-based face-to-face     | questionnaire                     |
| University of North | Black, 8% Other.                        | contacts, with individual treatment    |                                   |
| Carolina, local     |   | delivered online weekly for 3-         | Relevant follow-up timepoints:    |
| county government   | <u>Control group:</u>                   | months, followed by monthly            | Baseline, 3-months.               |
| and surrounding     | Waitlist condition (n=54)               | contact for 3-months.                  |                                   |
| community.          | Age: mean 43.7 years (±11.6)            |  |                                   |
|                     | BMI: mean 31.5 kg/m² (±4.0)             |  |                                   |
|                     | Sex/gender: 100% male (as per           | Control group:                         |                                   |
|                     | eligibility criteria).                  | Waitlist condition                     |                                   |
|                     | Race/ethnicity: 70% White, 22%          | Received a feedback report on          |                                   |
|                     | Black, 7% Other.                        | baseline measures, but no              |                                   |
|                     |   | recommendations were provided.         |                                   |
|                     |   | Offered one group session on 10        |                                   |
|                     |   | weeks of online program after 6-       |                                   |
|                     |   | month assessments.                     |                                   |

| Damschroder   | Study design:              | Intervention group:                        | Intervention group:                 | Outcome definition:               |
|---------------|----------------------------|--|-------------------------------------|-----------------------------------|
| et al. (2014) | RCT                        | ASPIRE Small-Changes – Phone               | ASPIRE Small-Changes – Phone        | • Exercise self-efficacy: Bespoke |
|               |                            | (n=162)                                    | 12-month individual phone-based     | questionnaire                     |
|               | <u>Country (locality):</u> | Age: mean 55.4 years (±10.0)               | intervention with weekly 30-minute  | • Diet self-efficacy – Stages of  |
|               | United States of           | BMI: mean 36.2 kg/m <sup>2</sup> (CI 35.2, | sessions for 3-months, fortnightly  | Change questionnaire              |
|               | America (USA)              | 37.1)                                      | 20-minute sessions for 6 months,    | • Satisfaction with life:         |
|               |                            | Sex/gender: 84% male.                      | then monthly 20-minute sessions     | Satisfaction with Life Scale      |
|               | <u>Setting:</u>            | Race/ethnicity: 41.4% Black,               | for 3-months. Sessions were         | (SWLS)                            |
|               | Two Midwestern             | 56.2% White, 2.5% Other.                   | provided by non-expert coaches      | • Quality of life: EuroQol 5-     |
|               | VHA medical                |  | with at least a bachelor's degree,  | dimension questionnaire (EQ5D)    |
|               | centres -                  | ASPIRE Small-Changes – Group               | and focused on review and progress, |                                   |
|               | maximised                  | (n=160)                                    | problem-solving, psycho-education   | Relevant follow-up timepoints:    |
|               | diversity of               | Age: mean 54.9 years (±9.5)                | content, and goal setting.          | Baseline, 12-months.              |
|               | proportion of non-         | BMI: mean 36.4 kg/m <sup>2</sup> (Cl 35.4, |                                     |                                   |
|               | white Veterans and         | 37.3)                                      | ASPIRE Small-Changes – Group        |                                   |
|               | urban/ suburban            | Sex/gender: 83.8% male.                    | 12-month individual face-to-face    |                                   |
|               | settings.                  | Race/ethnicity: 40.6% Black,               | intervention with weekly 90-minute  |                                   |
|               |                            | 58.8% White, 0.6% Other.                   | sessions for 3-months, fortnightly  |                                   |
|               |                            |  | 60-minute sessions for 6 months,    |                                   |
|               |                            | Control group:                             | then monthly 60-minute sessions     |                                   |

| MOVE! Weight Management                    | for 3-months. Sessions were           |  |
|--|---------------------------------------|--|
| Program (Usual care) (n=159)               | provided by non-expert coaches        |  |
| Age: mean 54.6 years (±10.5)               | with at least a bachelor's degree,    |  |
| BMI: mean 36.8 kg/m <sup>2</sup> (Cl 35.8. | and focused on review and progress,   |  |
| 37.8)                                      | problem-solving, psycho-education     |  |
| Sex/gender: 87.4% male.                    | content, and goal setting.            |  |
| Race/ethnicity: 40.3% Black,               |                                       |  |
| 57.2% White, 2.5% Other.                   |                                       |  |
|  | Control group:                        |  |
|  | MOVE! Weight Management               |  |
|  | Program (Usual care)                  |  |
|  | 12-month group-based face-to-face     |  |
|  | intervention with weekly 90-minute    |  |
|  | sessions for first 3-months, and      |  |
|  | drop-in follow-up groups twice-       |  |
|  | monthly or quarterly for 9 months.    |  |
|  | Provided with pedometer, food         |  |
|  | intake logbooks, and hand-outs on     |  |
|  | diet, physical activity and behaviour |  |
|  | change. Delivered by an               |  |

### THE ROLE OF MENTAL HEALTH IN ADULT

|               |                            |   | interdisciplinary team of            |                                     |
|---------------|----------------------------|---|--------------------------------------|-------------------------------------|
|               |                            |   | professional clinicians.             |                                     |
| Domene et al. | Study design:              | Intervention group:                     | Intervention group:                  | Outcome definition:                 |
| (2016)        | RCT                        | Zumba® fitness (n=12)                   | Zumba® fitness                       | • Quality of life – Mental health:  |
|               |                            | Age: mean 33 years (±11)                | 8-week Latin-themed aerobic dance    | Short Form-36 Health Survey (SF-    |
|               | <u>Country (locality):</u> | BMI: mean 26.7 kg/m <sup>2</sup> (±1.7) | intervention with weekly classes for | 36)                                 |
|               | United Kingdom             | Sex/gender: 100% female (as per         | 4 weeks and twice weekly classes for |                                     |
|               | (UK)                       | eligibility criteria).                  | final 4 weeks. Sessions delivered by | Relevant follow-up timepoints:      |
|               |                            | Race/ethnicity: NR.                     | members of Zumba® Instructor         | Baseline, 8 weeks.                  |
|               | <u>Setting:</u>            |   | Network.                             |                                     |
|               | Royal Borough of           | Control group:                          |                                      |                                     |
|               | Kingston and the           | Control (n=11)                          | Control group:                       |                                     |
|               | surrounding                | Age: mean 35 years (±13)                | Control                              |                                     |
|               | communities of             | BMI: mean 27.6 kg/m <sup>2</sup> (±2.0) | Maintained habitual activity.        |                                     |
|               | London.                    | Sex/gender: 100% female (as per         |                                      |                                     |
|               |                            | eligibility criteria).                  |                                      |                                     |
|               |                            | Race/ethnicity: NR.                     |                                      |                                     |
| Godino et al. | Study design:              | Intervention group:                     | Intervention group:                  | Outcome definition:                 |
| (2016)        | RCT                        | SMART intervention (n=202)              | SMART intervention                   | • Quality of life: Quality of Well- |
|               |                            |   |                                      | being Scale (QWS)                   |

| Country (locality): | Age: 61% 18-22 years, 28% 23-27         | 24-month online delivered             | • Depression: Center for       |
|---------------------|---|---------------------------------------|--------------------------------|
| United States of    | years, 7% 28-32 years, 3% 33-35         | individual intervention via 6 modes:  | Epidemiologic Studies          |
| America (USA)       | years.                                  | 1. Facebook, 2. Three mobile apps,    | Depression Scale (CES-D)       |
|                     | BMI: mean 28.9 kg/m <sup>2</sup> (±2.8) | 3. Text messaging, 4. Emails, 5.      |                                |
| Setting:            | Sex/gender: 71% female.                 | Website with blog posts, and 6. Brief | Relevant follow-up timepoints: |
| Three universities  | Race/ethnicity: 43% White or            | irregular online support from a       | Baseline, 24-months.           |
| in San Diego,       | Caucasian, 23% Asian, 21% Other,        | health coach. Participants able to    |                                |
| California with     | 8% Multiple, 3% Black or African        | set goals and track behaviours,       |                                |
| diverse population. | American, 2% American Indian,           | receive prompts, and participate in   |                                |
|                     | Alaska Native, Hawaiian Native, or      | challenges and campaigns set by the   |                                |
|                     | other Pacific Islander. 31% were        | health coach.                         |                                |
|                     | Hispanic.                               |                                       |                                |
|                     |   | Control group:                        |                                |
|                     | <u>Control group:</u>                   | Control                               |                                |
|                     | Control (n=202)                         | Accessed a different website and      |                                |
|                     | Age: 60% 18-22 years, 26% 23-27         | sent quarterly newsletters, both      |                                |
|                     | years, 12% 28-32 years, 1% 33-35        | containing general health             |                                |
|                     | years.                                  | information on a range of topics.     |                                |
|                     | BMI: mean 29 kg/m <sup>2</sup> (±2.7)   |                                       |                                |
|                     | Sex/gender: 70% female.                 |                                       |                                |

|             |                            | Race/ethnicity: 41% White or            |                                     |                                    |
|-------------|----------------------------|---|-------------------------------------|------------------------------------|
|             |                            | Caucasian, 25% Asian, 19% Other,        |                                     |                                    |
|             |                            | 10% Multiple, 5% Black or African       |                                     |                                    |
|             |                            | American, 1% American Indian,           |                                     |                                    |
|             |                            | Alaska Native, Hawaiian Native, or      |                                     |                                    |
|             |                            | other Pacific Islander. 31% were        |                                     |                                    |
|             |                            | Hispanic.                               |                                     |                                    |
|             |                            |   |                                     |                                    |
|             |                            | Overall, participants had a mean        |                                     |                                    |
|             |                            | age of 22.7 years (±3.8).               |                                     |                                    |
| Gray et al. | Study design:              | Intervention group:                     | Intervention group:                 | Outcome definition:                |
| (2013)      | RCT                        | Pilot Football Fans in Training (p-     | Pilot Football Fans in Training (p- | • Self-esteem: Rosenberg's self-   |
|             |                            | FFIT) programme (n=51)                  | FFIT) programme                     | esteem scale                       |
|             | <u>Country (locality):</u> | Age: mean 48.2 years (±8.4)             | 12-week group-based, face-to-face   | • Negative Affect: Positive and    |
|             | Scotland, United           | BMI: mean 34.5 kg/m <sup>2</sup> (±3.9) | male-tailored intervention at club  | Negative Affect Scale (PNAS)       |
|             | Kingdom, UK.               | Sex/gender: 100% male (as per           | home stadia. Weekly 90-minute       | • Quality of life – Mental health: |
|             |                            | eligibility criteria).                  | sessions delivering weight          | Short Form-12 Health Survey (SF-   |
|             | <u>Setting:</u>            | Race/ethnicity: 100% White UK.          | management education and            | 12)                                |
|             | Scottish Premier           |   | physical activity sessions. Daily   |                                    |
|             | League football            | <u>Control group:</u>                   | pedometer-based walking             | Relevant follow-up timepoints:     |

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|                | clubs (1 large club,       | Comparison (n=52)                       | programme and dietary deficit of                | Baseline, 12 weeks.            |
|----------------|----------------------------|---|---|--------------------------------|
|                | 1 smaller club).           | Age: mean 45.9 years (±8.4)             | 600kcal/day. Delivered by Scottish              |                                |
|                |                            | BMI: mean 34.5 kg/m <sup>2</sup> (±6.0) | Premier League club community                   |                                |
|                |                            | Sex/gender: 100% male (as per           | coaching staff.                                 |                                |
|                |                            | eligibility criteria).                  |   |                                |
|                |                            | Race/ethnicity: 98.1% White UK,         | Control group:                                  |                                |
|                |                            | 1.9% Mixed Race.                        | Comparison                                      |                                |
|                |                            |   | Received a standard information                 |                                |
|                |                            |   | booklet containing weight loss                  |                                |
|                |                            |   | advice.   |                                |
| Haapala et al. | Study design:              | Intervention group:                     | Intervention group:                             | Outcome definition:            |
| (2019)         | RCT                        | Mobile phone weight-loss                | Mobile phone weight-loss                        | • Diet self-efficacy: Bespoke  |
|                |                            | programme – Weight Balance®             | programme – Weight Balance® 12-                 | questionnaire                  |
|                | <u>Country (locality):</u> | (n=62)                                  | month text message-based,                       |                                |
|                | Finland                    | Age: mean 38.1 years (±4.7)             | individual intervention that                    | Relevant follow-up timepoints: |
|                |                            | BMI: mean 30.6 kg/m <sup>2</sup> (±2.7) | calculated daily energy requirement             | Baselines, 12-months.          |
|                | <u>Setting:</u>            | Sex/gender: 79% female.                 | and physical activity coefficients.             |                                |
|                | NR                         | Race/ethnicity: NR.                     | Participants were provided access to            |                                |
|                |                            |   | Weight Balance <sup>®</sup> website for dietary |                                |
|                |                            | <u>Control group:</u>                   | record keeping, tracking weight, and            |                                |

|                |                            | Control group (n=63)                    | nutrition and physical activity    |                                  |
|----------------|----------------------------|---|------------------------------------|----------------------------------|
|                |                            | Age: mean 38.0 years (±4.7)             | advice.                            |                                  |
|                |                            | BMI: mean 30.4 kg/m <sup>2</sup> (±2.8) |                                    |                                  |
|                |                            | Sex/gender: 76% female.                 | Control group:                     |                                  |
|                |                            | Race/ethnicity: NR.                     | Control group                      |                                  |
|                |                            |   | Offered weight loss programme      |                                  |
|                |                            |   | after 12-month visit.              |                                  |
|                |                            |   |                                    |                                  |
| Herring et al. | Study design:              | Intervention group:                     | Intervention group:                | Outcome definition:              |
| (2014)         | RCT                        | Resistance training (RT) (n=11)         | Resistance training (RT)           | • Exercise self-efficacy: Self-  |
|                |                            | Age: NR.                                | 12-week face-to-face intervention  | Efficacy for Regulating Physical |
|                | <u>Country (locality):</u> | BMI: mean 41.5 kg/m <sup>2</sup> (±5.2) | of usual care (weekly educational  | Activity (SERPA)                 |
|                | United Kingdom,            | Sex/gender: [post-intervention] 2       | sessions) plus resistance training | • Depression and anxiety:        |
|                | UK                         | males, 8 females.                       | intervention (2 supervised group   | Hospital Anxiety and Depression  |
|                |                            | Race/ethnicity: NR.                     | gym sessions and 1 structured home | Scale (HADS)                     |
|                | Setting:                   |   | session per week). Personalised    |                                  |
|                | Community weight           | Aerobic training (AT) (n=12)            | programmes given. Attendance,      |                                  |
|                | loss service.              | Age: NR.                                | activities and heart rate were     | Relevant follow-up timepoints:   |
|                |                            | BMI: mean 44.4 kg/m <sup>2</sup> (±4.4) | recorded in session.               | Baseline, 12 weeks.              |
|                |                            |   |                                    |                                  |
|              |                     | Sex/gender: [post-intervention] 3  | Aerobic training (AT)              |                                  |
|--------------|---------------------|------------------------------------|------------------------------------|----------------------------------|
|              |                     | males, 7 females.                  | 12-week face-to-face intervention  |                                  |
|              |                     | Race/ethnicity: NR.                | of usual care (weekly educational  |                                  |
|              |                     |                                    | sessions) plus aerobic training    |                                  |
|              |                     | Control group:                     | intervention (2 supervised group   |                                  |
|              |                     | Control group (n=10)               | gym sessions and 1 structured home |                                  |
|              |                     | Age: NR.                           | session per week). Personalised    |                                  |
|              |                     | BMI: mean 48.6 kg/m² (±7.8)        | programmes given. Attendance,      |                                  |
|              |                     | Sex/gender: [post-intervention] 3  | activities and heart rate were     |                                  |
|              |                     | males, 4 females.                  | recorded in session.               |                                  |
|              |                     | Race/ethnicity: NR.                |                                    |                                  |
|              |                     |                                    |                                    |                                  |
|              |                     | Overall, participants ranged from  | <u>Control group:</u>              |                                  |
|              |                     | 24-68 years of age.                | Control group                      |                                  |
|              |                     |                                    | Usual care – 12 weekly educational |                                  |
|              |                     |                                    | sessions.                          |                                  |
| Huber et al. | Study design:       | Intervention group:                | Intervention group:                | Outcome definition:              |
| (2015)       | RCT                 | Tele-coaching plus portion control | Tele-coaching plus portion control | • Diet self-efficacy: Weight     |
|              |                     | plate (n=45)                       | plate                              | Efficacy Lifestyle Questionnaire |
|              | Country (locality): |                                    |                                    | (WEL)                            |

| U                     | Jnited States of    | Age: mean 48.3 years (±12.3;            | 3-month individual, phone-based        |                                  |
|-----------------------|---------------------|---|--|----------------------------------|
| A                     | America (USA)       | range 20-65)                            | intervention: Participants receive     | Relevant follow-up timepoints:   |
|                       |                     | BMI: mean 36.5 kg/m <sup>2</sup> (±4.2) | portion control plate and              | Baseline, 3-months.              |
| <u>Se</u>             | Setting:            | Sex/gender: 84% female.                 | instructions, with tele-coaching calls |                                  |
| La                    | arge academic       | Race/ethnicity: 96% non-Hispanic        | fortnightly. Wellness coach            |                                  |
| p                     | orimary care        | White, 4% Other.                        | (Master's degree level) followed       |                                  |
| p                     | practice,           |   | motivational interviewing              |                                  |
|                       | Midwestern United   | <u>Control group:</u>                   | framework.                             |                                  |
| St                    | States              | Usual care (n=45)                       |  |                                  |
| (a                    | approximately       | Age: mean 47.4 years (±14.1;            | Control group:                         |                                  |
| 1                     | L30,000 patients).  | range 18-70)                            | Usual care                             |                                  |
|                       |                     | BMI: mean 36.1 kg/m <sup>2</sup> (±3.9) | Received pamphlets on healthy          |                                  |
|                       |                     | Sex/gender: 64% female.                 | eating and exercise habits.            |                                  |
|                       |                     | Race/ethnicity: 91% non-Hispanic        |  |                                  |
|                       |                     | White, 9% Other.                        |  |                                  |
| Hunt et al. <u>St</u> | Study design:       | Intervention group:                     | Intervention group:                    | Outcome definition:              |
| (2014) R              | RCT                 | FFIT (n=374)                            | Football Fans in Training (FFIT)       | • Self-esteem: Rosenberg's self- |
|                       |                     | Age: mean 47 years (±8.07)              | 12-week group-based, face-to-face      | esteem scale                     |
|                       | Country (locality): | BMI: mean 35.5 kg/m <sup>2</sup> (±5.1) | gender-sensitised intervention at      |                                  |
|                       |                     |   | professional football clubs. Weekly    |                                  |

|                | Scotland, United           | Sex/gender: 100% male (as per           | 90-minute sessions delivering         | Negative affect: Short Form of     |
|----------------|----------------------------|---|---------------------------------------|------------------------------------|
|                | Kingdom (UK)               | eligibility criteria).                  | weight management education and       | the Positive and Negative Affect   |
|                |                            | Race/ethnicity: 98.1% White, 1.4%       | physical activity sessions, with      | Scale (PANAS)                      |
|                | <u>Setting:</u>            | Other, 0.5% Missing.                    | behaviour change techniques and       | • Quality of life – Mental health: |
|                | Scottish                   |   | social support. Delivered by          | Short Form-12 Health Survey (SF-   |
|                | professional               | Control group:                          | community coaching staff.             | 12)                                |
|                | football clubs – 12        | Comparison (n=374)                      |                                       |                                    |
|                | clubs were in the          | Age: mean 47.2 years (±7.89)            | Control group:                        | Relevant follow-up timepoints:     |
|                | league in 2011-12          | BMI: mean 35.1 kg/m <sup>2</sup> (±4.8) | Comparison                            | Baseline, 12 weeks, 12-months.     |
|                | and 1 was                  | Sex/gender: 100% male (as per           | Waiting list comparison group that    |                                    |
|                | relegated in 2010-         | eligibility criteria).                  | was offered the intervention 12-      |                                    |
|                | 11.                        | Race/ethnicity: 98.7% White, 0.5%       | months later.                         |                                    |
|                |                            | White, 0.8% Missing.                    |                                       |                                    |
| Imayama et al. | Study design:              | Intervention group:                     | Intervention group:                   | Outcome definition:                |
| (2011)         | RCT                        | Dietary weight loss (n=118)             | Dietary weight loss                   | • Depression and anxiety: Brief    |
|                |                            | Age: mean 58.1 years (±5.9)             | 12-month intervention with            | Symptom Inventory-18 (BSI-18)      |
|                | <u>Country (locality):</u> | BMI: mean 31.0 kg/m <sup>2</sup> (±3.9) | individual sessions with dietician at | • Stress: Perceived Stress Scale   |
|                | United States of           | Sex/gender: 100% female (as per         | least twice, followed by small group  | (PSS)                              |
|                | America (USA)              | eligibility criteria).                  | sessions until week 24. Contact with  |                                    |
|                |                            |   | dieticians at least twice per month   |                                    |

| S | Setting:        | Race/ethnicity: 85.6% non-              | by group sessions or email/phone     | • Quality of life – Mental health: |
|---|-----------------|---|--------------------------------------|------------------------------------|
| F | Fred Hutchinson | Hispanic White.                         | for remaining intervention. Sessions | Short Form-36 Health Survey (SF-   |
| C | Cancer Research |   | focused on strategies and skills for | 36)                                |
| C | Center, greater | Aerobic exercise (n=117)                | weight loss.                         |                                    |
| S | Seattle, WA.    | Age: mean 58.1 years (±5.0)             |                                      | Relevant follow-up timepoints:     |
|   |                 | BMI: mean 30.7 kg/m <sup>2</sup> (±3.7) | Aerobic exercise                     | Baseline, 12-months.               |
|   |                 | Sex/gender: 100% female (as per         | 12-month intervention with 5 days    |                                    |
|   |                 | eligibility criteria).                  | per week of 45-minute aerobic        |                                    |
|   |                 | Race/ethnicity: 83.8% non-              | exercise, with 3 sessions supervised |                                    |
|   |                 | Hispanic White.                         | by a physiologist.                   |                                    |
|   |                 |   |                                      |                                    |
|   |                 | Dietary weight loss + Aerobic           | Dietary weight loss + Aerobic        |                                    |
|   |                 | exercise (n=117)                        | exercise                             |                                    |
|   |                 | Age: mean 58.0 years (±4.5)             | Received both the dietary weight     |                                    |
|   |                 | BMI: mean 31.0 kg/m <sup>2</sup> (±4.3) | loss and aerobic exercise            |                                    |
|   |                 | Sex/gender: 100% female (as per         | interventions.                       |                                    |
|   |                 | eligibility criteria).                  |                                      |                                    |
|   |                 | Race/ethnicity: 85.5% non-              | Control group:                       |                                    |
|   |                 | Hispanic White.                         | Control                              |                                    |
|   |                 |   |                                      |                                    |

|              |                            | Control group:                          | No intervention during study period. |                                   |
|--------------|----------------------------|---|--------------------------------------|-----------------------------------|
|              |                            | Control (n=87)                          | Offered 4 group diet sessions and 8  |                                   |
|              |                            | Age: 57.4 years (±4.4)                  | weeks of supervised exercise after   |                                   |
|              |                            | BMI: mean 30.7 kg/m <sup>2</sup> (±3.9) | 12-month data collection.            |                                   |
|              |                            | Sex/gender: 100% female (as per         |                                      |                                   |
|              |                            | eligibility criteria).                  |                                      |                                   |
|              |                            | Race/ethnicity: 85.1% non-              |                                      |                                   |
|              |                            | Hispanic White.                         |                                      |                                   |
| Jamal et al. | Study design:              | Intervention group:                     | Intervention group:                  | Outcome definition:               |
| (2016)       | RCT                        | GSLiM (Group Support Lifestyle          | GSLiM (Group Support Lifestyle       | • Diet self-efficacy: Weight      |
|              |                            | Modification) (n=97)                    | Modification)                        | Efficacy Lifestyle questionnaire  |
|              | <u>Country (locality):</u> | Age: mean 39.7 years (±9.2)             | 24 week face-to-face, group-based,   | (WEL)                             |
|              | Malaysia                   | BMI: mean 32.4 kg/m <sup>2</sup> (±4.8) | 2 phase intervention. Phase 1: Two-  | Negative affect: Automatic        |
|              |                            | Sex/gender: 71.1% female.               | day seminar, followed by fortnightly | Thought Questionnaire             |
|              | <u>Setting:</u>            | Race/ethnicity: 89.7% Malays,           | sessions for 3-months. Phase 2: One  | • Quality of life: WHO Quality of |
|              | Public university in       | 10.3% non-Malays.                       | day seminar, followed by 2 90-       | Life short form questionnaire     |
|              | Kuala Lumpur.              |   | minute sessions, and finished with a | (WHOQoL-BREF)                     |
|              |                            | Control group:                          | half-day seminar. Sessions focused   |                                   |
|              |                            | Comparison (n=97)                       | on problem solving and self-         | Relevant follow-up timepoints:    |
|              |                            | Age: mean 40.4 years (±9.5)             | monitoring and were a mixture of     | Baseline, 24 weeks.               |

|             |                            | BMI: mean 32.4 kg/m <sup>2</sup> (±3.8)     | education and practice experience.   |                                   |
|-------------|----------------------------|---|--------------------------------------|-----------------------------------|
|             |                            | Sex/gender: 74.2% female.                   | Hand-outs were provided at           |                                   |
|             |                            | Race/ethnicity: 93.8% Malays,               | sessions. Intervention providers     |                                   |
|             |                            | 6.2% non-Malays.                            | were dietician, exercise specialist  |                                   |
|             |                            |   | and psychologist.                    |                                   |
|             |                            |   |                                      |                                   |
|             |                            |   | Control group:                       |                                   |
|             |                            |   | Comparison                           |                                   |
|             |                            |   | Individual counselling with a        |                                   |
|             |                            |   | dietician once every 12 weeks for 24 |                                   |
|             |                            |   | weeks, which provided advice on      |                                   |
|             |                            |   | physical activity only.              |                                   |
| Jane et al. | Study design:              | Intervention group:                         | Intervention group:                  | Outcome definition:               |
| (2018)      | RCT                        | Pamphlet group (PG) (n=46)                  | Pamphlet group (PG)                  | • Quality of life: WHO Quality of |
|             |                            | Age: mean 54.1 years (SEM: 2.3)             | 12-week individual intervention      | Life short form questionnaire     |
|             | <u>Country (locality):</u> | BMI: mean 32.9 kg/m <sup>2</sup> (SEM: 1.3) | with weight management               | (WHOQoL-BREF)                     |
|             | Australia                  | Sex/gender: 91.3% female.                   | programme provided by written        | • Depression, anxiety and stress: |
|             |                            | Race/ethnicity: NR.                         | information in booklets. Instructed  | 21 question Depression Anxiety    |
|             | <u>Setting:</u>            |   | to follow a low                      | Stress Scale (DASS)               |
|             | Perth community.           | Facebook group (FG) (n=46)                  | energy/fat/carbohydrate and high     |                                   |

| Age: mean 47.0 years (SEM: 2.3)             | fat diet and issued a pedometer to    | Relevant follow-up timepoints: |
|---|---------------------------------------|--------------------------------|
| BMI: mean 32.5 kg/m <sup>2</sup> (SEM: 1.0) | aim for 10,000 steps per day.         | Baseline, 12 weeks.            |
| Sex/gender: 82.6% female.                   |                                       |                                |
| Race/ethnicity: NR.                         | Facebook group (FG)                   |                                |
|   | 12-week individual intervention       |                                |
| Control group:                              | with weight management                |                                |
| Control group (n=45)                        | programme provided by written         |                                |
| Age: mean 50.2 years (SEM: 2.4)             | information posted to Facebook        |                                |
| BMI: mean 33.3 kg/m <sup>2</sup> (SEM: 1.3) | group. Instructed to follow a low     |                                |
| Sex/gender: 80.9% female.                   | energy/fat/carbohydrate and high      |                                |
| Race/ethnicity: NR.                         | fat diet and issued a pedometer to    |                                |
|   | aim for 10,000 steps per day.         |                                |
|   |                                       |                                |
|   |                                       |                                |
|   | <u>Control group:</u>                 |                                |
|   | Control group                         |                                |
|   | Instructed to follow the Australian   |                                |
|   | Government dietary guidelines and     |                                |
|   | National Physical Activity Guidelines |                                |
|   | for Adults as standard care.          |                                |

| Jebb et al.   | Study design:              | Intervention group:                | Intervention group:                    | Outcome definition:                  |
|---------------|----------------------------|------------------------------------|--|--------------------------------------|
| (2011)        | RCT                        | Commercial programme (n=377)       | Commercial programme                   | • Emotional eating: Three Factor     |
|               |                            | Age: 46.5 years (±13.5)            | Free access to weekly group-based      | Eating Questionnaire R-21 (TFEQ      |
|               | <u>Country (locality):</u> | BMI: 31.5 kg/m <sup>2</sup> (±2.6) | face-to-face Weight Watchers           | R-21)                                |
|               | United Kingdom             | Sex/gender: 88% female.            | meetings and related internet          | • Quality of life – Obesity-related: |
|               | (UK), Germany and          | Race/ethnicity: NR.                | systems for 12-months.                 | Impact of Weight on Quality of       |
|               | Australia.                 |                                    |  | Life Lite (IWQOL-Lite)               |
|               |                            | Control group:                     | Control group:                         |                                      |
|               | <u>Setting:</u>            | Standard care (n=395)              | Standard care                          | Relevant follow-up timepoints:       |
|               | Perth community.           | Age: 48.2 years (±12.2)            | Received weight loss advice based      | Baseline, 12-months.                 |
|               |                            | BMI: 31.3 kg/m <sup>2</sup> (±2.6) | on national clinical guidelines from   |                                      |
|               |                            | Sex/gender: 86% female.            | local general practitioner (GP).       |                                      |
|               |                            | Race/ethnicity: NR.                |  |                                      |
| Kalarchian et | Study design:              | Intervention group:                | Intervention group:                    | Outcome definition:                  |
| al. (2013)    | RCT                        | Behavioural lifestyle intervention | Behavioural lifestyle intervention     | Depression: Beck Depression          |
|               |                            | (LIFESTYLE) (n=121)                | (LIFESTYLE)                            | Inventory (BDI)                      |
|               | <u>Country (locality):</u> | Age, sex/gender, BMI and           | 6-month individual intervention        |                                      |
|               | United States of           | race/ethnicity: NR.                | with a total of 12 face-to-face and 12 | Relevant follow-up timepoints:       |
|               | America (USA)              |                                    | telephone counselling sessions.        | Baseline, 6 months.                  |
|               |                            | <u>Control group:</u>              | Face-to-face sessions lasted an hour   |                                      |

|               | <u>Setting:</u>      | Usual care (n=119)                                 | and included review of self-         |                                      |
|---------------|----------------------|--|--------------------------------------|--------------------------------------|
|               | Bariatric Center of  | Age, sex/gender, BMI and                           | monitoring and a didactic            |                                      |
|               | Excellence at large, | race/ethnicity: NR.                                | presentation. Telephone sessions     |                                      |
|               | urban medical        |  | reviewed progress and covered        |                                      |
|               | centre.              | Baseline characteristics not                       | problem solving and goal setting.    |                                      |
|               |                      | provided. Overall, participants                    |                                      |                                      |
|               |                      | were mean 45.2 years old (±11),                    | <u>Control group:</u>                |                                      |
|               |                      | with mean BMI 47.9 kg/m <sup>2</sup> ( $\pm$ 6.7). | Usual care                           |                                      |
|               |                      | Participants were 86.7% female,                    | Synopsis of intervention information |                                      |
|               |                      | 82.6% White, and 0.8%                              | with no contact until 6-month        |                                      |
|               |                      | Hispanic/Latino.                                   | assessment. Usual care dictates that |                                      |
|               |                      |  | most participants are seen monthly   |                                      |
|               |                      |  | for 6 months under bariatric surgery |                                      |
|               |                      |  | program care.                        |                                      |
| Kraschnewski  | Study design:        | Intervention group:                                | Intervention group:                  | Outcome definition:                  |
| et al. (2011) | RCT                  | AchieveTogether (n=50)                             | AchieveTogether                      | • Quality of life – Obesity-related: |
|               |                      | Age: mean 50.7 years (±10.5)                       | 12-week online intervention where    | Impact of Weight on Quality of       |
|               | Country (locality):  | BMI: mean 32.7 kg/m <sup>2</sup> (±4.2)            | participants are guided through      | Life Lite (IWQOL-Lite)               |
|               | United States of     | Sex/gender: 62% female.                            | implementing 36 weight-control       |                                      |
|               | America (USA)        | Race/ethnicity: 96% White.                         | behaviours. At least weekly access   | Relevant follow-up timepoints:       |

|                        |                     |   | to website where prompted to enter     | Baseline, 12 weeks.            |
|------------------------|---------------------|---|--|--------------------------------|
| Se                     | etting:             | <u>Control group:</u>                   | weight, height and use of              |                                |
| Pe                     | enn State Hershey   | Control (n=50)                          | behaviours in last 7 days.             |                                |
| N                      | /ledical Center.    | Age: mean 49.9 years (±11.5)            | Participants received tailored         |                                |
|                        |                     | BMI: mean 33.7 kg/m <sup>2</sup> (±4.2) | feedback to choose behaviours to       |                                |
|                        |                     | Sex/gender: 77.6% female.               | sustain or adapt. Participants were    |                                |
|                        |                     | Race/ethnicity: 86% White.              | matched to a 'role model' and could    |                                |
|                        |                     |   | review their progress and strategies.  |                                |
|                        |                     |   |  |                                |
|                        |                     |   |  |                                |
|                        |                     |   | <u>Control group:</u>                  |                                |
|                        |                     |   | Control                                |                                |
|                        |                     |   | No access to website until the         |                                |
|                        |                     |   | completion of the trial.               |                                |
| Laing et al. <u>St</u> | tudy design:        | Intervention group:                     | Intervention group:                    | Outcome definition:            |
| (2014) R0              | RCT                 | Usual care + MyFitnessPal (MFP)         | Usual care + MyFitnessPal (MFP)        | • Diet self-efficacy: Bespoke  |
|                        |                     | (n=105)                                 | 6-month online calorie-counting        | questionnaire                  |
| <u>C</u>               | Country (locality): | Age: mean 43.1 years (±14)              | app intervention. App provides         |                                |
| U                      | United States of    | BMI: mean 33.3 kg/m <sup>2</sup> (±7)   | daily, individualised calorie goal and | Relevant follow-up timepoints: |
| A                      | merica (USA)        | Sex/gender: 70% female.                 | generates real-time reports of         | Baseline, 6 months.            |

|                 |                            | Race/ethnicity: 33% Hispanic, 53%     | weight trend and dietary             |                                  |
|-----------------|----------------------------|---------------------------------------|--------------------------------------|----------------------------------|
|                 | <u>Setting:</u>            | White, 18% Black, 7% Asian, 1%        | summaries. Participants were         | Notes:                           |
|                 | Ethnically diverse         | Native American or Pacific            | encouraged to use the social         | Unable to meta-analyse as SD (or |
|                 | and socio-                 | Islander.                             | networking feature. At 3-months, an  | equivalent) not reported.        |
|                 | economically               |                                       | educational healthy eating hand-out  |                                  |
|                 | diverse UCLA               | <u>Control group:</u>                 | was provided.                        |                                  |
|                 | primary care               | Usual care (n=107)                    |                                      |                                  |
|                 | clinics.                   | Age: mean 43.2 years (±15)            | Control group:                       |                                  |
|                 |                            | BMI: mean 33.3 kg/m <sup>2</sup> (±7) | Usual care                           |                                  |
|                 |                            | Sex/gender: 76% female.               | Participants were told to choose any |                                  |
|                 |                            | Race/ethnicity: 32% Hispanic, 42%     | activities they would like to lose   |                                  |
|                 |                            | White, 20% Black, 10% Asian, 0.5%     | weight. At 3-months, an educational  |                                  |
|                 |                            | Native American or Pacific            | healthy eating hand-out was          |                                  |
|                 |                            | Islander.                             | provided.                            |                                  |
| McRobbie et al. | Study design:              | Intervention group:                   | Intervention group:                  | Outcome definition:              |
| (2016)          | RCT                        | Weight Action Programme (WAP)         | 18-week group-based, face-to-face    | • Quality of life: EuroQol 5-    |
|                 |                            | group intervention (n=221)            | multimodal health behaviour          | dimension 5-level questionnaire  |
|                 | <u>Country (locality):</u> | Age: mean 46.6 years (±15)            | modification intervention.           | (EQ5D-5L)                        |
|                 | United Kingdom             | BMI: mean 35.0 kg/m² (±4.2)           | Intervention is delivered in the     | • Emotional eating: Three Factor |
|                 | (UK).                      | Sex/gender: 73% female.               | context of group support targeted    | Eating Questionnaire             |

|                     | Race/ethnicity: 39% White British, | aims to provide tools to lose weight. |                                |
|---------------------|------------------------------------|---------------------------------------|--------------------------------|
| <u>Setting:</u>     | 12% White other, 24% Black, 12%    | Received information about local      | Relevant follow-up timepoints: |
| 2 GP practices, one | Asian, 5% Mixed, 7% Other.         | exercise provision and where          | Baseline, 6 months, 12-months. |
| in the London       |                                    | 'exercise on prescription' was        |                                |
| borough of Tower    | <u>Control group:</u>              | available (and given relevant         |                                |
| Hamlets and one in  | Practice nurse intervention –      | vouchers and referrals).              |                                |
| Hackney.            | standard care (n=109)              |                                       |                                |
|                     | Age: mean 45.1 years (±14.2)       | <u>Control group:</u>                 |                                |
|                     | BMI: mean 35.7 kg/m² (±4.3)        | Practice nurse intervention –         |                                |
|                     | Sex/gender: 69% female.            | standard care                         |                                |
|                     | Race/ethnicity: 43% White British, | 8-week individual, face-to-face       |                                |
|                     | 10% White other, 24% Black, 15%    | intervention with practice nurses     |                                |
|                     | Asian, 1% Mixed, 7% Other.         | providing advice on diet and physical |                                |
|                     |                                    | activity delivering in 4 sessions     |                                |
|                     |                                    | lasting up to 30 minutes. Received    |                                |
|                     |                                    | information about local exercise      |                                |
|                     |                                    | provision and where 'exercise on      |                                |
|                     |                                    | prescription' was available (and      |                                |
|                     |                                    | given relevant vouchers and           |                                |
|                     |                                    | referrals).                           |                                |

| Morgan et al. | Study design:              | Intervention group:                      | Intervention group:                  | Outcome definition:                |
|---------------|----------------------------|--|--------------------------------------|------------------------------------|
| (2011)        | RCT                        | The Workplace POWER (WP)                 | 3-month individual, online and face- | • Exercise self-efficacy: Bespoke  |
| &             |                            | program (n=65)                           | to-face intervention with 4 major    | questionnaire                      |
| Morgan et al. | <u>Country (locality):</u> | Age: mean 44.8 years (±8.3)              | components: (1) information          | • Quality of life - Mental health: |
| (2012)        | Australia                  | BMI: mean 30.7 kg/m <sup>2</sup> (±3.6)  | sessions, (2) study website, (3)     | Short Form-12 Health Survey (SF-   |
|               |                            | Sex/gender: 100% men (as per             | resources, (4) group-based financial | 12)                                |
|               | <u>Setting:</u>            | eligibility criteria).                   | incentives.                          |                                    |
|               | Tomago, one of             | Race/ethnicity: NR.                      |                                      | Relevant follow-up timepoints:     |
|               | Australia's largest        |  | Control group:                       | Baseline, 14 weeks.                |
|               | producers of               | Control group:                           | 14-week waitlist control group.      |                                    |
|               | aluminium, located         | Control group (n=45)                     |                                      |                                    |
|               | around 13 km               | Age: mean 43.7 years (±9.1)              |                                      |                                    |
|               | northwest of               | BMI: mean 30.2 kg/m <sup>2</sup> (±3.5)  |                                      |                                    |
|               | Newcastle (NSW) in         | Sex/gender: 100% men (as per             |                                      |                                    |
|               | the industrial             | eligibility criteria).                   |                                      |                                    |
|               | suburb of Tomago.          | Race/ethnicity: NR.                      |                                      |                                    |
| Morgan et al. | Study design:              | Intervention group:                      | Intervention group:                  | Outcome definition:                |
| (2013)        | RCT                        | SHED-IT Resources (n=53)                 | SHED-IT Resources                    | • Quality of life - Mental health: |
|               |                            | Age: mean 48.0 years (±10.8)             | 3-month individual, online-based     | Short Form-12 Health Survey (SF-   |
|               | <u>Country (locality):</u> | BMI: mean 32.4 kg/m <sup>2+</sup> (±3.3) | intervention where participants      | 12)                                |

| Australia        | Sex/gender: 100% men (as per             | were provided with a weight loss   |                                |
|------------------|--|------------------------------------|--------------------------------|
|                  | eligibility criteria).                   | resources package (25 min SHED-IT  | Relevant follow-up timepoints: |
| <u>Setting:</u>  | Race/ethnicity: NR.                      | Weight Loss DVD for Blokes, the    | Baseline, 3-months.            |
| Hunter Region of |  | Weight Loss Handbook for Blokes,   |                                |
| New South Wales. | SHED-IT Online (n=54)                    | the Weight Loss Support Book for   |                                |
|                  | Age: mean 46.5 years (±11.1)             | Blokes and a pedometer, tape       |                                |
|                  | BMI: mean 32.8 kg/m <sup>2+</sup> (±3.4) | measure for weight circumference,  |                                |
|                  | Sex/gender: 100% male (as per            | and kilojoule counter book).       |                                |
|                  | eligibility criteria).                   |                                    |                                |
|                  | Race/ethnicity: NR.                      | SHED-IT Online                     |                                |
|                  |  | 3-month individual, online-based   |                                |
|                  | Control group:                           | intervention where in addition to  |                                |
|                  | Wait-list control (n=52)                 | the resource package, participants |                                |
|                  | Age: mean 48.0 years (±11.2)             | were provided a website user guide |                                |
|                  | BMI: mean 33.1 kg/m <sup>2+</sup> (±3.9) | to a freely available commercial   |                                |
|                  | Sex/gender: 100% male (as per            | website.                           |                                |
|                  | eligibility criteria).                   |                                    |                                |
|                  | Race/ethnicity: NR.                      | Control group:                     |                                |
|                  |  | Wait-list control                  |                                |

|              |                            |  | Received no intervention until after  |                                  |
|--------------|----------------------------|--|---------------------------------------|----------------------------------|
|              |                            |  | 6-month assessments.                  |                                  |
| Nanchahal et | Study design:              | Intervention group:                      | Intervention group:                   | Outcome definition:              |
| al. (2009)   | RCT                        | Structured support (SS) (n=31)           | Structured support (SS)               | • Depression and anxiety:        |
|              |                            | Age: mean 46 years (±12.12)              | 12-week individual, face-to-face      | Hospital Anxiety and Depression  |
|              | <u>Country (locality):</u> | BMI: mean 36.4 kg/m² (±5.45)             | structured programme based on         | Scales (HADS)                    |
|              | United Kingdom             | Sex/gender: 77% female.                  | clinical counselling constructs       | • Quality of life: EuroQol – 5   |
|              | (UK)                       | Race/ethnicity: NR.                      | (assess, advise, agree, assist,       | dimensions (EQ-5D)               |
|              |                            |  | arrange). Nurses supported setting    | • Self-esteem: Rosenberg's self- |
|              | <u>Setting:</u>            | Structured support and pedometer         | realistic weight targets and focused  | esteem scale                     |
|              | 8 GP practices, with       | (SSP) (n=31)                             | on lifestyle changes. Contacted at 12 |                                  |
|              | an average list size       | Age: mean 47.2 years (±11.4)             | weeks for a 45-minute appointment.    | Relevant follow-up timepoints:   |
|              | of                         | BMI: mean 37.5 kg/m <sup>2</sup> (±5.17) |                                       | Baseline, 12 weeks.              |
|              | 7500 patients,             | Sex/gender: 77% female.                  | Structured support and pedometer      |                                  |
|              | whose                      | Race/ethnicity: NR.                      | (SSP)                                 |                                  |
|              | characteristics            |  | Participants received SS              |                                  |
|              | follow UK                  | <u>Control group:</u>                    | intervention and were also provided   |                                  |
|              | population norms.          | Usual care (UC) (n=30)                   | a pedometer and instruction leaflet.  |                                  |
|              |                            | Age: mean 48.8 years (±11.82)            | Asked to record daily steps.          |                                  |
|              |                            | BMI: mean 35.3 kg/m² (±4.57)             |                                       |                                  |

|                 |                            | Sex/gender: 83% female.                  | Control group:                        |                                  |
|-----------------|----------------------------|--|---------------------------------------|----------------------------------|
|                 |                            | Race/ethnicity: NR.                      | Usual care (UC)                       |                                  |
|                 |                            |  | One individual 30-minute              |                                  |
|                 |                            |  | appointment with nurse.               |                                  |
| Nurkkala et al. | Study design:              | Intervention group:                      | Intervention group:                   | Outcome definition:              |
| (2015)          | RCT                        | <i>Lifestyle intervention (n=90)</i>     | Lifestyle intervention                | • Emotional eating: Three Factor |
|                 |                            | [details for per protocol                | 2-phase individual, face-to-face      | Eating Questionnaire 18 (TFEQ-   |
|                 | <u>Country (locality):</u> | participants]                            | intervention. Phase 1: 9-month        | 18)                              |
|                 | Finland                    | Age: mean 46 years (±10)                 | weight loss period. Phase 2: 27-      |                                  |
|                 |                            | BMI: median 34.3 kg/m <sup>2</sup> (IQR: | month weight maintenance period.      | Relevant follow-up timepoints:   |
|                 | <u>Setting:</u>            | 32.4, 38.9)                              | Year 1: Counselling with nutritionist | Baseline, 9 months.              |
|                 | NR                         | Sex/gender: 71% female.                  | (3 appointments) and with a           |                                  |
|                 |                            | Race/ethnicity: NR.                      | qualified nurse (11 appointments).    |                                  |
|                 |                            |  | Year 2: Met with nurse twice.         |                                  |
|                 |                            | <u>Control group:</u>                    |                                       |                                  |
|                 |                            | Control (n=30)                           | Control group:                        |                                  |
|                 |                            | [details are per protocol]               | Control                               |                                  |
|                 |                            | Age: mean 46 years (±10)                 | Met a qualified nurse once and        |                                  |
|                 |                            | BMI: median 35.8 kg/m <sup>2</sup> (IQR: | received a weight management          |                                  |
|                 |                            | 32.6, 39.4)                              | booklet.                              |                                  |

|                |                            | Sex/gender: 77% female.                 |                                       |                                  |
|----------------|----------------------------|---|---------------------------------------|----------------------------------|
|                |                            | Race/ethnicity: NR.                     |                                       |                                  |
| O'Brien et al. | Study design:              | Intervention group:                     | Intervention group:                   | Outcome definition:              |
| (2016)         | RCT                        | "Lose It" (n=14)                        | "Lose It"                             | • Diet self-efficacy: Weight     |
|                |                            | Age: mean 69.4 years (±6.8)             | 12-week individual and group online   | Efficacy Lifestyle Questionnaire |
|                | <u>Country (locality):</u> | BMI: mean 34.2 kg/m <sup>2</sup> (±7.2) | intervention. Participants were       | (WEL) subscale                   |
|                | United States of           | Sex/gender: 100% female (as per         | given link to a free commercial       |                                  |
|                | America (USA)              | eligibility criteria).                  | Internet programme for weight loss    | Relevant follow-up timepoints:   |
|                |                            | Race/ethnicity: 100% African            | ("Lose It") that records daily food,  | Baseline, 12 weeks.              |
|                | <u>Setting:</u>            | American; 7.1% Hispanic, 92.9%          | daily weight, and allows access to    |                                  |
|                | Rural region of            | Non-Hispanic.                           | peer support group (i.e., discussion  |                                  |
|                | Appalachia in              |   | board). Automated feedback was        |                                  |
|                | western North              | <u>Control group:</u>                   | provided when intake was recorded.    |                                  |
|                | Carolina.                  | Wellness Group (n=10)                   |                                       |                                  |
|                |                            | Age: mean 67.4 years (±6.8)             | <u>Control group:</u>                 |                                  |
|                |                            | BMI: mean 34 kg/m <sup>2</sup> (±9.3)   | 12-week individual online             |                                  |
|                |                            | Sex/gender: 100% female (as per         | intervention with daily wellness tips |                                  |
|                |                            | eligibility criteria).                  | (eye health, dental, mental health,   |                                  |
|                |                            |   | cancer prevention etc) provided by    |                                  |
|                |                            |   | email.                                |                                  |

|                 |                            | Race/ethnicity: 30% African             |                                     |                                  |
|-----------------|----------------------------|---|-------------------------------------|----------------------------------|
|                 |                            | American, 70% White; 100%               |                                     |                                  |
|                 |                            | Hispanic.                               |                                     |                                  |
| Petrella et al. | Study design:              | Intervention group:                     | Intervention group:                 | Outcome definition:              |
| (2017)          | RCT                        | Hockey FIT Program (n=40)               | Hockey FIT Program                  | • Self-esteem: Rosenberg's self- |
|                 |                            | Age: mean 49.1 years (±9.1)             | 52-week, 2 phase, group-based,      | esteem scale                     |
|                 | <u>Country (locality):</u> | BMI: mean 36 kg/m <sup>2</sup> (±5.9)   | face-to-face intervention. Phase 1: | Negative affect: International   |
|                 | Canada.                    | Sex/gender: 100% male (as per           | 12-week active phase with weekly    | Positive and Negative Affect     |
|                 |                            | eligibility criteria).                  | 90-minute sessions of classroom     | Schedule – Short Form (I-PANAS-  |
|                 | <u>Setting:</u>            | Race/ethnicity: 95% White.              | teaching and exercise sessions.     | SF)                              |
|                 | 2 ice hockey teams         |   | Phase 2: 40-week minimally          | • Quality of life: EuroQol 5-    |
|                 | from the Ontario           | <u>Control group:</u>                   | supported phase where participants  | dimension 3-level questionnaire  |
|                 | Hockey League.             | Waitlist Control (n=40)                 | are encouraged to continue          | (EQ5D-3L)                        |
|                 | Sessions delivered         | Age: mean 48.4 years (±9.1)             | behaviours, with 6 standardised     |                                  |
|                 | in team home               | BMI: mean 37.1 kg/m <sup>2</sup> (±6.1) | messages via online social          | Relevant follow-up timepoints:   |
|                 | arenas (medium-            | Sex/gender: 100% male (as per           | network/email to provide            | Baseline, 12 weeks.              |
|                 | sized media                | eligibility criteria).                  | encouragement.                      |                                  |
|                 | market, and                | Race/ethnicity: 95% White.              |                                     | Notes:                           |
|                 | smaller urban              |   | Control group:                      |                                  |
|                 | centre).                   |   | Waitlist Control                    |                                  |

|                  |                            |  | Invited to start the Hockey FIT       | 12-week measure used due to      |
|------------------|----------------------------|--|---------------------------------------|----------------------------------|
|                  |                            |  | program after 12-week                 | waitlist control beginning       |
|                  |                            |  | measurements.                         | intervention at 12 weeks.        |
| Rshikesan et al. | Study design:              | Intervention group:                      | Intervention group:                   | Outcome definition:              |
| (2016)           | RCT                        | Yoga training (n=40)                     | Yoga training                         | • Stress: Perceived Stress Scale |
|                  |                            | Age: mean 40.03 years (±8.74)            | 3-month group-based, face-to-face     | (PSS)                            |
|                  | <u>Country (locality):</u> | BMI: range 25.33-34.84 kg/m <sup>2</sup> | intervention with 90-minute           |                                  |
|                  | India.                     | Sex/gender: 100% male (as per            | sessions 5 days per week. Sessions    | Relevant follow-up timepoints:   |
|                  |                            | eligibility criteria).                   | were in group for the first 14 weeks, | Baseline, 14 weeks.              |
|                  | <u>Setting:</u>            | Race/ethnicity: NR.                      | after which participants were to      |                                  |
|                  | North east of              |  | continue at home. Sessions            |                                  |
|                  | Mumbai, India.             | <u>Control group:</u>                    | consisted of lecture, loosening       |                                  |
|                  |                            | Control group (n=40)                     | exercises, yoga practice and          |                                  |
|                  |                            | Age: mean 42.20 years (±12.06)           | meditation. All participants given a  |                                  |
|                  |                            | BMI: range 25.01-33.64 kg/m <sup>2</sup> | sample meal plan based on             |                                  |
|                  |                            | Sex/gender: 100% male (as per            | guidelines of National Institute of   |                                  |
|                  |                            | eligibility criteria).                   | Nutrition Hyderabad.                  |                                  |
|                  |                            | Race/ethnicity: NR.                      |                                       |                                  |
|                  |                            |  | Control group:                        |                                  |
|                  |                            |  | Control group                         |                                  |

|              |                            |   | Asked to continue with usual         |                                    |
|--------------|----------------------------|---|--------------------------------------|------------------------------------|
|              |                            |   | exercises. All participants given a  |                                    |
|              |                            |   | sample meal plan based on            |                                    |
|              |                            |   | guidelines of National Institute of  |                                    |
|              |                            |   | Nutrition Hyderabad.                 |                                    |
| Rubin et al. | Study design:              | Intervention group:                     | Intervention group:                  | Outcome definition:                |
| (2013)       | RCT                        | In-person support (n=138)               | In-person support                    | • Quality of life – Mental health: |
|              |                            | Age: mean 53.5 years (±10.5)            | 24-month intervention with online,   | Short Form-12 Health Survey (SF-   |
|              | <u>Country (locality):</u> | BMI: mean 36.8 kg/m <sup>2</sup> (±5.2) | telephone and face-to-face support.  | 12)                                |
|              | United States of           | Sex/gender: 63.8% female.               | Study-specific website provided      | • Quality of life: EuroQol 5-      |
|              | America (USA).             | Race/ethnicity: 42.8% African           | learning modules and tools for self- | dimension (EQ5D) questionnaire     |
|              |                            | American, 56.5% Caucasian, 0.7%         | monitoring of weight, diet and       | • Depression: Patient Health       |
|              | <u>Setting:</u>            | Other.                                  | exercise. Participants had weekly    | Questionnaire (PHQ-8)              |
|              | 6 primary care             |   | contact with health coaches (degree  |                                    |
|              | practices in               | Remote support only (n=139)             | qualified) for first 3-months of     | Relevant follow-up timepoints:     |
|              | Baltimore                  | Age: mean 55.8 years (±9.7)             | intervention - 9 group weight-loss   | Baseline, 24-months.               |
|              | metropolitan area.         | BMI: mean 36 kg/m <sup>2</sup> (±4.7)   | meetings (90-minute duration) and    |                                    |
|              |                            | Sex/gender: 63.3% female.               | 3 individual sessions (20-minute     |                                    |
|              |                            |   | duration). For the next 3-months,    |                                    |
|              |                            |   | participants had 3-monthly contacts  |                                    |

|  | Race/ethnicity: 1.4% Asian, 37.4% | – 1 group session and 2 individual     |  |
|--|-----------------------------------|--|--|
|  | African American, 59.7%           | sessions. For remainder of study,      |  |
|  | Caucasian, 1.4% Other.            | participants had 2 monthly contacts    |  |
|  |                                   | (1 group session and 1 individual      |  |
|  | Control group:                    | session).                              |  |
|  | Control (n=138)                   |  |  |
|  | Age: mean 52.9 years (±10.1)      | Remote support only                    |  |
|  | BMI: mean 36.8 kg/m² (±5.1)       | 24-month intervention with online      |  |
|  | Sex/gender: 63.8% female.         | and telephone support. Study-          |  |
|  | Race/ethnicity: 1.4% Asian, 42.8% | specific website provided learning     |  |
|  | African American, 52.2%           | modules and tools for self-            |  |
|  | Caucasian, 3.6% Other.            | monitoring of weight, diet and         |  |
|  |                                   | exercise. Participants had weekly      |  |
|  |                                   | contact with health coaches (Master    |  |
|  |                                   | degree qualified) for first 3-months   |  |
|  |                                   | of intervention $-12$ weekly phone     |  |
|  |                                   | calls. For the remainder of the study. |  |
|  |                                   | participants had 1 phone call per      |  |
|  |                                   | month                                  |  |
|  |                                   |  |  |
|  |                                   |  |  |

|               |                            |   | Control group:                         |                                    |
|---------------|----------------------------|---|--|------------------------------------|
|               |                            |   | Control                                |                                    |
|               |                            |   | Received weight control brochure.      |                                    |
|               |                            |   | Offered a meeting with a health        |                                    |
|               |                            |   | coach after the 24-month data          |                                    |
|               |                            |   | measurements.                          |                                    |
| Samuel-Hodge  | Study design:              | Intervention group:                       | Intervention group:                    | Outcome definition:                |
| et al. (2009) | RCT                        | Weight Wise Program (WWP)                 | Weight Wise Program (WWP)              | • Quality of life – Mental health: |
|               |                            | (n=72)                                    | 16-week group-based, face-to-face      | Short Form-8 Health Survey (SF-    |
|               | <u>Country (locality):</u> | Age: mean 51.9 years (SE 0.8)             | intervention with weekly education     | 8)                                 |
|               | United States of           | BMI: mean 34.5 kg/m <sup>2</sup> (SE 0.6) | sessions lasting 120 minutes lead by   | • Depression: Center for           |
|               | America (USA)              | Sex/gender: 100% female (as per           | a registered nurse. Sessions           | Epidemiologic Studies              |
|               |                            | eligibility criteria).                    | included of weigh-in, group sharing    | Depression Scale (CES-D)           |
|               | <u>Setting:</u>            | Race/ethnicity: 38% non-Hispanic          | and problem solving, education, and    |                                    |
|               | Wilmington, North          | Black, 61% non-Hispanic White.            | goal setting. Daily self-monitoring of | Relevant follow-up timepoints:     |
|               | Carolina, a mid-size       |   | diet and physical activity was         | Baseline, 5 months.                |
|               | city located in the        | <u>Control group:</u>                     | recommended. Participants              |                                    |
|               | Eastern part of the        | Control Group (n=71)                      | received a feedback report at week     |                                    |
|               | state.                     | Age: mean 53.7 years (SE 0.9)             | 6, 11 and 16. Points were earned for   |                                    |
|               |                            | BMI: mean 34.3 kg/m <sup>2</sup> (SE 0.6) | attendance, self-monitoring and        |                                    |

|               |                            | Sex/gender: 100% female (as per    | achieving goals (can be redeemed       |                                |
|---------------|----------------------------|------------------------------------|--|--------------------------------|
|               |                            | eligibility criteria).             | for prizes).                           |                                |
|               |                            | Race/ethnicity: 39% non-Hispanic   |  |                                |
|               |                            | Black, 59% non-Hispanic White.     | Control group:                         |                                |
|               |                            |                                    | Control Group                          |                                |
|               |                            |                                    | Two newsletters on skin health and     |                                |
|               |                            |                                    | preventing back pain were emailed      |                                |
|               |                            |                                    | to participants.                       |                                |
| Scholz et al. | Study design:              | Intervention group:                | Intervention group:                    | Outcome definition:            |
| (2013)        | RCT                        | Single planning intervention group | Single planning intervention group     | • Self-efficacy: Bespoke       |
|               |                            | (PG1) (n=72)                       | (PH1)                                  | questionnaire                  |
|               | <u>Country (locality):</u> | 3-weeks planning group (PG3)       | Planning sheet with instructions       |                                |
|               | NR                         | (n=76)                             | provided at the end of baseline visit. | Relevant follow-up timepoints: |
|               |                            | 6- weeks planning group (PG6)      | Participants formed up to 3 action     | Baseline, 4 months.            |
|               | <u>Setting:</u>            | (n=79)                             | plans for their low-fat diets and      |                                |
|               | NR                         | 9-weeks planning group (PG9)       | formed up to 3 coping plans.           |                                |
|               |                            | (n=74)                             | Participants were instructed to        |                                |
|               |                            | Age, sex/gender, BMI and           | visualise the situations, planned      |                                |
|               |                            | race/ethnicity: NR.                | actions and make a firm                |                                |
|               |                            |                                    | commitment to act as planned.          |                                |

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|                |                            | Control group:                                |                                      |                                    |
|----------------|----------------------------|---|--------------------------------------|------------------------------------|
|                |                            | Control group (n=72)                          | 3-weeks planning group (PG3)         |                                    |
|                |                            | Age, sex/gender, BMI and                      | 6- weeks planning group (PG6)        |                                    |
|                |                            | race/ethnicity: NR.                           | 9-weeks planning group (PG9)         |                                    |
|                |                            |   | Further intervention groups          |                                    |
|                |                            | The study did not report baseline             | completed more frequent planning     |                                    |
|                |                            | characteristics by group. Overall,            | sheets (baseline planning sheet plus |                                    |
|                |                            | participants were mean age 52.42              | 3, 6, or 9 additional sheets).       |                                    |
|                |                            | years (±12.79) with a range of 18-            | Duration of interventions            |                                    |
|                |                            | 82 years. Participants had mean               | determined to be 10 weeks.           |                                    |
|                |                            | BMI 31.06 kg/m <sup>2</sup> (±4.41). 72.4% of |                                      |                                    |
|                |                            | participants were female.                     | Control group:                       |                                    |
|                |                            |   | Control group                        |                                    |
|                |                            |   | No treatment.                        |                                    |
| Sellman et al. | <u>Study design:</u>       | Intervention group:                           | Intervention group:                  | Outcome definition:                |
| (2017)         | RCT                        | Green Prescription plus Kia Akina             | Green Prescription plus Kia Akina    | • Quality of life: WHO Quality of  |
|                |                            | (KA/GRx) (n=38)                               | (KA/GRx)                             | Life short form questionnaire      |
|                | <u>Country (locality):</u> | Age: mean 45.1 years (±10.9)                  | 12-month intervention (in addition   | (WHOQoL-BREF)                      |
|                | New Zealand                | BMI: mean 41 kg/m² (±7)                       | to usual care (detailed below))      | Psychological distress: Kessler    |
|                |                            | Sex/gender: 83% female.                       | provided by multiple modes of        | Psychological Distress Scale (K10) |

| <u>Setting:</u>  | Race/ethnicity: 70% Pākehā (NZ          | delivery (face-to-face, phone, web) |                                |
|------------------|---|-------------------------------------|--------------------------------|
| 4 geographically | European); 11% Māori/Pacific;           | on both individual and group-basis. | Relevant follow-up timepoints: |
| separate general | 19% Other.                              | Obesity recovery network primarily  | Baseline, 12-months.           |
| primary care     |   | providing psychological support,    |                                |
| venues in        | <u>Control group:</u>                   | and supporting diet modification,   |                                |
| Christchurch.    | Green Prescription (GRx) – usual        | increased physical activity and     |                                |
|                  | care (n=43)                             | adoption of behavioural strategies. |                                |
|                  | Age: mean 42.4 years (±10.9)            | Participants could select from      |                                |
|                  | BMI: mean 40.8 kg/m <sup>2</sup> (±7.3) | engagement options: (1) 6 face-to-  |                                |
|                  | Sex/gender: 85% female.                 | face monthly 2-hour workshops and   |                                |
|                  | Race/ethnicity: 67% Pākehā (NZ          | weekly facilitated group discussion |                                |
|                  | European); 13% Māori/Pacific;           | meetings (1 hour); (2) On-going     |                                |
|                  | 20% Other.                              | weekly email discussion group; (3)  |                                |
|                  |   | Daily text buddy system and regular |                                |
|                  |   | motivational text messages.         |                                |
|                  |   |                                     |                                |
|                  |   | Control group:                      |                                |
|                  |   | Green Prescription (GRx) – usual    |                                |
|                  |   | care                                |                                |

|                  |                            |                                       | Consultations with a qualified and     |                                |
|------------------|----------------------------|---------------------------------------|--|--------------------------------|
|                  |                            |                                       | experienced physical activity coach    |                                |
|                  |                            |                                       | to discover suitable physical activity |                                |
|                  |                            |                                       | options in their community. Attend     |                                |
|                  |                            |                                       | "Appetite for life" eating             |                                |
|                  |                            |                                       | programme, receive group support,      |                                |
|                  |                            |                                       | education sessions, and text/email     |                                |
|                  |                            |                                       | encouragement.                         |                                |
| Steinberg et al. | Study design:              | Intervention group:                   | Intervention group:                    | Outcome definition:            |
| (2014)           | RCT                        | Daily self-weighing intervention      | Daily self-weighing intervention       | • Body image: 16-item Body     |
|                  |                            | (n=47)                                | 6-month individual, online-based       | Shape Questionnaire (BSQ)      |
|                  | <u>Country (locality):</u> | Age: mean 43 years (±11.4)            | intervention. Participants were        | • Depression: Center for       |
|                  | United States of           | BMI: mean 33.2 kg/m <sup>2</sup> (±4) | encouraged to weight daily using an    | Epidemiologic Studies          |
|                  | America (USA)              | Sex/gender: 70% female.               | e-scale that transmits data to a       | Depression Scale (CES-D)       |
|                  |                            | Race/ethnicity: 13% Black, 77%        | website to display weight graphs.      |                                |
|                  | <u>Setting:</u>            | White, 10% Other.                     | Data was used to provide tailored      | Relevant follow-up timepoints: |
|                  | Chapel Hill NC.            |                                       | feedback via weekly emails. Weekly     | Baseline, 6 months.            |
|                  |                            | Control group:                        | emails also included behavioural       |                                |
|                  |                            | Delayed intervention control          | weight-control lessons.                |                                |
|                  |                            | (n=44)                                |  |                                |

|                |                            | Age: mean 44.7 years (±10.6)                  | Control group:                       |                                    |
|----------------|----------------------------|---|--------------------------------------|------------------------------------|
|                |                            | BMI: mean 31.1 kg/m <sup>2</sup> (±3.1)       | Delayed intervention control         |                                    |
|                |                            | Sex/gender: 80% female.                       | No intervention.                     |                                    |
|                |                            | Race/ethnicity: 18% Black, 71%                |                                      |                                    |
|                |                            | White, 11% Other.                             |                                      |                                    |
| Tapsell et al. | Study design:              | Intervention group:                           | Intervention group:                  | Outcome definition:                |
| (2017)         | RCT                        | Intervention (n=125)                          | Intervention                         | • Quality of life – Mental health: |
|                |                            | Age, sex/gender, BMI and                      | 12-month individual, face-to-face    | Short Form-12 Health Survey (SF-   |
|                | <u>Country (locality):</u> | race/ethnicity: NR.                           | intervention with 7 sessions of      | 12)                                |
|                | Australia                  |   | counselling across 1 year and        |                                    |
|                |                            | Control group:                                | quarterly brief support phone calls. | Relevant follow-up timepoints:     |
|                | <u>Setting:</u>            | Control group (n=126)                         | Counselling was based on             | Baseline, 12-months.               |
|                | Community-based -          | Age, sex/gender, BMI and                      | individualised programme of diet,    |                                    |
|                | Illawarra region,          | race/ethnicity: NR.                           | physical activity and behavioural    |                                    |
|                | south of Sydney.           |   | support for weight loss and          |                                    |
|                |                            | The study did not report baseline             | maintenance. Health coaching         |                                    |
|                |                            | characteristics by group. Overall,            | workbook provided to participants.   |                                    |
|                |                            | participants were median age 45               | Usual diet and physical activity     |                                    |
|                |                            | years (IQR 37, 51) with median                | patterns were assessed by dieticians |                                    |
|                |                            | BMI 32 kg/m <sup>2</sup> (IQR 29, 35). 74% of | and discussed with the exercise      |                                    |

| participants were female; 82%       | psychologists (if needed) who       |  |
|-------------------------------------|-------------------------------------|--|
| were Australian born, and 2%        | developed plans to adapt to         |  |
| were of Aboriginal or Torres Strait | healthier eating/exercise options.  |  |
| Islander Origin.                    |                                     |  |
|                                     |                                     |  |
|                                     | <u>Control group:</u>               |  |
|                                     | Control group                       |  |
|                                     | Participants were given dietary     |  |
|                                     | guidelines and health-related       |  |
|                                     | materials. Asked to reflect on      |  |
|                                     | current diets to identify changes   |  |
|                                     | that might align patterns more in   |  |
|                                     | accordance with dietary guidelines. |  |
|                                     | Received basic physical activity    |  |
|                                     | advice in line with the current     |  |
|                                     | Australian Physical Activity        |  |
|                                     | Guidelines. Phone calls at the same |  |
|                                     | intervals as intervention to remind |  |
|                                     | of the next appointment and ask if  |  |

|                 |                     |   | they have any concerns or              |                                  |  |
|-----------------|---------------------|---|--|----------------------------------|--|
|                 |                     |   | problems.                              |                                  |  |
| Teixeira et al. | Study design:       | Intervention group:                             | Intervention group:                    | Outcome definition:              |  |
| (2010)          | RCT                 | Intervention (n=113)                            | Intervention                           | • Emotional eating: Dutch Eating |  |
|                 |                     | Age, sex/gender, BMI and                        | 1-year group-based, face-to-face       | Behaviour Questionnaire (DEBQ)   |  |
|                 | Country (locality): | race/ethnicity: NR.                             | intervention with 30 sessions          | • Body image: Body Shape         |  |
|                 | Portugal            |   | targeting physical activity, diet, and | Questionnaire (BSQ)              |  |
|                 |                     | Control group:                                  | patterns ultimately supportive of      | • Diet self-efficacy: Weight     |  |
|                 | <u>Setting:</u>     | Comparison (n=112)                              | weight maintenance. A                  | Management Efficacy              |  |
|                 | University-based.   | Age, sex/gender, BMI and                        | comprehensive workbook was             | Questionnaire (WEL)              |  |
|                 |                     | race/ethnicity: NR.                             | provided to complement the             | • Exercise self-efficacy: Self-  |  |
|                 |                     |   | sessions. Intervention providers       | Efficacy for Exercise Behaviours |  |
|                 |                     | The study did not report baseline               | were PhD or MS Level exercise          | e (SEE)                          |  |
|                 |                     | characteristics by group. Overall,              | physiologists, nutritionists/          |                                  |  |
|                 |                     | participants were mean age 37.6                 | dieticians, and psychologists.         | Relevant follow-up timepoints:   |  |
|                 |                     | years (±7), with mean BMI 31.3                  |  | Baseline, 12-months.             |  |
|                 |                     | kg/m <sup>2</sup> (±4.1). All participants were | Control group:                         |                                  |  |
|                 |                     | female, as per the eligibility                  | Comparison                             |                                  |  |
|                 |                     | criteria.                                       | Received a general health education    |                                  |  |
|                 |                     |   | curriculum based on several 3 to 6-    |                                  |  |

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|              |                            |                                   | week long educational topics (e.g.,  |                                |  |
|--------------|----------------------------|-----------------------------------|--------------------------------------|--------------------------------|--|
|              |                            |                                   | preventive nutrition, stress         |                                |  |
|              |                            |                                   | management, self-care and            |                                |  |
|              |                            |                                   | effective communication skills).     |                                |  |
| White et al. | Study design:              | Intervention group:               | Intervention group:                  | Outcome definition:            |  |
| (2010)       | RCT                        | Group 1 (n=64)                    | Group 1                              | Quality of life: Bespoke       |  |
|              |                            | Age, sex/gender, BMI and          | 9 month, 2-phase, individual, face-  | questionnaire                  |  |
|              | <u>Country (locality):</u> | race/ethnicity: NR.               | to-face intervention providing       |                                |  |
|              | Scotland, United           |                                   | advice on reducing dietary energy,   | Relevant follow-up timepoints: |  |
|              | Kingdom (UK)               | Group 2 (n=62)                    | total fat and sucrose. Phase 1: 3-   | Baseline, 3-months.            |  |
|              |                            | Age, sex/gender, BMI and          | month weight reduction period.       |                                |  |
|              | <u>Setting:</u>            | race/ethnicity: NR.               | Phase 2: 9-month weight              | Notes:                         |  |
|              | Several, large             |                                   | maintenance period. Participants     | 3-month measure used as end of |  |
|              | companies,                 | <u>Control group:</u>             | received 2 advice sessions (baseline | weight loss period of          |  |
|              | outskirts of               | Group 3 (n=43)                    | and 3-months), and accompanying      | intervention.                  |  |
|              | Edinburgh.                 | Age, sex/gender, BMI and          | literature was provided.             |                                |  |
|              |                            | race/ethnicity: NR.               |                                      |                                |  |
|              |                            |                                   | Group 2                              |                                |  |
|              |                            | The study did not report baseline | 9 month, 2-phase, individual, face-  |                                |  |
|              |                            | characteristics by group.         | to-face intervention providing       |                                |  |

|               |                     | Characteristics were reported for    | advice on reducing dietary energy   |                                  |
|---------------|---------------------|--------------------------------------|-------------------------------------|----------------------------------|
|               |                     | completing participants (exc.        | and total fat and maintaining       |                                  |
|               |                     | withdrawals and dropouts             | sucrose intake at 10% of total      |                                  |
|               |                     | (n=126)).                            | energy. Phase 1: 3-month weight     |                                  |
|               |                     | Overall, participants were mean      | reduction period. Phase 2: 9-month  |                                  |
|               |                     | 37 years (SE 1.3), with mean BMI     | weight maintenance period.          |                                  |
|               |                     | 31.5 kg/m <sup>2</sup> (SE 0.7). All | Participants received 2 advice      |                                  |
|               |                     | participants were female, as per     | sessions (baseline and 3-months),   |                                  |
|               |                     | the eligibility criteria.            | and accompanying literature was     |                                  |
|               |                     |                                      | provided.                           |                                  |
|               |                     |                                      |                                     |                                  |
|               |                     |                                      | <u>Control group:</u>               |                                  |
|               |                     |                                      | Group 3                             |                                  |
|               |                     |                                      | No intervention.                    |                                  |
| Xenaki et al. | Study design:       | Intervention group:                  | Intervention group:                 | Outcome definition:              |
| (2018)        | RCT                 | Intervention – Stress management     | Intervention – Stress management    | Depression: Beck Depression      |
|               |                     | program (n=31)                       | program                             | Inventory (BDI)                  |
|               | Country (locality): | Age: mean 46.91 years (±2.98)        | 8-week individual intervention with | • Stress: Perceived Stress Scale |
|               | Greece              | BMI: mean 35.54 kg/m² (±2.98)        | weekly sessions comprised on        | (PSS)                            |
|               |                     | Sex/gender: 54.5% female.            | progressive muscle relaxation,      |                                  |

|                | Setting:             | Race/ethnicity: NR.                       | diaphragmatic breathing and guide     | Relevant follow-up timepoints: |
|----------------|----------------------|---|---------------------------------------|--------------------------------|
|                | Outpatient obesity   |   | visualisation. Participants were      | Baseline, 8 weeks.             |
|                | clinic of the Laiko  | <u>Control group:</u>                     | given instructions on progressively   |                                |
|                | General Hospital     | Control group (n=30)                      | thinking by replacing incorrect       |                                |
|                | (one of the largest  | Age: mean 44.48 years (±10.12)            | perceptions about nutrition with      |                                |
|                | hospitals in Athens, | BMI: mean 34.86 kg/m <sup>2</sup> (±2.86) | healthier food and habits and         |                                |
|                | Greece).             | Sex/gender: 47.8% female.                 | choices. Given compact disk with      |                                |
|                |                      | Race/ethnicity: NR.                       | recorded instructions and diaries     |                                |
|                |                      |   | detailing nature of the intervention. |                                |
|                |                      |   | Sessions were held by a health        |                                |
|                |                      |   | professional specialising in stress   |                                |
|                |                      |   | management techniques.                |                                |
|                |                      |   |                                       |                                |
|                |                      |   | Control group:                        |                                |
|                |                      |   | Control group                         |                                |
|                |                      |   | Received standard dietary and         |                                |
|                |                      |   | physical activity instructions.       |                                |
| Abbreviations: |                      | 1   | 1                                     | I                              |

*NR* - not reported; *RCT* – *Randomised Controlled Trial; BMI* – *Body Mass Index; IQR* – *Inter-Quartile Range; SE* – *Standard Error; SEM* – *Standard Error of the Mean; CI* – *Confidence Interval.* 

Rebecca A. Jones – January 2022

# A2.4 Ratings of risk of bias domains for included studies

Table A3. Ratings of risk of bias domains for included studies.

| Study reference       | Random sequence<br>generation (selection<br>bias) | Allocation concealment<br>(selection bias) | Blinding of participants<br>and personnel<br>(performance bias) | Blinding of outcome<br>assessment (detection<br>bias) | Incomplete outcome<br>data (attrition bias) | Selective reporting<br>(reporting bias) | Other sources of bias | Overall risk of bias |
|-----------------------|---|--|---|---|---|---|-----------------------|----------------------|
| Ahern et al. (2017)   | L   | L  | Н   | Н   | L   | U                                       | U                     | Unclear              |
| Alfaris et al. (2015) | L   | L  | Н   | Н   | Н   | U                                       | U                     | High                 |
| Ash et al. (2006)     | L   | U  | Н   | Н   | L   | U                                       | U                     | Unclear              |
| Astbury et al. (2018) | L   | L  | Н   | Н   | L   | L                                       | L                     | Low                  |
| Barnes et al. (2014)  | U   | U  | Н   | Н   | L   | L                                       | Н                     | High                 |
| Berry et al. (2011)   | Н   | U  | Н   | Н   | U   | L                                       | Н                     | High                 |
| Camolas et al. (2017) | U   | U  | Н   | Н   | L   | L                                       | U                     | Unclear              |
| Cleo et al. (2019)    | L   | L  | Н   | Н   | L   | L                                       | L                     | Low                  |
| Cramer et al. (2016)  | L   | L  | Н   | Н   | L   | U                                       | U                     | Unclear              |
| Crane et al. (2016)   | L   | U  | Н   | Н   | Н   | L                                       | U                     | Unclear              |

| Damschroder et al. (2014)  | L | L | Н | Н | L | U | U | Unclear |
|----------------------------|---|---|---|---|---|---|---|---------|
| Domene et al. (2016)       | U | U | Н | Н | L | U | U | Unclear |
| Godino et al. (2016)       | L | L | Н | Н | L | U | U | Unclear |
| Gray et al. (2013)         | L | U | Н | Н | L | L | L | Low     |
| Haapala et al. (2019)      | U | L | Н | Н | L | U | Н | High    |
| Herring et al. (2014)      | L | U | Н | Н | L | U | U | Unclear |
| Huber et al. (2015)        | L | L | Н | Н | L | U | U | Unclear |
| Hunt et al. (2014)         | L | L | Н | Н | U | L | L | Low     |
| Imayama et al. (2011)      | L | L | Н | Н | L | U | L | Low     |
| Jamal et al. (2016)        | U | L | Н | Н | L | L | L | Low     |
| Jane et al. (2018)         | L | U | Н | Н | U | U | U | Unclear |
| Jebb et al. (2011)         | L | L | Н | Н | L | U | U | Unclear |
| Kalarchian et al. (2013)   | U | U | Н | Н | Н | U | Н | High    |
| Kraschnewski et al. (2011) | U | L | Н | Н | Н | Н | Н | High    |
| Laing et al. (2014)        | L | L | Н | Н | L | L | U | Low     |
| McRobbie et al. (2016)     | L | L | Н | Н | L | L | U | Low     |
| Morgan et al. (2011) &     | U | L | Н | Н | Н | U | U | High    |
| Morgan et al. (2012)       |   |   |   |   |   |   |   |         |
| Morgan et al. (2013)       | L | L | Н | Н | L | L | U | Low     |

| Nanchahal et al. (2009)                       | U | U | Н | Н | Н | U | U | High    |
|---|---|---|---|---|---|---|---|---------|
| Nurkkala et al. (2015)                        | U | U | Н | Н | Н | U | U | High    |
| O'Brien et al. (2016)                         | Н | U | Н | Н | L | U | U | High    |
| Petrella et al. (2017)                        | L | L | Н | Н | L | L | L | Low     |
| Rshikesan et al. (2016)                       | U | U | Н | Н | Н | U | U | High    |
| Rubin et al. (2013)                           | L | U | Н | Н | Н | U | U | High    |
| Samuel-Hodge et al. (2009)                    | L | U | Н | Н | L | U | U | Unclear |
| Scholz et al. (2013)                          | U | U | Н | Н | Н | U | U | High    |
| Sellman et al. (2017)                         | L | L | Н | Н | Н | U | U | High    |
| Steinberg et al. (2014)                       | U | U | Н | Н | L | U | L | Unclear |
| Tapsell et al. (2017)                         | L | L | Н | Н | L | U | U | Unclear |
| Teixeira et al. (2010)                        | U | U | Н | Н | Н | U | Н | High    |
| White et al. (2010)                           | U | U | Н | Н | Н | Н | Н | High    |
| Xenaki et al. (2018)                          | U | Н | Н | Н | Н | U | U | High    |
| Key: L – Low risk; H – High risk, U – Unclear |   |   |   |   |   |   |   |         |

# A2.5 Summary of risk of bias ratings across studies



Figure A1. Summary of risk of bias ratings across studies
## A2.6 Assessment of publication bias at outcome level



Figures S2-39. Assessment of publication bias at outcome level.











Estimated  $\theta_{IV}$ 















A2.7 Changes in mental health at 12-months, comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis.

| Study  | Assessment tool | Hedges's g<br>with 95% Cl |
|--|-----------------|---------------------------|
| Body image concerns* [Post intervention] (n=1)                 |                 |                           |
| Teixeira et al. (2010)   | BSQ —           | -0.69 [ -0.96, -0.42]     |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = .\%$ , $H^2 = .$       |                 | -0.69 [ -0.96, -0.42]     |
| Test of $\theta_i = \theta_j$ : Q(0) = 0.00, p = .             |                 |                           |
| Depression* [Post intervention] (n=5)                          |                 |                           |
| Ahern et al. (2017) [12-week BWLP]                             | HADS -          | -0.26 [ -0.55, 0.03]      |
| Ahern et al. (2017) [52-week BWLP)                             | HADS -          | -0.23 [ -0.51, 0.06]      |
| Imayama et al. (2011) [Dietary+Exercise]                       | BSI-18          | -0.26 [ -0.66, 0.15]      |
| Imayama et al. (2011) [Dietary]                                | BSI-18          | 0.07 [ -0.47, 0.34]       |
| Imayama et al. (2011) [Exercise]                               | BSI-18          | 0.03 [ -0.44, 0.37]       |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$ |                 | -0.19 [ -0.34, -0.04]     |
| Test of $\theta_i = \theta_j$ : Q(4) = 1.37, p = 0.85          | •               |                           |
| Emotional eating* [Mean change] (n=1)                          |                 |                           |
| McRobbie et al. (2016)   | TFEQ -          | - 0.14 [ -0.13, 0.41]     |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = .\%$ , $H^2 = .$       |                 | 0.14 [ -0.13, 0.41]       |
| Test of $\theta_i = \theta_j$ : Q(0) = 0.00, p = .             | •               |                           |
| Emotional eating* [Post intervention] (n=1)                    |                 |                           |
| Teixeira et al. (2010)   | DEBQ            | -0.28 [ -0.54, -0.02]     |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = .\%$ , $H^2 = .$       |                 | -0.28 [ -0.54, -0.02]     |
| Test of $\theta_i = \theta_j$ : Q(0) = -0.00, p = .            | •               |                           |
| Negative affect* [Mean change] (n=1)                           |                 |                           |
| Hunt et al. (2014)   | PANAS           | -0.21 [ -0.36, -0.06]     |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = .\%$ , $H^2 = .$       |                 | -0.21 [ -0.36, -0.06]     |
| Test of $\theta_i = \theta_j$ : Q(0) = -0.00, p = .            | •               |                           |
| Quality of life - Global [Mean change] (n=3)                   |                 |                           |
| Astbury et al. (2018)  | EQ5D-index      | - 0.13 [ -0.15, 0.41]     |
| Damschroder et al. (2014) [ASPIRE-Group]                       | EQ5D-index -    | -0.12 [ -0.39, 0.15]      |
| Damschroder et al. (2014) [ASPIRE-Phone]                       | EQ5D-index      | 0.00 [ -0.27, 0.27]       |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$ | •               | 0.00 [ -0.16, 0.16]       |
| Test of $\theta_i = \theta_j$ : Q(2) = 1.50, p = 0.47          |                 |                           |
| Quality of life - Global [Post intervention] (n=4)             |                 |                           |
| Ahern et al. (2017) [12-week BWLP]                             | EQ5D3L –        | - 0.12 [ -0.17, 0.41]     |
| Ahern et al. (2017) [52-week BWLP)                             | EQ5D3L –        | - 0.11 [ -0.18, 0.40]     |
| McRobbie et al. (2016)   | EQ5D5L          | - 0.16 [ -0.15, 0.46]     |
| Sellman et al. (2017)  | WHOQOL          | — 0.04 [ -0.39, 0.47]     |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$ |                 | 0.12 [ -0.04, 0.28]       |
| Test of $\theta_i = \theta_j$ : Q(3) = 0.19, p = 0.98          | ľ               |                           |
| Quality of life - Mental health [Mean change] (n=1)            |                 |                           |
| Hunt et al. (2014)   | SF-12           | 0.04 [ -0.11, 0.19]       |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = .\%$ , $H^2 = .$       | •               | 0.04 [ -0.11, 0.19]       |
| Test of $\theta_i = \theta_j$ : Q(0) = -0.00, p = .            | ľ               |                           |

| Quality of life Mantal basith (Deat intervention) (n=4)   |                                 |                      |
|---|---------------------------------|----------------------|
| Quality of life - Mental health [Post Intervention] (n=4)   |                                 | 0.28 [ 0.02 0.70]    |
| Imayama et al. (2011) [Dietary]   |                                 | 0.30 [ -0.02, 0.79]  |
| Imayama et al. (2011) [Dietary]   | SF-30                           | 0.22 [ -0.19, 0.62]  |
| Solution at al. (2017) [Exercise]   | SF-30                           | 0.32 [-0.09, 0.72]   |
| Seliman et al. (2017)   | WHOQOL                          | 0.26 [-0.17, 0.69]   |
| Heterogeneity: $1 = 0.00, 1 = 0.00\%$ , $H = 1.00$  |                                 | 0.29 [ 0.09, 0.50]   |
| lest of $\theta_i = \theta_j$ : Q(3) = 0.36, p = 0.95   |                                 |                      |
| Quality of life - Obesity-related [Mean change] (n=1)   |                                 |                      |
| Astbury et al. (2018)   |                                 | 0 16 [ -0 12 0 44]   |
| Heterogeneity: $\tau^2 = 0.00 \ l^2 = \% \ H^2 =$   |                                 | 0.16[-0.12, 0.44]    |
| Test of $\theta_1 = \theta_1$ : $Q(0) = 0.00$ p =   |                                 | 0.10[ 0.12, 0.11]    |
|   |                                 |                      |
| Satisfaction with life [Mean change] (n=2)  |                                 |                      |
| Damschroder et al. (2014) [ASPIRE-Group]  | SWL –                           | -0.09 [ -0.37, 0.18] |
| Damschroder et al. (2014) [ASPIRE-Phone]  | SWL -                           | -0.16 [ -0.43, 0.12] |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$  |                                 | -0.12 [ -0.32, 0.07] |
| Test of $\theta_i = \theta_j$ : Q(1) = 0.10, p = 0.75   |                                 |                      |
|   |                                 |                      |
| Self efficacy - Diet [Post intervention] (n=4)  |                                 |                      |
| Damschroder et al. (2014) [ASPIRE-Group]  | SOCQ -                          | 0.17 [ -0.15, 0.48]  |
| Damschroder et al. (2014) [ASPIRE-Phone]  | SOCQ -                          | 0.26 [ -0.06, 0.58]  |
| Haapala et al. (2009)   | Bespoke questionnaire           | -0.13 [ -0.56, 0.31] |
| Teixeira et al. (2010)  | WMEQ                            | 0.63 [ 0.36, 0.90]   |
| Heterogeneity: $\tau^2 = 0.07$ , $I^2 = 70.71\%$ , $H^2 = 3.41$   |                                 | 0.26 [ -0.04, 0.56]  |
| Test of $\theta_i = \theta_j$ : Q(3) = 10.35, p = 0.02  |                                 |                      |
|   |                                 |                      |
| Self efficacy - Exercise [Post intervention] (n=3)  |                                 |                      |
| Damschroder et al. (2014) [ASPIRE-Group]  | Bespoke questionnaire           | 0.23 [ -0.09, 0.55]  |
| Damschroder et al. (2014) [ASPIRE-Phone]  | Bespoke questionnaire —         | 0.38 [ 0.06, 0.70]   |
| Teixeira et al. (2010)  | SEEB                            | - 0.77 [ 0.50, 1.04] |
| Heterogeneity: $\tau^2$ = 0.06, $I^2$ = 70.53%, $H^2$ = 3.39  |                                 | 0.47 [ 0.15, 0.79]   |
| Test of $\theta_i = \theta_j$ : Q(2) = 7.03, p = 0.03   | •                               |                      |
|   |                                 |                      |
| Self efficacy [Post intervention] (n=6)   | 0050                            |                      |
| Ash et al. (2006) [FBI]   | GSES                            | 0.84 [ 0.15, 1.53]   |
| Ash et al. (2006) [IDT]   | GSES                            | 0.83 [ 0.19, 1.47]   |
| Scholz et al. (2013) [PG1]  | Bespoke questionnaire           | 0.19 [ -0.32, 0.71]  |
| Scholz et al. (2013) [PG3]  | Bespoke questionnaire           | 0.25 [ -0.27, 0.76]  |
| Scholz et al. (2013) [PG6]  | Bespoke questionnaire           | 0.15 [ -0.31, 0.62]  |
| Scholz et al. (2013) [PG9]  | Bespoke questionnaire           | 0.27 [ -0.24, 0.78]  |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$  |                                 | 0.35 [ 0.13, 0.57]   |
| Test of $\theta_i = \theta_j$ : Q(5) = 5.39, p = 0.37   | •                               |                      |
|   |                                 |                      |
| Seif-esteem [Mean change] (n=2)   |                                 | 0.57.1.0.44 0.701    |
| Hunt et al. (2014)  | RSES                            | 0.57 [ 0.41, 0.72]   |
| Heterogeneity: $T = 0.00$ , $I = .%$ , $H = .$  |                                 | 0.57 [ 0.41, 0.72]   |
| lest of $\theta_i = \theta_j$ : Q(0) = -0.00, p = .   |                                 |                      |
| Overall   |                                 | 0 11 [ 0 0 1 0 0 1   |
| Heterogeneity: $\tau^2 = 0.07 \ l^2 = 76.13\% \ H^2 - 4.10$   |                                 | 0.11[0.01, 0.21]     |
| There is the second se | Favours intervention Favours of | control              |
| p = 0.00  |                                 |                      |
| Test of group differences: $Q_b(14) = 124.77$ , p = 0.00  |                                 | 1                    |
|   | -1 0                            | 1 2                  |

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APPENDICES

Figure A40. Changes in mental health at 12-months, comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis.

For variables with asterisks (\*), negative estimates indicate a desired change in favour of the intervention; for all other variables, positive estimates indicate a desired change in favour of the intervention.

# A2.8 Sensitivity analyses

| Study   | Assessment tool | Hedges's g<br>with 95% Cl |
|---|-----------------|---------------------------|
| Anxiety (n=9)   |                 |                           |
| Ahern et al. (2017) [12-week BWLP]  | HADS            | -0.12 [ -0.32, 0.07]      |
| Ahern et al. (2017) [52-week BWLP)  | HADS            | 0.02 [ -0.19, 0.24]       |
| Herring et al. (2014) [Aerobic Exercise]                                      | HADS —          | -0.72 [ -1.84, 0.40]      |
| Herring et al. (2014) [Resistance Exercise]                                   | HADS —          | -0.04 [ -1.13, 1.04]      |
| Imayama et al. (2011) [Dietary+Exercise]                                      | BSI-18          | -0.26 [ -0.66, 0.15]      |
| Imayama et al. (2011) [Dietary]   | BSI-18 -        | -0.20 [ -0.60, 0.21]      |
| Imayama et al. (2011) [Exercise]  | BSI-18 -        | -0.31 [ -0.72, 0.09]      |
| Jane et al. (2018) [FB]   | DASS            | 0.61 [ -0.21, 1.42]       |
| Jane et al. (2018) [PG]   | DASS            |                           |
| Heterogeneity: $\tau^2 = 0.21$ , $I^2 = 84.22\%$ , $H^2 = 6.34$               | L 🔶             | 0.03 [ -0.33, 0.39]       |
| Test of $\theta_i = \theta_j$ : Q(8) = 23.91, p = 0.00                        |                 |                           |
| Body image concerns (n=1)   |                 |                           |
| Steinberg et al. (2014)   | BSQ -           | -0.31 [ -0.73, 0.10]      |
|   |                 |                           |
| Depression (n=11)   |                 |                           |
| Ahern et al. (2017) [12-week BWLP]  | HADS            | -0.33 [ -0.53, -0.13]     |
| Ahern et al. (2017) [52-week BWLP)  | HADS            | -0.22 [ -0.44, -0.01]     |
| Godino et al. (2016)  | CES-D           | -0.27 [ -0.49, -0.05]     |
| Herring et al. (2014) [Aerobic Exercise]                                      | HADS —          | -0.61 [ -1.72, 0.50]      |
| Herring et al. (2014) [Resistance Exercise]                                   | HADS —          | 0.02 [ -1.06, 1.11]       |
| Imayama et al. (2011) [Dietary+Exercise]                                      | BSI-18          | -0.26 [ -0.66, 0.15]      |
| Imayama et al. (2011) [Dietary]   | BSI-18          | -0.07 [ -0.47, 0.34]      |
| Imayama et al. (2011) [Exercise]  | BSI-18 -        | -0.03 [ -0.44, 0.37]      |
| Jane et al. (2018) [FB]   | DASS —          | -0.06 [ -0.86, 0.74]      |
| Jane et al. (2018) [PG]   | DASS —          | 0.06 [ -0.73, 0.85]       |
| Steinberg et al. (2014)   | CES-D -         | -0.20 [ -0.61, 0.22]      |
| Heterogeneity: $\tau^2$ = 0.00, I <sup>2</sup> = 0.00%, H <sup>2</sup> = 1.00 | •               | -0.23 [ -0.34, -0.13]     |
| Test of $\theta_i = \theta_j$ : Q(10) = 4.03, p = 0.95                        | ,               |                           |
| Emotional eating (n=1)  |                 |                           |
| Jebb et al. (2011)  | TFEQ            | -0.07 [ -0.26, 0.12]      |



Figure A41. Sensitivity analysis of changes in mental health (post-intervention) comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis. Estimates to the left of the line indicate a desired change in favouring of the intervention.

| Study   | Assessment tool                         |                      |           | Hedges's<br>with 95% | g<br>Cl |
|---|---|----------------------|-----------|----------------------|---------|
| Anxiety (n=2)   |   |                      |           |                      |         |
| Cleo et al. (2019) [DSD]  | Bespoke questionnaire                   |                      |           | -0.05 [ -0.75,       | 0.66]   |
| Cleo et al. (2019) [TTT]  | Bespoke questionnaire                   |                      |           | -0.39 [-1.12,        | 0.33]   |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0$  | 0.00%, H <sup>2</sup> = 1.00            |                      |           | -0.22 [ -0.72,       | 0.29]   |
| Test of $\theta_i = \theta_j$ : Q(1) = 0.45, p =  | 0.50                                    |                      |           |                      |         |
| Depression (n=3)  |   |                      |           |                      |         |
| Cleo et al. (2019) [DSD]  | Bespoke questionnaire                   |                      |           | -0.03 [ -0.74,       | 0.67]   |
| Cleo et al. (2019) [TTT]  | Bespoke questionnaire                   |                      | -         | -0.71 [ -1.45,       | 0.03]   |
| Samuel-Hodge et al. (2009)  | CES-D                                   |                      | <b> </b>  | -0.04 [ -0.38,       | 0.31]   |
| Heterogeneity: $\tau^2 = 0.02$ , $I^2 = 1$  | 9.39%, H <sup>2</sup> = 1.24            |                      |           | -0.17 [-0.51,        | 0.18]   |
| Test of $\theta_i = \theta_j$ : Q(2) = 2.70, p =  | 0.26                                    |                      |           |                      |         |
| Emotional eating (n=1)  |   |                      |           |                      |         |
| McRobbie et al. (2016)  | TFEQ                                    |                      |           | 0.14 [-0.14,         | 0.43]   |
| Negative affect (n=3)   |   |                      |           |                      |         |
| Hunt et al. (2014)  | PANAS                                   |                      |           | -0.30 [ -0.45.       | -0.15]  |
| Jamal et al. (2016)   | ATQ                                     | _                    |           | -0.08 [ -0.36.       | 0.201   |
| Petrella et al. (2017)  | PNA Scale                               |                      |           | 0.20 [ -0.23.        | 0.641   |
| Heterogeneity: $\tau^2 = 0.03$ , $I^2 = 6$  | 64.96%, H <sup>2</sup> = 2.85           | -                    |           | -0.12 [ -0.38,       | 0.15]   |
| Test of $\theta_{i} = \theta_{j}$ : Q(2) = 5.63, p =  | 0.06                                    | -                    |           | • /                  |         |
| Overall   |   |                      |           | -0.10 [-0.27,        | 0.06]   |
| Heterogeneity: $\tau^2 = 0.02$ , $I^2 = 4$<br>Test of $\theta_i = \theta_j$ : Q(8) = 13.74, p | I0.41%, H <sup>2</sup> = 1.68<br>= 0.09 | Favours intervention | Favours c | ontrol               |         |
| Test of aroup differences: Q.(3   | (3) = 2.81, $p = 0.42$                  |                      |           |                      |         |
|   | ,, <u>-</u> -1                          | .5 -15 (             | ) .5      |                      |         |

Figure A42. Sensitivity analysis of changes in mental health (change from baseline) comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis. Estimates to the left of the line indicate a desired change in favouring of the intervention.

| Study  | Assessment tool      |                 |                      | Hedges's       | g      |
|--|----------------------|-----------------|----------------------|----------------|--------|
| Ouglity of life Clobal (n=6)   | Assessment tool      |                 |                      | WI(IT 95%      |        |
| Aborn at al. (2017) [12 wook DMI D]  | FOED2L               |                 |                      | 0.00 [ 0.40    | 0.001  |
| Ahern et al. (2017) [12-week BWLF]   |                      |                 |                      | 0.00[-0.12,    | 0.20]  |
| Coding at al. (2017) [52-week BWLF)  |                      |                 |                      | 0.00[0.12      | 0.00]  |
|  |                      |                 |                      | 1 46 [ 2 24    | 0.50]  |
|  |                      |                 |                      | 1 06 [ 2 92    | 1.001  |
| Jane et al. (2016) [PG]  |                      |                 |                      |                | -1.09] |
| MicRobble et al. (2016)<br>Heterogeneity: $r^2 = 0.70$ , $l^2 = 07.00\%$ , $ll^2 = 22.2$ |                      |                 |                      | 0.10[-0.12,    | 0.49]  |
| Therefore $H = 0.70, T = 97.00\%, H = 33.3$  |                      |                 |                      | -0.40[-1.10,   | 0.30]  |
| Test of $\sigma_i = \sigma_i$ . $Q(5) = 52.79$ , $p = 0.00$                              |                      |                 |                      |                |        |
| Quality of life - Mental health (n=8)  |                      |                 |                      |                |        |
| Cramer et al. (2016)   | SF-36                |                 |                      | 0.86 [ 0.31,   | 1.41]  |
| Domene et al. (2016)   | SF-36                |                 |                      | 0.83 [ -0.05,  | 1.70]  |
| Gray et al. (2013)   | SF-12                |                 | -                    | 0.64 [ 0.35,   | 0.93]  |
| Imayama et al. (2011) [Dietary+Exercise]   | SF-36                |                 |                      | 0.38 [ -0.02,  | 0.79]  |
| Imayama et al. (2011) [Dietary]  | SF-36                |                 | -                    | 0.22 [ -0.19,  | 0.62]  |
| Imayama et al. (2011) [Exercise]   | SF-36                |                 |                      | 0.32 [ -0.09,  | 0.72]  |
| Morgan et al. (2013) [SHED-IT-Online]  | SF-12                | -               | -                    | 0.15 [ -0.31,  | 0.62]  |
| Morgan et al. (2013) [SHED-IT-Resources]   | SF-12                |                 |                      | 0.44 [ -0.03,  | 0.91]  |
| Heterogeneity: $\tau^2 = 0.01$ , $I^2 = 13.92\%$ , $H^2 = 1.16$                          | 3                    |                 | •                    | 0.45 0.28,     | 0.61]  |
| Test of $\theta_i = \theta_j$ : Q(7) = 7.88, p = 0.34                                    |                      |                 |                      | -              |        |
|  |                      |                 |                      |                |        |
| Satisfaction with life (n=2)   | 014/                 |                 |                      | 0.001.000      | 0.471  |
| Ahem et al. (2017) [12-week BVVLP]   | SVVL                 |                 |                      | -0.03 [ -0.23, | 0.17]  |
| Anem et al. $(2017)$ [52-week BVVLP)   | SVVL                 |                 |                      | 0.05[-0.16,    | 0.27]  |
| Heterogeneity: $f = 0.00, T = 0.00\%, H = 1.00$  |                      |                 |                      | 0.01[-0.14,    | 0.16]  |
| lest of $\Theta_{i} = \Theta_{j}$ : Q(1) = 0.30, p = 0.58                                |                      |                 |                      |                |        |
| Self efficacy (n=2)  |                      |                 |                      |                |        |
| Ash et al. (2006) [FBI]  | GSES                 |                 |                      | 0.50 [ -0.13,  | 1.13]  |
| Ash et al. (2006) [IDT]  | GSES                 | -               |                      | 0.24 [ -0.42,  | 0.89]  |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$                           |                      |                 | •                    | 0.37 [ -0.08,  | 0.83]  |
| Test of $\theta_i = \theta_j$ : Q(1) = 0.32, p = 0.57                                    |                      |                 |                      |                |        |
| Self efficacy - Diet (n=2)   |                      |                 |                      |                |        |
| Damschroder et al. (2014) [ASPIRE-Group]   | SOC0                 |                 |                      | 0 17 [ -0 15   | 0 481  |
| Damschroder et al. (2014) [ASPIRE-Phone]   | SOCO                 |                 |                      | 0.26[-0.06     | 0.58]  |
| Heterogeneity: $\tau^2 = 0.00$ $I^2 = 0.00\%$ $H^2 = 1.00$                               | oood                 |                 |                      | 0.21 [ -0.01   | 0.441  |
| Test of $\theta_i = \theta_i$ ; Q(1) = 0.15, p = 0.69                                    |                      |                 | <b>▼</b>             |                | •···]  |
|  |                      |                 |                      |                |        |
| Self efficacy - Exercise (n=4)   |                      |                 |                      |                |        |
| Damschroder et al. (2014) [ASPIRE-Group]   | Bespoke questionnair | e               |                      | 0.23 [ -0.09,  | 0.55]  |
| Damschroder et al. (2014) [ASPIRE-Phone]   | Bespoke questionnair | e               | - <b></b> -          | 0.38 [ 0.06,   | 0.70]  |
| Herring et al. (2014) [Aerobic Exercise]   | SERPA                |                 |                      | 1.62 [ 0.38,   | 2.86]  |
| Herring et al. (2014) [Resistance Exercise]  | SERPA                |                 |                      | 1.79 [ 0.52,   | 3.06]  |
| Heterogeneity: $\tau^2 = 0.40$ , $I^2 = 85.61\%$ , $H^2 = 6.95$                          | 5                    |                 |                      | 0.79 [ 0.06,   | 1.52]  |
| Test of $\theta_i = \theta_j$ : Q(3) = 9.38, p = 0.02                                    |                      |                 |                      |                |        |
| Overall  |                      |                 |                      | 0.22 [ 0.06.   | 0.38]  |
| Heterogeneity: $\tau^2 = 0.10$ . $I^2 = 77.40\%$ . $H^2 = 4.42$                          | 2                    |                 |                      | L              |        |
| Test of $\theta_i = \theta_i$ : Q(23) = 78.50. n = 0.00                                  |                      | Favours control | Favours intervention | ו              |        |
|  |                      |                 |                      |                |        |
| Test of group differences: $Q_b(5) = 20.97$ , p = 0.0                                    | JU                   |                 | 1                    |                |        |
|  |                      | -2              | 0 2 4                |                |        |

Figure A43. Sensitivity analysis of changes in mental health (post-intervention) comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis. Estimates to the right of the line indicate a desired change in favouring of the intervention.

| Study   | Assessment tool     |               |                      | Hedges's g<br>with 95% Cl |
|---|---------------------|---------------|----------------------|---------------------------|
| Quality of life - Global (n=6)  |                     |               |                      |                           |
| Astbury et al. (2018)   | EQ5D-index          | -             |                      | 0.22 [ -0.09, 0.53]       |
| Cleo et al. (2019) [DSD]  | Bespoke questionnai | e             |                      | 0.90 [ 0.11, 1.69]        |
| Cleo et al. (2019) [TTT]  | Bespoke questionnai | е             |                      | 0.96 [ 0.13, 1.78]        |
| Damschroder et al. (2014) [ASPIRE-Group]  | EQ5D-index          |               | _                    | -0.12 [ -0.40, 0.15]      |
| Damschroder et al. (2014) [ASPIRE-Phone]  | EQ5D-index          |               | <b>-</b>             | 0.00 [ -0.27, 0.27]       |
| Petrella et al. (2017)  | EQ5D3L              |               |                      | 0.58 [ 0.13, 1.02]        |
| Heterogeneity: $\tau^2 = 0.11$ , $I^2 = 74.59\%$ , $H^2 = 3.94$   |                     |               | <b>•</b>             | 0.30 [ -0.02, 0.63]       |
| Test of $\theta_i = \theta_j$ : Q(5) = 16.04, p = 0.01  |                     |               |                      |                           |
| Quality of life - Mental health (n=3)   |                     |               |                      |                           |
| Hunt et al. (2014)  | PANAS               |               |                      | 0.21 [ 0.05, 0.36]        |
| Jamal et al. (2016)   | WHOQOL              | -             | —                    | 0.07 [ -0.22, 0.35]       |
| Samuel-Hodge et al. (2009)  | SF-8                |               | -                    | 0.01 [ -0.33, 0.36]       |
| Heterogeneity: $\tau^2$ = 0.00, $I^2$ = 0.00%, $H^2$ = 1.00   |                     |               | <b>♦</b>             | 0.15 [ 0.03, 0.28]        |
| Test of $\theta_i = \theta_j$ : Q(2) = 1.50, p = 0.47   |                     |               |                      |                           |
| Quality of life - Obesity-related (n=1)   |                     |               |                      |                           |
| Astbury et al. (2018)   | OWL-QOL             |               | -8-                  | 0.37 [ 0.06, 0.68]        |
| Satisfaction with life (n=2)  |                     |               |                      |                           |
| Damschroder et al. (2014) [ASPIRE-Group]  | Deiner SWL          | _             | _                    | -0.09 [ -0.37, 0.18]      |
| Damschroder et al. (2014) [ASPIRE-Phone]  | Deiner SWL          |               | -                    | -0.16 [ -0.43, 0.12]      |
| Heterogeneity: $\tau^{2} = 0.00$ , $l^{2} = 0.00\%$ , $H^{2} = 1.00$<br>Test of $\theta_{l} = \theta_{j}$ : Q(1) = 0.10, p = 0.75 |                     |               | •                    | -0.12 [ -0.32, 0.07]      |
| Self efficacy - Diet (n=1)  |                     |               |                      |                           |
| Jamal et al. (2016)   | WEL                 |               |                      | 0.39 [ 0.11, 0.68]        |
|   |                     |               |                      |                           |
| Overall   |                     |               |                      | 0.16 [ 0.02, 0.29]        |
| Heterogeneity: $\tau^2 = 0.03$ , $I^2 = 60.27\%$ , $H^2 = 2.52$<br>Test of $\theta_i = \theta_j$ : Q(12) = 30.23, p = 0.00        | Fa                  | vours control | Favours intervention |                           |
| Test of group differences: $Q_b(4) = 13.52$ , p = 0.0   | )1                  |               | 1                    | 1                         |
|   |                     | -1 (          | ) 1 2                | 2                         |

Figure A44. Sensitivity analysis of changes in mental health (change from baseline) comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using

random-effects pairwise meta-analysis. Estimates to the right of the line indicate a desired change in favouring of the intervention.



Figure A45. Sensitivity analysis of changes in self-esteem comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis. Estimates to the right of the line indicate a desired change in favouring of the intervention.

#### THE ROLE OF MENTAL HEALTH IN ADULT

#### BEHAVIOURAL WEIGHT MANAGEMENT INTERVENTIONS

| Study  | Assessment tool       |           |            |            | Hedges's<br>with 95% | g<br>Cl | Weight<br>(%) |
|--|-----------------------|-----------|------------|------------|----------------------|---------|---------------|
| Depression* (n=5)  |                       |           |            |            |                      |         |               |
| Ahern et al. (2017) [12-week BWLP]                             | HADS                  |           | -          |            | -0.26 [ -0.55,       | 0.03]   | 7.38          |
| Ahern et al. (2017) [52-week BWLP)                             | HADS                  |           | -          |            | -0.23 [ -0.51,       | 0.06]   | 7.41          |
| Imayama et al. (2011) [Dietary+Exercise]                       | BSI-18 -              |           | <u> </u>   |            | -0.26 [ -0.66,       | 0.15]   | 5.21          |
| Imayama et al. (2011) [Dietary]                                | BSI-18                |           | <u> </u>   |            | -0.07 [ -0.47,       | 0.34]   | 5.23          |
| Imayama et al. (2011) [Exercise]                               | BSI-18                |           | <b>—</b>   |            | -0.03 [ -0.44,       | 0.37]   | 5.22          |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$ |                       | •         |            |            | -0.19 [ -0.34,       | -0.04]  |               |
| Test of $\theta_i = \theta_j$ : Q(4) = 1.37, p = 0.85          |                       |           |            |            |                      |         |               |
| Quality of life - Global (n=4)                                 |                       |           |            |            |                      |         |               |
| Ahern et al. (2017) [12-week BWLP]                             | EQ5D3L                | _         |            |            | 0.12 [ -0.17,        | 0.41]   | 7.34          |
| Ahern et al. (2017) [52-week BWLP)                             | EQ5D3L                |           |            |            | 0.11 [ -0.18,        | 0.40]   | 7.35          |
| McRobbie et al. (2016)   | EQ5D5L                | _         |            |            | 0.16 [ -0.15,        | 0.46]   | 7.01          |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$ |                       |           | ◆          |            | 0.13 [ -0.04,        | 0.30]   |               |
| Test of $\theta_i = \theta_j$ : Q(2) = 0.04, p = 0.98          |                       |           |            |            |                      |         |               |
| Quality of life - Mental health (n=4)                          |                       |           |            |            |                      |         |               |
| Imayama et al. (2011) [Dietary+Exercise]                       | SF-36                 |           |            | -          | 0.38 [ -0.02,        | 0.79]   | 5.19          |
| Imayama et al. (2011) [Dietary]                                | SF-36                 |           |            |            | 0.22 [ -0.19,        | 0.62]   | 5.22          |
| Imayama et al. (2011) [Exercise]                               | SF-36                 | -         |            |            | 0.32 [ -0.09,        | 0.72]   | 5.20          |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$ |                       |           |            |            | 0.30 [ 0.07,         | 0.54]   |               |
| Test of $\theta_i = \theta_j$ : Q(2) = 0.33, p = 0.85          |                       |           |            |            |                      |         |               |
| Self efficacy (n=6)  |                       |           |            |            |                      |         |               |
| Ash et al. (2006) [FBI]  | GSES                  |           |            | -          | 0.84 [ 0.15,         | 1.53]   | 2.46          |
| Ash et al. (2006) [IDT]  | GSES                  |           |            |            | 0.83 [ 0.19,         | 1.47]   | 2.75          |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$ |                       |           |            |            | 0.83 [ 0.36,         | 1.30]   |               |
| Test of $\theta_i = \theta_j$ : Q(1) = 0.00, p = 0.99          |                       |           |            |            |                      |         |               |
| Self efficacy - Diet (n=4)                                     |                       |           |            |            |                      |         |               |
| Damschroder et al. (2014) [ASPIRE-Group]                       | SOCQ                  | _         |            |            | 0.17 [ -0.15,        | 0.48]   | 6.77          |
| Damschroder et al. (2014) [ASPIRE-Phone]                       | SOCQ                  | -         |            |            | 0.26 [ -0.06,        | 0.58]   | 6.77          |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$ |                       |           | ◆          |            | 0.21 [ -0.01,        | 0.44]   |               |
| Test of $\theta_i = \theta_j$ : Q(1) = 0.15, p = 0.69          |                       |           |            |            |                      |         |               |
| Self efficacy - Exercise (n=3)                                 |                       |           |            |            |                      |         |               |
| Damschroder et al. (2014) [ASPIRE-Group]                       | Bespoke questionnaire | -         |            |            | 0.23 [ -0.09,        | 0.55]   | 6.76          |
| Damschroder et al. (2014) [ASPIRE-Phone]                       | Bespoke questionnaire |           |            |            | 0.38 [ 0.06,         | 0.70]   | 6.73          |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$ |                       |           |            |            | 0.31 [ 0.08,         | 0.53]   |               |
| Test of $\theta_i = \theta_j$ : Q(1) = 0.41, p = 0.52          |                       |           |            |            |                      |         |               |
|  |                       |           |            |            |                      |         |               |
|  | Favour                | s control | Favours in | tervention |                      |         |               |
|  | -                     |           |            |            |                      |         |               |
|  |                       | 5         | 0.5        | 1 1.       | 5                    |         |               |

Figure A46. Sensitivity analysis of changes in mental health (post-intervention) at 12-months, comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis. For variables with an asterisk (\*), negative estimates indicate a

desired change in favour of the intervention; for all other variables, positive estimates indicate a desired change in favour of the intervention.

| Study   | Assessmen | t tool          |                       | Hedges's<br>with 95% | g<br>Cl | Weight<br>(%) |
|---|-----------|-----------------|-----------------------|----------------------|---------|---------------|
| Emotional eating* (n=1)   |           |                 |                       |                      |         |               |
| McRobbie et al. (2016)  | TFEQ      | _               |                       | 0.14 [ -0.13,        | 0.41]   | 9.40          |
| Negative affect* (n=1)  |           |                 |                       |                      |         |               |
| Hunt et al. (2014)  | PANAS     |                 |                       | -0.21 [ -0.36,       | -0.06]  | 11.66         |
| Quality of life - Global (n=3)  |           |                 |                       |                      |         |               |
| Astbury et al. (2018)   | EQ5D-ind  | dex —           |                       | 0.13 [ -0.15,        | 0.41]   | 9.15          |
| Damschroder et al. (2014) [ASPIRE-Group]  | EQ5D-ind  | dex —           |                       | -0.12 [ -0.39,       | 0.15]   | 9.34          |
| Damschroder et al. (2014) [ASPIRE-Phone]  | EQ5D-ind  | dex —           | <b></b>               | 0.00 [ -0.27,        | 0.27]   | 9.35          |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$  |           |                 | $\blacktriangleright$ | 0.00 [ -0.16,        | 0.16]   |               |
| Test of $\theta_i = \theta_j$ : Q(2) = 1.50, p = 0.47   |           |                 |                       |                      |         |               |
| Quality of life - Mental health (n=1)   |           |                 |                       |                      |         |               |
| Hunt et al. (2014)  | SF-12     |                 |                       | 0.04 [ -0.11,        | 0.19]   | 11.67         |
| Quality of life - Obesity-related (n=1)<br>Astbury et al. (2018)  | OWL-QC    | DL —            |                       | 0.16 [ -0.12,        | 0.44]   | 9.15          |
| Satisfaction with life (n=2)  |           | _               |                       |                      |         |               |
| Damschroder et al. (2014) [ASPIRE-Group]  | SWL       |                 |                       | -0.09 [ -0.37,       | 0.18]   | 9.34          |
| Damschroder et al. (2014) [ASPIRE-Phone]  | SWL       |                 | _                     | -0.16 [ -0.43,       | 0.12]   | 9.33          |
| Heterogeneity: $t = 0.00$ , $I = 0.00\%$ , $H = 1.00$<br>Test of $\theta_i = \theta_j$ : $Q(1) = 0.10$ , $p = 0.75$ |           |                 |                       | -0.12[-0.32,         | 0.07]   |               |
| Self-esteem (n=2)   |           |                 |                       |                      |         |               |
| Hunt et al. (2014)  | RSES      |                 |                       | 0.57 [ 0.41,         | 0.72]   | 11.62         |
|   |           |                 |                       |                      | -       |               |
|   |           | Favours control | Favours intervention  |                      |         |               |
|   |           | 5               | 0.5                   | י<br>1               |         |               |

Figure A47. Sensitivity analysis of changes in global quality of life (change from baseline) at 12-months, comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis. Positive estimates indicate a desired change in favour of the intervention.

# A2.9 Meta-regression analyses

| Characteristic (number of studies)           | Simple meta-regression |                |                |                             |
|--|------------------------|----------------|----------------|-----------------------------|
|  | <u>B</u>               | <u>95% CI</u>  | <u>P value</u> | <u>Adj. R<sup>2</sup> %</u> |
| Intervention type                            |                        |                |                |                             |
| Education only (n=6)                         | .429                   | (075, .932)    | 0.095          | 0                           |
| Physical activity only (n=3)                 | 413                    | (-1.060, .234) | 0.211          | 0                           |
| Education and physical activity              | 265                    | (970, .439)    | 0.461          | 0                           |
| (n=2)  |                        |                |                |                             |
| Delivery format                              | 1                      |                |                |                             |
| Group only (n=4)                             | 234                    | (866, .398)    | 0.468          | 0                           |
| Individual only (n=4)                        | .546                   | (.131, .961)   | 0.010          | 86.16                       |
| Group and individual (n=3)                   | 249                    | (519, .020)    | 0.070          | 0                           |
| Delivery mode                                | 1                      | I              | I              |                             |
| Face-to-face only (n=6)                      | 257                    | (871, .357)    | 0.412          | 0                           |
| Online only (n=1)                            | .689                   | (143, 1.521)   | 0.105          | 96.81                       |
| Resources only (n=1)                         | 1.933                  | (1.004,        | 0.001          | 100                         |
|  |                        | 2.862)         |                |                             |
| Mixed modes (n=3)                            | 249                    | (519, .020)    | 0.070          | 0                           |
| Intervention target gender                   | 1                      |                |                |                             |
| Female (n=3)                                 | 249                    | (519, .020)    | 0.070          | 0                           |
| Male and female (n=8)                        | .249                   | (020, .519)    | 0.070          | 0                           |
| Percentage of intervention participants that | were wome              | n (%)          |                |                             |
| 60-69%                                       | 083                    | (.777, .610)   | 0.814          | 0                           |
| 70-79%                                       | 252                    | (967, .463)    | 0.490          | 0                           |
| 80-89%                                       | .454                   | (217, 1.125)   | 0.185          | 95.24                       |
| 90-100%                                      | .091                   | (531, .713)    | 0.774          | 0                           |
| Mean age of intervention participants (years | 5)                     |                |                | ·                           |
| 30-39 years                                  | 351                    | (905, .203)    | 0.214          | 0                           |
| 40-49 years                                  | .187                   | (445, .820)    | 0.561          | 0                           |
| 50-59 years                                  | .284                   | (304, .871)    | 0.344          | 0                           |

# Table A4. Results from meta-regression of anxiety (post-intervention) (n=11).

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| Mean BMI of intervention participants (kg/m <sup>2</sup> )                      |      |               |       |   |  |
|---|------|---------------|-------|---|--|
| 30-34.9 (Obesity I)   | .416 | (120, .953)   | 0.128 | 0 |  |
| 35-39.9 (Obesity II)  | 059  | (837, .719)   | 0.882 | 0 |  |
| 40+ (Obesity III)   | 417  | (-,926, .091) | 0.108 | 0 |  |
| Abbreviations: b estimated meta-regression coefficient; CI confidence interval. |      |               |       |   |  |

| $\cdot$ = = $\cdot$ = = $\cdot$ = : | Table A5. Results from | n meta-regression | of global | quality of life | (post-intervention) | ) (n=11). |
|---|------------------------|-------------------|-----------|-----------------|---------------------|-----------|
|---|------------------------|-------------------|-----------|-----------------|---------------------|-----------|

| Characteristic (number of studies)            | Simple meta-regression |                 |                |                             |  |  |  |
|---|------------------------|-----------------|----------------|-----------------------------|--|--|--|
|   | <u>b</u>               | <u>95% CI</u>   | <u>P value</u> | <u>Adj. R<sup>2</sup> %</u> |  |  |  |
| Delivery format                               | 1                      | I               | 1              | 1                           |  |  |  |
| Group (n=3)                                   | .268                   | (783, 1.318)    | 0.617          | 0                           |  |  |  |
| Individual (n=7)                              | 275                    | (-1.257, .707)  | 0.583          | 0                           |  |  |  |
| Group and individual (n=1)                    | .112                   | (-1.548, 1.772) | 0.895          | 0                           |  |  |  |
| Delivery mode                                 | 1                      |                 | 1              | 1                           |  |  |  |
| Face-to-face (n=7)                            | .947                   | (.133, 1.760)   | 0.023          | 30.74                       |  |  |  |
| Online (n=2)                                  | -1.523                 | (-3.044,002)    | 0.050          | 30.02                       |  |  |  |
| Resources (n=1)                               | -2.082                 | (-3.326,838)    | 0.001          | 64.63                       |  |  |  |
| Mixed modes (n=1)                             | .155                   | (-1.071, 1.382) | 0.804          | 0                           |  |  |  |
| Intervention target gender                    | 1                      | I               | 1              | 1                           |  |  |  |
| Female (n=2)                                  | 1.145                  | (.212, 2.078)   | 0.016          | 42.35                       |  |  |  |
| Male and female (n=9)                         | -1.145                 | (-2.078,2119)   | 0.016          | 42.35                       |  |  |  |
| Percentage of intervention participants the   | at were wom            | nen (%)         | 1              | 1                           |  |  |  |
| 60-69%  | 023                    | (827, .781)     | 0.955          | 0                           |  |  |  |
| 70-79%  | 132                    | (808, .545)     | 0.703          | 0                           |  |  |  |
| 80-89%  | 746                    | (-1.506, .013)  | 0.054          | 18.24                       |  |  |  |
| 90-100%                                       | .841                   | (.440, 1.242)   | <0.001         | 100                         |  |  |  |
| Mean age of intervention participants (years) |                        |                 |                |                             |  |  |  |
| 20-29 years                                   | .164                   | (-1.458, 1.786) | 0.843          | 0                           |  |  |  |
| 30-39 years                                   | 1.145                  | (.212, 2.078)   | 0.016          | 42.35                       |  |  |  |
| 40-49 years                                   | 386                    | (-1.365, .594)  | 0.440          | 0                           |  |  |  |
| 50-59 years                                   | 441                    | (1.400, .519)   | 0.368          | 0                           |  |  |  |

| Mean BMI of intervention participants (kg/m <sup>2</sup> )                      |      |                 |       |   |  |  |
|---|------|-----------------|-------|---|--|--|
| 25-29.9 (Overweight)  | .164 | (-1.458, 1.786) | 0.843 | 0 |  |  |
| 30-34.5 (Obesity I)   | 145  | (-1.148, .859)  | 0.778 | 0 |  |  |
| 35-39.9 (Obesity II) .096 (996, 1.188) 0.863 0                                  |      |                 |       |   |  |  |
| Abbreviations: b estimated meta-regression coefficient; Cl confidence interval. |      |                 |       |   |  |  |

A2.10 Pooled intervention effects at post-intervention after adjustment for heterogeneity.

|  |               |                                   | Hedges's g           |
|--|---------------|-----------------------------------|----------------------|
| Study  | Assessment to | ol                                | with 95% CI          |
| Anxiety* [Post intervention] (n=11)                              |               |                                   |                      |
| Ahern et al. (2017) [12-week BWLP]                               | HADS          | -                                 | -0.12 [ -0.32, 0.07] |
| Ahern et al. (2017) [52-week BWLP)                               | HADS          | -#-                               | 0.02 [ -0.19, 0.24]  |
| Herring et al. (2014) [Aerobic Exercise]                         | HADS          |                                   | -0.72 [ -1.84, 0.40] |
| Herring et al. (2014) [Resistance Exercise]                      | HADS          |                                   | -0.04 [ -1.13, 1.04] |
| Imayama et al. (2011) [Dietary+Exercise]                         | BSI-18        |                                   | -0.26 [ -0.66, 0.15] |
| Imayama et al. (2011) [Dietary]                                  | BSI-18        |                                   | -0.20 [ -0.60, 0.21] |
| Imayama et al. (2011) [Exercise]                                 | BSI-18        |                                   | -0.31 [ -0.72, 0.09] |
| Jane et al. (2018) [FB]  | DASS          |                                   | 0.61 [ -0.21, 1.42]  |
| Nanchahal et al. (2009) [SSP]                                    | HADS          |                                   | -0.14 [ -0.82, 0.53] |
| Nanchahal et al. (2009) [SS]                                     | HADS          | <b>_</b>                          | 0.05 [ -0.60, 0.71]  |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00\%$ | 0             | •                                 | -0.10 [ -0.22, 0.02] |
| Test of $\theta_i = \theta_j$ : Q(9) = 7.46, p = 0.59            |               |                                   |                      |
| Overall  |               |                                   | -0.10 [ -0.22, 0.02] |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00\%$ | 0             |                                   |                      |
| Test of $\theta_i = \theta_j$ : Q(9) = 7.46, p = 0.59            |               | Favours intervention Favours cont | rol                  |
| Test of group differences: $Q_b(0) = 0.00$ , p = .               |               |                                   |                      |
|  |               | -2 -1 0 1                         | -                    |

Figure A48. After adjustment for heterogeneity: Changes in anxiety (post-intervention) comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis.

|   |                     |                      | Hedges's g            |
|---|---------------------|----------------------|-----------------------|
| Study   | Assessment tool     |                      | with 95% CI           |
| Quality of life (Global) (n=7)                          |                     |                      |                       |
| Ahern et al. (2017) [12-week BWLP]                      | EQ5D3L              | -                    | - 0.08 [-0.12, 0.28]  |
| Ahern et al. (2017) [52-week BWLP)                      | EQ5D3L              | -                    | 0.11 [ -0.11, 0.33]   |
| Jane et al. (2018) [FB]                                 | WHOQOL              |                      | -1.46 [ -2.34, -0.57] |
| McRobbie et al. (2016)                                  | EQ5D5L              | +                    | 0.18 [ -0.12, 0.49]   |
| Nanchahal et al. (2009) [SSP]                           | EQ5D-index          |                      | -0.12 [ -0.79, 0.56]  |
| Nanchahal et al. (2009) [SS]                            | EQ5D-index          |                      | -0.07 [ -0.73, 0.59]  |
| Sellman et al. (2017)                                   | WHOQOL              |                      | 0.04 [ -0.39, 0.47]   |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2$ | <sup>2</sup> = 1.00 | •                    | 0.06 [ -0.06, 0.18]   |
| Test of $\theta_i = \theta_j$ : Q(6) = 12.63, p = 0.05  |                     |                      |                       |
| Overall   |                     | •                    | 0.06 [ -0.06, 0.18]   |
| Heterogeneity: $r^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2$    | <sup>2</sup> = 1.00 |                      |                       |
| Test of $\theta_i = \theta_j$ : Q(6) = 12.63, p = 0.05  |                     | Favours intervention | Favours control       |
| Test of group differences: $Q_b(0) = -0.00$             | , p = .             | -2 -1 0              | 1                     |

Figure A49. After adjustment for heterogeneity: Changes in global quality of life (post-intervention) adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis.

## A2.11 Subgroup analyses

## Anxiety (post-intervention)

| Study  | Assessment tool          | Hedges's g<br>with 95% Cl |
|--|--------------------------|---------------------------|
| Intervention (IIC) (n=2)                                       |                          |                           |
| Herring et al. (2014) [Aerobic Exercise]                       |                          | -0.72[-1.84_0.40]         |
| Herring et al. (2014) [Resistance Exercise]                    |                          | -0.04 [-1.13, 1.04]       |
| Hotorogopoity: $x^2 = 0.00 \ l^2 = 0.00\% \ H^2 = 1.00\%$      |                          |                           |
| Therefore the form $r = 0.00, r = 0.00, r = 0.00$              | 5                        | -0.37 [-1.13, 0.41]       |
| Test of $\theta_i = \theta_j$ . Q(1) = 0.72, p = 0.39          |                          |                           |
| Minimal or inactive (n=9)                                      |                          |                           |
| Ahern et al. (2017) [12-week BWLP]                             | HADS                     | -0.12 [ -0.32, 0.07]      |
| Ahern et al. (2017) [52-week BWLP)                             | HADS                     | 0.02 [ -0.19, 0.24]       |
| Imayama et al. (2011) [Dietary+Exercise]                       | BSI-18 -                 | -0.26 [ -0.66, 0.15]      |
| Imayama et al. (2011) [Dietary]                                | BSI-18 -                 | -0.20 [ -0.60, 0.21]      |
| Imayama et al. (2011) [Exercise]                               | BSI-18 -                 | -0.31 [ -0.72, 0.09]      |
| Jane et al. (2018) [FB]  | DASS                     | 0.61 [ -0.21, 1.42]       |
| Jane et al. (2018) [PG]  | DASS                     | 1.83 [ 0.91, 2.76]        |
| Nanchahal et al. (2009) [SSP]                                  | HADS —                   | -0.14 [ -0.82, 0.53]      |
| Nanchahal et al. (2009) [SS]                                   | HADS —                   | 0.05 [ -0.60, 0.71]       |
| Heterogeneity: $\tau^2 = 0.13$ , $I^2 = 77.78\%$ , $H^2 = 4.5$ | 50 🔶                     | 0.04 [ -0.25, 0.33]       |
| Test of $\theta_i = \theta_j$ : Q(8) = 22.78, p = 0.00         |                          |                           |
|  |                          |                           |
| Overall  | <b>•</b>                 | -0.02 [ -0.25, 0.21]      |
| Heterogeneity: $\tau^2 = 0.07$ , $I^2 = 61.23\%$ , $H^2 = 2.5$ | 58                       |                           |
| Test of $\theta_i = \theta_j$ : Q(10) = 24.10, p = 0.01        | Favours intervention Fav | vours control             |
| Test of group differences: $Q_b(1) = 0.93$ , p = 0.3           | 34                       |                           |
|  | -2 0                     | 2 4                       |

Figure A50. Changes in anxiety (post-intervention), stratified by comparator group intensity, comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis.

There was no evidence for a difference in intervention or comparator groups for anxiety (post-intervention) when compared to an intervention-intensity usual care comparator group (SMD - 0.37 (95% CI -1.15, 0.41; n=2; l<sup>2</sup>=0%)) or minimal or inactive intensity comparator group (SMD 0.04 (95% CI -0.25, 0.33; n=9; l<sup>2</sup>=77.78%)).

| Study As  | sessment tool                        | Hedges's g<br>with 95% CI |
|---|--------------------------------------|---------------------------|
| Group (n=4)   |                                      |                           |
| Ahern et al. (2017) [12-week BWLP]                              | HADS                                 | -0.12 [ -0.32, 0.07]      |
| Ahern et al. (2017) [52-week BWLP)                              | HADS                                 | 0.02 [ -0.19, 0.24]       |
| Herring et al. (2014) [Aerobic Exercise]                        | HADS —                               | -0.72 [ -1.84, 0.40]      |
| Herring et al. (2014) [Resistance Exercise]                     | HADS —                               | -0.04 [ -1.13, 1.04]      |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$  | •                                    | -0.07 [ -0.21, 0.08]      |
| Test of $\theta_i = \theta_j$ : Q(3) = 2.29, p = 0.52           |                                      |                           |
| Group and individual (n=3)                                      |                                      |                           |
| Imayama et al. (2011) [Dietary+Exercise]                        | BSI-18 -                             | -0.26 [ -0.66, 0.15]      |
| Imayama et al. (2011) [Dietary]                                 | BSI-18 –                             | -0.20 [ -0.60, 0.21]      |
| Imayama et al. (2011) [Exercise]                                | BSI-18 -                             | -0.31 [ -0.72, 0.09]      |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$  | •                                    | -0.26 [ -0.49, -0.02]     |
| Test of $\theta_i = \theta_j$ : Q(2) = 0.16, p = 0.92           |                                      |                           |
| Individual (n=4)  |                                      |                           |
| Jane et al. (2018) [FB]   | DASS -                               | 0.61 [ -0.21, 1.42]       |
| Jane et al. (2018) [PG]   | DASS —                               | 1.83 [ 0.91, 2.76]        |
| Nanchahal et al. (2009) [SSP]                                   | HADS —                               | -0.14 [ -0.82, 0.53]      |
| Nanchahal et al. (2009) [SS]                                    | HADS —                               | 0.05 [ -0.60, 0.71]       |
| Heterogeneity: $\tau^2 = 0.58$ , $I^2 = 79.69\%$ , $H^2 = 4.92$ |                                      | 0.54 [ -0.29, 1.38]       |
| Test of $\theta_i = \theta_j$ : Q(3) = 13.15, p = 0.00          |                                      |                           |
| Overall   | •                                    | -0.02 [ -0.25, 0.21]      |
| Heterogeneity: $\tau^2 = 0.07$ , $I^2 = 61.23\%$ , $H^2 = 2.58$ |                                      |                           |
| Test of $\theta_i = \theta_j$ : Q(10) = 24.10, p = 0.01         | Favours intervention Favours control |                           |
| Test of group differences: $Q_b(2) = 4.17$ , p = 0.12           |                                      |                           |
|   | -2 0 2                               | 4                         |

Figure A51. Changes in anxiety (post-intervention), stratified by delivery format, comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis.

There was no evidence of an effect for anxiety (post-intervention) when the intervention was delivered exclusively to individuals (SMD 0.54 (95% CI -0.29, 1.38; n=4; l<sup>2</sup>=79.69%)). There was evidence to suggest an effect in favour of the intervention when delivered exclusively to groups (SMD -0.07 (95% CI -0.21, 0.08; n=4; l<sup>2</sup>=0%)), and evidence of an effect in favour of the intervention when the intervention was delivered to both groups and individuals (SMD -0.26 (95% CI -0.49, -0.02; n=3; l<sup>2</sup>=0%)).

| Study  | Assessment tool           | Hedges's g<br>with 95% Cl |
|--|---------------------------|---------------------------|
| 12 weeks (n=7)   |                           |                           |
| Ahern et al. (2017) [12-week BWLP]                             | HADS                      | -0.12 [ -0.32. 0.07]      |
| Herring et al. (2014) [Aerobic Exercise]                       | HADS                      | -0.72 [ -1.84, 0.40]      |
| Herring et al. (2014) [Resistance Exercise]                    | HADS —                    | -0.04 [ -1.13, 1.04]      |
| Jane et al. (2018) [FB]  | DASS                      | - 0.61 [ -0.21, 1.42]     |
| Jane et al. (2018) [PG]  | DASS -                    | 1.83 [ 0.91, 2.76]        |
| Nanchahal et al. (2009) [SSP]                                  | HADS —                    | -0.14 [ -0.82, 0.53]      |
| Nanchahal et al. (2009) [SS]                                   | HADS —                    | 0.05 [ -0.60, 0.71]       |
| Heterogeneity: $\tau^2 = 0.38$ , $I^2 = 78.47\%$ , $H^2 = 4.6$ | 64 🔶                      | 0.20 [ -0.35, 0.74]       |
| Test of $\theta_i = \theta_j$ : Q(6) = 20.53, p = 0.00         |                           |                           |
| 52 weeks (n=4)   |                           |                           |
| Ahern et al. (2017) [52-week BWLP)                             | HADS                      | 0.02 [ -0.19, 0.24]       |
| Imayama et al. (2011) [Dietary+Exercise]                       | BSI-18 -                  | -0.26 [ -0.66, 0.15]      |
| Imayama et al. (2011) [Dietary]                                | BSI-18 -                  | -0.20 [ -0.60, 0.21]      |
| Imayama et al. (2011) [Exercise]                               | BSI-18 -                  | -0.31 [ -0.72, 0.09]      |
| Heterogeneity: $\tau^2 = 0.01$ , $I^2 = 22.37\%$ , $H^2 = 1.2$ | 9                         | -0.13 [ -0.32, 0.06]      |
| Test of $\theta_i = \theta_j$ : Q(3) = 3.11, p = 0.37          |                           |                           |
| Overall  |                           | -0.02 [ -0.25, 0.21]      |
| Heterogeneity: $\tau^2 = 0.07$ . $I^2 = 61.23\%$ . $H^2 = 2.5$ | 58                        |                           |
| Test of $\theta_i = \theta_j$ : Q(10) = 24.10, p = 0.01        | Favours intervention Favo | urs control               |
| Test of group differences: $Q_b(1) = 1.25$ , $p = 0.2$         | -2 0                      | 2 4                       |

Figure A52. Changes in anxiety (post-intervention), stratified by intervention duration, comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis.

There was no evidence of an effect for anxiety (post-intervention) when the intervention was 12 weeks in duration (SMD 0.20 (95% CI -0.35, 0.74; n=7;  $I^2$ =78.47%)), however there was evidence to suggest an effect in favour of the intervention when 52 weeks in duration (SMD -0.13 (95% CI -0.32, 0.06; n=4;  $I^2$ =22.37%)).

| Study  | ssessment tool                       | Hedges's g<br>with 95% Cl             |
|--|--------------------------------------|---------------------------------------|
| Education and physical activity (n=2)                              |                                      |                                       |
| Imavama et al. (2011) [Dietarv+Exercise]                           | BSI-18                               | -0.26 [ -0.66, 0.15]                  |
| Nanchahal et al. (2009) [SSP]                                      | HADS —                               | -0.14 [ -0.82, 0.53]                  |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$     | •                                    | -0.23 [ -0.58, 0.12]                  |
| Test of $\theta_i = \theta_j$ : Q(1) = 0.08, p = 0.77              |                                      | , , , , , , , , , , , , , , , , , , , |
| Education-based (n=6)  |                                      |                                       |
| Ahern et al. (2017) [12-week BWLP]                                 | HADS                                 | -0.12 [ -0.32, 0.07]                  |
| Ahern et al. (2017) [52-week BWLP)                                 | HADS                                 | 0.02 [ -0.19, 0.24]                   |
| Imayama et al. (2011) [Dietary]                                    | BSI-18 -                             | -0.20 [ -0.60, 0.21]                  |
| Jane et al. (2018) [FB]  | DASS —                               | 0.61 [ -0.21, 1.42]                   |
| Jane et al. (2018) [PG]  | DASS —                               | 1.83 [ 0.91, 2.76]                    |
| Nanchahal et al. (2009) [SS]                                       | HADS —                               | 0.05 [ -0.60, 0.71]                   |
| Heterogeneity: $\tau^2 = 0.33$ , $I^2 = 90.64\%$ , $H^2 = 10.64\%$ | 8 🔶                                  | 0.26 [ -0.25, 0.78]                   |
| Test of $\theta_i = \theta_j$ : Q(5) = 19.76, p = 0.00             |                                      |                                       |
| Physical activity (n=3)  |                                      |                                       |
| Herring et al. (2014) [Aerobic Exercise]                           | HADS —                               | -0.72 [ -1.84, 0.40]                  |
| Herring et al. (2014) [Resistance Exercise]                        | HADS —                               | -0.04 [ -1.13, 1.04]                  |
| Imayama et al. (2011) [Exercise]                                   | BSI-18 -                             | -0.31 [ -0.72, 0.09]                  |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$     | •                                    | -0.33 [ -0.69, 0.03]                  |
| Test of $\theta_i = \theta_j$ : Q(2) = 0.74, p = 0.69              |                                      |                                       |
| Overall  | •                                    | -0.02 [ -0.25, 0.21]                  |
| Heterogeneity: $\tau^2 = 0.07$ , $I^2 = 61.23\%$ , $H^2 = 2.58$    |                                      |                                       |
| Test of $\theta_i = \theta_j$ : Q(10) = 24.10, p = 0.01            | Favours intervention Favours control |                                       |
| Test of group differences: $Q_b(2) = 3.56$ , p = 0.17              |                                      |                                       |
|  | -2 0 2                               | 4                                     |

Figure A53. Changes in anxiety (post-intervention), stratified by intervention type, comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis.

There was no evidence of an effect for anxiety (post-intervention) when the intervention was exclusively education-based (SMD 0.26 (95% -0.25, 0.78; n=6;  $I^2$ =90.64%)) or a mixture of education and physical activity (SMD -0.23 (95% CI -.58, -.12; n=2;  $I^2$ =0%)). There is evidence to suggest an effect in favour of the intervention when the intervention exclusively provided physical activity (SMD -0.33 (95% CI -0.69, 0.03; n=3;  $I^2$ =0%)).

| Study As  | ssessment tool                 | Hedges's g<br>with 95% Cl |
|---|--------------------------------|---------------------------|
| Face-to-face (n=6)  |                                |                           |
| Ahern et al. (2017) [12-week BWLP]                              | HADS                           | -0.12 [ -0.32, 0.07]      |
| Ahern et al. (2017) [52-week BWLP)                              | HADS                           | 0.02 [ -0.19, 0.24]       |
| Herring et al. (2014) [Aerobic Exercise]                        | HADS —                         | -0.72 [ -1.84, 0.40]      |
| Herring et al. (2014) [Resistance Exercise]                     | HADS —                         | -0.04 [ -1.13, 1.04]      |
| Nanchahal et al. (2009) [SSP]                                   | HADS —                         | -0.14 [ -0.82, 0.53]      |
| Nanchahal et al. (2009) [SS]                                    | HADS —                         | 0.05 [ -0.60, 0.71]       |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$  | •                              | -0.07 [ -0.20, 0.07]      |
| Test of $\theta_i = \theta_j$ : Q(5) = 2.47, p = 0.78           |                                |                           |
| Mixed modes (n=3)   |                                |                           |
| Imayama et al. (2011) [Dietary+Exercise]                        | BSI-18                         | -0.26 [ -0.66, 0.15]      |
| Imayama et al. (2011) [Dietary]                                 | BSI-18 –                       | -0.20 [ -0.60, 0.21]      |
| Imayama et al. (2011) [Exercise]                                | BSI-18 -                       | -0.31 [ -0.72, 0.09]      |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$  | •                              | -0.26 [ -0.49, -0.02]     |
| Test of $\theta_i = \theta_j$ : Q(2) = 0.16, p = 0.92           |                                |                           |
| Online (n=1)  |                                |                           |
| Jane et al. (2018) [FB]   | DASS                           | 0.61 [ -0.21, 1.42]       |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = .\%$ , $H^2 = .$        |                                | 0.61 [ -0.21, 1.42]       |
| Test of $\theta_i = \theta_j$ : Q(0) = 0.00, p = .              |                                |                           |
| Resources (n=1)   |                                |                           |
| Jane et al. (2018) [PG]   | DASS                           | 1.83 [ 0.91, 2.76]        |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = .\%$ , $H^2 = .$        |                                | 1.83 [ 0.91, 2.76]        |
| Test of $\theta_i = \theta_j$ : Q(0) = 0.00, p = .              |                                |                           |
| Overall   | •                              | -0.02 [ -0.25, 0.21]      |
| Heterogeneity: $\tau^2 = 0.07$ , $I^2 = 61.23\%$ , $H^2 = 2.58$ |                                |                           |
| Test of $\theta_i = \theta_j$ : Q(10) = 24.10, p = 0.01         | Favours intervention Favours c | ontrol                    |
| Test of group differences: $Q_b(3) = 21.47$ , p = 0.00          | D                              |                           |
|   | -2 0                           | 2 4                       |

Figure A54. Changes in anxiety (post-intervention), stratified by delivery mode, comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis.

There was evidence of an effect for anxiety (post-intervention) in favour of the intervention when provided by a mixture of delivery modes (SMD -0.26 (95% CI -0.49, -0.02; n=3; l<sup>2</sup>=0%)), and evidence to suggest an effect in favour of the intervention when delivered face-to-face (SMD - 0.07 (95% CI -0.20, 0.07; n=6; l<sup>2</sup>=0%)). Only one study reported anxiety (post-intervention) for an

intervention exclusively providing resources or exclusively online, and therefore these subgroups could not be analysed through stratification.

| Study   | Assessment tool                      | Hedges's g<br>with 95% Cl | Weight<br>(%) |
|---|--------------------------------------|---------------------------|---------------|
| Female (n=3)  |                                      |                           | . ,           |
| Imayama et al. (2011) [Dietary+Exercise]                        | BSI-18 -                             | -0.26 [ -0.66, 0.15]      | 11.84         |
| lmayama et al. (2011) [Dietary]                                 | BSI-18 –                             | -0.20 [ -0.60, 0.21]      | 11.86         |
| Imayama et al. (2011) [Exercise]                                | BSI-18 -                             | -0.31 [ -0.72, 0.09]      | 11.82         |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.0\%$ | 0 🔶                                  | -0.26 [ -0.49, -0.02]     |               |
| Test of $\theta_i = \theta_j$ : Q(2) = 0.16, p = 0.92           |                                      |                           |               |
| Male and female (n=8)   |                                      |                           |               |
| Ahern et al. (2017) [12-week BWLP]                              | HADS                                 | -0.12 [ -0.32, 0.07]      | 16.56         |
| Ahern et al. (2017) [52-week BWLP)                              | HADS                                 | 0.02 [ -0.19, 0.24]       | 16.16         |
| Herring et al. (2014) [Aerobic Exercise]                        | HADS —                               | -0.72 [ -1.84, 0.40]      | 3.42          |
| Herring et al. (2014) [Resistance Exercise]                     | HADS —                               | -0.04 [ -1.13, 1.04]      | 3.58          |
| Jane et al. (2018) [FB]   | DASS —                               | 0.61 [ -0.21, 1.42]       | 5.52          |
| Jane et al. (2018) [PG]   | DASS —                               | 1.83 [ 0.91, 2.76]        | 4.63          |
| Nanchahal et al. (2009) [SSP]                                   | HADS —                               | -0.14 [ -0.82, 0.53]      | 7.18          |
| Nanchahal et al. (2009) [SS]                                    | HADS —                               | 0.05 [ -0.60, 0.71]       | 7.43          |
| Heterogeneity: $\tau^2 = 0.25$ , $I^2 = 83.26\%$ , $H^2 = 5.4$  | 97 🔶                                 | 0.16 [ -0.27, 0.59]       |               |
| Test of $\theta_i = \theta_j$ : Q(7) = 20.65, p = 0.00          |                                      |                           |               |
| Overall   | •                                    | -0.02 [ -0.25, 0.21]      |               |
| Heterogeneity: $\tau^2 = 0.07$ , $I^2 = 61.23\%$ , $H^2 = 2.4$  | 58                                   |                           |               |
| Test of $\theta_i = \theta_j$ : Q(10) = 24.10, p = 0.01         | Favours intervention Favours control |                           |               |
| Test of group differences: $Q_b(1) = 2.79$ , p = 0.             | 09                                   |                           |               |
|   | -2 0 2                               | 4                         |               |

Figure A55. Changes in anxiety (post-intervention), stratified by intervention target gender, comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis.

There was evidence of an effect for anxiety (post-intervention) in favour of the intervention when provided exclusively to females (SMD -0.26 (95% CI -0.49, -0.02; n=3;  $I^2=0\%$ )), however there was no evidence of a difference when delivered to a mixture of males and females (SMD 0.16 (95% CI -0.27, 0.59; n=8;  $I^2=83.26\%$ )).

| Study As   | sessment tool                        | Hedges's g<br>with 95% CI |
|--|--------------------------------------|---------------------------|
| 60-69  |                                      |                           |
| Ahern et al. (2017) [12-week BWLP]                               | HADS                                 | -0.12 [ -0.32, 0.07]      |
| Ahern et al. (2017) [52-week BWLP)                               | HADS                                 | 0.02 [ -0.19, 0.24]       |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$   | •                                    | -0.06 [ -0.20, 0.09]      |
| Test of $\theta_i = \theta_j$ : Q(1) = 0.96, p = 0.33            |                                      |                           |
| 70-79  |                                      |                           |
| Herring et al. (2014) [Aerobic Exercise]                         | HADS —                               | -0.72 [ -1.84, 0.40]      |
| Nanchahal et al. (2009) [SSP]                                    | HADS —                               | -0.14 [ -0.82, 0.53]      |
| Nanchahal et al. (2009) [SS]                                     | HADS —                               | 0.05 [ -0.60, 0.71]       |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$   | <b>•</b>                             | -0.14 [ -0.57, 0.29]      |
| Test of $\theta_i = \theta_j$ : Q(2) = 1.37, p = 0.50            |                                      |                           |
| 80-89  |                                      |                           |
| Herring et al. (2014) [Resistance Exercise]                      | HADS —                               | -0.04 [ -1.13, 1.04]      |
| Jane et al. (2018) [FB]  | DASS                                 | 0.61 [ -0.21, 1.42]       |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$   | -                                    | 0.37 [ -0.28, 1.02]       |
| Test of $\theta_i = \theta_j$ : Q(1) = 0.87, p = 0.35            |                                      |                           |
| 90-100   |                                      |                           |
| Imayama et al. (2011) [Dietary+Exercise]                         | BSI-18                               | -0.26 [ -0.66, 0.15]      |
| Imayama et al. (2011) [Dietary]                                  | BSI-18 -                             | -0.20 [ -0.60, 0.21]      |
| Imayama et al. (2011) [Exercise]                                 | BSI-18 -                             | -0.31 [ -0.72, 0.09]      |
| Jane et al. (2018) [PG]  | DASS                                 | 1.83 [ 0.91, 2.76]        |
| Heterogeneity: $\tau^2 = 0.82$ , $I^2 = 93.44\%$ , $H^2 = 15.25$ |                                      | 0.20 [ -0.73, 1.12]       |
| Test of $\theta_i = \theta_j$ : Q(3) = 18.73, p = 0.00           |                                      |                           |
| Overall  | •                                    | -0.02 [ -0.25, 0.21]      |
| Heterogeneity: $\tau^2 = 0.07$ , $I^2 = 61.23\%$ , $H^2 = 2.58$  |                                      |                           |
| Test of $\theta_i = \theta_j$ : Q(10) = 24.10, p = 0.01          | Favours intervention Favours control |                           |
| Test of group differences: $Q_b(3) = 2.04$ , p = 0.56            | -2 0 2                               | <br>                      |
|  |                                      | -                         |

Figure A56. Changes in anxiety (post-intervention), stratified by percentage of interventions participants that were women (%), comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis.

There was no evidence of a difference between intervention and comparator for anxiety (postintervention) for any stratified analyses of percentage of intervention participants that were women (%).

| Study A   | Assessment tool              | Hedges's g<br>with 95% Cl |
|---|------------------------------|---------------------------|
| 30-39   |                              |                           |
| Imayama et al. (2011) [Dietary+Exercise]                        | BSI-18 -                     | -0.26 [ -0.66, 0.15]      |
| Imayama et al. (2011) [Exercise]                                | BSI-18 -                     | -0.31 [ -0.72, 0.09]      |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$  | •                            | -0.29 [ -0.57, 0.00]      |
| Test of $\theta_i = \theta_j$ : Q(1) = 0.03, p = 0.85           |                              |                           |
| 40-49   |                              |                           |
| Jane et al. (2018) [FB]   | DASS —                       | 0.61 [ -0.21, 1.42]       |
| Nanchahal et al. (2009) [SSP]                                   | HADS —                       | -0.14 [ -0.82, 0.53]      |
| Nanchahal et al. (2009) [SS]                                    | HADS —                       | 0.05 [ -0.60, 0.71]       |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$  | •                            | 0.12 [ -0.29, 0.52]       |
| Test of $\theta_i = \theta_j$ : Q(2) = 1.99, p = 0.37           |                              |                           |
| 50-59   |                              |                           |
| Ahern et al. (2017) [12-week BWLP]                              | HADS                         | -0.12 [ -0.32, 0.07]      |
| Ahern et al. (2017) [52-week BWLP)                              | HADS                         | 0.02 [ -0.19, 0.24]       |
| Imayama et al. (2011) [Dietary]                                 | BSI-18 -                     | -0.20 [ -0.60, 0.21]      |
| Jane et al. (2018) [PG]   | DASS                         | 1.83 [ 0.91, 2.76]        |
| Heterogeneity: $\tau^2 = 0.65$ , $I^2 = 96.49\%$ , $H^2 = 28.4$ | .8 🔶                         | 0.30 [ -0.53, 1.12]       |
| Test of $\theta_i = \theta_j$ : Q(3) = 17.45, p = 0.00          |                              |                           |
| NR  |                              |                           |
| Herring et al. (2014) [Aerobic Exercise]                        | HADS                         | -0.72 [ -1.84, 0.40]      |
| Herring et al. (2014) [Resistance Exercise]                     | HADS —                       | -0.04 [ -1.13, 1.04]      |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$  |                              | -0.37 [ -1.15, 0.41]      |
| Test of $\theta_i = \theta_j$ : Q(1) = 0.72, p = 0.39           |                              |                           |
| Overall   | •                            | -0.02 [ -0.25, 0.21]      |
| Heterogeneity: $\tau^2 = 0.07$ , $I^2 = 61.23\%$ , $H^2 = 2.58$ | i                            |                           |
| Test of $\theta_i = \theta_j$ : Q(10) = 24.10, p = 0.01         | Favours intervention Favours | vours control             |
| Test of group differences: $Q_b(3) = 3.96$ , $p = 0.27$         | ,                            |                           |
|   | -2 0                         | 2 4                       |

Figure A57. Changes in anxiety (post-intervention), stratified by mean age of interventions participants, comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis.

There was some evidence of an effect for anxiety (post-intervention) in favour of the intervention when participants had a mean age between 30-39 years (SMD -0.29 (95% CI -0.57, 0.00; n=2;  $I^2=0\%$ )). There was no evidence of a difference between intervention and comparator for any other stratified analyses.

| Study Ass  | essment tool                         | Hedges's g<br>with 95% Cl |
|--|--------------------------------------|---------------------------|
| 30-34.9 (Obesity I)  |                                      |                           |
| Ahern et al. (2017) [12-week BWLP]                             | HADS                                 | -0.12 [ -0.32, 0.07]      |
| Ahern et al. (2017) [52-week BWLP)                             | HADS                                 | 0.02 [-0.19, 0.24]        |
| Imayama et al. (2011) [Dietary]                                | BSI-18 -                             | -0.20 [ -0.60, 0.21]      |
| Jane et al. (2018) [FB]  | DASS -                               | 0.61 [ -0.21, 1.42]       |
| Jane et al. (2018) [PG]  | DASS —                               | 1.83 [ 0.91, 2.76]        |
| Heterogeneity: $r^2 = 0.47$ , $I^2 = 94.08\%$ , $H^2 = 16.89$  | -                                    | 0.33 [-0.32, 0.98]        |
| Test of $\theta_i = \theta_j$ : Q(4) = 19.72, p = 0.00         |                                      |                           |
| 35-39.9 (Obesity II)   |                                      |                           |
| Nanchahal et al. (2009) [SSP]                                  | HADS —                               | -0.14 [ -0.82, 0.53]      |
| Nanchahal et al. (2009) [SS]                                   | HADS —                               | 0.05 [-0.60, 0.71]        |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$ | •                                    | -0.04 [ -0.51, 0.43]      |
| Test of $\theta_i = \theta_j$ ; Q(1) = 0.17, p = 0.68          |                                      | _ , _                     |
| 40+ (Obesity III)  |                                      |                           |
| Herring et al. (2014) [Aerobic Exercise]                       | HADS —                               | -0.72 [ -1.84, 0.40]      |
| Herring et al. (2014) [Resistance Exercise]                    | HADS —                               | -0.04 [ -1.13, 1.04]      |
| Imayama et al. (2011) [Dietary+Exercise]                       | BSI-18 -                             | -0.26 [-0.66, 0.15]       |
| Imayama et al. (2011) [Exercise]                               | BSI-18 -                             | -0.31 [ -0.72, 0.09]      |
| Heterogeneity: $r^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$    | •                                    | -0.30 [ -0.57, -0.03]     |
| Test of $\theta_i = \theta_j$ : Q(3) = 0.80, p = 0.85          |                                      |                           |
| Overall  |                                      | -0.02[-0.25_0.21]         |
| Heterogeneity: $r^2 = 0.07$ $l^2 = 61.23\%$ $H^2 = 2.58$       |                                      | 0.02 [ 0.20, 0.21]        |
| Test of $A = A$ : $O(10) = 24.10$ , $n = 0.01$                 | Eavours intervention Eavours control |                           |
| 1031010j = 0j. Q(10) = 24.10, p = 0.01                         |                                      |                           |
| Test of group differences: $Q_b(2) = 3.40$ , p = 0.18          | r                                    |                           |
|  | -2 0 2                               | 4                         |

Figure A60. Changes in anxiety (post-intervention), stratified by mean BMI of interventions participants (kg/m<sup>2</sup>), comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis.

There was evidence of an effect for anxiety (post-intervention) in favour of the intervention when participants had a mean BMI 40+ kg/m<sup>2</sup> (SMD -0.30 (95% CI -0.57, -0.03; n=4; l<sup>2</sup>=0%)). There was no evidence of a difference between intervention and comparator for any other stratified analyses.

## Depression (post-intervention)

| Study As  | ssessment to | ol                        | Hedges's g<br>with 95% CI |
|---|--------------|---------------------------|---------------------------|
| Intervention (UC) (n=3)   |              |                           |                           |
| Godino et al. (2016)  | CES-D        |                           | -0.27 [ -0.49, -0.05]     |
| Herring et al. (2014) [Aerobic Exercise]                        | HADS         |                           | -0.61 [ -1.72, 0.50]      |
| Herring et al. (2014) [Resistance Exercise]                     | HADS         |                           | 0.02 [ -1.06, 1.11]       |
| Heterogeneity: $r^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$     |              | •                         | -0.27 [ -0.48, -0.06]     |
| Test of $\theta_i = \theta_j$ : Q(2) = 0.64, p = 0.72           |              |                           |                           |
| Minimal or inactive (n=11)                                      |              |                           |                           |
| Ahern et al. (2017) [12-week BWLP]                              | HADS         |                           | -0.33 [ -0.53, -0.13]     |
| Ahern et al. (2017) [52-week BWLP)                              | HADS         | -8-                       | -0.22 [ -0.44, -0.01]     |
| Imayama et al. (2011) [Dietary+Exercise]                        | BSI-18       |                           | -0.26 [ -0.66, 0.15]      |
| Imayama et al. (2011) [Dietary]                                 | BSI-18       |                           | -0.07 [ -0.47, 0.34]      |
| Imayama et al. (2011) [Exercise]                                | BSI-18       |                           | -0.03 [ -0.44, 0.37]      |
| Jane et al. (2018) [FB]   | DASS         |                           | -0.06 [ -0.86, 0.74]      |
| Jane et al. (2018) [PG]   | DASS         |                           | 0.06 [ -0.73, 0.85]       |
| Kalarchian et al. (2013)  | BDI          |                           | 0.09 [-0.21, 0.39]        |
| Nanchahal et al. (2009) [SSP]                                   | HADS         |                           | -0.26 [ -0.93, 0.42]      |
| Nanchahal et al. (2009) [SS]                                    | HADS         |                           | — 0.03 [-0.63, 0.68]      |
| Steinberg et al. (2014)   | CES-D        |                           | -0.20 [ -0.61, 0.22]      |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 12.16\%$ , $H^2 = 1.14$ |              | •                         | -0.17 [ -0.28, -0.05]     |
| Test of $\theta_i = \theta_j$ : Q(10) = 7.27, p = 0.70          |              |                           |                           |
| Usual care (undefined) (n=1)                                    |              |                           |                           |
| Barnes et al. (2014)  | BDI          |                           | -0.10[-0.61, 0.41]        |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = .\%$ , $H^2 = .$        |              |                           | -0.10[-0.61, 0.41]        |
| Test of $\theta_i = \theta_j$ : Q(0) = 0.00, p = .              |              |                           |                           |
| Overall   |              | •                         | -0.19 [ -0.29, -0.10]     |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 1.54\%$ , $H^2 = 1.02$  |              |                           |                           |
| Test of $\theta_i = \theta_j$ : Q(14) = 8.63, p = 0.85          |              | Favours intervention Favo | ours control              |
| Test of group differences: $Q_t(2) = 0.83$ , p = 0.66           |              | -2 -1 0                   | <u>_</u><br>1             |

Figure A61. Changes in depression (post-intervention), stratified by comparator group intensity, comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis.

There was evidence of an effect for depression (post-intervention) in favour of the intervention when compared to an intervention-intensity usual care comparator group (SMD -0.27 (95% CI -

0.48, -0.06; n=3; l<sup>2</sup>=0%)) and minimal or inactive intensity comparator group (SMD -0.17 (95% Cl -0.28, -0.05; n=11; l<sup>2</sup>=12.16%)).

| Study A  | ssessment to | ol                   | Hedges's g<br>with 95% Cl |
|--|--------------|----------------------|---------------------------|
| Group (n=4)  |              |                      |                           |
| Ahern et al. (2017) [12-week BWLP]                             | HADS         |                      | -0.33 [ -0.53, -0.13]     |
| Ahern et al. (2017) [52-week BWLP)                             | HADS         |                      | -0.22 [ -0.44, -0.01]     |
| Herring et al. (2014) [Aerobic Exercise]                       | HADS         |                      | -0.61 [ -1.72, 0.50]      |
| Herring et al. (2014) [Resistance Exercise]                    | HADS         |                      | 0.02 [-1.06, 1.11]        |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$ |              | •                    | -0.28 [ -0.43, -0.14]     |
| Test of $\theta_i = \theta_j$ : Q(3) = 1.13, p = 0.77          |              |                      |                           |
| Group and individual (n=3)                                     |              |                      |                           |
| Imayama et al. (2011) [Dietary+Exercise]                       | BSI-18       |                      | -0.26 [ -0.66, 0.15]      |
| Imayama et al. (2011) [Dietary]                                | BSI-18       |                      | -0.07 [-0.47, 0.34]       |
| Imayama et al. (2011) [Exercise]                               | BSI-18       |                      | -0.03 [ -0.44, 0.37]      |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$ |              | •                    | -0.12 [ -0.35, 0.12]      |
| Test of $\theta_i = \theta_j$ ; Q(2) = 0.70, p = 0.71          |              |                      |                           |
| Individual (n=8)   |              |                      |                           |
| Barnes et al. (2014)   | BDI          |                      | -0.10[-0.61, 0.41]        |
| Godino et al. (2016)   | CES-D        |                      | -0.27 [-0.49, -0.05]      |
| Jane et al. (2018) [FB]  | DASS         |                      | -0.06 [ -0.86, 0.74]      |
| Jane et al. (2018) [PG]  | DASS         |                      | 0.06 [ -0.73, 0.85]       |
| Kalarchian et al. (2013)                                       | BDI          | _                    | 0.09 [-0.21, 0.39]        |
| Nanchahal et al. (2009) [SSP]                                  | HADS         |                      | -0.26 [ -0.93, 0.42]      |
| Nanchahal et al. (2009) [SS]                                   | HADS         |                      | 0.03 [-0.63, 0.68]        |
| Steinberg et al. (2014)  | CES-D        |                      | -0.20 [ -0.61, 0.22]      |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 3.70\%$ , $H^2 = 1.04$ |              | •                    | -0.13 [ -0.28, 0.02]      |
| Test of $\theta_i = \theta_j$ ; Q(7) = 4.31, p = 0.74          |              |                      |                           |
| Overall  |              | •                    | -0.19 [ -0.29, -0.10]     |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$ |              |                      |                           |
| Test of $\theta_i = \theta_j$ : Q(14) = 8.63, p = 0.85         |              | Favours intervention | Favours control           |
| Test of group differences: $Q_b(2) = 2.53$ , p = 0.28          | 3            |                      |                           |
|  |              | -2 -1 (              | ) 1                       |

Figure A62. Changes in depression (post-intervention), stratified by delivery format, comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis.

There was no evidence of an effect for depression (post-intervention) when the intervention was delivered to both groups and individuals (SMD -0.12 (95% CI -0.35, 0.12; n=3; l<sup>2</sup>=0%)), however there was evidence of an effect in favour of the intervention when delivered exclusively to groups (SMD -0.28 (95% CI -0.43, -0.14; n=4; l<sup>2</sup>=0%)). Effect estimates were suggestive of an effect in favour of the intervention when delivered exclusively to individuals (SMD -0.13 (95% CI -0.28, 0.02; n=8; l<sup>2</sup>=3.70%)).

#### THE ROLE OF MENTAL HEALTH IN ADULT

#### BEHAVIOURAL WEIGHT MANAGEMENT INTERVENTIONS

| Study   | Assessment to | ol Hedges's g                         |
|---|---------------|---------------------------------------|
| Face-to-face (n=6)  |               |                                       |
| Ahern et al. (2017) [12-week BWLP]                              | HADS          | -0.33 [ -0.53, -0.13]                 |
| Ahern et al. (2017) [52-week BWLP)                              | HADS          | -0.22 [ -0.44, -0.01]                 |
| Herring et al. (2014) [Aerobic Exercise]                        | HADS          | -0.61 [ -1.72, 0.50]                  |
| Herring et al. (2014) [Resistance Exercise]                     | HADS          | 0.02 [ -1.06,   1.11]                 |
| Nanchahal et al. (2009) [SSP]                                   | HADS          | -0.26 [ -0.93, 0.42]                  |
| Nanchahal et al. (2009) [SS]                                    | HADS          | 0.03 [ -0.63, 0.68]                   |
| Heterogeneity: $r^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$     |               | -0.27 [ -0.40, -0.13]                 |
| Test of $\theta_i = \theta_j$ : Q(5) = 1.95, p = 0.86           |               |                                       |
| Mixed modes (n=6)   |               |                                       |
| Barnes et al. (2014)  | BDI           | -0.10 [ -0.61, 0.41]                  |
| Godino et al. (2016)  | CES-D         | -0.27 [ -0.49, -0.05]                 |
| Imayama et al. (2011) [Dietary+Exercise]                        | BSI-18        | -0.26 [ -0.66, 0.15]                  |
| Imayama et al. (2011) [Dietary]                                 | BSI-18        | -0.07 [ -0.47, 0.34]                  |
| Imayama et al. (2011) [Exercise]                                | BSI-18        | -0.03 [ -0.44, 0.37]                  |
| Kalarchian et al. (2013)  | BDI           |                                       |
| Heterogeneity: $\tau^2 = 0.01$ , $I^2 = 15.12\%$ , $H^2 = 1.13$ | 3             | -0.12 [ -0.28, 0.03]                  |
| Test of $\theta_i = \theta_j$ : Q(5) = 4.32, p = 0.50           |               |                                       |
| Online (n=2)  |               |                                       |
| Jane et al. (2018) [FB]   | DASS          | -0.06 [ -0.86, 0.74]                  |
| Steinberg et al. (2014)   | CES-D         | -0.20 [ -0.61, 0.22]                  |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$  |               | -0.17 [ -0.54, 0.20]                  |
| Test of $\theta_i = \theta_j$ : Q(1) = 0.08, p = 0.77           |               |                                       |
| Resources (n=1)   |               |                                       |
| Jane et al. (2018) [PG]   | DASS          | • 0.06 [ -0.73, 0.85]                 |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = .\%$ , $H^2 = .$        |               | 0.06 [ -0.73, 0.85]                   |
| Test of $\theta_i = \theta_j$ : Q(0) = 0.00, p = .              |               |                                       |
| Overall   |               | • -0.19 [ -0.29, -0.10]               |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 1.54\%$ , $H^2 = 1.02$  |               |                                       |
| Test of $\theta_i = \theta_j$ : Q(14) = 8.63, p = 0.85          |               | Favours intervention Favours control  |
| Test of group differences: $Q_b(3) = 2.31$ , p = 0.5            | 1             | · · · · · · · · · · · · · · · · · · · |
|   |               | -2 -1 0 1                             |

Figure A63. Changes in depression (post-intervention), stratified by delivery mode, comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis.

There was evidence of an effect for depression (post-intervention) in favour of the intervention when the intervention was delivered face-to-face (SMD -0.27 (95% -0.40, -0.13; n=6;  $l^2=0\%$ )). 336
Evidence suggests an effect in favour of the intervention when provided by a mixture of different delivery modes (SMD -0.12 (95% CI -0.28, 0.03; n=6; l<sup>2</sup>=15.12%)), however there was no evidence of an effect when the intervention was exclusively delivered online (SMD -0.17 (95% CI -0.54, 0.20; n=2; l<sup>2</sup>=0%)). Only one study reported depression (post-intervention) for an intervention exclusively providing resources, and therefore this subgroup could not be analysed through stratification.

| Study A  | ssessment too | ol                   | Hedges's g<br>with 95% Cl |
|--|---------------|----------------------|---------------------------|
| Education and physical activity (n=2)                          |               |                      |                           |
| Imayama et al. (2011) [Dietary+Exercise]                       | BSI-18        |                      | -0.26 [ -0.66, 0.15]      |
| Nanchahal et al. (2009) [SSP]                                  | HADS          |                      | -0.26 [ -0.93, 0.42]      |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$ |               | -                    | -0.26 [ -0.60, 0.09]      |
| Test of $\theta_i = \theta_j$ : Q(1) = 0.00, p = 1.00          |               |                      |                           |
| Education-based (n=10)   |               |                      |                           |
| Ahern et al. (2017) [12-week BWLP]                             | HADS          |                      | -0.33 [ -0.53, -0.13]     |
| Ahern et al. (2017) [52-week BWLP)                             | HADS          |                      | -0.22 [ -0.44, -0.01]     |
| Barnes et al. (2014)   | BDI           |                      | -0.10[-0.61, 0.41]        |
| Godino et al. (2016)   | CES-D         |                      | -0.27 [ -0.49, -0.05]     |
| Imayama et al. (2011) [Dietary]                                | BSI-18        |                      | -0.07 [ -0.47, 0.34]      |
| Jane et al. (2018) [FB]  | DASS          |                      | -0.06 [ -0.86, 0.74]      |
| Jane et al. (2018) [PG]  | DASS          |                      | • 0.06 [ -0.73, 0.85]     |
| Kalarchian et al. (2013)                                       | BDI           | _                    | 0.09 [ -0.21, 0.39]       |
| Nanchahal et al. (2009) [SS]                                   | HADS          |                      | 0.03 [ -0.63, 0.68]       |
| Steinberg et al. (2014)  | CES-D         |                      | -0.20 [ -0.61, 0.22]      |
| Heterogeneity: $r^2 = 0.00$ , $I^2 = 9.93\%$ , $H^2 = 1.11$    |               | •                    | -0.19 [ -0.30, -0.08]     |
| Test of $\theta_i = \theta_j$ : Q(9) = 7.17, p = 0.62          |               |                      |                           |
| Physical activity (n=3)  |               |                      |                           |
| Herring et al. (2014) [Aerobic Exercise]                       | HADS          |                      | -0.61 [ -1.72, 0.50]      |
| Herring et al. (2014) [Resistance Exercise]                    | HADS          |                      | 0.02 [ -1.06, 1.11]       |
| Imayama et al. (2011) [Exercise]                               | BSI-18        |                      | -0.03 [ -0.44, 0.37]      |
| Heterogeneity: $r^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$    |               |                      | -0.09 [ -0.44, 0.27]      |
| Test of $\theta_i = \theta_j$ : Q(2) = 0.98, p = 0.61          |               |                      |                           |
| Overall  |               | •                    | -0.19 [ -0.29, -0.10]     |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 1.54\%$ , $H^2 = 1.02$ |               |                      |                           |
| Test of $\theta_i = \theta_j$ : Q(14) = 8.63, p = 0.85         |               | Favours intervention | Favours control           |
| Test of group differences: $Q_b(2) = 0.46$ , p = 0.79          |               |                      |                           |
|  |               | -2 -1                | ) 1                       |

Figure A64. Changes in depression (post-intervention), stratified by intervention type, comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis.

There was no evidence of an effect for depression (post-intervention) when the intervention exclusively provided physical activity (SMD -0.09 (95% CI -0.44, 0.27; n=3; l<sup>2</sup>=0%)). There was evidence of an effect in favour of the intervention when providing an education-based intervention (SMD -0.19 (95% CI -0.30, -0.08; n=10; l<sup>2</sup>=9.93%)), and evidence to suggest an effect in favour of the intervention when providing a mix of education and physical activity (SMD -0.26 (95% CI -0.60, 0.09; n=2; l<sup>2</sup>=0%)).

| Study  | Assessment to | ol                   | Hedges's g<br>with 95% CI  |
|--|---------------|----------------------|----------------------------|
| 60-69  |               |                      |                            |
| Ahern et al. (2017) [12-week BWLP]                               | HADS          | -                    | -0.33 [ -0.53, -0.13]      |
| Ahern et al. (2017) [52-week BWLP)                               | HADS          | -                    | -0.22 [ -0.44, -0.01]      |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00\%$ | )             | •                    | -0.28 [ -0.43, -0.14]      |
| Test of $\theta_i = \theta_j$ : Q(1) = 0.49, p = 0.48            |               | ·                    |                            |
| 70-79  |               |                      |                            |
| Godino et al. (2016)   | CES-D         |                      | -0.27 [ -0.49, -0.05]      |
| Herring et al. (2014) [Aerobic Exercise]                         | HADS          |                      | -0.61 [ -1.72, 0.50]       |
| Nanchahal et al. (2009) [SSP]                                    | HADS          | <b>_</b>             | -0.26 [ -0.93, 0.42]       |
| Nanchahal et al. (2009) [SS]                                     | HADS          |                      | 0.03 [ -0.63, 0.68]        |
| Steinberg et al. (2014)  | CES-D         |                      | -0.20 [ -0.61, 0.22]       |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00\%$ | )             | •                    | -0.24 [ -0.42, -0.07]      |
| Test of $\theta_i = \theta_j$ : Q(4) = 1.19, p = 0.88            |               |                      |                            |
| 80-89  |               |                      |                            |
| Barnes et al. (2014)   | BDI           |                      | -0.10 [ -0.61, 0.41]       |
| Herring et al. (2014) [Resistance Exercise]                      | HADS          |                      | 0.02 [ -1.06, 1.11]        |
| Jane et al. (2018) [FB]  | DASS          |                      | -0.06 [ -0.86, 0.74]       |
| Kalarchian et al. (2013)   | BDI           | _                    | 0.09 [ -0.21, 0.39]        |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00\%$ | )             | •                    | 0.03 [ -0.21, 0.27]        |
| Test of $\theta_i = \theta_j$ : Q(3) = 0.45, p = 0.93            |               |                      |                            |
| 90-100   |               |                      |                            |
| Imayama et al. (2011) [Dietary+Exercise]                         | BSI-18        |                      | -0.26 [ -0.66, 0.15]       |
| Imayama et al. (2011) [Dietary]                                  | BSI-18        |                      | -0.07 [ -0.47, 0.34]       |
| Imayama et al. (2011) [Exercise]                                 | BSI-18        |                      | -0.03 [ -0.44, 0.37]       |
| Jane et al. (2018) [PG]  | DASS          | ·                    | <b>0.06</b> [ -0.73, 0.85] |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00\%$ | )             | -                    | -0.10 [ -0.33, 0.12]       |
| Test of $\theta_i = \theta_j$ : Q(3) = 0.88, p = 0.83            |               |                      |                            |
| Overall  |               | •                    | -0.19 [ -0.29, -0.10]      |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 1.54\%$ , $H^2 = 1.02$   | 2             |                      |                            |
| Test of $\theta_i = \theta_j$ : Q(14) = 8.63, p = 0.85           |               | Favours intervention | Favours control            |
| Test of group differences: $Q_b(3) = 5.62$ , p = 0.7             | 13            |                      |                            |
|  |               | -2 -1 (              | D 1                        |

Figure A65. Changes in depression (post-intervention), stratified by percentage of interventions participants that were women (%), comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis.

There was evidence of an effect for depression (post-intervention) in favour of the intervention when 70-79% of participants were women (SMD -0.24 (95% CI -0.42, -0.07; n=5;  $I^2=0\%$ )). There

was no evidence of a difference between intervention and comparator for any other stratified analyses.

| Study  | Assessment tool |                      | Hedges's g<br>with 95% Cl | Weight<br>(%) |
|--|-----------------|----------------------|---------------------------|---------------|
| 20-29  |                 |                      |                           |               |
| Godino et al. (2016)   | CES-D           |                      | -0.27 [ -0.49, -0.05]     | 17.94         |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = .\%$ , $H^2 = .$         |                 | •                    | -0.27 [ -0.49, -0.05]     |               |
| Test of $\theta_i = \theta_j$ : Q(0) = 0.00, p = .               |                 |                      |                           |               |
| 30-39  |                 |                      |                           |               |
| Imayama et al. (2011) [Dietary+Exercise]                         | BSI-18          |                      | -0.26 [ -0.66, 0.15]      | 5.36          |
| Imayama et al. (2011) [Exercise]                                 | BSI-18          |                      | -0.03 [ -0.44, 0.37]      | 5.38          |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00\%$ | 00              |                      | -0.14 [ -0.43, 0.14]      |               |
| Test of $\theta_i = \theta_j$ : Q(1) = 0.60, p = 0.44            |                 |                      |                           |               |
| 40-49  |                 |                      |                           |               |
| Barnes et al. (2014)   | BDI             |                      | -0.10 [ -0.61, 0.41]      | 3.37          |
| Jane et al. (2018) [FB]  | DASS            |                      | -0.06 [ -0.86, 0.74]      | 1.39          |
| Kalarchian et al. (2013)   | BDI             |                      | 0.09 [ -0.21, 0.39]       | 9.54          |
| Nanchahal et al. (2009) [SSP]                                    | HADS            |                      | -0.26 [ -0.93, 0.42]      | 1.96          |
| Nanchahal et al. (2009) [SS]                                     | HADS            |                      | 0.03 [ -0.63, 0.68]       | 2.09          |
| Steinberg et al. (2014)  | CES-D           |                      | -0.20 [ -0.61, 0.22]      | 5.12          |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00\%$ | 00              |                      | -0.04 [ -0.24, 0.15]      |               |
| Test of $\theta_i = \theta_j$ : Q(5) = 1.75, p = 0.88            |                 |                      |                           |               |
| 50-59  |                 |                      |                           |               |
| Ahern et al. (2017) [12-week BWLP]                               | HADS            |                      | -0.33 [ -0.53, -0.13]     | 21.41         |
| Ahern et al. (2017) [52-week BWLP)                               | HADS            |                      | -0.22 [ -0.44, -0.01]     | 18.15         |
| Imayama et al. (2011) [Dietary]                                  | BSI-18          |                      | -0.07 [ -0.47, 0.34]      | 5.39          |
| Jane et al. (2018) [PG]  | DASS            |                      | 0.06 [ -0.73, 0.85]       | 1.42          |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00\%$ | 00              | •                    | -0.25 [ -0.38, -0.11]     |               |
| Test of $\theta_i = \theta_j$ : Q(3) = 2.04, p = 0.56            |                 |                      |                           |               |
| NR   |                 |                      |                           |               |
| Herring et al. (2014) [Aerobic Exercise]                         | HADS            |                      | -0.61 [ -1.72, 0.50]      | 0.72          |
| Herring et al. (2014) [Resistance Exercise]                      | HADS            |                      | 0.02 [ -1.06, 1.11]       | 0.76          |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.0$    | 00              |                      | -0.29 [ -1.06, 0.49]      |               |
| Test of $\theta_i = \theta_j$ : Q(1) = 0.64, p = 0.42            |                 |                      |                           |               |
| Overall  |                 | •                    | -0.19 [ -0.29, -0.10]     |               |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 1.54\%$ , $H^2 = 1.4\%$  | 02              |                      |                           |               |
| Test of $\theta_i = \theta_j$ : Q(14) = 8.63, p = 0.85           |                 | Favours intervention | Favours control           |               |
| Test of group differences: $Q_b(4) = 3.58$ , p = 0               | ).47            |                      |                           |               |
|  |                 | -2 -1 0              | ) 1                       |               |

Figure A66. Changes in depression (post-intervention), stratified by mean age of interventions participants (years), comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis.

There was no evidence of a difference between intervention and comparator for any stratified analyses.

|  |                 |                      | Hedges's g            | Weight |
|--|-----------------|----------------------|-----------------------|--------|
| Study  | Assessment tool |                      | with 95% CI           | (%)    |
| 25-29.9 (Overweight)   |                 | _                    |                       |        |
| Godino et al. (2016)   | CES-D           | -                    | -0.27 [ -0.49, -0.05] | 17.94  |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = .\%$ , $H^2 = .$         |                 | •                    | -0.27 [ -0.49, -0.05] |        |
| Test of $\theta_i = \theta_j$ : Q(0) = 0.00, p = .               |                 |                      |                       |        |
| 30-34.9 (Obesity I)  |                 |                      |                       |        |
| Ahern et al. (2017) [12-week BWLP]                               | HADS            |                      | -0.33 [ -0.53, -0.13] | 21.41  |
| Ahern et al. (2017) [52-week BWLP)                               | HADS            | -8-                  | -0.22 [ -0.44, -0.01] | 18.15  |
| Barnes et al. (2014)   | BDI             |                      | -0.10 [ -0.61, 0.41]  | 3.37   |
| lmayama et al. (2011) [Dietary]                                  | BSI-18          |                      | -0.07 [ -0.47, 0.34]  | 5.39   |
| Jane et al. (2018) [FB]  | DASS            |                      | -0.06 [ -0.86, 0.74]  | 1.39   |
| Jane et al. (2018) [PG]  | DASS            |                      | •                     | 1.42   |
| Steinberg et al. (2014)  | CES-D           |                      | -0.20 [ -0.61, 0.22]  | 5.12   |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00\%$ | )               | •                    | -0.23 [ -0.35, -0.11] |        |
| Test of $\theta_i = \theta_j$ : Q(6) = 2.55, p = 0.86            |                 |                      |                       |        |
| 35-39.9 (Obesity II)   |                 |                      |                       |        |
| Nanchahal et al. (2009) [SSP]                                    | HADS            |                      | -0.26 [ -0.93, 0.42]  | 1.96   |
| Nanchahal et al. (2009) [SS]                                     | HADS            |                      | 0.03 [ -0.63, 0.68]   | 2.09   |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00\%$ | )               |                      | -0.11 [ -0.58, 0.36]  |        |
| Test of $\theta_i = \theta_j$ : Q(1) = 0.35, p = 0.55            |                 |                      |                       |        |
| 40+ (Obesity III)  |                 |                      |                       |        |
| Herring et al. (2014) [Aerobic Exercise]                         | HADS            |                      | -0.61 [ -1.72, 0.50]  | 0.72   |
| Herring et al. (2014) [Resistance Exercise]                      | HADS            |                      | 0.02 [ -1.06, 1.11]   | 0.76   |
| Imayama et al. (2011) [Dietary+Exercise]                         | BSI-18          |                      | -0.26 [ -0.66, 0.15]  | 5.36   |
| Imayama et al. (2011) [Exercise]                                 | BSI-18          |                      | -0.03 [ -0.44, 0.37]  | 5.38   |
| Kalarchian et al. (2013)   | BDI             | _                    | 0.09 [ -0.21, 0.39]   | 9.54   |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00\%$ | )               |                      | -0.05 [ -0.25, 0.15]  |        |
| Test of $\theta_i = \theta_j$ : Q(4) = 2.86, p = 0.58            |                 |                      |                       |        |
| Overall  |                 | •                    | -0.19 [ -0.29, -0.10] |        |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 1.54\%$ , $H^2 = 1.02$   | 2               |                      | -                     |        |
| Test of $\theta_i = \theta_j$ : Q(14) = 8.63, p = 0.85           |                 | Favours intervention | Favours control       |        |
| Test of group differences: $Q_b(3) = 2.87$ , p = 0.4             | 41              |                      |                       |        |
|  |                 | -2 -1 0              | ) 1                   |        |

Figure A67. Changes in depression (post-intervention), stratified by mean BMI of interventions participants (kg/m<sup>2</sup>), comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis.

There was evidence of an effect for depression (post-intervention) in favour of the intervention when participants had a mean BMI between 30-34.9 kg/m<sup>2</sup> (SMD -0.23 (95% CI -0.35, -0.11; n=7; I<sup>2</sup>=0%)). There is no evidence of a difference between intervention and comparator when participants had a mean BMI between 35-39.9 kg/m<sup>2</sup> (SMD -0.11 (95% CI -0.58, 0.36; n=2; I<sup>2</sup>=0%)), or 40+ kg/m<sup>2</sup> (SMD -0.05 (95% CI -0.25, 0.15; n=5; I<sup>2</sup>=1.54%)).

### Quality of life – global (post-intervention)



Figure A68. Changes in global quality of life (post-intervention), stratified by comparator group intensity, comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis.

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There was evidence to suggest an effect for global quality of life (post-intervention) in favour of the intervention when compared to an intervention-intensity usual care comparator group (SMD 0.11 (95% CI -0.06, 0.27; n=3;  $I^2$ =0%)), however no evidence of an effect when compared to minimal or inactive intensity comparator group (SMD -0.15 (95% CI -0.82, 0.52; n=8;  $I^2$ =95.04%)).



Figure A69. Changes in global quality of life (post-intervention), stratified by gender of intervention participants, comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis.

There was evidence of an effect for global quality of life (post-intervention) in favour of the intervention when provided exclusively to females (SMD 0.91 (95% CI 0.52, 1.39; n=2;  $l^2=0$ %)),

where there is no evidence of an effect when provided to both males and females (SMD -0.25 (95% CI -0.68, 0.18; n=9;  $I^2=92.56$ %)).

| Study  | Assessment tool        |                 | Hedges's g<br>with 95% CI |
|--|------------------------|-----------------|---------------------------|
| Group (n=3)  | ,                      |                 |                           |
| Ahern et al. (2017) [12-week BWLP]                       | EQ5D3L                 |                 | 0.08 [ -0.12, 0.28]       |
| Ahern et al. (2017) [52-week BWLP)                       | EQ5D3L                 |                 | 0.11 [ -0.11, 0.33]       |
| McRobbie et al. (2016)                                   | EQ5D5L                 | -               | 0.18 [-0.12, 0.49]        |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2$  | <sup>2</sup> = 1.00    |                 | • 0.11 [-0.02, 0.25]      |
| Test of $\theta_i = \theta_j$ : Q(2) = 0.29, p = 0.87    |                        |                 |                           |
| Group and individual (n=1)                               |                        |                 |                           |
| Sellman et al. (2017)                                    | WHOQOL                 | -1              | 0.04 [ -0.39, 0.47]       |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = .\%$ , $H^2 = .$ |                        | •               | 0.04 [ -0.39, 0.47]       |
| Test of $\theta_i$ = $\theta_j$ : Q(0) = 0.00, p = .     |                        |                 |                           |
| Individual (n=7)   |                        |                 |                           |
| Godino et al. (2016)                                     | QWS                    |                 | 0.08 [ -0.13, 0.30]       |
| Jane et al. (2018) [FB]                                  | WHOQOL                 |                 | -1.46 [ -2.34, -0.57]     |
| Jane et al. (2018) [PG]                                  | WHOQOL                 |                 | -1.96 [ -2.83, -1.09]     |
| Nanchahal et al. (2009) [SSP]                            | EQ5D-index             |                 | -0.12 [ -0.79, 0.56]      |
| Nanchahal et al. (2009) [SS]                             | EQ5D-index             |                 | -0.07 [ -0.73, 0.59]      |
| White et al. (2010) [Group 1]                            | Bespoke questionnaire  |                 |                           |
| White et al. (2010) [Group 2]                            | Bespoke questionnaire  |                 |                           |
| Heterogeneity: $r^2 = 1.03$ , $I^2 = 93.30\%$ , H        | H <sup>2</sup> = 14.92 |                 | -0.20 [ -0.99, 0.59]      |
| Test of $\theta_i = \theta_j$ : Q(6) = 51.39, p = 0.00   |                        |                 |                           |
| Overall  |                        | •               | -0.06 [ -0.51, 0.40]      |
| Heterogeneity: $r^2 = 0.51$ , $I^2 = 94.00\%$ , H        | H <sup>2</sup> = 16.67 |                 |                           |
| Test of $\theta_i = \theta_j$ : Q(10) = 51.82, p = 0.00  |                        | Favours control | Favours intervention      |
| Test of group differences: $Q_b(2) = 0.66$ ,             | p = 0.72               |                 |                           |
|  | -4                     | -2 (            | ) 2                       |

Figure A70. Changes in global quality of life (post-intervention), stratified by delivery format, comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis.

There is evidence to suggest an effect for global quality of life (post-intervention) in favour of the intervention when provided exclusively to groups (SMD 0.11 (95% CI -0.02, 0.25; n=3;  $I^2=0\%$ )), whilst there was no evidence of an effect when delivered exclusively to individuals (SMD -0.20 (95% CI -0.99, 0.59; n=7;  $I^2=93.30\%$ )). Only one study reported global quality of life (post-

intervention) for an intervention exclusively delivered to both groups and individuals, and therefore this subgroup could not be analysed through stratification.

| Study  | Assessment tool       |                 | Hedges's g<br>with 95% CI               |
|--|-----------------------|-----------------|---|
| Face-to-face (n=7)                                       |                       |                 |   |
| Ahern et al. (2017) [12-week BWLP]                       | EQ5D3L                | I               | 0.08 [ -0.12, 0.28]                     |
| Ahern et al. (2017) [52-week BWLP)                       | EQ5D3L                |                 | 0.11 [ -0.11, 0.33]                     |
| McRobbie et al. (2016)                                   | EQ5D5L                | -               | 0.18 [ -0.12, 0.49]                     |
| Nanchahal et al. (2009) [SSP]                            | EQ5D-index            |                 | -0.12 [ -0.79, 0.56]                    |
| Nanchahal et al. (2009) [SS]                             | EQ5D-index            | _               | -0.07 [ -0.73, 0.59]                    |
| White et al. (2010) [Group 1]                            | Bespoke questionnaire |                 |   |
| White et al. (2010) [Group 2]                            | Bespoke questionnaire |                 | 0.76 [ 0.22, 1.30]                      |
| Heterogeneity: $\tau^2 = 0.09$ , $I^2 = 75.09\%$ , H     | <sup>2</sup> = 4.01   |                 | • 0.27 [ -0.01, 0.55]                   |
| Test of $\theta_i = \theta_j$ : Q(6) = 16.81, p = 0.01   |                       |                 |   |
| Mixed modes (n=2)  |                       |                 |   |
| Godino et al. $(2016)$                                   | OWS                   |                 | 0.08[-0.13_0.30]                        |
| Sellman et al. (2017)                                    | WHOQOI                | -               |   |
| Heterogeneity: $\tau^2 = 0.00 \ I^2 = 0.00\% \ H^2$      | = 1 00                |                 | 0.07 [-0.12 0.27]                       |
| Test of $\theta_i = \theta_j$ : Q(1) = 0.04, p = 0.85    |                       |                 | • |
|  |                       |                 |   |
| Online (n=1)   |                       |                 |   |
| Jane et al. (2018) [FB]                                  | WHOQOL                |                 | -1.46 [ -2.34, -0.57]                   |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = .\%$ , $H^2 = .$ |                       |                 | -1.46 [ -2.34, -0.57]                   |
| Test of $\theta_i = \theta_j$ : Q(0) = 0.00, p = .       |                       |                 |   |
| Resources (n=1)  |                       |                 |   |
| Jane et al. (2018) [PG]                                  | WHOQOL                |                 | -1.96 [ -2.83, -1.09]                   |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = .\%$ , $H^2 = .$ |                       |                 | -1.96 [ -2.83, -1.09]                   |
| Test of $\theta_i$ = $\theta_j$ : Q(0) = 0.00, p = .     |                       |                 |   |
| Overall  |                       |                 | -0.06[-0.51_0.40]                       |
| Heterogeneity: $\tau^2 = 0.51 \ I^2 = 94.00\% \ H$       | $^{2}$ = 16.67        |                 |   |
| Test of $\theta_i = \theta_j$ : Q(10) = 51.82, p = 0.00  |                       | Favours control | Favours intervention                    |
| Test of group differences: $Q_b(3) = 33.86$              | , p = 0.00            |                 |   |
|  | -4                    | -2 (            | ) 2                                     |

Figure A71. Changes in global quality of life (post-intervention), stratified by delivery mode, comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis. There was evidence to suggest an effect for global quality of life (post-intervention) in favour of the intervention when delivered face-to-face (SMD 0.27 (95% CI -0.01, 0.55; n=7; l<sup>2</sup>=75.09%)), however there was no evidence of an effect when delivered by a mixture of delivery modes (SMD 0.07 (95% CI -0.12, 0.27; n=2; l<sup>2</sup>=0%)). Only one study reported global quality of life delivered an intervention by exclusively providing resources or exclusively online, and therefore these subgroups could not be analysed through stratification.

| Study  | Assessment tool       |                     |                 | Hedges's<br>with 95% | g<br>Cl |
|--|-----------------------|---------------------|-----------------|----------------------|---------|
| 60-69  |                       |                     |                 |                      |         |
| Ahern et al. (2017) [12-week BWLP]                     | EQ5D3L                | 1                   | -               | 0.08 [ -0.12,        | 0.28]   |
| Ahern et al. (2017) [52-week BWLP)                     | EQ5D3L                | -                   | -               | 0.11 [ -0.11,        | 0.33]   |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , H    | <sup>2</sup> = 1.00   |                     | •               | 0.10 [ -0.05,        | 0.24]   |
| Test of $\theta_i = \theta_j$ : Q(1) = 0.04, p = 0.83  |                       |                     |                 |                      |         |
| 70-79  |                       |                     |                 |                      |         |
| Godino et al. (2016)                                   | QWS                   | -                   | -               | 0.08 [ -0.13,        | 0.30]   |
| McRobbie et al. (2016)                                 | EQ5D5L                | -                   |                 | 0.18 [ -0.12,        | 0.49]   |
| Nanchahal et al. (2009) [SSP]                          | EQ5D-index            |                     |                 | -0.12 [ -0.79,       | 0.56]   |
| Nanchahal et al. (2009) [SS]                           | EQ5D-index            |                     | <b>—</b>        | -0.07 [ -0.73,       | 0.59]   |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , H    | <sup>2</sup> = 1.00   |                     | •               | 0.09 [ -0.07,        | 0.26]   |
| Test of $\theta_i = \theta_j$ : Q(3) = 0.93, p = 0.82  |                       |                     |                 |                      |         |
| 80-89  |                       |                     |                 |                      |         |
| Jane et al. (2018) [FB]                                | WHOQOL                |                     |                 | -1.46 [ -2.34,       | -0.57]  |
| Sellman et al. (2017)                                  | WHOQOL                | -                   | -               | 0.04 [ -0.39,        | 0.47]   |
| Heterogeneity: $\tau^2 = 0.99$ , $I^2 = 88.73\%$ , I   | $H^2 = 8.88$          |                     |                 | -0.66 [ -2.12,       | 0.80]   |
| Test of $\theta_i = \theta_j$ : Q(1) = 8.88, p = 0.00  |                       |                     |                 |                      |         |
| 90-100   |                       |                     |                 |                      |         |
| White et al. (2010) [Group 1]                          | Bespoke questionnair  | е                   |                 | 1.06 [ 0.51,         | 1.61]   |
| White et al. (2010) [Group 2]                          | Bespoke questionnair  | е                   |                 | 0.76 [ 0.22,         | 1.30]   |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , H    | <sup>2</sup> = 1.00   |                     |                 | 0.91 [ 0.52,         | 1.30]   |
| Test of $\theta_i = \theta_j$ : Q(1) = 0.57, p = 0.45  |                       |                     |                 |                      |         |
| Overall  | 2                     | •                   |                 | 0.12 [ -0.18,        | 0.42]   |
| Heterogeneity: $\tau^2 = 0.18$ , $I^2 = 85.79\%$ , I   | H <sup>2</sup> = 7.04 |                     |                 |                      |         |
| Test of $\theta_i = \theta_j$ : Q(9) = 30.14, p = 0.00 | F                     | avours intervention | Favours control |                      |         |
| Test of group differences: $Q_b(3) = 16.99$            | 9, p = 0.00           |                     |                 |                      |         |
|  |                       | -2 -1 (             | 0 1 2           |                      |         |

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Figure A72. Changes in global quality of life (post-intervention), stratified by percentage of interventions participants that were women (%), comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis.

There was evidence of an effect for global quality of life (post-intervention) in favour of the intervention when 90-100% of participants were women (SMD 0.91 (95% Cl 0.52, 1.30; n=2;  $l^2=0\%$ )). There is some evidence of an effect in favour of the intervention when 60-69% of participants were women (SMD 0.10 (95% Cl -0.05, 0.24; n=2;  $l^2=0\%$ )), or 70-79% were women (SMD 0.09 (95% Cl -0.07, 0.26; n=4;  $l^2=0\%$ )). There is no evidence of a difference between intervention and comparator when 80-89% were women (SMD -0.66 (95% Cl -2.12, 0.80; n=2;  $l^2=88.73\%$ )).

| Study   | Assessment tool        |                      |              | Hedges's<br>with 95% | s g<br>Cl |
|---|------------------------|----------------------|--------------|----------------------|-----------|
| 20-29   |                        |                      |              |                      |           |
| Godino et al. (2016)  | QWS                    | I                    | C            | ).08 [ -0.13,        | 0.30]     |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = .\%$ , $H^2 = .$  |                        | •                    | <b>ф</b> с   | ).08 [ -0.13,        | 0.30]     |
| Test of $\theta_i = \theta_j$ : Q(0) = 0.00, p = .  |                        |                      |              |                      |           |
| 30-39   |                        |                      |              |                      |           |
| White et al. (2010) [Group 1]   | Bespoke questionnaire  |                      |              | .06 [ 0.51,          | 1.61]     |
| White et al. (2010) [Group 2]   | Bespoke questionnaire  |                      |              | ).76 [ 0.22,         | 1.30]     |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2$   | <sup>2</sup> = 1.00    |                      | • C          | ).91 [ 0.52,         | 1.30]     |
| Test of $\theta_i = \theta_j$ : Q(1) = 0.57, p = 0.45   |                        |                      |              |                      |           |
| 40-49   |                        |                      |              |                      |           |
| Jane et al. (2018) [FB]   | WHOQOL                 | —— <b>—</b> —        | -1           | 1.46 [ -2.34,        | -0.57]    |
| McRobbie et al. (2016)  | EQ5D5L                 |                      | <b>с</b>     | ).18 [ -0.12,        | 0.49]     |
| Nanchahal et al. (2009) [SSP]   | EQ5D-index             |                      | -0           | ).12 [ -0.79,        | 0.56]     |
| Nanchahal et al. (2009) [SS]  | EQ5D-index             |                      | -0           | ).07 [ -0.73,        | 0.59]     |
| Heterogeneity: $\tau^2 = 0.34$ , $I^2 = 79.28\%$ , H  | $H^2 = 4.83$           | -                    | -0           | ).29 [ -0.94,        | 0.36]     |
| Test of $\theta_i = \theta_j$ : Q(3) = 11.94, p = 0.01  |                        |                      |              |                      |           |
| 50-59   |                        |                      |              |                      |           |
| Ahern et al. (2017) [12-week BWLP]  | EQ5D3L                 | I                    | C C          | ).08 [ -0.12,        | 0.28]     |
| Ahern et al. (2017) [52-week BWLP)  | EQ5D3L                 |                      | . (          | ).11 [ -0.11,        | 0.33]     |
| Jane et al. (2018) [PG]   | WHOQOL                 |                      | -1           | .96 [ -2.83,         | -1.09]    |
| Sellman et al. (2017)   | WHOQOL                 | -                    | - C          | ).04 [ -0.39,        | 0.47]     |
| Heterogeneity: $\tau^2 = 0.78$ , $I^2 = 96.96\%$ , H<br>Test of $A = A$ : $O(3) = 20.78$ , $p = 0.00$ | H <sup>2</sup> = 32.90 |                      | -0           | ).36 [ -1.26,        | 0.54]     |
|   |                        |                      |              |                      |           |
| Overall   | 2                      | •                    | -0           | ).06 [ -0.51,        | 0.40]     |
| Heterogeneity: $\tau^2 = 0.51$ , $I^2 = 94.00\%$ , H  | H <sup>∠</sup> = 16.67 |                      |              |                      |           |
| Test of $\theta_i = \theta_j$ : Q(10) = 51.82, p = 0.00   |                        | Favours intervention | Favours cont | trol                 |           |
| Test of group differences: $Q_b(3) = 17.66$   | 6, p = 0.00            |                      | ļ            |                      |           |
|   |                        | 4 -2                 | 0 2          |                      |           |

Figure A73. Changes in global quality of life (post-intervention), stratified by mean age of interventions participants, comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis.

There was evidence of an effect for global quality of life (post-intervention) in favour of the intervention when participants had a mean age between 30-39 year (SMD 0.91 (95% CI 0.52, 1.30; n=2;  $I^2=0\%$ )). There is no evidence of a difference between intervention and comparator

when participants had a mean age between 40-49 years (SMD -0.29 (95% CI -0.94, 0.36; n=4;  $I^2$ =79.28%)), or 50-59 years (SMD -0.36 (95% CI -1.26, 0.54; n=4;  $I^2$ =96.96%)).

| Study  | Assessment tool        |                      |            | Hedges's<br>with 95% | s g<br>Cl |
|--|------------------------|----------------------|------------|----------------------|-----------|
| 25-29.9 (Overweight)                                     |                        |                      |            |                      |           |
| Godino et al. (2016)                                     | QWS                    |                      |            | 0.08 [ -0.13,        | 0.30]     |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = .\%$ , $H^2 = .$ |                        | •                    | •          | 0.08 [ -0.13,        | 0.30]     |
| Test of $\theta_i = \theta_j$ : Q(0) = 0.00, p = .       |                        |                      |            |                      |           |
| 30-34.5 (Obesity I)                                      |                        |                      |            |                      |           |
| Ahern et al. (2017) [12-week BWLP]                       | EQ5D3L                 |                      |            | 0.08 [ -0.12,        | 0.28]     |
| Ahern et al. (2017) [52-week BWLP)                       | EQ5D3L                 |                      |            | 0.11 [ -0.11,        | 0.33]     |
| Jane et al. (2018) [FB]                                  | WHOQOL                 |                      |            | -1.46 [ -2.34,       | -0.57]    |
| Jane et al. (2018) [PG]                                  | WHOQOL                 |                      |            | -1.96 [ -2.83,       | -1.09]    |
| Sellman et al. (2017)                                    | WHOQOL                 | -                    | -          | 0.04 [ -0.39,        | 0.47]     |
| White et al. (2010) [Group 1]                            | Bespoke questionnaire  |                      |            | 1.06 [ 0.51,         | 1.61]     |
| White et al. (2010) [Group 2]                            | Bespoke questionnaire  |                      |            | 0.76 [ 0.22,         | 1.30]     |
| Heterogeneity: $\tau^2 = 1.01$ , $I^2 = 96.47\%$ , H     | H <sup>2</sup> = 28.30 |                      |            | -0.14 [ -0.92,       | 0.63]     |
| Test of $\theta_i = \theta_j$ : Q(6) = 50.87, p = 0.00   |                        |                      |            |                      |           |
| 35-39.9 (Obesity II)                                     |                        |                      |            |                      |           |
| McRobbie et al. (2016)                                   | EQ5D5L                 |                      | -          | 0.18 [ -0.12,        | 0.49]     |
| Nanchahal et al. (2009) [SSP]                            | EQ5D-index             | -                    | <b> </b>   | -0.12 [ -0.79,       | 0.56]     |
| Nanchahal et al. (2009) [SS]                             | EQ5D-index             |                      |            | -0.07 [ -0.73,       | 0.59]     |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2$  | <sup>2</sup> = 1.00    | •                    |            | 0.10 [ -0.16,        | 0.36]     |
| Test of $\theta_i = \theta_j$ : Q(2) = 0.93, p = 0.63    |                        |                      |            |                      |           |
| Overall  |                        |                      |            | -0.06 [ -0.51.       | 0.401     |
| Heterogeneity: $\tau^2 = 0.51$ , $I^2 = 94.00\%$ , H     | H <sup>2</sup> = 16.67 |                      |            | . ,                  |           |
| Test of $\theta_i = \theta_j$ : Q(10) = 51.82, p = 0.00  |                        | Favours intervention | Favours co | ontrol               |           |
| Test of group differences: $Q_b(2) = 0.34$ ,             | p = 0.84               |                      |            |                      |           |
|  | -                      | 4 -2                 | 5 2        | 2                    |           |

Figure A74. Changes in global quality of life (post-intervention), stratified by mean BMI of interventions participants (kg/m2), comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis.

There was evidence of an effect for global quality of life (post-intervention) in favour of the intervention when participants had a mean age between 40-49 years (SMD 0.46 (95% CI 0.10, 0.83; n=3;  $l^2=45.13\%$ )). There is no evidence of a difference between intervention and comparator

when participants had a mean age between 50-59 years (SMD 0.00 (95% CI -0.14, 0.15; n=5;  $I^2=0\%$ )).

# Quality of life – global (change from baseline)

|  |                       |                      | Hedges's g           |
|--|-----------------------|----------------------|----------------------|
| Study  | Assessment tool       |                      | with 95% CI          |
| Intervention (UC) (n=3)  |                       |                      |                      |
| Astbury et al. (2018)  | EQ5D-index            |                      | 0.22 [ -0.09, 0.53]  |
| Damschroder et al. (2014) [ASPIRE-Group]                         | EQ5D-index -          | -                    | -0.12 [ -0.40, 0.15] |
| Damschroder et al. (2014) [ASPIRE-Phone]                         | EQ5D-index -          | F                    | 0.00 [ -0.27, 0.27]  |
| Heterogeneity: $\tau^2 = 0.01$ , $I^2 = 25.60\%$ , $H^2 = 1.34$  | 1 🔶                   | •                    | 0.02 [ -0.17, 0.21]  |
| Test of $\theta_i = \theta_j$ : Q(2) = 2.77, p = 0.25            |                       |                      |                      |
|  |                       |                      |                      |
| Minimal or inactive (n=5)  |                       |                      |                      |
| Cleo et al. (2019) [DSD]   | Bespoke questionnaire |                      | 0.90 [ 0.11, 1.69]   |
| Cleo et al. (2019) [TTT]   | Bespoke questionnaire |                      | 0.96 [ 0.13, 1.78]   |
| Petrella et al. (2017)   | EQ5D3L                |                      | 0.58 [ 0.13, 1.02]   |
| Rubin et al. (2013) [In-person support]                          | EQ5D-VAS —            |                      | -0.05 [ -0.39, 0.29] |
| Rubin et al. (2013) [Remote support only]                        | EQ5D-VAS —            | <b></b>              | 0.10 [ -0.25, 0.45]  |
| Heterogeneity: $\tau^2 = 0.12$ , $I^2 = 67.46\%$ , $H^2 = 3.0\%$ | 7                     |                      | 0.39 [ 0.01, 0.77]   |
| Test of $\theta_i = \theta_j$ : Q(4) = 11.22, p = 0.02           |                       |                      |                      |
|  |                       |                      |                      |
| Overall  | •                     | •                    | 0.19 [ -0.03, 0.40]  |
| Heterogeneity: $\tau^2$ = 0.05, $I^2$ = 60.21%, $H^2$ = 2.5      | 1                     |                      |                      |
| Test of $\theta_i = \theta_j$ : Q(7) = 17.07, p = 0.02           | Favours control       | Favours intervention |                      |
| Test of group differences: $Q_b(1) = 2.85$ , p = 0.0             | 9                     |                      |                      |
|  | -1 0                  | 1                    | ר<br>2               |
|  |                       |                      |                      |

Figure A75. Changes in global quality of life (change from baseline), stratified by comparator group intensity, comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis.

There was no evidence of an effect for global quality of life (change from baseline) when the intervention was compared to intervention-intensity usual care comparator groups (SMD 0.02 (95% CI-0.17, 0.21; n=3; I<sup>2</sup>=25.60%)), however there was evidence of an effect in favour of the intervention when compared to minimal or inactive intensity comparator group (SMD 0.39 (95% CI 0.01, 0.77; n=5; I<sup>2</sup>=67.46%)).

| Study   | Assessment tool       |                 | Hedges's g<br>with 95% CI |
|---|-----------------------|-----------------|---------------------------|
| 0   |                       |                 |                           |
| Damschroder et al. (2014) [ASPIRE-Group]                        | EQ5D-index -          | F               | -0.12 [ -0.40, 0.15]      |
| Damschroder et al. (2014) [ASPIRE-Phone]                        | EQ5D-index -          | -               | 0.00 [-0.27, 0.27]        |
| Petrella et al. (2017)  | EQ5D3L                |                 | 0.58 [ 0.13, 1.02]        |
| Heterogeneity: $\tau^2 = 0.09$ , $I^2 = 77.35\%$ , $H^2 = 4.41$ |                       |                 | 0.12 [-0.27, 0.50]        |
| Test of $\theta_i = \theta_j$ : Q(2) = 7.15, p = 0.03           |                       |                 |                           |
| 60-69   |                       |                 |                           |
| Astbury et al. (2018)   | EQ5D-index -          | +-              | 0.22 [-0.09, 0.53]        |
| Rubin et al. (2013) [In-person support]                         | EQ5D-VAS —            | <b></b>         | -0.05 [ -0.39, 0.29]      |
| Rubin et al. (2013) [Remote support only]                       | EQ5D-VAS —            |                 | 0.10 [-0.25, 0.45]        |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$  | •                     | •               | 0.10 [-0.09, 0.29]        |
| Test of $\theta_i = \theta_j$ : Q(2) = 1.36, p = 0.51           |                       |                 |                           |
| 70-79   |                       |                 |                           |
| Cleo et al. (2019) [DSD]  | Bespoke questionnaire | <b>_</b>        | 0.90 [ 0.11, 1.69]        |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = .\%$ , $H^2 = .$        |                       |                 | 0.90 [ 0.11, 1.69]        |
| Test of $\theta_i = \theta_j$ : Q(0) = 0.00, p = .              |                       |                 |                           |
| 20.00   |                       |                 |                           |
|   | Posneko guestienneiro |                 | 0.06[0.13,1.78]           |
| Heterogeneity: $r^2 = 0.00 I^2 = \% H^2 =$                      | bespoke questionnaire |                 | 0.90 [ 0.13, 1.78]        |
| Test of $\theta_{i} = \theta_{i}$ : Q(0) = 0.00, p = .          |                       |                 | 0.90[0.13, 1.70]          |
|   |                       |                 |                           |
| Overall   |                       | •               | 0.19 [-0.03, 0.40]        |
| Heterogeneity: $\tau^2 = 0.05$ , $I^2 = 60.21\%$ , $H^2 = 2.51$ |                       |                 |                           |
| Test of $\theta_i = \theta_j$ : Q(7) = 17.07, p = 0.02          | Favours intervention  | Favours control |                           |
| Test of group differences: $Q_b(3) = 7.38$ , p = 0.06           | <u> </u>              |                 |                           |
|   | -1 (                  | 0 1 2           |                           |

Figure A76. Changes in global quality of life (change from baseline), stratified by percentage of interventions participants that were women (%), comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis.

There was no evidence of a difference between intervention and comparator for global quality of life change from baseline) when 0% of participants were women (SMD 0.12 (95% CI 0.12 (95% CI -0.27, 0.50; n=3;  $I^2$ =77.35%)). There is some evidence of an effect in favour of the intervention when 60-69% of participants were women (SMD 0.10 (95% CI -0.09, 0.29; n=3; I=0%)).

| Study  | Assessment tool       |                 | Hedges's g<br>with 95% CI |
|--|-----------------------|-----------------|---------------------------|
| 40-49  |                       |                 |                           |
| Astbury et al. (2018)  | EQ5D-index -          | -               | 0.22 [ -0.09, 0.53]       |
| Cleo et al. (2019) [TTT]   | Bespoke questionnaire |                 | 0.96 [ 0.13, 1.78]        |
| Petrella et al. (2017)   | EQ5D3L                |                 | 0.58 [ 0.13, 1.02]        |
| Heterogeneity: $\tau^2 = 0.05$ , $I^2 = 45.13\%$ , $H^2 = 1.82$  | 2                     | <b></b>         | 0.46 [ 0.10, 0.83]        |
| Test of $\theta_i = \theta_j$ : Q(2) = 3.66, p = 0.16            |                       |                 |                           |
|  |                       |                 |                           |
| 50-59  |                       |                 |                           |
| Cleo et al. (2019) [DSD]   | Bespoke questionnaire | <b>_</b>        | 0.90 [ 0.11, 1.69]        |
| Damschroder et al. (2014) [ASPIRE-Group]                         | EQ5D-index            | _               | -0.12 [ -0.40, 0.15]      |
| Damschroder et al. (2014) [ASPIRE-Phone]                         | EQ5D-index -          | F               | 0.00 [ -0.27, 0.27]       |
| Rubin et al. (2013) [In-person support]                          | EQ5D-VAS —            | <b> </b>        | -0.05 [ -0.39, 0.29]      |
| Rubin et al. (2013) [Remote support only]                        | EQ5D-VAS —            | -               | 0.10 [ -0.25, 0.45]       |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$   |                       |                 | 0.00 [ -0.14, 0.15]       |
| Test of $\theta_i = \theta_j$ : Q(4) = 6.26, p = 0.18            |                       |                 |                           |
|  |                       | •               |                           |
| Overall  |                       | •               | 0.19 [ -0.03, 0.40]       |
| Heterogeneity: $\tau^2 = 0.05$ , $I^2 = 60.21\%$ , $H^2 = 2.5\%$ |                       |                 |                           |
| Test of $\theta_i = \theta_j$ : Q(7) = 17.07, p = 0.02           | Favours intervention  | Favours control |                           |
| Test of group differences: $Q_b(1) = 5.17$ , p = 0.02            | 2                     |                 |                           |
|  | -1 0                  | 1 2             | 2                         |

Figure A77. Changes in global quality of life (change from baseline), stratified by mean ages of interventions participants (years), comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis.

There was evidence of an effect for global quality of life (change from baseline) in favour of the intervention when participants had a mean age between 40-49 years (SMD 0.46 (95% CI 0.10, 0.83; n=3;  $I^2$ =45.13%)). There is no evidence of a difference between intervention and comparator when participants had a mean age between 50-59 years (SMD 0.00 (95% CI -0.14, 0.15; n=5;  $I^2$ =0%)).

| Study A   | ssessment tool                  | Hedges's g<br>with 95% CI |
|---|---------------------------------|---------------------------|
| Group (n=3)   |                                 |                           |
| Cramer et al. (2016)  | SF-36                           | 0.86 [ 0.31, 1.41]        |
| Domene et al. (2016)  | SF-36                           | 0.83 [ -0.05, 1.70]       |
| Gray et al. (2013)  | SF-12                           | 0.64 [ 0.35, 0.93]        |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$  |                                 | 0.70 [ 0.45, 0.94]        |
| Test of $\theta_i = \theta_j$ : Q(2) = 0.55, p = 0.76           |                                 |                           |
| Group and individual (n=4)                                      |                                 |                           |
| Imayama et al. (2011) [Dietary+Exercise]                        | SF-36                           | 0.38 [ -0.02, 0.79]       |
| Imayama et al. (2011) [Dietary]                                 | SF-36                           | 0.22 [ -0.19, 0.62]       |
| Imayama et al. (2011) [Exercise]                                | SF-36                           | 0.32 [ -0.09, 0.72]       |
| Sellman et al. (2017)   | WHOQOL                          | 0.26 [ -0.17, 0.69]       |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$  | -                               | 0.29 [ 0.09, 0.50]        |
| Test of $\theta_i = \theta_j$ : Q(3) = 0.36, p = 0.95           |                                 |                           |
| Individual (n=3)  |                                 |                           |
| Morgan et al. (2011) & (2012)                                   | SF-12                           | - 0.72 [ 0.33, 1.10]      |
| Morgan et al. (2013) [SHED-IT-Online]                           | SF-12                           | 0.15 [ -0.31, 0.62]       |
| Morgan et al. (2013) [SHED-IT-Resources]                        | SF-12                           | 0.44 [ -0.03, 0.91]       |
| Heterogeneity: $\tau^2 = 0.03$ , $I^2 = 40.62\%$ , $H^2 = 1.68$ |                                 | 0.46 [ 0.13, 0.79]        |
| Test of $\theta_i = \theta_j$ : Q(2) = 3.33, p = 0.19           |                                 |                           |
| Overall   | •                               | 0.46 [ 0.31, 0.61]        |
| Heterogeneity: $\tau^2 = 0.01$ , $I^2 = 15.02\%$ , $H^2 = 1.18$ |                                 |                           |
| Test of $\theta_i = \theta_j$ : Q(9) = 10.36, p = 0.32          | Favours control Favours interve | ention                    |
| Test of group differences: $Q_b(2)$ = 6.13, p = 0.05            |                                 |                           |
|   | 5 0 .5 1                        | 1.5                       |

### Quality of life – mental health (post-intervention)

Figure A78. Changes in mental health-related quality of life (post-intervention), stratified by delivery format, comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis.

There was evidence of an effect for mental health-related quality of life (post-intervention) in favour of the interventions when delivered exclusively to groups (SMD 0.70 (95% CI 0.45, 0.94; n=3;  $I^2$ =0%)), exclusively to individuals (SMD 0.46 (95% CI 0.13, 0.79; n=3;  $I^2$ =40.62%), and to both groups and individuals (SMD 0.29 (95% CI 0.09, 0.50; n=4;  $I^2$ =0%)).

|   |                                      | Hedges's g            |
|---|--------------------------------------|-----------------------|
| Study A   | Assessment tool                      | with 95% CI           |
| Face-to-face (n=3)  |                                      |                       |
| Cramer et al. (2016)  | SF-36                                | 0.86 [ 0.31, 1.41]    |
| Domene et al. (2016)  | SF-36                                | - 0.83 [ -0.05, 1.70] |
| Gray et al. (2013)  | SF-12                                | 0.64 [ 0.35, 0.93]    |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$  |                                      | 0.70 [ 0.45, 0.94]    |
| Test of $\theta_i = \theta_j$ : Q(2) = 0.55, p = 0.76           |                                      |                       |
| Mixed modes (n=6)   |                                      |                       |
| Imayama et al. (2011) [Dietary+Exercise]                        | SF-36                                | 0.38 [ -0.02, 0.79]   |
| Imayama et al. (2011) [Dietary]                                 | SF-36                                | 0.22 [ -0.19, 0.62]   |
| Imayama et al. (2011) [Exercise]                                | SF-36                                | 0.32 [ -0.09, 0.72]   |
| Morgan et al. (2011) & (2012)                                   | SF-12                                | 0.72 [ 0.33, 1.10]    |
| Morgan et al. (2013) [SHED-IT-Online]                           | SF-12                                | 0.15 [ -0.31, 0.62]   |
| Sellman et al. (2017)   | WHOQOL                               | 0.26 [ -0.17, 0.69]   |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.88\%$ , $H^2 = 1.01$  | •                                    | 0.36 [ 0.19, 0.53]    |
| Test of $\theta_i = \theta_j$ : Q(5) = 4.71, p = 0.45           |                                      |                       |
| Resources (n=1)   |                                      |                       |
| Morgan et al. (2013) [SHED-IT-Resources]                        | SF-12                                | 0.44 [ -0.03, 0.91]   |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = .\%$ , $H^2 = .$        |                                      | 0.44 [ -0.03, 0.91]   |
| Test of $\theta_i = \theta_j$ : Q(0) = 0.00, p = .              |                                      |                       |
| Overall   | •                                    | 0.46 [ 0.31, 0.61]    |
| Heterogeneity: $\tau^2 = 0.01$ , $I^2 = 15.02\%$ , $H^2 = 1.18$ |                                      |                       |
| Test of $\theta_i = \theta_j$ : Q(9) = 10.36, p = 0.32          | Favours control Favours intervention |                       |
| Test of group differences: $Q_b(2) = 5.10$ , $p = 0.08$         |                                      | _                     |
|   | 5 0 .5 1 1.5                         |                       |

Figure A79. Changes in mental health-related quality of life (post-intervention), stratified by delivery mode, comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis.

There was evidence of an effect for mental health-related quality of life (post-intervention) in favour of the interventions when delivered face-to-face (SMD 0.70 (95% CI 0.45, 0.94; n=3;  $I^2=0\%$ )) or via a mixture of delivery modes (SMD 0.36 (95% CI 0.19, 0.53; n=6;  $I^2=0.88\%$ ). Only one study reported mental health-related quality of life delivering an intervention that exclusively provided resources, and therefore this subgroup could not be analysed through stratification.

| Study A   | ssessment tool  |                      | Hedges's g<br>with 95% Cl |
|---|-----------------|----------------------|---------------------------|
| Education and physical activity (n=4)                           |                 |                      |                           |
| Grav et al. (2013)  | SF-12           |                      | 0.64 [ 0.35, 0.93]        |
| Imayama et al. (2011) [Dietary+Exercise]                        | SF-36           |                      | 0.38 [ -0.02. 0.79]       |
| Morgan et al. (2013) [SHED-IT-Online]                           | SF-12           |                      | 0.15 [ -0.31, 0.62]       |
| Morgan et al. (2013) [SHED-IT-Resources]                        | SF-12           |                      | 0.44 [ -0.03, 0.91]       |
| Heterogeneity: $\tau^2 = 0.01$ , $I^2 = 19.88\%$ , $H^2 = 1.25$ |                 | •                    | 0.45 [ 0.23, 0.67]        |
| Test of $\theta_i = \theta_j$ : Q(3) = 3.36, p = 0.34           |                 |                      |                           |
| Education-based (n=3)   |                 |                      |                           |
| Imayama et al. (2011) [Dietary]                                 | SF-36 —         |                      | 0.22 [ -0.19, 0.62]       |
| Morgan et al. (2011) & (2012)                                   | SF-12           |                      | 0.72 [ 0.33, 1.10]        |
| Sellman et al. (2017)   | WHOQOL -        |                      | 0.26 [ -0.17, 0.69]       |
| Heterogeneity: $\tau^2 = 0.04$ , $I^2 = 46.22\%$ , $H^2 = 1.86$ |                 |                      | 0.41 [ 0.08, 0.73]        |
| Test of $\theta_i = \theta_j$ : Q(2) = 3.70, p = 0.16           |                 |                      |                           |
| Physical activity (n=3)   |                 |                      |                           |
| Cramer et al. (2016)  | SF-36           |                      | 0.86 [ 0.31, 1.41]        |
| Domene et al. (2016)  | SF-36 -         |                      | 0.83 [ -0.05, 1.70]       |
| Imayama et al. (2011) [Exercise]                                | SF-36 -         |                      | 0.32 [ -0.09, 0.72]       |
| Heterogeneity: $\tau^2 = 0.05$ , $I^2 = 36.53\%$ , $H^2 = 1.58$ |                 |                      | 0.59 [ 0.18, 1.01]        |
| Test of $\theta_i = \theta_j$ : Q(2) = 2.85, p = 0.24           |                 |                      |                           |
| Overall   |                 | •                    | 0.46 [ 0.31, 0.61]        |
| Heterogeneity: $\tau^2 = 0.01$ , $I^2 = 15.02\%$ , $H^2 = 1.18$ |                 |                      |                           |
| Test of $\theta_i = \theta_j$ : Q(9) = 10.36, p = 0.32          | Favours control | Favours intervention |                           |
| Test of group differences: $Q_b(2) = 0.51$ , p = 0.78           | 5 (             | D.5 1 1.5            | -                         |

Figure A80. Changes in mental health-related quality of life (post-intervention), stratified by intervention type, comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis.

There is evidence of an effect for mental health-related quality of life (post-intervention) in favour of the intervention when exclusively providing physical activity (SMD 0.59 (95% CI 0.18, 1.01; n=3;  $I^2$ =36.53%)), exclusively providing an education-based intervention (SMD 0.41 (95% CI 0.08, 0.73; n=3;  $I^2$ =46.22%)), and when providing a mix of education and physical activity (SMD 0.45 (95% CI 0.23, 0.67; n=4;  $I^2$ =19.88%)).

| Chudu A   | an and the l         |                 | Hedges's g            |
|---|----------------------|-----------------|-----------------------|
| Study A   | ssessment tool       |                 | with 95% CI           |
| 0   |                      |                 |                       |
| Gray et al. (2013)  | SF-12                |                 | 0.64 [ 0.35, 0.93]    |
| Morgan et al. (2011) & (2012)                                   | SF-12                |                 | 0.72 [ 0.33, 1.10]    |
| Morgan et al. (2013) [SHED-IT-Online]                           | SF-12                |                 | 0.15 [ -0.31, 0.62]   |
| Morgan et al. (2013) [SHED-IT-Resources]                        | SF-12                |                 | 0.44 [ -0.03, 0.91]   |
| Heterogeneity: $\tau^2 = 0.01$ , $I^2 = 21.67\%$ , $H^2 = 1.28$ |                      | -               | 0.53 [ 0.31, 0.75]    |
| Test of $\theta_i = \theta_j$ : Q(3) = 4.09, p = 0.25           |                      |                 |                       |
| 80-89   |                      |                 |                       |
| Sellman et al. (2017)   | WHOQOL —             |                 | 0.26 [ -0.17, 0.69]   |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = .\%$ , $H^2 = .$        | -                    |                 | 0.26 [ -0.17, 0.69]   |
| Test of $\theta_i = \theta_j$ : Q(0) = 0.00, p = .              |                      |                 |                       |
| 90-100  |                      |                 |                       |
| Cramer et al. (2016)  | SF-36                |                 | 0.86 [ 0.31, 1.41]    |
| Domene et al. (2016)  | SF-36 -              |                 | - 0.83 [ -0.05, 1.70] |
| Imayama et al. (2011) [Dietary+Exercise]                        | SF-36                |                 | 0.38 [ -0.02, 0.79]   |
| Imayama et al. (2011) [Dietary]                                 | SF-36 —              |                 | 0.22 [ -0.19, 0.62]   |
| Imayama et al. (2011) [Exercise]                                | SF-36 -              |                 | 0.32 [ -0.09, 0.72]   |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$  |                      | •               | 0.41 [ 0.20, 0.62]    |
| Test of $\theta_i = \theta_j$ : Q(4) = 4.48, p = 0.34           |                      |                 |                       |
| Overall   |                      | •               | 0.46 [ 0.31. 0.61]    |
| Heterogeneity: $\tau^2 = 0.01$ . $I^2 = 15.02\%$ . $H^2 = 1.18$ |                      | -               |                       |
| Test of $\theta_i = \theta_j$ : Q(9) = 10.36, p = 0.32          | Favours intervention | Favours control |                       |
| Test of group differences: $Q_b(2) = 1.40$ , p = 0.50           |                      |                 |                       |
|   | 5 (                  | 0 .5 1 1.5      | _                     |

Figure A81. Changes in mental health-related quality of life (post-intervention), stratified by percentage of interventions participants that were women (%), comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis.

There was evidence of an effect for mental health-related quality of life (post-intervention) in favour of the intervention when 0% of participants were women (SMD 0.53 (95% CI 0.31, 0.75; n=4;  $I^2$ =21.67%)), or 90-100% of participants were women (SMD 0.41 (95% CI 0.20, 0.62; n=5;  $I^2$ =0%)).

|   |                      |                 | Hedges's g          |
|---|----------------------|-----------------|---------------------|
| Study   | Assessment tool      |                 | with 95% CI         |
| 30-39   |                      |                 |                     |
| Domene et al. (2016)  | SF-36                | •               | 0.83 [ -0.05, 1.70] |
| Imayama et al. (2011) [Dietary+Exercise]                        | SF-36                |                 | 0.38 [ -0.02, 0.79] |
| Imayama et al. (2011) [Exercise]                                | SF-36 -              |                 | 0.32 [ -0.09, 0.72] |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$  |                      |                 | 0.40 [ 0.12, 0.67]  |
| Test of $\theta_i = \theta_j$ : Q(2) = 1.08, p = 0.58           |                      |                 |                     |
| 40-49   |                      |                 |                     |
| Cramer et al. (2016)  | SF-36                | <b>_</b>        | 0.86 [ 0.31, 1.41]  |
| Gray et al. (2013)  | SF-12                |                 | 0.64 [ 0.35, 0.93]  |
| Morgan et al. (2011) & (2012)                                   | SF-12                | <b></b>         | 0.72 [ 0.33, 1.10]  |
| Morgan et al. (2013) [SHED-IT-Online]                           | SF-12                |                 | 0.15 [ -0.31, 0.62] |
| Morgan et al. (2013) [SHED-IT-Resources]                        | SF-12                |                 | 0.44 [ -0.03, 0.91] |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 9.79\%$ , $H^2 = 1.11$  |                      | •               | 0.58 [ 0.38, 0.77]  |
| Test of $\theta_i = \theta_j$ : Q(4) = 5.18, p = 0.27           |                      |                 |                     |
| 50-59   |                      |                 |                     |
| lmayama et al. (2011) [Dietary]                                 | SF-36 —              |                 | 0.22 [ -0.19, 0.62] |
| Sellman et al. (2017)   | WHOQOL -             |                 | 0.26 [ -0.17, 0.69] |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$  |                      |                 | 0.24 [ -0.06, 0.53] |
| Test of $\theta_i = \theta_j$ : Q(1) = 0.02, p = 0.89           |                      |                 |                     |
| Overall   |                      | •               | 0.46 [ 0.31, 0.61]  |
| Heterogeneity: $\tau^2 = 0.01$ , $I^2 = 15.02\%$ , $H^2 = 1.18$ | i                    |                 |                     |
| Test of $\theta_i = \theta_j$ : Q(9) = 10.36, p = 0.32          | Favours intervention | Favours control |                     |
| Test of group differences: $Q_b(2) = 3.79$ , p = 0.15           | i                    |                 | -                   |
|   | 5                    | 0.5 1 1.5       |                     |

Figure A82. Changes in mental health-related quality of life (post-intervention), stratified by mean age of intervention participants (years), comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis.

There was evidence of an effect for mental health-related quality of life (post-intervention) in favour of the intervention when participants had a mean age between 30-39 years (SMD 0.40 (95% CI 0.12, 0.67; n=3; l<sup>2</sup>=0%) or 40-49 years (SMD 0.58 (95% CI 0.38, 0.77; n=5; l<sup>2</sup>=9.79%)). There is some evidence of an effect for mental health-related quality of life (post-intervention) in favour of the intervention when participants had a mean age between 50-59 years (SMD 0.24 (95% CI -0.06, 0.53; n=2; l<sup>2</sup>=0%)).

|  |                                      | Hedges's g          |
|--|--------------------------------------|---------------------|
| Study A  | ssessment tool                       | with 95% CI         |
| 25-29.9 (Overweight)   |                                      |                     |
| Domene et al. (2016)   | SF-36                                |                     |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = .\%$ , $H^2 = .$                       |                                      | 0.83 [ -0.05, 1.70] |
| Test of $\theta_i = \theta_j$ : Q(0) = 0.00, p = .                             |                                      |                     |
| 30-34.9 (Obesity I)  |                                      |                     |
| Cramer et al. (2016)   | SF-36                                | 0.86 [ 0.31, 1.41]  |
| Gray et al. (2013)   | SF-12                                | 0.64 [ 0.35, 0.93]  |
| Imayama et al. (2011) [Dietary]  | SF-36                                | 0.22 [ -0.19, 0.62] |
| Morgan et al. (2011) & (2012)  | SF-12                                | 0.72 [ 0.33, 1.10]  |
| Morgan et al. (2013) [SHED-IT-Online]  | SF-12                                | 0.15 [ -0.31, 0.62] |
| Morgan et al. (2013) [SHED-IT-Resources]                                       | SF-12                                | 0.44 [ -0.03, 0.91] |
| Sellman et al. (2017)  | WHOQOL                               | 0.26 [ -0.17, 0.69] |
| Heterogeneity: $\tau^2$ = 0.02, I <sup>2</sup> = 31.94%, H <sup>2</sup> = 1.47 | •                                    | 0.48 [ 0.29, 0.67]  |
| Test of $\theta_i = \theta_j$ : Q(6) = 8.95, p = 0.18                          |                                      |                     |
| 40+ (Obesity III)  |                                      |                     |
| Imayama et al. (2011) [Dietary+Exercise]                                       | SF-36                                | 0.38 [ -0.02, 0.79] |
| Imayama et al. (2011) [Exercise]   | SF-36                                | 0.32 [ -0.09, 0.72] |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = 0.00\%$ , $H^2 = 1.00$                 |                                      | 0.35 [ 0.06, 0.64]  |
| Test of $\theta_i = \theta_j$ : Q(1) = 0.05, p = 0.82                          |                                      |                     |
| Overall  | •                                    | 0.46 [ 0.31, 0.61]  |
| Heterogeneity: $\tau^2 = 0.01$ , $I^2 = 15.02\%$ , $H^2 = 1.18$                |                                      |                     |
| Test of $\theta_i = \theta_j$ : Q(9) = 10.36, p = 0.32                         | Favours intervention Favours control |                     |
| Test of group differences: $Q_b(2)$ = 1.25, p = 0.54                           |                                      |                     |
|  | -5 0 5 1                             | 1.5                 |

Figure A83. Changes in mental health-related quality of life (post-intervention), stratified by mean BMI of intervention participants (kg/m<sup>2</sup>), comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis.

There was evidence of an effect for mental health-related quality of life (post-intervention) in favour of the intervention when participants had a mean BMI between 30-39 kg/m<sup>2</sup> (SMD 0.48 (95% Cl 0.29, 0.67; n=7; l2=31.94%)) or 40+ kg/m<sup>2</sup> (SMD 0.35 (95% Cl 0.06, 0.64; n=2; l<sup>2</sup>=0%)).

Hednes's a

| Study  | Assessment tool         |                      | with 95% Cl          |
|--|-------------------------|----------------------|----------------------|
| Intervention (UC) (n=4)  |                         |                      |                      |
| Damschroder et al. (2014) [ASPIRE-Group]                         | Bespoke questionnaire   |                      | 0.23 [ -0.09, 0.55]  |
| Damschroder et al. (2014) [ASPIRE-Phone]                         | Bespoke questionnaire   |                      | 0.38 [ 0.06, 0.70]   |
| Herring et al. (2014) [Aerobic Exercise]                         | SERPA                   |                      | 1.62 [ 0.38, 2.86]   |
| Herring et al. (2014) [Resistance Exercise]                      | SERPA                   |                      | - 1.79 [ 0.52, 3.06] |
| Heterogeneity: $\tau^2 = 0.40$ , $I^2 = 85.61\%$ , $H^2 = 6.95$  | 5                       |                      | 0.79 [ 0.06, 1.52]   |
| Test of $\theta_i = \theta_j$ : Q(3) = 9.38, p = 0.02            |                         |                      |                      |
|  |                         |                      |                      |
| Minimal or inactive (n=4)  |                         |                      |                      |
| Berry et al. (2011)  | ESES                    |                      | 0.63 [ 0.10, 1.16]   |
| Crane et al. (2016)  | Bespoke questionnaire — | <b>-</b>             | 0.04 [ -0.34, 0.41]  |
| Morgan et al. (2011) & (2012)                                    | Bespoke questionnaire   |                      | 0.42 [ 0.04, 0.80]   |
| Teixeira et al. (2010)   | SEEB                    |                      | 0.77 [ 0.50, 1.04]   |
| Heterogeneity: $\tau^2 = 0.08$ , $I^2 = 67.71\%$ , $H^2 = 3.10$  | )                       | •                    | 0.47 [ 0.14, 0.80]   |
| Test of $\theta_i = \theta_j$ : Q(3) = 9.96, p = 0.02            |                         |                      |                      |
|  |                         |                      |                      |
| Overall  |                         | •                    | 0.49 [ 0.25, 0.74]   |
| Heterogeneity: $\tau^2 = 0.06$ , $I^2 = 60.25\%$ , $H^2 = 2.5\%$ | 2                       |                      |                      |
| Test of $\theta_i = \theta_j$ : Q(7) = 20.02, p = 0.01           | Favours control         | Favours intervention |                      |
| Test of group differences: $Q_b(1) = 0.61$ , p = 0.4             | 3                       |                      |                      |
|  | (                       | 0 1 2                | т<br>3               |

### Self efficacy – exercise (post-intervention)

Figure A84. Changes in exercise self-efficacy (post-intervention), stratified by comparator group intensity, comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis.

There was evidence of an effect for exercise-related self-efficacy (post-intervention) in favour of the intervention when compared to an intervention-intensity usual care comparator group (SMD 0.79 (95% Cl 0.06, 1.52; n=4; l<sup>2</sup>=85.61%)) and minimal or inactivity intensity comparator group (SMD 0.47 (95% Cl 0.14, 0.80; n=4; l<sup>2</sup>=67.71%)).

| Study   | Assessment tool         |                      | Hedges's g<br>with 95% Cl |
|---|-------------------------|----------------------|---------------------------|
| Group (n=5)   |                         |                      |                           |
| Berry et al. (2011)   | ESES                    |                      | 0.63 [ 0.10, 1.16]        |
| Damschroder et al. (2014) [ASPIRE-Group]                        | Bespoke questionnaire   |                      | 0.23 [ -0.09, 0.55]       |
| Herring et al. (2014) [Aerobic Exercise]                        | SERPA                   |                      | — 1.62 [ 0.38, 2.86]      |
| Herring et al. (2014) [Resistance Exercise]                     | SERPA                   |                      | — 1.79 [ 0.52, 3.06]      |
| Teixeira et al. (2010)  | SEEB                    |                      | 0.77 [ 0.50, 1.04]        |
| Heterogeneity: $\tau^2 = 0.15$ , $I^2 = 71.72\%$ , $H^2 = 3.54$ | l.                      |                      | 0.75 [ 0.31, 1.19]        |
| Test of $\theta_i = \theta_j$ : Q(4) = 12.58, p = 0.01          |                         |                      |                           |
| Individual (n=3)  |                         |                      |                           |
| Crane et al. (2016)   | Bespoke questionnaire — | -                    | 0.04 [ -0.34, 0.41]       |
| Damschroder et al. (2014) [ASPIRE-Phone]                        | Bespoke questionnaire   |                      | 0.38 [ 0.06, 0.70]        |
| Morgan et al. (2011) & (2012)                                   | Bespoke questionnaire   |                      | 0.42 [ 0.04, 0.80]        |
| Heterogeneity: $\tau^2 = 0.01$ , $I^2 = 15.21\%$ , $H^2 = 1.18$ | 3                       | •                    | 0.29 [ 0.06, 0.51]        |
| Test of $\theta_i = \theta_j$ : Q(2) = 2.45, p = 0.29           |                         |                      |                           |
| Overall   |                         | •                    | 0.49 [ 0.25, 0.74]        |
| Heterogeneity: $\tau^2 = 0.06$ , $I^2 = 60.25\%$ , $H^2 = 2.52$ | 2                       |                      |                           |
| Test of $\theta_i = \theta_j$ : Q(7) = 20.02, p = 0.01          | Favours control         | Favours intervention |                           |
| Test of group differences: $Q_b(1) = 3.38$ , p = 0.0            | 7                       |                      |                           |
|   |                         | 0 1 2                | 3                         |
|   |                         |                      |                           |

Figure A85. Changes in exercise self-efficacy (post-intervention), stratified by delivery format, comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis.

There was evidence of an effect for exercise-related self-efficacy (post-intervention) in favour of the interventions when delivered exclusively to groups (SMD 0.75 (95% CI 0.31, 1.19; n=5;  $I^2$ =71.72%)), exclusively to individuals (SMD 0.29 (95% CI 0.06, 0.51; n=3;  $I^2$ =15.21%). No contributing studies provided the intervention to both groups and individuals.

|  |                         |                      | Hedges's g           |
|--|-------------------------|----------------------|----------------------|
| Study  | Assessment tool         |                      | with 95% CI          |
| 12 weeks (n=4)   |                         |                      |                      |
| Berry et al. (2011)  | ESES                    |                      | 0.63 [ 0.10, 1.16]   |
| Herring et al. (2014) [Aerobic Exercise]                         | SERPA                   |                      | — 1.62 [ 0.38, 2.86] |
| Herring et al. (2014) [Resistance Exercise]                      | SERPA                   |                      | — 1.79 [ 0.52, 3.06] |
| Morgan et al. (2011) & (2012)                                    | Bespoke questionnaire   |                      | 0.42 [ 0.04, 0.80]   |
| Heterogeneity: $\tau^2 = 0.21$ , $I^2 = 64.15\%$ , $H^2 = 2.7$   | 9                       |                      | 0.87 [ 0.27, 1.47]   |
| Test of $\theta_i = \theta_j$ : Q(3) = 6.84, p = 0.08            |                         |                      |                      |
|  |                         |                      |                      |
| 26 weeks (n=1)   |                         |                      |                      |
| Crane et al. (2016)  | Bespoke questionnaire — | <b>—</b>             | 0.04 [ -0.34, 0.41]  |
| Heterogeneity: $\tau^2 = 0.00$ , $I^2 = .\%$ , $H^2 = .$         |                         |                      | 0.04 [ -0.34, 0.41]  |
| Test of $\theta_i = \theta_j$ : Q(0) = 0.00, p = .               |                         |                      |                      |
| 52 weeks (n=3)   |                         |                      |                      |
| Demochroder et al. (2014) [ASDIDE Croup]                         | Poopoko guastiannaira   |                      | 0.00 0.000 0.000     |
| Damschilder et al. (2014) [ASPIRE-Gloup]                         | Bespoke questionnaire   |                      | 0.23 [ -0.09, 0.55]  |
| Damschröder et al. (2014) [ASPIRE-Phone]                         | Bespoke questionnaire   |                      | 0.38 [ 0.06, 0.70]   |
| Teixeira et al. (2010)   | SEEB                    |                      | 0.77 [ 0.50, 1.04]   |
| Heterogeneity: $f = 0.06$ , $I = 70.53\%$ , $H = 3.3$            | 9                       |                      | 0.47 [ 0.15, 0.79]   |
| lest of $\theta_i = \theta_j$ : Q(2) = 7.03, p = 0.03            |                         |                      |                      |
| Overall  |                         | •                    | 0.49 [ 0.25, 0.74]   |
| Heterogeneity: $\tau^2 = 0.06$ . $I^2 = 60.25\%$ . $H^2 = 2.5\%$ | 2                       |                      |                      |
| Test of $\theta_i = \theta_i$ : Q(7) = 20.02, p = 0.01           | -<br>Favours control    | Favours intervention |                      |
| Test of group differences: $O_{1}(2) = 6.05$ , $p = 0.02$        | 15                      |                      |                      |
| $a_{b}(z) = 0.05, p = 0.0$                                       |                         |                      |                      |
|  |                         | 0 1 2                | 3                    |

Figure A86. Changes in exercise self-efficacy (post-intervention), stratified by intervention duration, comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis.

There was evidence of a desired effect for exercise-related self-efficacy (post-intervention) when the intervention was 12-weeks (SMD 0.87 (95% Cl 0.27, 1.47; n=4; l<sup>2</sup>=64.15%)) or 52-weeks (SMD 0.47 (95% Cl 0.15, 0.79; n=3; l<sup>2</sup>=70.53%)) in duration. Only one study reporting exercise-related self-efficacy delivered an intervention for 26-weeks in duration, and therefore this subgroup could not be analysed through stratification.

# A4. Appendices for Chapter Four

# A4.1 Statistical Analysis Plan – July 2020

The impact of participant mental health on attendance and engagement with a trial of behavioural weight management programmes: Secondary analysis of the WRAP trial.

| Name          | Role   |
|---------------|--|
| Rebecca Jones | PhD student / Lead author  |
| Amy Ahern     | PhD supervisor / Senior author   |
| Julia Mueller | Advise on protocol and project development   |
| Stephen Sharp | Review and inform statistical components   |
| Simon Griffin | Review and critically appraise manuscript  |
| Ann Vincent   | Provide PPI input to study aims, data interpretation, and critically appraise manuscript |

# Author responsibilities

# 1 Introduction

# 1.1 Aims/objectives

I have identified limited research assessing the predictive nature of participant mental health on intervention/trial attendance and engagement, and inconsistencies in the findings of the research available. Therefore, I aim to investigate how participant mental health influences intervention attendance and engagement, and attendance at trial follow-up visits.

# Objectives:

Identify whether baseline mental health is associated with WW session attendance.

Identify whether baseline mental health is associated with engagement with WW e-tools, online resources, and the WW mobile phone app.

Identify whether baseline mental health is associated with attendance at study follow-up visits.

### 2 Methods

#### 2.1 Study design

This study is a secondary data analysis of the Weight loss Referrals for Adults in Primary care (WRAP) trial, a non-blinded, multi-arm, randomised controlled trial comparing three intervention arms: (1) Brief intervention, (2) 12-weeks commercial weight loss programme, (3) 52-weeks commercial weight loss programme. Participants who met eligibility criteria and gave informed consent were randomly assigned to an intervention arm on a 2:5:5 ratio. More detailed trial methods are reported elsewhere.<sup>199</sup>

Ethical approval was received from NRES Committee East of England Cambridge East and local approvals from NRES Committee North West Liverpool Central and NRES Committee South Central Oxford. This trial was registered with Current Controlled Trials (ISRCTN82857232).

# 2.2 Participants

Adults with a body mass index of 28 kg/m<sup>2</sup> or greater, residing in the United Kingdom, were eligible for participation in the trial. Further details of inclusion and exclusion criteria can be found elsewhere.<sup>199</sup> All participants gave written informed consent.

#### 2.3 Intervention

Participants randomly assigned to the 12- or 52 week-commercial weight loss programme were provided with vouchers to attend a weekly local Weight Watchers meeting for the duration of the intervention they were assigned to (12-weeks or 52-weeks). Participants were provided with a unique code to access digital tools for the duration of their assigned intervention.

Participants assigned to the brief intervention control group were given a 32-page printed booklet by the British Heart Foundation of self-help weight-management strategies.<sup>61</sup> Research staff read a scripted booklet introduction to the participant.

# 3 Analysis methods

# 3.1 Outcome definitions

Study participants were examined at baseline, 3-, 12-, 24- and 60-months.

# 3.1.1 Primary outcomes

Attendance at WW sessions in the first 3-months of intervention [Continuous ordered]

# 3.1.2 Secondary outcomes

Weekly frequency of use of WW e-tools or online resources (reported at 3-months) [Categorical ordered]

- Daily/almost daily
- 3-5 times per week
- 1-2 times per week
- Never/almost never

Weekly frequency of use of the WW mobile phone app (reported at 3-months) [Categorical ordered]

- Daily/almost daily
- 3-5 times per week
- 1-2 times per week
- Never/almost never

# Attendance at study visits [Categorical]

- Did attend
- Did not attend

# 3.1.3 Exposure outcomes

- Depression Measured by Hospital Anxiety and Depression Scale (HADS) [Continuous]
- Anxiety Measured by Hospital Anxiety and Depression Scale (HADS) [Continuous]
- Quality of life EQ5D [Continuous]
- Satisfaction with life [Continuous]

#### 3.1.4 Control variables

- Study arm
- GP practice (robust standard errors calculated to allow for clustering)

### 3.2 Analysis methods

Stata v16 will be used for all statistical analyses. Exposure outcomes at baseline will be assessed for predictive effect of intervention attendance and engagement over the first 3-months of an intervention. Variables found to be significantly associated (p<0.05) with change in dependent variables in univariable models will be included in mutually adjusted models.

Negative binomial regression will be conducted to assess the predictive effect on intervention attendance, controlling for intervention arm and using robust standard errors to allow for clustering by GP practice.

Ordered logistic regression will be conducted to assess the predictive effect on intervention engagement, controlling for intervention arm and using robust standard errors to allow for clustering by GP practice.

Logistic regression was conducted to assess the association between baseline participant mental health and attendance at study follow-up visits (at 3-, 12-, 24-, and 60-months), controlling for study arm and using robust standard errors to allow for clustering by GP practice.

### 3.2.1 Assumption testing

The association between exposure and outcome variables must be linear, and residuals must be normally distributed with constant variance. If the assumptions for linear regression or mutually adjusted regression are not met, the data will be transformed in preparation for data analysis. *Univariable linear regression*: Linearity will be assessed by visually inspected a scatterplot of the exposure variable against the outcome variable. Normal distribution will be assessed by histogram (with superimposed normal curve) or a Normal P-P Plot. Homoscedasticity will be assessed by plotting the regression standardised residuals against the regression standardised predicted value.

*Mutually adjusted regression*: Linearity will be assessed by scatterplots and partial regression plots. Normal distribution will be assessed by histogram (with superimposed normal curve) and a Normal P-P Plot, or a Normal Q-Q Plot of the studentised residuals. Homoscedasticity will be assessed by plotting the studentised residuals against the unstandardised predicted values.

# 3.2.2 Dealing with missing data

Participants with missing values of key outcomes will be excluded by complete-case analysis (which assumes outcome data are missing at random conditional on covariates in the model).

A sensitivity analysis will be performed using multiple imputation by chained equations, which also assumes outcome data are missing at random but provides increased precision compared with a complete-case analysis. For sensitivity analyses, variables with  $\geq$  5% missing data will have data imputed by multiple imputation by chained equations (MICE). Variables with  $\geq$  25% missing data will be excluded from analyses. Data will be re-analysed with the imputed data and compared to the complete-case analysis to assess the robustness of the findings, and whether missing data influenced the results.

# 3.2.3 Interpretation and presentation of results

|           | Total<br>(n= ) | 12-week WW<br>(n=) | 52-week WW<br>(n= ) | Brief<br>intervention<br>(n= ) |
|-----------|----------------|--------------------|---------------------|--------------------------------|
| Age       |                |                    |                     |                                |
| Sex       |                |                    |                     |                                |
| Education |                |                    |                     |                                |
| etc       |                |                    |                     |                                |

Descriptive characteristics will be presented by study arm:

Results of the final regression models will be reported in table format with the following data:

|                            | Attendance at WW | sessions     |    |
|----------------------------|------------------|--------------|----|
| Mental health at baseline: | Incidence rate   | Number       | of |
|                            | ratio (95% CI)   | participants |    |
|                            |                  |              |    |
|                            |                  |              |    |
|                            |                  |              |    |

|                            | Engagement with WW online tools |              |
|----------------------------|---------------------------------|--------------|
| Mental health at baseline: | Odds Ratio (95%                 | Number of    |
|                            | CI)                             | participants |
|                            |                                 |              |
|                            |                                 |              |
|                            |                                 |              |

|                            | Engagement with WW app |              |
|----------------------------|------------------------|--------------|
| Mental health at baseline: | Odds Ratio (95%        | Number of    |
|                            | CI)                    | participants |
|                            |                        |              |
|                            |                        |              |
|                            |                        |              |

|                            | Attendance at study follow-up visits |              |
|----------------------------|--------------------------------------|--------------|
| Mental health at baseline: | Odds Ratio (95%                      | Number of    |
|                            | CI)                                  | participants |
|                            |                                      |              |
|                            |                                      |              |
|                            |                                      |              |

# A4.2 Correlation matrix of mental health-related exposure variables.

Table A1. Correlation matrix of mental health-related exposure variables.

|  | Global quality of | Satisfaction with | Anxiety |
|--|-------------------|-------------------|---------|
|  | life              | life              |         |
| Satisfaction with life   | 0.27              | /                 | /       |
| Anxiety  | -0.34             | -0.42             | /       |
| Depression   | -0.43             | -0.50             | 0.63    |
| Note: Statistics presented are Pearson correlation coefficients. |                   |                   |         |

# A5. Appendices for Chapter Five

# A5.1 Statistical Analysis Plan – July 2020

Long-term impact of a commercial adult weight management programme on depression and anxiety: 5-year follow up of the WRAP trial.

### Author responsibilities

| Name          | Role                                       |
|---------------|--|
| Rebecca Jones | PhD student / Lead author                  |
| Amy Ahern     | PhD supervisor / Senior author             |
| Julia Mueller | Advise on protocol and project development |
| Stephen Sharp | Review and inform statistical components   |
| Simon Griffin | Review and critically appraise manuscript  |

# 1 Introduction

# 1.1 Aims and objectives

There is a distinct lack of evidence reporting the long-term impact of behavioural weight management programmes on mental health. This study aims to evaluate the impact of attending a commercial weight management programme on mental health-related outcomes at 5-years after completion.

Aim: Identify how referral to a commercial weight management programme impacts mental health-related outcomes at 5-years from baseline.

# Primary objectives:

Identify whether referral to a 52-week or 12-week weight management programme results in greater improvements in mental health-related outcomes than brief intervention at 5-years from baseline.

Identify whether referral to a 52-week weight management programme results in greater improvements in mental health-related outcomes than referral to a 12-week weight management programme at 5-years from baseline.

# 2 Methods

# 2.1 Study design

This study is a secondary data analysis of the Weight loss Referrals for Adults in Primary care (WRAP) trial, a non-blinded, multi-arm, randomised controlled trial comparing three intervention arms: (1) Brief intervention, (2) 12-week commercial weight loss programme, (3) 52-week commercial weight loss programme. Participants who met eligibility criteria and gave informed consent were randomly assigned to an intervention arm on a 2:5:5 ratio. More detailed trial methods are reported elsewhere.<sup>199</sup>

Ethical approval was received from NRES Committee East of England Cambridge East and local approvals from NRES Committee North West Liverpool Central and NRES Committee South Central Oxford. This trial was registered with Current Controlled Trials (ISRCTN82857232).

# 2.2 Participants

Adults with a body mass index of 28 kg/m<sup>2</sup> or greater, residing in the United Kingdom, were eligible for participation in the trial. Further details of inclusion and exclusion criteria can be found elsewhere.<sup>199</sup> All participants gave written informed consent.

# 2.3 Intervention

Participants randomly assigned to the 12- or 52 week-commercial weight loss programmes were provided with vouchers to attend a weekly local Weight Watchers meeting for the duration of the intervention they were assigned to (12-weeks or 52-weeks). Participants were provided with a unique code to access digital tools for the duration of their assigned intervention.

Participants assigned to the brief intervention control group were given a 32-page printed booklet by the British Heart Foundation of self-help weight-management strategies.<sup>61</sup> Research staff read a scripted booklet introduction to the participant.

### 2.4 Study outcomes

### 2.4.1 Timing of outcome assessments

Study participants were examined at baseline, 3-, 12-, 24- and 60-months.

# 2.4.2 Primary outcomes

- 5-year change in depression (Hospital Anxiety and Depression Scale [HADS]) from baseline. [Continuous]
- 5-year change in anxiety (HADS) from baseline. [Continuous]
- Minimal important difference (MID) as a change of ±2 points in HADS score.

### 2.4.3 Control variables

- Baseline depression and anxiety (Hospital Anxiety and Depression Scale [HADS]) [Continuous]
- Gender [Categorical male / female]
- Research centre [Categorical by research centre ID]
- Intervention arm [Categorical BI / CP12 / CP52]

### 3 Analysis methods

### 3.1 Analysis of study outcomes

Stata v16 will be used for all statistical analyses. The proportion of participants with 'increase' ( $\geq$  +2 units), 'decrease' ( $\leq$  -2 units), or 'no change' (>-2 and <2 units) in depression and anxiety

symptoms from baseline to 5-years will be presented by intervention arm (number of participants and percentage).

# 3.1.1 Analysis for primary objectives

The primary analysis will compare 5-year change in depression and anxiety between the three randomised groups, adjusting for baseline depression and anxiety, gender, and research centre using ANCOVA (analysis of covariance). For the primary objectives, analyses are adjusted for gender and research centre as trial randomisation was stratified by these variables. If there is an overall significant difference (p<0.05) between the three groups based on an F-test, then differences and 95% confidence intervals comparing 52-week programme vs. brief intervention, 52-week programme vs. 12-week programme, and 12-week programme vs. brief intervention group will be estimated using the Scheffé test. If there is no significant difference between the brief intervention and 12-week programme, a secondary analysis will compare 52-week programme and the other groups (12-week programme and brief intervention) combined.

If the assumptions for ANCOVA are not met, the data will be transformed in preparation for data analysis. Assumptions will be checked as follows: Shapiro-Wilk tests of normality (normal distribution), Levene's test for homogeneity of variances (homogeneity of variances), and scatterplot of the standardised residuals against the predicted values (homoscedasticity).

# 3.2 Dealing with missing data

Participants with missing values of key outcomes will be excluded by complete-case analysis (which assumes outcome data are missing at random conditional on covariates in the model). For the primary study objectives, a sensitivity analysis will be performed using multiple imputation by chained equations which also assumes outcome data are missing at random, but provides increased precision compared with a complete-case analysis. For sensitivity analyses, variables with  $\geq$  5% missing data will have data imputed by multiple imputation by chained equations (MICE). Variables with  $\geq$  25% missing data will be excluded from analyses. Data will be re-analysed with the imputed data and compared to the complete-case analysis to assess the robustness of the findings, and whether missing data influenced the results.
### 3.3 Presentation of results

Descriptive characteristics will be presented by study arm:

|     | Total (n= ) | 12-week WW (n= ) | 52-week WW (n= ) | Brief | intervention |
|-----|-------------|------------------|------------------|-------|--------------|
|     |             |                  |                  | (n= ) |              |
| Age |             |                  |                  |       |              |
| Sex |             |                  |                  |       |              |
| etc |             |                  |                  |       |              |

Primary objectives: Changes from baseline in mental health between baseline and 5 years:

|                        | Mean chan<br>from baseli<br>SD) | ge in men<br>ine to 60-r | tal health<br>nonths (± | Estimated differences between groups<br>(95% CI) |  |  |  |
|------------------------|---------------------------------|--------------------------|-------------------------|--|--|--|--|
|                        |                                 |                          |                         |  |  |  |  |
| Depression<br>symptoms |                                 |                          |                         |  |  |  |  |
| Anxiety<br>symptoms    |                                 |                          |                         |  |  |  |  |

Proportion of participants experiencing a decrease, no change, or increase in symptoms of depression or anxiety

| Change in symptoms of depression or anxiety |                              | Number of participants (%) |      |      |  |
|---|------------------------------|----------------------------|------|------|--|
| at 60-months from baseline                  |                              | BI                         | CP12 | CP52 |  |
| Depression                                  | Decrease (≤ -2 units)        |                            |      |      |  |
| symptoms                                    | No change (>-2 and <2 units) |                            |      |      |  |
|   | Increase (≥ +2 units)        |                            |      |      |  |
| Anxiety                                     | Decrease (≤ -2 units)        |                            |      |      |  |
| symptoms                                    | No change (>-2 and <2 units) |                            |      |      |  |
|   | Increase (≥ 2 units)         |                            |      |      |  |

A5.2 Histograms of change in anxiety and depression from baseline to 3-, 12-, 24-, and 60-months.

Figures S1-8. Histograms of change in anxiety and depression from baseline to 3-, 12-, 24-, and 60-months.







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# A6. Appendices for Chapter Six

#### A6.1 Statistical Analysis Plan – July 2020

Participant characteristics associated with changes in mental health in a trial of behavioural weight management programmes: Secondary analysis of the WRAP trial.

| Author | responsibilities |
|--------|------------------|
|--------|------------------|

| Name          | Role                                       |
|---------------|--|
| Rebecca Jones | PhD student / Lead author                  |
| Amy Ahern     | PhD supervisor / Senior author             |
| Julia Mueller | Advise on protocol and project development |
| Stephen Sharp | Review and inform statistical components   |
| Simon Griffin | Review and critically appraise manuscript  |

#### AMENDMENT TO SAP (NOV 2021):

I initially planned to conduct analyses to investigate the potential moderation effects of attendance to inform the development of programme engagement strategies. However, on reflection, I recognised that rate of attendance did not satisfy the usual definition of a moderator as it may be predicted by the exposure variables, and it was measured during follow-up (as the usual definition of a moderator variable which requires this variable to be measured either before or at the same time as the exposure variable of interest). As such, the moderation analyses were removed the study.

### 1 Introduction

#### 1.1 Aims and objectives

I aim to assess how baseline and early changes in participant characteristics are associated with changes in mental health during and after a behavioural weight management intervention. I also aim to assess whether programme attendance moderate the relationship between participant characteristics and changes in mental health.

## Objectives:

- Identify whether baseline individual characteristics predict change in mental health during and after a commercial weight management intervention.
- Identify whether early changes in individual characteristics are associated with early changes in mental health.
- Identify whether early changes in individual characteristics predict change in mental health during and after a commercial weight management intervention.
- Identify whether intervention attendance moderates the relationship between exposure outcomes and mental health outcomes.

## 2 Methods

# 2.1 Study design

This study is a secondary data analysis of the Weight loss Referrals for Adults in Primary care (WRAP) trial, a non-blinded, multi-arm, randomised controlled trial comparing three intervention arms: (1) Brief intervention, (2) 12-weeks commercial weight loss programme, (3) 52-weeks commercial weight loss programme. Participants who met eligibility criteria and gave informed consent were randomly assigned to an intervention arm on a 2:5:5 ratio. More detailed trial methods are reported elsewhere.<sup>199</sup>

Ethical approval was received from NRES Committee East of England Cambridge East and local approvals from NRES Committee North West Liverpool Central and NRES Committee South Central Oxford. This trial was registered with Current Controlled Trials (ISRCTN82857232).

# 2.2 Participants

Adults with a body mass index of 28 kg/m<sup>2</sup> or greater, residing in the United Kingdom, were eligible for participation in the trial. Further details of inclusion and exclusion criteria can be found elsewhere.<sup>199</sup> All participants gave written informed consent.

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#### 2.3 Intervention

Participants randomly assigned to the 12- or 52 week-commercial weight loss programme were provided with vouchers to attend a weekly local Weight Watchers meeting for the duration of the intervention they were assigned to (12-weeks or 52-weeks). Participants were provided with a unique code to access digital tools for the duration of their assigned intervention.

Participants assigned to the brief intervention control group were given a 32-page printed booklet by the British Heart Foundation of self-help weight-management strategies.<sup>61</sup> Research staff read a scripted booklet introduction to the participant.

### 3 Analysis methods

## 3.1 Outcome definitions

Study participants were examined at baseline, 3-, 12-, 24- and 60-months.

### 3.1.1 Primary outcomes

Change in depression and anxiety (on a continuous scale) between baseline and 3-, 12-, 24- and 60-months.

### 3.1.2 Exposure outcomes

- Demographics: age, sex, BMI, education, socioeconomical status
- Psychological factors: baseline depression and anxiety, quality of life by EQ5D, satisfaction with life, cognitive dietary restraint, self-regulation, habit strength
- Programme attendance in first 3-months of WW sessions

### 3.1.3 Potential confounders and effect modifiers

- Study arm
- GP practice (robust standard errors calculated to allow for clustering)

### 3.2 Analysis methods

Stata v16 will be used for all statistical analyses.

<u>Association between baseline participant characteristics and changes in depression and anxiety</u> <u>symptoms:</u> Linear regression will be conducted to estimate the association between participant characteristics at baseline and changes in symptoms of depression and anxiety between baseline and 3-, 12-, 24-, and 60-months, controlling for intervention arm and using robust standard errors to allow for clustering by GP practice. Characteristics found to be significantly associated (P<0.05) with change in dependent variables will be included in mutually adjusted models.

<u>Association between early changes in participant characteristics and changes in depression and anxiety symptoms:</u> Linear regression will be conducted to estimate the association between early changes in participant characteristics (i.e., baseline to 3-months) and changes in symptoms of depression and anxiety between baseline and 3-, 12-, 24-, and 60-months, controlling for intervention arm and using robust standard errors to allow for clustering by GP practice. Characteristics found to be significantly associated (P<0.05) with change in dependent variables will be included in mutually adjusted models.

<u>Intervention attendance moderation</u>: Using data from intervention arms only, the moderating effects of programme attendance on characteristics consistently associated with change in depression and anxiety will be assessed by including interaction parameters, controlling for randomised group. Intervention attendance will be treated as a categorical variable, categorised as low ( $\leq$ 4 sessions), moderate (>4 &  $\leq$ 8 sessions) or high attendance (>8 &  $\leq$ 12 sessions).

# 3.2.1 Assumption testing

The association between exposure and outcome variables must be linear, and residuals must be normally distributed with constant variance. If the assumptions for linear regression or mutually adjusted regression are not met, the data will be transformed in preparation for data analysis.

*Univariable linear regression*: Linearity will be assessed by visually inspected a scatterplot of the exposure variable against the outcome variable. Normal distribution will be assessed by histogram (with superimposed normal curve) or a Normal P-P Plot. Homoscedasticity will be 382

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assessed by plotting the regression standardised residuals against the regression standardised predicted value.

*Mutually adjusted regression*: Linearity will be assessed by scatterplots and partial regression plots. Normal distribution will be assessed by histogram (with superimposed normal curve) and a Normal P-P Plot, or a Normal Q-Q Plot of the studentised residuals. Homoscedasticity will be assessed by plotting the studentised residuals against the unstandardised predicted values.

#### 3.2.2 Dealing with missing data

Participants with missing values of key outcomes will be excluded by complete-case analysis (which assumes outcome data are missing at random conditional on covariates in the model).

A sensitivity analysis will be performed using multiple imputation by chained equations, which also assumes outcome data are missing at random but provides increased precision compared with a complete-case analysis. For sensitivity analyses, variables with  $\geq$  5% missing data will have data imputed by multiple imputation by chained equations (MICE). Variables with  $\geq$  25% missing data will be excluded from analyses. Data will be re-analysed with the imputed data and compared to the complete-case analysis to assess the robustness of the findings, and whether missing data influenced the results.

### 3.2.3 Interpretation and presentation of results

|           | Total | 12-week WW | 52-week WW | Brief        |
|-----------|-------|------------|------------|--------------|
|           | (n= ) | (n= )      | (n= )      | intervention |
|           |       |            |            | (n= )        |
| Age       |       |            |            |              |
| Sex       |       |            |            |              |
| Education |       |            |            |              |
| etc       |       |            |            |              |

Descriptive characteristics will be presented by study arm:

Results will present the baseline predictors of change in mental health from baseline to 3-months as the primary outcome, and baseline predictors of change in mental health from baseline to 12-, 24-, and 60-months as the secondary outcomes. The findings for each timepoint will be visually assessed for consistency across timepoints.

Results of the final regression models will be reported in table format with the following data:

|          | Change in depression between baseline and X |              |              |  |  |
|----------|---|--------------|--------------|--|--|
| Variable | Coefficient                                 | 95% Cl Lower | 95% Cl Upper |  |  |
|          | (Standard error)                            |              |              |  |  |
|          |   |              |              |  |  |
|          |   |              |              |  |  |

|          | Change in anxiety between baseline and X |              |              |  |  |
|----------|--|--------------|--------------|--|--|
| Variable | Coefficient                              | 95% Cl Lower | 95% Cl Upper |  |  |
|          | (Standard error)                         |              |              |  |  |
|          |  |              |              |  |  |
|          |  |              |              |  |  |

# A6.2 Effect of baseline participant characteristics on changes in depression and anxiety

Table A1. Independent linear regression to assess the effect of baseline participant characteristics on changes in symptoms of depression and

anxiety – controlled for study arm and clustering by GP practice.

|   |                                 | Unstandardised<br>coefficient (95% CI) | Number of<br>participants | Unstandardised<br>coefficient (95% CI) | Number of<br>participants |
|---|---------------------------------|--|---------------------------|--|---------------------------|
| Participant characteristics at baseline |                                 | Change in depression from months       | m baseline to 3-          | Change in anxiety from months          | baseline to 3-            |
| Age (years)                             |                                 | 0.01 (0.00, 0.03)                      | 935                       | 0.00 (-0.01, 0.01)                     | 935                       |
| BMI (kg/m <sup>2</sup> )                |                                 | -0.02 (-0.04, 0.00)                    | 935                       | 0.00 (-0.04, 0.05)                     | 935                       |
| Socioeconomi                            | c status                        | -0.05 (-0.11, 0.02)                    | 934                       | -0.04 (-0.11, 0.03)                    | 934                       |
|   | GCSE or equivalent              | -0.44 (-1.60, 0.73)                    |                           | -0.76* (-1.38, -0.15)                  |                           |
| Education                               | A-Level or equivalent           | -0.49 (-1.52, 0.54)                    | 862                       | -0.75 (-1.40, -0.11)                   | 862                       |
| education as                            | Post-secondary study            | -0.06 (-1.41, 1.29)                    |                           | 0.24 (-0.63, 1.10)                     |                           |
| reference                               | University degree or equivalent | -0.34 (-1.43, 0.74)                    |                           | -0.58 (-1.22, 0.06)                    |                           |
| group/                                  | Higher degree or equivalent     | -0.09 (-1.12, 0.94)                    |                           | -0.53 (-1.26, 0.20)                    |                           |
| Global quality                          | of life                         | -0.22 (-1.05, 0.61)                    | 913                       | -0.50 (-1.10, 0.10)                    | 913                       |
| Satisfaction w                          | ith life                        | 0.02 (-0.01, 0.05)                     | 926                       | 0.01 (-0.02, 0.03)                     | 926                       |
| Total dietary restraint                 |                                 | 0.04 (0.00, 0.09)                      | 933                       | -0.02 (-0.08, 0.05)                    | 933                       |
| Flexible dietary restraint              |                                 | 0.07 (-0.01, 0.14)                     | 933                       | -0.01 (-0.12, 0.09)                    | 933                       |
| Rigid dietary restraint                 |                                 | 0.07 (-0.02, 0.16)                     | 933                       | -0.03 (-0.14, 0.07)                    | 933                       |
| Entering<br>treatment                   | Autonomous regulation score     | -0.14 (-0.26, -0.01)                   | 934                       | -0.06 (-0.21, 0.08)                    | 934                       |

| self-<br>regulation   | Controlled regulation score   | -0.09 (-0.26, 0.09)  | 928 | -0.03 (-0.18, 0.12)  | 928 |
|---|-------------------------------|----------------------|-----|----------------------|-----|
| Diet self-<br>regulation  | Autonomous self-control score | -0.13 (-0.32, 0.06)  | 931 | -0.08 (-0.30, 0.15)  | 931 |
|   | Controlled self-control score | -0.05 (-0.19, 0.08)  | 929 | -0.05 (-0.20, 0.09)  | 929 |
|   | Amotivation score             | 0.11 (-0.02, 0.24)   | 928 | 0.09 (-0.09, 0.26)   | 928 |
|   | Autonomous self-control score | -0.04 (-0.15, 0.07)  | 926 | -0.06 (-0.25, 0.13)  | 926 |
| regulation  | Controlled self-control score | -0.08 (-0.27, 0.11)  | 923 | -0.04 (-0.21, 0.12)  | 923 |
|   | Amotivation score             | 0.15 (0.01, 0.29)    | 920 | 0.04 (-0.11, 0.18)   | 920 |
| Baseline depre  | ession                        | -0.22 (-0.28, -0.16) | 935 | -0.08 (-0.12, -0.03) | 935 |
| Baseline anxiety  |                               | -0.05 (-0.10, 0.00)  | 935 | -0.19 (-0.23, -0.14) | 935 |
| Total number of Weight Watchers sessions attended in the first 3-months |                               | -0.04 (-0.15, 0.06)  | 534 | -0.02 (-0.13, 0.09)  | 534 |
| Weekly use of<br>WW e-  | Daily/Almost daily            | 0.00 (-0.52, 0.52)   |     | 0.03 (-0.33, 0.38)   |     |
| tools/online<br>resources   | 3-5 times per week            | -0.74 (-1.57, 0.08)  | 742 | -0.60 (-1.42, 0.21)  | 742 |
| (never as<br>reference<br>group)  | 1-2 times per week            | -0.06 (-0.68, 0.56)  |     | -0.22 (-0.68, 0.23)  | -   |
| Weekly use of   | Daily/Almost daily            | -0.41 (-1.10, 0.28)  |     | -0.01 (-0.50, 0.49)  |     |
| WW mobile   | 3-5 times per week            | -0.80 (-1.61, 0.00)  |     | -0.30 (-1.47, 0.88)  |     |
| app (never as<br>reference<br>group)                                    | 1-2 times per week            | 0.05 (-1.07, 1.18)   | 744 | -0.21 (-1.22, 0.81)  | 744 |

| Sex (female<br>as reference<br>group)   | Male  | 0.24 (-0.10, 0.59)   | 935   | 0.13 (-0.17, 0.44)  | 935                             |
|---|---|--|---|---|---------------------------------|
| Self-reported<br>dietary  | History of behavioural repetition   | -0.14 (-0.21, -0.08)   | 930   | 0.00 (-0.08, 0.08)  | 930                             |
| habits  | Lack of control   | -0.09 (-0.19, 0.01)  | 920   | -0.01 (-0.11, 0.10)   | 920                             |
|   | Lack of awareness   | -0.11 (-0.20, -0.02)   | 925   | -0.02 (-0.12, 0.08)   | 925                             |
| Self-reported   | History of behavioural repetition   | -0.06 (-0.15, 0.03)  | 926   | 0.00 (-0.12, 0.11)  | 926                             |
| habits  | Lack of control   | -0.06 (-0.18, 0.05)  | 916   | 0.00 (-0.13, 0.13)  | 916                             |
| Lack of awareness   |   | -0.04 (-0.14, 0.06)  | 918   | 0.00 (-0.12, 0.11)  | 918                             |
| Participant charactoristic at basolino  |   | Change in depression from baseline to 12- Change in anxiety from baseline to   |   |   |                                 |
| Participant cha   | iracteristic at baseline  | <b>J I</b>   |   | 5 5   |                                 |
| Participant cho   | iracteristic at baseline  | months   | 1   | months  |                                 |
| Age (years)   | iracteristic at baseline  | <i>months</i><br>0.00 (-0.02, 0.03)  | 756   | <i>months</i><br>0.00 (-0.02, 0.01)   | 756                             |
| Age (years)<br>BMI (kg/m²)  | iracteristic at baseline  | <i>months</i><br>0.00 (-0.02, 0.03)<br>-0.04 (-0.07, 0.00)   | 756<br>756  | months           0.00 (-0.02, 0.01)           -0.02 (-0.06, 0.01)   | 756<br>756                      |
| Age (years)<br>BMI (kg/m <sup>2</sup> )<br>Socioeconomic  | c status  | months           0.00 (-0.02, 0.03)           -0.04 (-0.07, 0.00)           -0.09 (-0.17, -0.02)   | 756<br>756<br>755                                   | months           0.00 (-0.02, 0.01)           -0.02 (-0.06, 0.01)           -0.07 (-0.14, 0.01)   | 756<br>756<br>755               |
| Age (years)<br>BMI (kg/m <sup>2</sup> )<br>Socioeconomic  | c status<br>GCSE or equivalent  | months           0.00 (-0.02, 0.03)           -0.04 (-0.07, 0.00)           -0.09 (-0.17, -0.02)           -0.79 (-1.72, 0.14)   | 756<br>756<br>755                                   | months           0.00 (-0.02, 0.01)           -0.02 (-0.06, 0.01)           -0.07 (-0.14, 0.01)           -0.02 (-1.08, 1.04)   | 756<br>756<br>755               |
| Age (years)<br>BMI (kg/m <sup>2</sup> )<br>Socioeconomic<br>Education   | c status<br>GCSE or equivalent<br>A-Level or equivalent   | months           0.00 (-0.02, 0.03)           -0.04 (-0.07, 0.00)           -0.09 (-0.17, -0.02)           -0.79 (-1.72, 0.14)           0.14 (-1.93, -0.05)   | 756<br>756<br>755                                   | months           0.00 (-0.02, 0.01)           -0.02 (-0.06, 0.01)           -0.07 (-0.14, 0.01)           -0.02 (-1.08, 1.04)           0.33 (-0.57, 1.23)  | 756<br>756<br>755               |
| Participant chaAge (years)BMI (kg/m²)SocioeconomiaEducation(no formaleducation as   | c status<br>GCSE or equivalent<br>A-Level or equivalent<br>Post-secondary study   | months           0.00 (-0.02, 0.03)           -0.04 (-0.07, 0.00)           -0.09 (-0.17, -0.02)           -0.79 (-1.72, 0.14)           0.14 (-1.93, -0.05)           -0.05 (-2.57, 0.03)   | 756<br>756<br>755<br>693                            | months           0.00 (-0.02, 0.01)           -0.02 (-0.06, 0.01)           -0.07 (-0.14, 0.01)           -0.02 (-1.08, 1.04)           0.33 (-0.57, 1.23)           0.68 (-0.58, 1.94)   | 756<br>756<br>755               |
| Age (years)<br>BMI (kg/m <sup>2</sup> )<br>Socioeconomic<br>Education<br>(no formal<br>education as<br>reference<br>group)                | c status<br>GCSE or equivalent<br>A-Level or equivalent<br>Post-secondary study<br>University degree or<br>equivalent   | months           0.00 (-0.02, 0.03)           -0.04 (-0.07, 0.00)           -0.09 (-0.17, -0.02)           -0.79 (-1.72, 0.14)           0.14 (-1.93, -0.05)           -0.05 (-2.57, 0.03)           0.29 (-1.73, 0.08)  | 756<br>756<br>755<br>693                            | months           0.00 (-0.02, 0.01)           -0.02 (-0.06, 0.01)           -0.07 (-0.14, 0.01)           -0.02 (-1.08, 1.04)           0.33 (-0.57, 1.23)           0.68 (-0.58, 1.94)           0.08 (-0.83, 0.99)  | 756<br>756<br>755<br>693        |
| Participant chaAge (years)BMI (kg/m²)SocioeconomiaEducation(no formaleducation asreferencegroup)  | c status<br>GCSE or equivalent<br>A-Level or equivalent<br>Post-secondary study<br>University degree or<br>equivalent<br>Higher degree or equivalent            | months         0.00 (-0.02, 0.03)         -0.04 (-0.07, 0.00)         -0.09 (-0.17, -0.02)         -0.79 (-1.72, 0.14)         0.14 (-1.93, -0.05)         -0.05 (-2.57, 0.03)         0.29 (-1.73, 0.08)         0.08 (-1.57, 0.42)   | 756<br>755<br>755<br>- 693                          | months         0.00 (-0.02, 0.01)         -0.02 (-0.06, 0.01)         -0.07 (-0.14, 0.01)         -0.02 (-1.08, 1.04)         0.33 (-0.57, 1.23)         0.68 (-0.58, 1.94)         0.08 (-0.83, 0.99)         0.22 (-0.65, 1.09)   | 756<br>756<br>755<br>693        |
| Participant characterizationAge (years)BMI (kg/m²)SocioeconomicEducation(no formaleducation asreferencegroup)Global quality               | c status<br>GCSE or equivalent<br>A-Level or equivalent<br>Post-secondary study<br>University degree or<br>equivalent<br>Higher degree or equivalent<br>of life | months         0.00 (-0.02, 0.03)         -0.04 (-0.07, 0.00)         -0.09 (-0.17, -0.02)         -0.79 (-1.72, 0.14)         0.14 (-1.93, -0.05)         -0.05 (-2.57, 0.03)         0.29 (-1.73, 0.08)         0.08 (-1.57, 0.42)         0.27 (-0.61, 1.14)  | 756<br>756<br>755<br>693<br>742                     | months           0.00 (-0.02, 0.01)           -0.02 (-0.06, 0.01)           -0.07 (-0.14, 0.01)           -0.02 (-1.08, 1.04)           0.33 (-0.57, 1.23)           0.68 (-0.58, 1.94)           0.08 (-0.83, 0.99)           0.22 (-0.65, 1.09)           0.91 (-0.05, 1.86)                              | 756<br>756<br>755<br>693<br>742 |
| Participant characterizationAge (years)BMI (kg/m²)SocioeconomiaEducation(no formaleducation asreferencegroup)Global qualitySatisfaction w | c status<br>GCSE or equivalent<br>A-Level or equivalent<br>Post-secondary study<br>University degree or<br>equivalent<br>Higher degree or equivalent<br>of life | months           0.00 (-0.02, 0.03)           -0.04 (-0.07, 0.00)           -0.09 (-0.17, -0.02)           -0.79 (-1.72, 0.14)           0.14 (-1.93, -0.05)           -0.05 (-2.57, 0.03)           0.29 (-1.73, 0.08)           0.08 (-1.57, 0.42)           0.27 (-0.61, 1.14)           0.00 (-0.04, 0.05) | 756         755         693         742         750 | months           0.00 (-0.02, 0.01)           -0.02 (-0.06, 0.01)           -0.07 (-0.14, 0.01)           -0.02 (-1.08, 1.04)           0.33 (-0.57, 1.23)           0.68 (-0.58, 1.94)           0.08 (-0.83, 0.99)           0.22 (-0.65, 1.09)           0.91 (-0.05, 1.86)           0.01 (-0.02, 0.05) | 756<br>755<br>693<br>742<br>750 |

| Flexible dietar  | y restraint                                     | 0.05 (-0.12, 0.23)   | 755 | -0.03 (-0.19, 0.12)  | 755 |
|--|---|----------------------|-----|----------------------|-----|
| Rigid dietary r  | estraint  | 0.01 (-0.15, 0.17)   | 755 | -0.09 (-0.22, 0.03)  | 755 |
| Entering<br>treatment  | Autonomous regulation score                     | -0.17 (-0.39, 0.05)  | 755 | -0.16 (-0.34, 0.03)  | 755 |
| self-<br>regulation  | Controlled regulation score                     | -0.12 (-0.37, 0.14)  | 751 | -0.18 (-0.38, 0.02)  | 751 |
| Diet self-<br>regulation   | Autonomous self-control score                   | -0.07 (-0.33, 0.19)  | 752 | -0.14 (-0.47, 0.19)  | 752 |
|  | Controlled self-control score                   | -0.10 (-0.29, 0.10)  | 750 | -0.12 (-0.31, 0.07)  | 750 |
|  | Amotivation score                               | 0.15 (-0.11, 0.42)   | 750 | 0.08 (-0.08, 0.24)   | 750 |
| Exercise self-<br>regulation   | Autonomous self-control score                   | -0.06 (-0.25, 0.14)  | 750 | -0.09 (-0.30, 0.12)  | 750 |
|  | Controlled self-control score                   | -0.12 (-0.32, 0.09)  | 748 | -0.09 (-0.31, 0.13)  | 748 |
|  | Amotivation score                               | 0.09 (-0.12, 0.30)   | 745 | 0.00 (-0.16, 0.16)   | 745 |
| Baseline depre   | ession  | -0.22 (-0.32, -0.13) | 756 | -0.12 (-0.20, -0.04) | 756 |
| Baseline anxie   | ty  | -0.06 (-0.13, 0.02)  | 756 | -0.22 (-0.28, -0.16) | 756 |
| Total number<br>attended in th   | of Weight Watchers sessions<br>e first 3-months | -0.10 (-0.18, -0.03) | 414 | -0.09 (-0.17, 0.00)  | 414 |
| Weekly use of  | Daily/Almost daily                              | 0.23 (-0.34, 0.79)   |     | 0.54 (-0.11, 1.19)   |     |
| WW e-<br>tools/online<br>resources<br>(never as<br>reference<br>group) | 3-5 times per week                              | -0.79 (-1.88, -0.05) | _   | -0.13 (-1.05, 0.78)  | _   |
|  | 1-2 times per week                              | -0.05 (-0.61, 0.85)  | 566 | 0.51 (-0.16, 1.17)   | 566 |
|  | Daily/Almost daily                              | 0.34 (-0.63, 1.30)   | 568 | 0.77 (0.02, 1.52)    | 568 |

| Weekly use of  | 3-5 times per week                | 1.30 (-1.85, 1.04)  |     | 0.08 (-0.70, 0.85)  |     |
|--|-----------------------------------|---|-----|---------------------|-----|
| WW mobile<br>app (never as<br>reference<br>group)              | 1-2 times per week                | 1.04 (-0.48, 1.49)  |     | 0.45 (-0.52, 1.42)  |     |
| Sex (female<br>as reference<br>group)                          | Male                              | 0.19 (-0.17, 0.56)  | 756 | -0.04 (-0.47, 0.39) | 756 |
| Self-reported  | History of behavioural repetition | -0.06 (-0.22, 0.10)   | 747 | 0.00 (-0.15, 0.15)  | 747 |
| babite   | Lack of control                   | -0.07 (-0.23, 0.08)   | 738 | -0.01 (-0.17, 0.14) | 738 |
| nabits   | Lack of awareness                 | -0.05 (-0.21, 0.12)   | 744 | 0.04 (-0.13, 0.21)  | 744 |
| Self-reported  | History of behavioural repetition | -0.04 (-0.14, 0.07)   | 746 | -0.02 (-0.16, 0.12) | 746 |
| exercise   | Lack of control                   | -0.04 (-0.14, 0.07)   | 736 | -0.04 (-0.22, 0.14) | 736 |
| Habits   | Lack of awareness                 | -0.06 (-0.19, 0.08)   | 739 | -0.04 (-0.22, 0.13) | 739 |
| Participant cha  | aracteristic at baseline          | Change in depression from baseline to 24- Change in anxiety from baselin months |     | baseline to 24-     |     |
| Age (years)  |                                   | 0.01 (-0.02, 0.03)  | 754 | -0.01 (-0.02, 0.01) | 754 |
| BMI (kg/m <sup>2</sup> )                                       |                                   | -0.02 (-0.07, 0.03)   | 754 | -0.02 (-0.08, 0.04) | 754 |
| Socioeconomi   | c status                          | -0.03 (-0.09, 0.04)   | 753 | -0.03 (-0.14, 0.08) | 753 |
|  | GCSE or equivalent                | -0.99 (-2.24, 0.26)   |     | 0.44 (-0.65, 1.53)  |     |
| Education<br>(no formal<br>education as<br>reference<br>group) | A-Level or equivalent             | -1.09 (-2.17, 0.00)   |     | 0.26 (-0.74, 1.27)  |     |
|  | Post-secondary study              | -1.01 (-2.74, 0.72)   | 603 | 0.39 (-1.05, 1.83)  | 693 |
|  | University degree or equivalent   | -0.76 (-2.14, 0.61)   |     | 0.37 (-0.79, 1.53)  |     |
| 9. 0 %P/   | Higher degree or equivalent       | -0.49 (-1.52, 0.53)   |     | 0.70 (-0.49, 1.88)  |     |
| Global quality of life   |                                   | 0.66 (-0.42, 1.74)  | 739 | 0.69 (-0.39, 1.77)  | 739 |

| Satisfaction with life                                     |                                  | 0.01 (-0.04, 0.05)   | 748 | 0.01 (-0.02, 0.05)   | 748 |
|--|----------------------------------|----------------------|-----|----------------------|-----|
| Total dietary r  | estraint                         | 0.00 (-0.08, 0.07)   | 753 | -0.04 (-0.14, 0.05)  | 753 |
| Flexible dietar  | y restraint                      | 0.06 (-0.07, 0.18)   | 753 | -0.01 (-0.18, 0.17)  | 753 |
| Rigid dietary r  | estraint                         | -0.07 (-0.21, 0.07)  | 753 | -0.12 (-0.27, 0.03)  | 753 |
| Entering<br>treatment                                      | Autonomous regulation score      | -0.20 (-0.42, 0.01)  | 753 | -0.17 (-0.41, 0.07)  | 753 |
| self-<br>regulation  | Controlled regulation score      | -0.14 (-0.38, 0.10)  | 747 | -0.06 (-0.28, 0.16)  | 747 |
| Diet solf  | Autonomous self-control<br>score | -0.17 (-0.38, 0.04)  | 750 | -0.02 (-0.38, 0.34)  | 750 |
| regulation   | Controlled self-control score    | -0.07 (-0.29, 0.15)  | 748 | -0.03 (-0.30, 0.25)  | 748 |
|  | Amotivation score                | 0.08 (-0.10, 0.27)   | 747 | 0.08 (-0.11, 0.27)   | 747 |
|  | Autonomous self-control score    | -0.08 (-0.25, 0.09)  | 746 | -0.07 (-0.34, 0.20)  | 746 |
| regulation   | Controlled self-control score    | -0.11 (-0.34, 0.12)  | 743 | -0.01 (-0.31, 0.30)  | 743 |
|  | Amotivation score                | 0.09 (-0.14, 0.32)   | 739 | 0.02 (-0.25, 0.29)   | 739 |
| Baseline depre   | ession                           | -0.24 (-0.31, -0.17) | 754 | -0.10 (-0.18, -0.02) | 754 |
| Baseline anxie   | ty                               | -0.10 (-0.15, -0.05) | 754 | -0.28 (-0.34, -0.21) | 754 |
| Total number of WW sessions attended in the first 3-months |                                  | -0.14 (-0.26, -0.03) | 422 | -0.11 (-0.24, 0.01)  | 422 |
| Weekly use of  | Daily/Almost daily               | 0.56 (0.06, 1.06)    |     | 0.12 (-0.34, 0.59)   |     |
| WW e-  | 3-5 times per week               | -0.09 (-1.01, 0.82)  | 557 | 0.22 (-1.10, 1.53)   | 557 |
| resources<br>(never as                                     | 1-2 times per week               | 0.43 (-0.08, 0.94)   |     | 0.29 (-0.30, 0.88)   |     |

| reference<br>group)      |                                 |                           |                   |                                       |      |
|--------------------------|---------------------------------|---------------------------|-------------------|---------------------------------------|------|
| Weekly use of            | Daily/Almost daily              | 0.29 (-0.39, 0.96)        |                   | 0.61 (-0.18, 1,40)                    |      |
| WW mobile                | 3-5 times per week              | -0.48 (-2.61, 1.65)       |                   | 0.22 (-1.08, 1.52)                    | -    |
| app (never as            |                                 | 0.10 ( 2.01, 1.00)        | 557               | 0.22 ( 1.00, 1.02)                    | 557  |
| reference                | 1-2 times per week              | 0.05 (-1.05, 1.15)        |                   | -0.06 (-0.66, 0.54)                   |      |
| group)                   |                                 |                           |                   |                                       |      |
| Sex (female              |                                 |                           |                   |                                       |      |
| as reference             | Male                            | 0.61 (0.12, 1.09)         | 754               | 0.38 (-0.18, 0.94)                    | 754  |
| group)                   |                                 |                           |                   |                                       |      |
|                          | History of behavioural          |                           | - 40              |                                       | - 40 |
| Self-reported            | repetition                      | 0.02 (-0.17, 0.20)        | 748               | 0.02 (-0.13, 0.17)                    | /48  |
| dietary                  | Lack of control                 | -0.06 (-0.23, 0.12)       | 740               | 0.00 (-0.19, 0.19)                    | 740  |
| nabits                   | Lack of awareness               | -0.02 (-0.19, 0.15)       | 743               | 0.00 (-0.18, 0.18)                    | 743  |
| Salf reported            | History of behavioural          | -0.07 (-0.20, 0.05)       | 745               | -0.02 (-0.14, 0.10)                   | 745  |
| evercise                 | repetition                      | 0.01 ( 0.20, 0.03)        | 145               | 0.02 ( 0.14, 0.10)                    | 145  |
| habite                   | Lack of control                 | -0.12 (-0.21, -0.02)      | 738               | -0.04 (-0.19, 0.10)                   | 738  |
|                          | Lack of awareness               | -0.07 (-0.18, 0.04)       | 740               | -0.03 (-0.17, 0.10)                   | 740  |
| Participant cho          | uractoristic at basolino        | Change in depression from | n baseline to 60- | Change in anxiety from baseline to 60 |      |
| r un cicipant cha        |                                 | months                    |                   | months                                |      |
| Age (years)              |                                 | -0.01 (-0.03, 0.01)       | 474               | -0.03 (-0.05, -0.01)                  | 474  |
| BMI (kg/m <sup>2</sup> ) |                                 | -0.02 (-0.09, 0.06)       | 474               | 0.05 (0.00, 0.11)                     | 474  |
| Socioeconomic status     |                                 | -0.03 (-0.18, 0.11)       | 474               | -0.03 (-0.22, 0.15)                   | 474  |
| Education                | GCSE or equivalent              | -0.43 (-1.60, 0.73)       |                   | 0.38 (-0.72, 1.47)                    |      |
| (no formal               | A-Level or equivalent           | -0.55 (-1.69, 0.58)       | 1                 | -0.28 (-1.27, 0.71)                   | 1    |
| education as             | Post-secondary study            | -0.40 (-2.63, 1.83)       | 437               | 0.54 (-1.06, 2.13)                    | 437  |
| reference<br>group)      | University degree or equivalent | -0.67 (-1.56, 0.23)       |                   | -0.26 (-1.44, 0.92)                   | ]    |

|  | Higher degree or equivalent   | 0.36 (-1.14, 1.87)   |     | 0.49 (-1.05, 2.03)   |     |
|--|-------------------------------|----------------------|-----|----------------------|-----|
| Global quality   | of life                       | 0.71 (-1.36, 2.78)   | 469 | 0.72 (-0.50, 1.94)   | 469 |
| Satisfaction w   | ith life                      | 0.01 (-0.04, 0.07)   | 473 | 0.00 (-0.06, 0.05)   | 473 |
| Total dietary r  | estraint                      | -0.06 (-0.15, 0.04)  | 472 | -0.11 (-0.21, -0.01) | 472 |
| Flexible dietar  | y restraint                   | -0.04 (-0.23, 0.15)  | 472 | -0.15 (-0.36, 0.05)  | 472 |
| Rigid dietary r  | estraint                      | -0.13 (-0.27, 0.00)  | 472 | -0.18 (-0.31, -0.05) | 472 |
| Entering<br>treatment                                      | Autonomous regulation score   | -0.18 (-0.51, 0.14)  | 473 | -0.15 (-0.51, 0.20)  | 473 |
| self-<br>regulation  | Controlled regulation score   | -0.10 (-0.36, 0.16)  | 468 | -0.12 (-0.33, 0.10)  | 468 |
| Diet oolf  | Autonomous self-control score | -0.31 (-0.76, 0.14)  | 473 | -0.28 (-0.68, 0.12)  | 473 |
| regulation   | Controlled self-control score | -0.10 (-0.34, 0.15)  | 472 | -0.02 (-0.26, 0.22)  | 472 |
|  | Amotivation score             | 0.20 (-0.08, 0.48)   | 471 | 0.26 (-0.09, 0.61)   | 471 |
|  | Autonomous self-control score | -0.30 (-0.64, 0.04)  | 470 | -0.34 (-0.59, -0.08) | 470 |
| regulation   | Controlled self-control score | -0.16 (-0.36, 0.04)  | 468 | -0.06 (-0.36, 0.24)  | 468 |
|  | Amotivation score             | 0.31 (0.04, 0.57)    | 466 | 0.18 (-0.17, 0.53)   | 466 |
| Baseline depre   | ession                        | -0.32 (-0.40, -0.23) | 474 | -0.07 (-0.14, 0.01)  | 474 |
| Baseline anxie   | ty                            | -0.09 (-0.16, -0.02) | 474 | -0.29 (-0.38, -0.20) | 474 |
| Total number of WW sessions attended in the first 3-months |                               | -0.05 (-0.27, 0.17)  | 250 | 0.06 (-0.18, 0.29)   | 250 |
| Weekly use of  | Daily/Almost daily            | 0.67 (-0.35, 1.70)   |     | -0.03 (-0.71, 0.64)  |     |
| WW e-  | 3-5 times per week            | -0.33 (-1.93, 1.28)  | 336 | -0.06 (-1.41, 1.29)  | 336 |
| tools/online   | 1-2 times per week            | 0.12 (-0.84, 1.07)   |     | 0.33 (-0.45, 1.11)   |     |

| resources   |                                   |                     |     |                     |     |  |  |
|---|-----------------------------------|---------------------|-----|---------------------|-----|--|--|
| (never as   |                                   |                     |     |                     |     |  |  |
| reference   |                                   |                     |     |                     |     |  |  |
| group)  |                                   |                     |     |                     |     |  |  |
| Weekly use of   | Daily/Almost daily                | 0.78 (-0.67, 2.22)  |     | -0.16 (-1.57, 1.25) |     |  |  |
| WW mobile   | 3-5 times per week                | 0.01 (-2.29, 2.31)  |     | 1.44 (-0.63, 3.50)  |     |  |  |
| app (never as   |                                   |                     | 336 |                     | 336 |  |  |
| reference   | 1-2 times per week                | -0.19 (-0.98, 0.61) |     | -0.11 (-1.21, 0.99) |     |  |  |
| group)  |                                   |                     |     |                     |     |  |  |
| Sex (female   |                                   |                     |     |                     |     |  |  |
| as reference  | Male                              | 0.15 (-0.56, 0.85)  | 474 | -0.03 (-0.76, 0.70) | 474 |  |  |
| group)  |                                   |                     |     |                     |     |  |  |
| Self-reported   | History of behavioural repetition | 0.03 (-0.15, 0.22)  | 470 | 0.11 (-0.10, 0.32)  | 470 |  |  |
| uletary<br>babite   | Lack of control                   | 0.03 (-0.19, 0.24)  | 466 | 0.09 (-0.12, 0.31)  | 466 |  |  |
| liabits   | Lack of awareness                 | -0.01 (-0.20, 0.19) | 468 | 0.02 (-0.20, 0.24)  | 468 |  |  |
| Self-reported<br>exercise                                     | History of behavioural repetition | -0.04 (-0.19, 0.11) | 468 | 0.07 (-0.10, 0.23)  | 468 |  |  |
|   | Lack of control                   | 0.03 (-0.12, 0.18)  | 465 | 0.09 (-0.07, 0.24)  | 465 |  |  |
|   | Lack of awareness                 | 0.02 (-0.14, 0.18)  | 466 | 0.08 (-0.06, 0.21)  | 466 |  |  |
| Abbreviations: CI – Confidence interval, WW – Weight Watchers |                                   |                     |     |                     |     |  |  |

Table A2. A. Mutually adjusted multinomial regression to assess the effect of baseline participant characteristics on categorised changes in

symptoms of anxiety – controlled for study arm and clustering by GP practice.

| Mutually adjusted multinomial regression to assess the effect of baseline participant characteristics on categorised changes in symptoms of anxiety. |                                   |                     | Relative Risk Ratio<br>[RRR] (95% CI) | Number of participants by<br>categorised change in<br>anxiety symptoms (%) |
|--|-----------------------------------|---------------------|---------------------------------------|--|
| Change in anviatu  | Decrease in symptoms of anxiety,  | Baseline depression | 0.92 (0.86, 0.99)                     | Decrease: 305 (33%)  |
| from baseline to 3-  | compared to no change in symptoms | Baseline anxiety    | 1.25 (1.19, 1.32)                     | No change: 521 (56%)   |
| months   | Increase in symptoms of anxiety,  | Baseline depression | 1.08 (1.00, 1.15)                     | Increase: 109 (12%)  |
|  | compared to no change in symptoms | Baseline anxiety    | 0.99 (0.93, 1.06)                     |  |
| Change in anviety  | Decrease in symptoms of anxiety,  | Baseline depression | 0.93 (0.88, 0.98)                     | Decrease: 234 (31%)  |
| from bacoling to 12  | compared to no change in symptoms | Baseline anxiety    | 1.22 (1.16, 1.29)                     | No change: 403 (53%)   |
| months   | Increase in symptoms of anxiety,  | Baseline depression | 0.99 (0.91, 1.09)                     | Increase: 119 (16%)  |
|  | compared to no change in symptoms | Baseline anxiety    | 0.99 (0.93, 1.07)                     |  |
| Change in anviety  | Decrease in symptoms of anxiety,  | Baseline depression | 0.88 (0.82, 0.95)                     | Decrease: 212 (28%)  |
| from baseline to 24-   | compared to no change in symptoms | Baseline anxiety    | 1.30 (1.22, 1.38)                     | No change: 406 (54%)   |
| months   | Increase in symptoms of anxiety,  | Baseline depression | 1.06 (0.98, 1.15)                     | Increase: 136 (18%)  |
| monuis   | compared to no change in symptoms | Baseline anxiety    | 0.96 (0.90, 1.15)                     |  |
| Change in anviety  | Decrease in symptoms of anxiety,  | Baseline depression | 0.95 (0.87, 1.03)                     | Decrease: 155 (33%)  |
| Change in anxiety  | compared to no change in symptoms | Baseline anxiety    | 1.25 (1.17, 1.33)                     | No change: 238 (50%)   |
| months   | Increase in symptoms of anxiety,  | Baseline depression | 1.10 (1.04, 1.16)                     | Increase: 81 (17%)   |
| months   | compared to no change in symptoms | Baseline anxiety    | 0.98 (0.94, 1.03)                     |  |

Table A2. B. Mutually adjusted multinomial regression to assess the effect of baseline participant characteristics on categorised changes in

symptoms of depression – controlled for study arm and clustering by GP practice.

| Mutually adjusted multinomial regression to assess the effect of baseline participant characteristics on categorised changes in symptoms of depression. |                                     |                     | Relative Risk Ratio<br>[RRR] (95% CI) | Number of participants<br>by categorised change<br>in depression<br>symptoms |
|---|-------------------------------------|---------------------|---------------------------------------|--|
| Change in   | Decrease in symptoms of depression, | Baseline depression | 1.31 (1.19, 1.44)                     | Decrease: 282 (30%)  |
| depression from   | compared to no change in symptoms   | Baseline anxiety    | 0.96 (0.88, 1.04)                     | No change: 558 (60%)   |
| baseline to 3-  | Increase in symptoms of depression, | Baseline depression | 1.01 (0.92, 1.10)                     | Increase: 95 (10%)   |
| months  | compared to no change in symptoms   | Baseline anxiety    | 1.13 (1.05, 1.21)                     |  |
| Change in   | Decrease in symptoms of depression, | Baseline depression | 1.31 (1.22, 1.41)                     | Decrease: 221 (29%)  |
| depression from   | compared to no change in symptoms   | Baseline anxiety    | 0.96 (0.92, 0.997)                    | No change: 436 (58%)   |
| baseline to 12-   | Increase in symptoms of depression, | Baseline depression | 1.03 (0.95, 1.11)                     | Increase: 99 (13%)   |
| months  | compared to no change in symptoms   | Baseline anxiety    | 1.10 (1.03, 1.17)                     |  |
| Change in   | Decrease in symptoms of depression, | Baseline depression | 1.29 (1.18, 1.41)                     | Decrease: 201 (27%)  |
| depression from   | compared to no change in symptoms   | Baseline anxiety    | 1.04 (0.99, 1.09)                     | No change: 429 (57%)   |
| baseline to 24-   | Increase in symptoms of depression, | Baseline depression | 1.02 (0.95, 1.10)                     | Increase: 124 (16%)  |
| months  | compared to no change in symptoms   | Baseline anxiety    | 1.09 (1.02, 1.16)                     |  |
| Change in   | Decrease in symptoms of depression, | Baseline depression | 1.31 (1.22, 1.40)                     | Decrease: 140 (30%)  |
| depression from   | compared to no change in symptoms   | Baseline anxiety    | 0.997 (0.93, 1.07)                    | No change: 244 (51%)   |
| baseline to 60-   | Increase in symptoms of depression, | Baseline depression | 1.00 (0.92, 1.09)                     | Increase: 90 (19%)   |
| months  | compared to no change in symptoms   | Baseline anxiety    | 1.12 (1.06, 1.09)                     |  |

# A6.3 Sensitivity analyses

**Table A3.** Sensitivity analyses: Independent linear regression using imputed data to assess the effect of baseline participant characteristics on changes in symptoms of depression and anxiety – controlled for study arm and clustering by GP practice.

|                                   |                                       | Unstandardised coefficient | Unstandardised coefficient    |  |
|-----------------------------------|---------------------------------------|----------------------------|-------------------------------|--|
|                                   |                                       | (95% CI)                   | (95% CI)                      |  |
| Participant characteristic at     | haseline                              | Change in anxiety from     | Change in depression from     |  |
| r un trespunt en ar acteristic at | · · · · · · · · · · · · · · · · · · · |                            | baseline to 3-months (n=1267) |  |
| Age (years)                       |                                       | 0.00 (-0.02, 0.01)         | 0.01 (0.00, 0.03)             |  |
| BMI (kg/m <sup>2</sup> )          |                                       | 0.01 (-0.03, 0.04)         | -0.02 (-0.06, 0.01)           |  |
| Socioeconomic status              |                                       | -0.04 (-0.11, 0.04)        | -0.04 (-0.11, 0.03)           |  |
|                                   | GCSE or equivalent                    | -0.67 (-1.48, 0.15)        | -0.42 (-1.40, 0.56)           |  |
|                                   | A-Level or equivalent                 | -0.69 (-1.52, 0.14)        | -0.51 (-1.50, 0.48)           |  |
| Education (none as base)          | Post-secondary study                  | 0.24 (-1.01, 1.49)         | -0.04 (-1.34, 1.25)           |  |
|                                   | University degree or equivalent       | -0.54 (-1.40, 0.31)        | -0.32 (-1.28, 0.64)           |  |
|                                   | Higher degree or equivalent           | -0.44 (-1.37, 0.48)        | -0.05 (-1.04, 0.93)           |  |
| Global quality of life            |                                       | -0.60 (-1.39, 0.19)        | -0.27 (-1.10, 0.56)           |  |
| Satisfaction with life            |                                       | 0.01 (-0.02, 0.03)         | 0.02 (-0.01, 0.05)            |  |
| Total dietary restraint           |                                       | -0.01 (-0.08, 0.05)        | 0.06 (0.00, 0.11)             |  |
| Flexible dietary restraint        |                                       | 0.00 (-0.11, 0.11)         | 0.09 (-0.01, 0.18)            |  |
| <b>Rigid dietary restraint</b>    |                                       | -0.04 (-0.15, 0.07)        | 0.07 (-0.03, 0.18)            |  |
| Entering treatment self-          | Autonomous regulation score           | -0.05 (-0.21, 0.10)        | -0.14 (-0.30, 0.02)           |  |
| regulation                        | Controlled regulation score           | -0.05 (-0.20, 0.09)        | -0.12 (-0.28, 0.05)           |  |
|                                   | Autonomous self-control score         | -0.06 (-0.28, 0.17)        | -0.14 (-0.34, 0.06)           |  |
| Diet self-regulation              | Controlled self-control score         | -0.06 (-0.20, 0.09)        | -0.07 (-0.21, 0.07)           |  |
|                                   | Amotivation score                     | 0.06 (-0.11, 0.23)         | 0.10 (-0.04, 0.24)            |  |

|   | Autonomous self-control score     | -0.04 (-0.23, 0.15)  | -0.03 (-0.18, 0.13)  |  |  |
|---|-----------------------------------|----------------------|----------------------|--|--|
| Exercise self-regulation                | Controlled self-control score     | -0.06 (-0.22, 0.11)  | -0.08 (-0.27, 0.10)  |  |  |
|   | Amotivation score                 | 0.03 (-0.13, 0.19)   | 0.14 (-0.02, 0.29)   |  |  |
| Baseline depression                     |                                   | -0.06 (-0.11, 0.00)  | -0.18 (-0.24, -0.12) |  |  |
| Baseline anxiety                        |                                   | -0.14 (-0.19, -0.08) | -0.05 (-0.10, 0.01)  |  |  |
| Sex (female as reference group)         | Male                              | 0.11 (-0.25, 0.48)   | 0.17 (-0.24, 0.57)   |  |  |
| Colf reported distance                  | History of behavioural repetition | 0.00 (-0.12, 0.11)   | -0.15 (-0.24, -0.06) |  |  |
| babite                                  | Lack of control                   | 0.01 (-0.10, 0.12)   | -0.09 (-0.21, 0.03)  |  |  |
| nabits                                  | Lack of awareness                 | -0.01 (-0.13, 0.11)  | -0.11 (-0.22, 0.01)  |  |  |
| Calf non-outed                          | History of behavioural repetition | -0.01 (-0.12, 0.11)  | -0.07 (-0.16, 0.02)  |  |  |
| Self-reported exercise                  | Lack of control                   | -0.01 (-0.13, 0.11)  | -0.08 (-0.19, 0.02)  |  |  |
|   | Lack of awareness                 | 0.00 (-0.12, 0.11)   | -0.07 (-0.17, 0.03)  |  |  |
| Abbreviations: CI – Confidence interval |                                   |                      |                      |  |  |

**Table A4.** Sensitivity analyses: Multiple linear regression using imputed data to assess the effect of baseline participant characteristics on changes in symptoms of depression and anxiety – controlled for study arm and clustering by GP practice.

|   | Unstandardised coefficient (95% CI)                     |
|---|---|
| Participant characteristic at baseline                          | Change in anxiety from baseline to 3-months (n=1267)    |
| Baseline depression   | 0.07 (0.00, 0.14)                                       |
| Baseline anxiety  | -0.18 (-0.24, -0.12)                                    |
| Participant characteristic at baseline                          | Change in depression from baseline to 3-months (n=1267) |
| Baseline depression   | -0.17 (-0.23, -0.10)                                    |
| Self-reported dietary habits: History of behavioural repetition | -0.09 (-0.18, -0.01)                                    |
| Abbreviations: CI – Confidence interval                         |   |

# A6.4 Effect of early changes in participant characteristics on changes in depression and anxiety

Table A5. Independent linear regression to assess the effect of early changes in participant characteristics on changes in symptoms of depression

and anxiety – controlled for study arm and clustering by GP practice.

|                                     |                                      | Unstandardised                        | Number of    | Unstandardised         | Number of      |
|-------------------------------------|--------------------------------------|---------------------------------------|--------------|------------------------|----------------|
|                                     |                                      | coefficient (95% CI)                  | participants | coefficient (95% CI)   | participants   |
| Change from brooking to 2 months in |                                      | Change in depression from baseline to |              | Change in anxiety from | baseline to 3- |
| Change nom baseline                 |                                      | 3-months                              |              | months                 |                |
| Global quality of life              |                                      | -2.96 (-4.68, -1.24)                  | 887          | -2.00 (-3.07, -0.93)   | 887            |
| Satisfaction with life              |                                      | -0.10 (-0.14, -0.06)                  | 912          | -0.09 (-0.12, -0.05)   | 912            |
| Total dietary restrain              | nt                                   | -0.14 (-0.19, -0.09)                  | 929          | -0.02 (-0.09, 0.05)    | 929            |
| Flexible dietary restr              | aint                                 | -0.23 (-0.30, -0.15)                  | 929          | -0.05 (-0.14, 0.05)    | 929            |
| <b>Rigid dietary restrain</b>       | it                                   | -0.16 (-0.25, -0.07)                  | 929          | -0.02 (-0.14, 0.10)    | 929            |
| Treatment self-                     | Autonomous regulation score          | -0.11 (-0.19, -0.02)                  | 855          | 0.09 (-0.04, 0.21)     | 855            |
| regulation                          | <b>Controlled regulation score</b>   | 0.13 (-0.02, 0.28)                    | 849          | 0.19 (0.03, 0.35)      | 849            |
|                                     | Autonomous self-control              | -0 17 (-0 39 0 06)                    | 91/          | -0.06 (-0.34, 0.23)    | 91/            |
| Dist colf-regulation                | score                                | -0.17 (-0.35, 0.00)                   | J14          | -0.00 (-0.34, 0.23)    | J14            |
| Diet sell-legulation                | Controlled self-control score        | 0.12 (-0.05, 0.30)                    | 911          | 0.25 (0.09, 0.41)      | 911            |
|                                     | Amotivation score                    | 0.12 (-0.04, 0.28)                    | 910          | 0.16 (0.02, 0.30)      | 910            |
|                                     | Autonomous self-control              |                                       | 803          | -0.16(-0.31, -0.02)    | 803            |
| Exercise self-                      | score                                | -0.14 (-0.30, 0.01)                   | 033          | -0.10 (-0.31, -0.02)   | 695            |
| regulation                          | Control score                        | 0.20 (-0.02, 0.42)                    | 889          | 0.18 (-0.03, 0.40)     | 889            |
|                                     | Amotivation score                    | 0.02 (-0.17, 0.20)                    | 885          | 0.06 (-0.08, 0.21)     | 885            |
| Self-reported<br>dietary habits     | History of behavioural<br>repetition | 0.30 (0.21, 0.39)                     | 909          | 0.07 (-0.03, 0.18)     | 909            |

|                         | Lack of control                    | 0.15 (0.06, 0.24)   | 891 | 0.07 (-0.03, 0.17)  | 891 |
|-------------------------|------------------------------------|---|-----|---------------------|-----|
|                         | Lack of awareness                  | 0.28 (0.17, 0.38)   | 902 | 0.09 (-0.01, 0.18)  | 902 |
| Self-reported           | History of behavioural repetition  | 0.21 (0.08, 0.34)   | 902 | 0.16 (0.03, 0.30)   | 902 |
| exercise habits         | Lack of control                    | 0.13 (0.02, 0.23)   | 886 | 0.16 (0.05, 0.28)   | 886 |
|                         | Lack of awareness                  | 0.15 (0.04, 0.26)   | 891 | 0.17 (0.04, 0.30)   | 891 |
| Change from baseline    | e to 3-months in :                 | Change in depression from 3- to 12-<br>months Change in anxiety from 3- to 12-r |     | - to 12-months      |     |
| Global quality of life  |                                    | 0.84 (-0.47, 2.14)  | 676 | 0.66 (-0.68, 2.00)  | 676 |
| Satisfaction with life  |                                    | 0.02 (-0.02, 0.06)  | 690 | 0.01 (-0.02, 0.04)  | 690 |
| Total dietary restrain  | nt                                 | 0.07 (0.00, 0.14)   | 700 | 0.05 (-0.01, 0.11)  | 700 |
| Flexible dietary restr  | Flexible dietary restraint         |   | 700 | 0.06 (-0.05, 0.17)  | 700 |
| Rigid dietary restraint |                                    | 0.12 (0.01, 0.23)   | 700 | 0.08 (-0.04, 0.20)  | 700 |
| Treatment self-         | Autonomous regulation score        | 0.10 (-0.03, 0.24)  | 640 | 0.10 (-0.06, 0.26)  | 640 |
| regulation              | <b>Controlled regulation score</b> | 0.02 (-0.24, 0.28)  | 635 | 0.10 (-0.12, 0.33)  | 635 |
| Dist calf very lation   | Autonomous self-control score      | 0.14 (-0.11, 0.39)  | 687 | 0.10 (-0.15, 0.35)  | 687 |
| Diet self-regulation    | Controlled self-control score      | 0.11 (-0.20, 0.42)  | 684 | 0.01 (-0.16, 0.17)  | 684 |
|                         | Amotivation score                  | -0.08 (-0.24, 0.08)   | 684 | -0.10 (-0.26, 0.05) | 684 |
| Exercise self-          | Autonomous self-control<br>score   | 0.07 (-0.16, 0.30)  | 673 | -0.02 (-0.18, 0.14) | 673 |
| regulation              | Control score                      | -0.01 (-0.25, 0.23)   | 670 | -0.03 (-0.25, 0.19) | 670 |
|                         | Amotivation score                  | 0.04 (-0.19, 0.27)  | 667 | 0.03 (-0.22, 0.27)  | 667 |
| Self-reported           | History of behavioural repetition  | -0.01 (-0.16, 0.13)   | 684 | 0.02 (-0.08, 0.13)  | 684 |
| dietary habits          | Lack of control                    | 0.01 (-0.12, 0.15)  | 668 | 0.01 (-0.11, 0.12)  | 668 |
|                         | Lack of awareness                  | -0.07 (-0.23, 0.09)   | 677 | -0.01 (-0.11, 0.10) | 677 |

| Self-reported                 | History of behavioural repetition  | -0.03 (-0.13, 0.08)                           | 679 | 0.05 (-0.12, 0.21)                     | 679 |
|-------------------------------|------------------------------------|---|-----|--|-----|
| exercise habits               | Lack of control                    | 0.01 (-0.11, 0.12)                            | 665 | -0.10 (-0.23, 0.04)                    | 665 |
|                               | Lack of awareness                  | 0.02 (-0.10, 0.14)                            | 668 | 0.02 (-0.13, 0.17)                     | 668 |
| Change from baseline          | e to 3-months in :                 | Change in depression from 3- to 24-<br>months |     | Change in anxiety from 3- to 24-months |     |
| Global quality of life        |                                    | 0.12 (-1.99, 2.23)                            | 664 | 0.60 (-1.05, 2.26)                     | 664 |
| Satisfaction with life        |                                    | 0.05 (0.00, 0.10)                             | 678 | 0.02 (-0.03, 0.06)                     | 678 |
| Total dietary restrain        | nt                                 | 0.08 (-0.01, 0.18)                            | 691 | 0.04 (-0.05, 0.14)                     | 691 |
| Flexible dietary restr        | aint                               | 0.07 (-0.06, 0.19)                            | 691 | 0.01 (-0.11, 0.14)                     | 691 |
| <b>Rigid dietary restrain</b> | it                                 | 0.16 (0.01, 0.32)                             | 691 | 0.11 (-0.06, 0.28)                     | 691 |
| Treatment self-               | Autonomous regulation score        | 0.18 (0.00, 0.36)                             | 635 | 0.14 (-0.01, 0.28)                     | 635 |
| regulation                    | <b>Controlled regulation score</b> | 0.01 (-0.22, 0.24)                            | 629 | -0.12 (-0.31, 0.06)                    | 629 |
| Diet self-regulation          | Autonomous self-control score      | 0.15 (-0.05, 0.36)                            | 679 | 0.06 (-0.17, 0.29)                     | 679 |
|                               | Controlled self-control score      | -0.08 (-0.29, 0.13)                           | 676 | -0.17 (-0.36, 0.02)                    | 676 |
|                               | Amotivation score                  | -0.09 (-0.30, 0.13)                           | 675 | -0.04 (-0.26, 0.17)                    | 675 |
| Exercise self-                | Autonomous self-control<br>score   | 0.15 (-0.05, 0.34)                            | 664 | 0.05 (-0.18, 0.27)                     | 664 |
| regulation                    | Control score                      | 0.02 (-0.19, 0.23)                            | 660 | -0.07 (-0.28, 0.14)                    | 660 |
|                               | Amotivation score                  | -0.09 (-0.25, 0.07)                           | 657 | -0.11 (-0.29, 0.08)                    | 657 |
| Self-reported                 | History of behavioural repetition  | -0.15 (-0.34, 0.03)                           | 675 | -0.03 (-0.14, 0.08)                    | 675 |
| dietary habits                | Lack of control                    | -0.06 (-0.21, 0.10)                           | 660 | -0.09 (-0.24, 0.07)                    | 660 |
|                               | Lack of awareness                  | -0.07 (-0.22, 0.09)                           | 667 | -0.04 (-0.18, 0.10)                    | 667 |
| Self-reported                 | History of behavioural repetition  | -0.13 (-0.30, 0.05)                           | 668 | -0.06 (-0.33, 0.22)                    | 668 |
|                               | Lack of control                    | -0.08 (-0.20, 0.05)                           | 657 | -0.14 (-0.32, 0.05)                    | 657 |

|   | Lack of awareness                 | -0.17 (-0.34, 0.00)                           | 661 | -0.10 (-0.30, 0.10)                    | 661 |
|---|-----------------------------------|---|-----|--|-----|
| Change from baseline to 3-months in :   |                                   | Change in depression from 3- to 60-<br>months |     | Change in anxiety from 3- to 60-months |     |
| Global quality of life                  |                                   | 1.61 (-1.05, 4.27)                            | 400 | 1.48 (-0.71, 3.68)                     | 400 |
| Satisfaction with life                  |                                   | 0.07 (0.00, 0.14)                             | 410 | 0.04 (-0.04, 0.13)                     | 410 |
| Total dietary restrain                  | it                                | 0.09 (0.01, 0.18)                             | 413 | 0.00 (-0.11, 0.11)                     | 413 |
| Flexible dietary restr                  | aint                              | 0.03 (-0.09, 0.16)                            | 413 | -0.04 (-0.23, 0.14)                    | 413 |
| <b>Rigid dietary restrain</b>           | t                                 | 0.23 (0.08, 0.38)                             | 413 | 0.05 (-0.15, 0.25)                     | 413 |
| Treatment self-                         | Autonomous regulation score       | 0.07 (-0.20, 0.34)                            | 406 | -0.04 (-0.28, 0.20)                    | 406 |
| regulation                              | Controlled regulation score       | -0.13 (-0.57, 0.30)                           | 401 | -0.37 (-0.69, -0.05)                   | 401 |
| Dist colf regulation                    | Autonomous self-control score     | -0.09 (-0.56, 0.38)                           | 408 | -0.44 (-0.78, -0.09)                   | 408 |
| Diet self-regulation                    | Controlled self-control score     | -0.07 (-0.47, 0.32)                           | 406 | -0.37* (-0.61, -0.12)                  | 406 |
|   | Amotivation score                 | -0.15 (-0.33, 0.03)                           | 405 | -0.03 (-0.35, 0.30)                    | 405 |
| Exercise self-                          | Autonomous self-control score     | -0.17 (-0.44, 0.09)                           | 400 | -0.32 (-0.56, -0.07)                   | 400 |
| regulation                              | Control score                     | -0.12 (-0.44, 0.20)                           | 397 | -0.20 (-0.48, 0.09)                    | 397 |
|   | Amotivation score                 | -0.25 (-0.52, 0.03)                           | 396 | -0.03 (-0.37, 0.31)                    | 396 |
| Self-reported                           | History of behavioural repetition | -0.17 (-0.40, 0.07)                           | 402 | -0.01 (-0.28, 0.27)                    | 402 |
| dietary habits                          | Lack of control                   | -0.02 (-0.20, 0.16)                           | 394 | 0.01 (-0.21, 0.22)                     | 394 |
|   | Lack of awareness                 | -0.11 (-0.26, 0.04)                           | 400 | 0.02 (-0.20, 0.23)                     | 400 |
| Self-reported                           | History of behavioural repetition | 0.05 (-0.12, 0.23)                            | 399 | 0.07 (-0.22, 0.36)                     | 399 |
| exercise habits                         | Lack of control                   | 0.01 (-0.23, 0.25)                            | 391 | -0.07 (-0.37, 0.23)                    | 391 |
|   | Lack of awareness                 | 0.08 (-0.11, 0.26)                            | 394 | 0.03 (-0.26, 0.33)                     | 394 |
| Abbreviations: CI – Confidence interval |                                   |   |     |  |     |

A6.5 Number and percentage of missing data for all study variables.

 Table A6. Number and percentage of missing data for all study variables.

| Participant characteristics         |              | Number (and percentage) of missing data |              |              |               |  |
|-------------------------------------|--------------|---|--------------|--------------|---------------|--|
|                                     |              | Brief intervention                      | 12-week CWMP | 52-week CWMP | Total (/1267) |  |
|                                     |              | (/211)                                  | (/528)       | (/528)       | 10tat (/1207) |  |
| Age (years)                         | At baseline  | 0                                       | 0            | 0            | 0             |  |
| Sex                                 | At baseline  | 0                                       | 0            | 0            | 0             |  |
| Education                           | At baseline  | 15 (7%)                                 | 54 (10%)     | 61 (12%)     | 130 (10 %)    |  |
| Socioeconomic status                | At baseline  | 0                                       | 0            | 2 (0%)       | 2 (0 %)       |  |
|                                     | At baseline  | 7 (3%)                                  | 12 (2%)      | 11 (3%)      | 30 (2%)       |  |
|                                     | 3-months*    | 79 (37%)                                | 149 (28%)    | 94 (18%)     | 322 (25%)     |  |
| Depression score                    | 12-months*   | 103 (49%)                               | 208 (39%)    | 191 (36%)    | 502 (40%)     |  |
|                                     | 24-months*   | 96 (46%)                                | 210 (40%)    | 200 (38%)    | 506 (40%)     |  |
|                                     | 60-months*   | 145 (69%)                               | 320 (61%)    | 324 (61%)    | 789 (62%)     |  |
|                                     | At baseline  | 7 (3%)                                  | 12 (2%)      | 11 (3%)      | 30 (2%)       |  |
|                                     | 3-months*    | 79 (37%)                                | 149 (28%)    | 94 (18%)     | 322 (25%)     |  |
| Anxiety score                       | 12-months*   | 103 (49%)                               | 208 (40%)    | 191 (36%)    | 502 (40%)     |  |
|                                     | 24-months*   | 96 (45%)                                | 210 (40%)    | 200 (38%)    | 506 (40%)     |  |
|                                     | 60-months*   | 145 (69%)                               | 320 (61%)    | 324 (61%)    | 789 (62%)     |  |
| $\mathbf{DMI}\left(leg(m^2)\right)$ | At baseline  | 0                                       | 0            | 0            | 0             |  |
| BMI (Kg/m²)                         | At 3-months* | 67 (32%)                                | 123 (23%)    | 73 (14%)     | 263 (21%)     |  |
| Global quality of life              | At baseline  | 14 (7%)                                 | 20 (4%)      | 24 (5%)      | 58 (5%)       |  |
|                                     | At 3-months* | 82 (39%)                                | 159 (30%)    | 106 (20%)    | 347 (27%)     |  |
| Satisfaction with life              | At baseline  | 9 (4%)                                  | 14 (3%)      | 17 (3%)      | 40 (3%)       |  |
|                                     | At 3-months* | 80 (38%)                                | 152 (29%)    | 100 (19%)    | 332 (26%)     |  |

| Total dietary restraint    |                        | At baseline  | 7 (3%)   | 12 (2%)   | 12 (2 %)  | 31 (2%)    |
|----------------------------|------------------------|--------------|----------|-----------|-----------|------------|
|                            |                        | At 3-months* | 80 (38%) | 148 (28%) | 93 (181%) | 321 (25%)  |
| Flexible dietary restraint |                        | At baseline  | 7 (3%)   | 12 (2%)   | 12 (2%)   | 31 (2%)    |
|                            |                        | At 3-months* | 80 (38%) | 148 (28%) | 93 (18%)  | 321 (25%)  |
| <b>Rigid dietary res</b>   | straint                | At baseline  | 7 (3%)   | 12 (2%)   | 12 (2%)   | 31 (2%)    |
|                            |                        | At 3-months* | 80 (38%) | 148 (28%) | 93 (18%)  | 321 (25%)  |
| Entering                   | Autonomous             | At baseline  | 7 (3%)   | 10 (2%)   | 12 (2%)   | 29 (2%)    |
| regulation.                | regulation score       | At 3-months* | 91 (43)  | 177 (34%) | 131 (25%) | 399 (31%)  |
|                            | Controlled             | At baseline  | 9 (4%)   | 13 (2%)   | 14 (3%)   | 36 (3%)    |
|                            | regulation score       | At 3-months* | 91 (43%) | 177 (34%) | 131 (25%) | 399 (31%)  |
| Diet self-                 | Autonomous self-       | At baseline  | 7 (3%)   | 12 (2%)   | 13 (2%)   | 32 (3%)    |
| regulation: cor            | control score          | At 3-months* | 81 (38%) | 153 (29%) | 102 (19%) | 336 (27%)  |
|                            | Controlled self-       | At baseline  | 7 (3%)   | 13 (2%)   | 14 (3%)   | 34 (3%)    |
| control score              | control score          | At 3-months* | 82 (39%) | 153 (29%) | 102 (19%) | 337 (27%)  |
| Amotivation                | Amotivation score      | At baseline  | 7 (3%)   | 14 (3%)   | 16 (3%)   | 37 (3%)    |
|                            | Amotivation score      | At 3-months* | 82 (39%) | 154 (29%) | 102 (19%) | 338 (27%)  |
| Exercise self-             | Autonomous self-       | At baseline  | 10 (5%)  | 15 (3%)   | 16 (3%)   | 41 (3%)    |
| regulation                 | control score          | At 3-months* | 86 (41%) | 163 (31%) | 107 (20%) | 356 (28%)  |
|                            | Controlled self-       | At baseline  | 10 (5%)  | 17 (3 %)  | 19 (4%)   | 46 (4%)    |
|                            | control score          | At 3-months* | 87 (41%) | 163 (31%) | 107 (20%) | 357 (28%)  |
|                            | Amotivation score      | At baseline  | 10 (5%)  | 18 (3%)   | 22 (4%)   | 50 (4%)    |
|                            |                        | At 3-months* | 87 (41%) | 164 (31%) | 108 (20%) | 359 (28 %) |
| Self-reported              | History of behavioural | At baseline  | 9 (4%)   | 18 (3%)   | 12 (2%)   | 39 (3%)    |
| aretary navits.            | repetition             | At 3-months* | 81 (38%) | 153 (29%) | 106 (20%) | 340 (27%)  |
|                            | Lack of control        | At baseline  | 9 (4%)   | 19 (4%)   | 17 (3%)   | 45 (4%)    |

|   |   | At 3-months* | 82 (39%)    | 157 (30%)      | 107 (20%)  | 346 (27%) |
|---|---|--------------|-------------|----------------|------------|-----------|
|   | Lack of awareness   | At baseline  | 11 (5%)     | 22 (4%)        | 22 (4%)    | 55(4%)    |
|   |   | At 3-months* | 83 (39%)    | 159 (30%)      | 113 (21%)  | 355 (28%) |
| Self-reported   | History of  | At baseline  | 9 (4%)      | 18 (3%)        | 14 (3%)    | 41 (3%)   |
| habits:   | repetition  | At 3-months* | 82 (39 %)   | 155 (29%)      | 108 (20 %) | 345 (27%) |
| Lack of cont  | Lack of control   | At baseline  | 9 (4%)      | 25 (5%)        | 20 (4%)    | 54 (4%)   |
|   |   | At 3-months* | 84 (40%)    | 158 (30%)      | 111 (21%)  | 353 (28%) |
|   |   | At baseline  | 11 (5%)     | 26 (5%)        | 21 (4%)    | 58 (5%)   |
|   | Lack of awareness   | At 3-months* | 85 (40.28%) | 159 (30%)      | 114 (22%)  | 358 (28%) |
| Total number of Weight Watchers sessions attended<br>in the first 3-months*                                   |   | 256 (48%)    | 168 (32%)   | 424/1056 (40%) |            |           |
| Weekly use of WW e-tools/online resources *   |   | 173 (33%)    | 128 (24%)   | 301/1056 (29%) |            |           |
| Weekly use of WW mobile app *   |   | 172 (33%)    | 127 (24%)   | 299/1056 (28%) |            |           |
| * variables excluded from multiple imputation by chained equations due to greater than 25% total missing data |   |              |             |                |            |           |
| Abbreviations: BI   | Abbreviations: BI - Brief Intervention, CWMP - Commercial Weight Management Programme, WW – Weight Watchers |              |             |                |            |           |

# A7. Appendices for Chapter Seven

# A7.1 SWiM-C Trial Protocol

| -   | Supporting Weight Management during                            |  |  |  |  |
|---|--|--|--|--|--|
| SUPPORTING WEIGHT MANAGEMENT                          | COVID-19 – The SWiM-C Randomised                               |  |  |  |  |
|   | Controlled Trial   |  |  |  |  |
| Scientific title                                      | An acceptance-based programme for weight management during     |  |  |  |  |
|   | the COVID-19 pandemic in people with overweight and obesity    |  |  |  |  |
|   | (SWiM-C Study).  |  |  |  |  |
| Lay title   | Supporting Weight Management during COVID-19 (SWiM-C)          |  |  |  |  |
| Trial Registration                                    | ISRCTN12107048   |  |  |  |  |
| REC Reference   | PRE.2020.049 COV19   |  |  |  |  |
| Funding reference         NIHR-PGfAR RP-PG-0216-20010 |  |  |  |  |  |
| Sponsor   | Carolyn Read, Research Governance Officer                      |  |  |  |  |
|   | University of Cambridge, School of Clinical Medicine, Box 111, |  |  |  |  |
|   | Cambridge Biomedical Campus, Cambridge, CB2 0SP                |  |  |  |  |
|   |  |  |  |  |  |
|   |  |  |  |  |  |
| Principal Investigator                                | Dr Amy Ahern   |  |  |  |  |
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|   | 01223 769138   |  |  |  |  |
|   | Ala34@cam.ac.uk  |  |  |  |  |
| Study Coordinator                                     | Mrs Jenny Woolston   |  |  |  |  |
| (contact for public                                   | MRC Epidemiology Unit, University of Cambridge, Box 285,       |  |  |  |  |
| queries)  | Institute of Metabolic Sciences, CB2 0QQ                       |  |  |  |  |
|   | 01223 769204   |  |  |  |  |

|                  | Jenny.Woolston@mrc-epid.cam.ac.uk                 |
|------------------|---|
| Co-Investigators | Dr Rebecca Richards, University of Cambridge      |
|                  | Ms Marie Stubbings, University of Cambridge       |
|                  | Ms Fiona Whittle, University of Cambridge         |
|                  | Ms Rebecca Jones, University of Cambridge         |
|                  | Mr Jack Birch, University of Cambridge            |
|                  | Professor Simon Griffin, University of Cambridge  |
|                  | Mr Stephen Sharp, University of Cambridge         |
|                  | Professor Andrew Hill, University of Leeds        |
|                  | Dr Robbie Duschinsky, University of Cambridge     |
|                  | Professor Stephen Morris, University of Cambridge |
|                  | Dr Carly Hughes, The Fakenham Medical Practice    |
|                  | Professor Alan Brennan, University of Sheffield   |
|                  | Dr Francesco Fusco, University of Cambridge       |
|                  | Mrs Jennifer Bostock, PPI Representative          |

### **Protocol Signatures**

I give my approval for the attached protocol entitled "An acceptance-based programme for weight management during the COVID-19 pandemic in people with overweight and obesity (SWiM-C randomised controlled trial)" version 5.0, dated 25/05/2021

Principal Investigators

Name: Dr Amy Ahern

Signature: \_\_\_\_\_

Date: \_\_\_25.05.2021\_\_\_\_\_\_

# Protocol Revision Chronology

| Version | Date       | Details                       |
|---------|------------|-------------------------------|
| 1.0     | 17/04/2020 | Original protocol             |
| 1.1     | 24/04/2020 | PHQ-9 is replaced with the    |
|         |            | PHQ-8. SWiM participants      |
|         |            | receive control materials     |
|         |            | after study ends.             |
| 2.0     | 18/05/2020 | Follow up changed to 4        |
|         |            | months                        |
| 3.0     | 26/06/2020 | Addition of social media      |
|         |            | advertising as method of      |
|         |            | recruitment                   |
| 4.0     | 03/08/2020 | Addition of qualitative SWiM  |
|         |            | coach interviews              |
| 5.0     | 25/05/2021 | Addition of a 12 month follow |
|         |            | up                            |

## Acronyms and abbreviations

| ACT | Acceptance and Commitment Therapy                                   |
|-----|---|
|     | ACT is an action-based approach to behavioural therapy that         |
|     | encourages accepting thoughts and feelings, rather than fighting or |
|     | avoiding them, or trying to change them. ACT encourages             |
|     | responding to thoughts in a more helpful way in order to move       |
|     | towards one's goals that are in line with core values. Another core |
|     | message of ACT is accepting what is outside of one's personal       |
|                 | control and committing to action to change things that are within    |
|-----------------|--|
|                 | one's control.   |
| COVID-19        | A new illness, caused by a virus called coronavirus, that can affect |
|                 | your lungs and airways.  |
| EASO            | European Association for the Study of Obesity                        |
|                 | EASO is a federation of professional membership associations from    |
|                 | 34 European countries. It is the voice of the European obesity       |
|                 | community, representing scientists, health care practitioners,       |
|                 | physicians, public health experts and patients. EASO is in official  |
|                 | relations with the World Health Organisation (WHO) Regional Office   |
|                 | for Europe and is a founding member of the EU Platform on Diet,      |
|                 | Physical Activity and Health.  |
| SWiM            | Supporting Weight Management during COVID-19                         |
|                 | A web-based supported self-help intervention that aims to support    |
|                 | adults with overweight and obesity to prevent weight gain by         |
|                 | helping them to manage their eating behaviours, be more physically   |
|                 | active and protect their emotional wellbeing.                        |
| - SWiM Sessions | Weekly modules delivering educational material, reflective exercises |
|                 | and behavioural experiments based on Acceptance and                  |
|                 | Commitment Therapy (ACT) and habit theory.                           |
| - SWiM Coach    | A trained member of the SWiM team providing telephone and            |
|                 | email-based support to intervention participants.                    |
| - SWiM Practice | Reflective exercises and behavioural experiments assigned at the     |
|                 | end of SWiM Sessions for participants to complete between            |
|                 | sessions.  |
| - SWiM Aids     | A feature of the SWiM platform that collates the core exercises and  |
|                 | concepts from each SWiM Session, providing the participants with     |
|                 | easy access to the core intervention components.                     |



#### BACKGROUND

The social distancing and isolation measures imposed during the COVID-19 pandemic beginning March 2020, including the closure of community weight management programmes and services, mean that adults with overweight and obesity in the UK are at increasing vulnerability to weight gain, and associated negative impacts on physical health and mental wellbeing. Usual habits and routines are disrupted, stress and anxiety are likely to be high, usual coping mechanisms may be limited, and people are likely to respond by developing unhealthy habits such as comfort eating and sedentary behaviour and may experience increased low mood resulting from this. We have previously shown that preventing weight gain can reduce diabetes incidence amongst people

with type 2 diabetes, even among people who already have overweight or obesity.<sup>339</sup> Other studies show that annual weight gain can typically be attributed to discrete periods of time (e.g., holidays) and that this weight gain is typically not compensated for.<sup>340,341</sup> Thus, weight gain during social distancing could have a significant impact on the health and wellbeing of people with overweight and obesity.

There is good evidence that interventions based on acceptance and commitment therapy (ACT) are effective for weight management and may improve mental wellbeing and psychological determinants of weight control.<sup>135</sup> However, acceptance-based programmes are usually psychologist-led and the cost and scarcity of psychologists specialising in obesity mean it is not possible to support everyone who would benefit from this type of intervention. It is possible to deliver self-help versions of acceptance-based programmes.<sup>140</sup> However, there is currently insufficient evidence on mode of delivery or cost-effectiveness to recommend scalable implementation of self-help versions of acceptance-based interventions, particularly in the context of weight management.<sup>135</sup>

We have developed a supported self-help intervention (SWiM; Supporting Weight Management during COVID 19) that aims to help adults with overweight and obesity to manage their weight and eating behaviour, be more physically active, and protect their emotional wellbeing. This intervention is adapted from the SWiM programme, which was originally developed to help people to maintain weight after weight loss. The adaptations speak specifically to the restrictions associated with COVID 19, including outside access, social distancing, and isolation. The 12-week intervention is based on ACT, targets known psychological determinants of weight management and is delivered via an online platform with remote support from a guide or coach. The current study compares the effectiveness of SWiM with standard written materials giving advice on diet, physical activity and mental health during the COVID-19 pandemic.

The COVID19 crisis represents a unique situation of unknown duration, but some form of social distancing is likely to last for many months and could reoccur. If the SWiM intervention proves to be effective it could be rolled out on a larger scale to support people through the current crisis. Findings may also be generalisable to other situations involving high levels of stress, reduced access to resources, and/or low levels of mobility. Qualitative interviews with participants will give insight into the extent to which findings from this study are context dependent and give insight into how the intervention could be adapted for other contexts.

## AIMS AND OBJECTIVES

### Aim

To evaluate the effect of the SWiM intervention on weight, eating behaviour, physical activity and wellbeing compared to current standard advice for people with overweight and obesity. Primary Objective

To evaluate the effect of SWiM on weight at 4 months and 12 months follow-up, compared to standard advice on diet, physical activity and mood.

## **Secondary Objectives**

To evaluate the effect of SWiM on eating behaviour, physical activity and psychological wellbeing compared to standard advice.

To evaluate the cost-effectiveness of the SWiM intervention compared to standard advice.

To understand the experience of participants and the extent to which the programme meets their needs.

To explore potential causal mechanisms, and contextual factors that may be associated with variations in outcome.

## STUDY DESIGN

This is a pragmatic, randomised, single-blind, parallel group, two-arm trial. Participants will be randomised to either the SWiM intervention or to a standard advice wait list control using a computer-generated sequence with 1:1 allocation stratified by sex and BMI classification. Participants will complete outcome assessments online at baseline, at 4 months and at 12 months follow-up.

## PARTICIPANTS

Participants (N=360) will be adults with overweight or obesity (Age  $\geq$ 18 years; BMI $\geq$ 25kg/m2) who have a good understanding of written English (materials are not suitable for non-English language speakers), are willing to be randomised to either intervention and to complete outcome assessments online, and who own a set of scales that they can weigh themselves with during the study. Participants will be excluded from taking part if they have had bariatric surgery in the last 2 years.

#### 4.1 Recruitment

Participants will be recruited online through obesity and weight management organisations, volunteer databases and social media. Recruitment adverts have been reviewed by patient and public involvement representatives to ensure sensitivity. Adverts and email invitations will include a link to a secure web form which will be used to provide participant information, confirm eligibility, and obtain informed consent. Once informed consent is given, baseline data will be collected.

#### Randomisation

Once baseline data have been collected, eligible participants will be allocated to one of the two intervention arms in a 1:1 allocation using block randomisation (block size 6) stratified by BMI classification (25-30, 30-40, 40+) and sex (male, female). The randomisation sequence will be computer-generated by the trial statistician and incorporated into the trial database by the data manager. The sequence will be unknown to all other personnel, including study coordinators, outcome assessors and investigators.

Randomised allocation will be revealed to the participant by phone or email, which will provide detail of the allocated intervention. If they have been allocated to SWiM, they will receive a web link to access the website with instructions for getting started. If allocated to standard advice waitlist control, they will be emailed a PDF of the European Association for the Study of Obesity (EASO) guidance on diet, physical activity and mood during the COVID 19 pandemic.<sup>342</sup>

#### PLANNED INTERVENTION AND CONTROL

## 5.1 Supporting Weight Management during the COVID-19 pandemic (SWiM) programme

SWiM is a supported self-help programme that uses acceptance-based strategies to support adults with overweight and obesity to manage their weight and eating behaviour, be more physically active, and protect their emotional wellbeing. The intervention includes access to an online web platform with 12 modules (SWiM sessions) consisting of psychoeducational content, reflective exercises, and behavioural experiments. Content is described in Table 1. SWiM is intended to be a 12 week intervention, with 1 session completed per week. Participants are encouraged to weigh themselves weekly and to record their weight at the start of each session. Between sessions, participants are asked to complete more reflective exercises and behavioural experiments known as 'SWiM Practice'. Automated email reminders are sent to participants to remind them to log in and complete sessions each week. After the participant has completed the week 4 session, they will receive a telephone call from their SWiM Coach. This will be a 20 minute call to check in and see how the participant is getting on with the intervention and to ensure they understand the content. A tailored email will also be sent at week 10. At the end of the study, participants will then receive the same standard advice materials as the control group.

| Session                          | Content                                |
|----------------------------------|--|
| Welcome to SWiM                  | What is SWiM?                          |
|                                  | Let's take a tour around SWiM!         |
|                                  | Meet the SWiM Team                     |
| Session 1: Eating Well During    | 1.0 Tracking Your Progress             |
| Lockdown                         | 1.1 Eating Well During The Lockdown    |
|                                  | 1.2 Alcohol and COVID19                |
|                                  | 1.3 SWiM Practice: Planning Your Meals |
| Session 2: Staying Active During | 2.0 Checking in                        |
| Lockdown                         | 2.1 Physical Activity and COVID19      |
|                                  | 2.2 Physical Activity Recommendations  |
|                                  | 2.2 Tips for Staying Active            |

| TABLE 1. | SWiM    | Intervention | Outline a  | nd Content |
|----------|---------|--------------|------------|------------|
|          | 2441141 |              | outilite u |            |

|                                      | 2.3 SWiM Practice: Your Physical Activity Plan  |
|--------------------------------------|---|
| Session 3: Planning and Goal-Setting | 3.0 Checking in                                 |
|                                      | 3.1 Your Weight Maintenance Plan                |
|                                      | 3.2 SMART Goals and Plans                       |
|                                      | 3.3 SWiM Practice: Goal Setting                 |
| Session 4: Control and Acceptance    | 4.0 Checking in                                 |
|                                      | 4.1 Control and Acceptance                      |
|                                      | 4.2 What Matters to You?                        |
|                                      | 4.3 SWiM Practice: Values, Goals and Actions    |
| Session 5: Being Willing             | 5.0 Checking in                                 |
|                                      | 5.1 Values and Goals                            |
|                                      | 5.2 Being Willing                               |
|                                      | 5.3 SWiM Practice: 'Even If' Thoughts           |
| Session 6: Overcoming Obstacles      | 6.0 Checking in                                 |
|                                      | 6.1 Identifying Your Obstacles                  |
|                                      | 6.2 Planning for Obstacles                      |
|                                      | 6.3 How to Deal with a Lapse                    |
|                                      | 6.4 SWiM Practice: Being BOLD                   |
| Session 7: Emotional Eating          | 7.0 Checking in                                 |
|                                      | 7.1 What is Emotional Eating?                   |
|                                      | 7.2 Breaking the Cycle                          |
|                                      | 7.3 SWiM Practice: Emotional Responses Diary    |
| Session 8: Stress Management         | 8.0 Checking in                                 |
|                                      | 8.1 Stress and Weight Gain                      |
|                                      | 8.2 Control What You Can, Accept What You Can't |
|                                      | 8.3 Defusion: Unplugging the Sink               |
|                                      | 8.4 Mindful Breathing                           |
|                                      | 8.5 How to get a good night's sleep             |
|                                      | 8.6 SWiM Practice: Practising Defusion          |
| Session 9: Urges and Cravings        | 9.0 Checking in                                 |
|                                      | 9.1 We All Have Urges and Cravings              |

#### BEHAVIOURAL WEIGHT MANAGEMENT INTERVENTIONS

|                                       | 9.2 Recapping Defusion                         |
|---------------------------------------|--|
|                                       | 9.3 Urge Surfing                               |
|                                       | 9.4 SWiM Practice: Learning to Surf            |
| Session 10: Habits and Being Flexible | 10.0 Checking in                               |
|                                       | 10.1 Forming Helpful Habits                    |
|                                       | 10.2 Breaking Unhelpful Habits                 |
|                                       | 10.3 Being Flexible                            |
|                                       | 10.4 SWiM Practice: Breaking Unhelpful Habits  |
| Session 11: Weight Stigma and Self-   | 11.0 Checking in                               |
| Acceptance                            | 11.1 The Impact of Weight Stigma               |
|                                       | 11.2 How to Deal with Weight Stigma            |
|                                       | 11.3 Self-Acceptance                           |
|                                       | 11.4 SWiM Practice: Practicing Self-Acceptance |
| Session 12: Friends and Family        | 12.0 Checking in                               |
|                                       | 12.1 Friends and Family                        |
|                                       | 12.2 How to Get the Support You Need           |
|                                       | 12.3 Breaking Unhelpful Food Rules             |
|                                       | 12.4 SWiM Practice: Rule Breaking and Being    |
|                                       | Assertive                                      |
|                                       | 12.5 Going Forward – Maintaining Motivation    |

#### Web Platform

On the SWiM web platform, intervention content is divided into SWiM sessions, which are each divided into activities. Progress through the sessions is presented as a 'journey' using a map-like graphic. Star icons "light up" when activities/sessions are competed (figure.2). As participants complete core skills exercises, these are stored in "SWiM Aids" where they can be accessed without revisiting specific sessions. The web platform is designed to allow participants to revisit past sessions and skills, and it is intended that future roll out would include indefinite access to the website.



Figure 2: Screenshot of participant 'journey' page of SWiM website

The web platform includes a weight tracker, which tracks weight over time, displayed in a visual graphic display. The weight tracker generates a line graph that automatically updates as data is inputted by the participant. As part of the first session, participants are asked to enter their current weight. The weight tracker automatically sets a weight maintenance target range with a boundary of +/-3kg that they are encouraged to stick within. This boundary can be adjusted if required as weight changes over time. Each session starts with a reflection on the previous session and SWiM practice and entry of weight data into the tracker.

#### 5.2 Control Intervention

Participants who are randomised to the control arm will receive standard advice from the European Association for the Study of Obesity (EASO) on diet, physical activity and mood during

the COVID 19 pandemic.<sup>342</sup> They will also be wait-listed to receive access to the SWiM website after the study ends.

## OUTCOMES AND MEASURES

## **Primary Outcome**

• Self-reported weight at 4 months.

## Secondary Outcomes

- Patient Health Questionnaire 8-item (PHQ-8) <sup>267,268</sup>
- Generalized Anxiety Disorder 7-item (GAD-7) scale<sup>269</sup>
- Perceived Stress Scale (PSS-4)
- Acceptance and Action Questionnaire Weight Related (Revised) (AAQW-R) <sup>343</sup>
- Three-Factor Eating Questionnaire (TFEQ-R21) <sup>225</sup>
- International Physical Activity Questionnaire (IPAQ) <sup>344</sup>
- Health related quality of life and wellbeing (EQ-5D-L ; ICECAP-A ) <sup>345346</sup>
- Website Usage (data analytics)

They will also complete bespoke questionnaires on demographics and intervention engagement (adapted from Perski et al., 2020)<sup>347</sup>

## MEASUREMENTS AND DATA COLLECTION

## Visit Schedule

Participants will complete online assessments at 0,4 and 12 months. Details of which measures will be taken at each timepoint are summarised in Table 4. Participants will be given an honorarium for completing (£10 for baseline and £20 for the 4 and 12 month visit). Honoraria for assessment completion are not dependent on intervention engagement/completion.

|                            | STUDY PERIO     |          |           |           |
|----------------------------|-----------------|----------|-----------|-----------|
|                            | Enrolment       | Baseline | Follow Up |           |
| TIMEPOINT**                | -t <sub>1</sub> | 0        | 4 months  | 12 months |
| ENROLMENT:                 |                 |          |           |           |
| Online screening           | Х               |          |           |           |
| Informed consent           |                 | Х        |           |           |
| Randomisation              |                 | Х        |           |           |
| INTERVENTIONS:             |                 |          |           |           |
| Supporting Weight          |                 |          |           |           |
| Maintenance (SWiM)         |                 |          |           |           |
| Standard Advice            |                 | Х        |           |           |
| ASSESSMENTS:               |                 |          |           |           |
| Height                     |                 | Х        |           |           |
| Weight                     |                 | Х        | Х         | Х         |
| Demographics               |                 | Х        |           |           |
| Eating Behaviour           |                 | Х        | х         | х         |
| Physical Activity          |                 | Х        | х         | Х         |
| Quality of Life /Wellbeing |                 | Х        | х         | Х         |
| Intervention Engagement    |                 |          | X         | Х         |

## TABLE 4: Schedule of Enrolment, Interventions, and Assessments

#### Outcome Assessments

All outcomes will be assessed via online self-report questionnaires. Participants will be asked to weigh themselves on the day that they complete the outcome assessment so that they can report a self-measured weight. At 12 months, intervention and control participants will complete the intervention engagement questionnaire, since control participants received access to the SWiM website after the 4-month follow-up. This will allow us to control for intervention engagement in analyses, and to compare intervention experiences between intervention participants who received the website in conjunction with support by a coach, and control participants who received only the website without coach support.

Participants will complete a demographics questionnaire at baseline based on Progress-Plus<sup>348</sup> factors.

The study coordination team will send email/phone reminders to participants if a questionnaire has not been completed after 7 days.

#### Website analytics

Engagement and intervention usage will be assessed through website analytics. Reports on webtraffic, frequency and duration of visits will be available via secure download directly from the SWiM online platform. Access will be limited to authorised members of the research team.

## STATISTICS AND QUANTITATIVE DATA ANALYSIS

#### Statistical analysis

A detailed statistical analysis plan will be developed and signed off by the Trial Steering Committee (TSC) prior to analysis. Participants will be analysed in the group to which they were randomised, based on the intention-to-treat principle. The primary analysis will estimate the baseline-adjusted difference between intervention groups in change in weight from baseline to 4 months, using a linear regression model including randomisation group, baseline weight, and the randomisation stratifiers (sex, BMI classification). Participants with missing values of weight

at 4 months will be excluded (ie, a complete-case analysis which assumes outcome data are missing at random conditional on covariates in the model). If there are >5% of participants with missing values of weight, a sensitivity analysis will be performed using multiple imputation by chained equations – this makes the missing at random assumption but provides increased precision compared with a complete-case analysis. Linear regression will be used to estimate the baseline-adjusted difference between intervention groups in change in weight from baseline to 12 months and 4 months to 12 months. Since the control group was waitlisted and therefore received access to the SWiM website after the 4-month follow-up, analyses at 12 months will need to account for intervention usage in the control group. Regression models for the 12-month follow-up will therefore include intervention engagement (as measured using the intervention engagement questionnaire and/or website analytics) as a covariate. Full details of this analysis will be provided in the statistical analysis plan. Continuous secondary outcomes will be analysed using the same method.

#### Sample size calculation

Based on previous trials of weight gain prevention over similar periods, we designed the study to have 90% power to detect a difference between randomised groups in mean change in body weight from baseline to 4 months of 1kg as significant at the 5% level. Based on our previous studies in similar populations, we assumed a SD of 6kg for weight and a correlation between repeated measures of 0.9. Allowing for a 20% drop out, 360 participants (180 per group) would be required.

#### Cost-effectiveness analysis

A cost-effectiveness analysis (CEA) will be undertaken, comparing the incremental costs and effects of the SWiM programme (i.e., acceptance-based weight maintenance) versus standard care.

The outcomes used in the cost-effectiveness analysis will be the change in weight over time and the health-related quality of life (HRQOL), which will be expressed in Quality Adjusted Life Years (QALYs). Although the current value set for the 5 levels version of the EuroQol EQ-5D

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questionnaire (EQ-5D-5L) suffer from low quality and reliability issues, we anticipate that these problems will be solved by the time the analysis will be performed. <sup>349</sup> In the absence of high-quality and reliable value set for the EQ-5D-5L, the analyses will be conducted using the cross-walk algorithm developed by van Hout et al as conform with the NICE position statement. <sup>349,350</sup>

Missing data in outcomes is anticipated, and it will be handled using multiple imputation methods.

The imputed mean cost and mean effectiveness in each arm will be used to obtain an incremental cost-effectiveness ratio (ICER), which is calculated by dividing the mean cost difference by the mean effectiveness difference. These mean differences will be ascertained by using regression methods and will be adjusted by the prespecified subgroups accordingly to the statistical analysis plan. Additionally, these regressions will be adjusted by the HRQOL, costs and any other unbalanced variable observed at randomisation. The uncertainty around the incremental cost and incremental effectiveness estimates will be calculated using non-parametric methods and presented as cost-effectiveness probabilities. A non-parametric bootstrapping will simulate an appropriate number of pairs of mean cost and effectiveness differences, which will be plotted on the cost-effectiveness plane. Estimating the proportion of the bootstrapped cost and effectiveness pairs with corresponding ICERs below the cost-effectiveness threshold will allow estimating the cost-effectiveness probability. Although NICE has identified a range of acceptable ICERs for an additional cost per additional QALYs (i.e., NICE thresholds: £20-30,000 per QALY), a similar threshold for bodyweight loss measures is not available yet. Therefore, the costeffectiveness probabilities will be computed by varying the maximum acceptable ICER and each time re-calculating the proportion of plotted points with ICERs below this figure. The so obtained probabilities will enable the construction of the cost-effectiveness acceptability curve. Besides the ICER, we will present the results of the analysis using quality of life data by calculating the net monetary benefits (NMB) of each intervention. NMB will be computed by using the NICE costeffectiveness thresholds to transform the health benefits in their health care costs equivalent. Therefore, the costs observed during the study will be subtracted to these monetary estimates of the health benefits to obtain the respective NMB for each arm. The intervention with the highest NMB will be considered cost-effective.

#### QUALITATIVE STUDY

The qualitative component of this feasibility study aims to explore participants' experiences of the intervention programme and the study, and the individual and contextual factors that influenced their engagement. We will also explore how well the intervention supports people's weight management and emotional wellbeing and how the programme could be improved to provide better support.

The qualitative component will further explore the SWiM coaches' experiences of delivering the intervention programme, engaging with participants, and supporting participants with weight management and emotional wellbeing. We aim to explore how the programme could be improved in the future.

#### Data collection

Individual semi-structured interviews (n~30) will be conducted at the end of the study. Participants will be purposively sampled using outcome data (broad demographic, range of adherence and weight outcomes) in participants from both trial arms (2:1 ratio, intervention: control). Questions will focus on participants' experiences of SWiM, including the benefits and challenges experienced, their remaining needs at the programme end, and the extent and manner of programme implementation. Participants will receive a £20 gift voucher as an honorarium for taking part in the qualitative interview.

All SWiM coaches (n=7) will be invited to take in individual semi-structured interviews. Questions will focus on coaches' experiences of delivering SWiM-C, including the engaging with participants, supporting participants' needs, and the programme acceptability. Participants will receive a £20 gift voucher as an honorarium for taking part in the qualitative interview.

#### Analysis

Qualitative analysis will explore the perceived feasibility and acceptability of the programme; individual and contextual factors that influence implementation and effectiveness; what participants experienced as key facilitators or barriers to weight control during the pandemic; the impact the intervention had on emotional wellbeing, and any needs they felt were not met. Data pertinent to different groups (intervention participants, control group participants, and SWiM-C coaches) will be analysed and presented separately. Findings will then be integrated narratively.

Recordings will be transcribed by an experienced external agency and checked for accuracy by the research team. Verbatim transcripts will be coded using NVivo software, retaining a focus on narrative sequences and transitions as well as salient themes. A dual coding approach will be used as follows: a first inductive round based on emerging themes relating to the research questions; a second round sensitised by quantitative findings. In the first inductive stage, open codes will be generated based on line-by-line scrutiny of verbatim transcripts uploaded into NVivo. Inconsistencies between coders will be resolved through discussion.

#### DATA MANAGEMENT

#### **Data Security**

The MRC Epidemiology Unit has an over-arching data management policy (DMP) that encompasses the standards and processes applied to all research and operational activities in the Unit. The PIs will ensure that all data generated, stored and shared from this trial will be handled in compliance with the DMP and the General Data Protection Regulations. The data controller will be the University of Cambridge. The legal basis for holding and processing the data as outlined in the protocol is to enable the team to conduct health research in the public interest.

All electronic data will be held on the Unit's secure networks, collated in version controlled uniquely identified databases.

Participation will be under full informed e-consent, including for the storage and use of data collected. At any point, participants can choose to opt out of any aspect of data collection or processing. As stated on the information sheet, any data collected up until the point of withdrawal will continue to be held by the study team.

Personal identifiable data will be held in the Study Database developed by the MRC Epidemiology Unit Data Manager in SQL server. It will have secure encrypted transmission. This will only be accessed by the core study team at the University of Cambridge using designated usernames and passwords. The database will be kept on the unit's private network which is used for the storage

of identifiable data. It is automatically backed up to ensure no loss of data. All systems are run by professional IT staff and data handling and back-up processes are managed to standards equivalent to those defined in the MRC Information Security Policy and meet the University of Cambridge Data Security Policy. The Study Coordinator and Data Manager will monitor the accuracy of the database with validation checks against the data collection forms. All resulting datasets will be anonymised and stored securely. The study database will also be used to record study data, including randomisation group, eligibility criteria met and attendance at appointments. Questionnaire webforms will be held in separate link-anonymised data files, and will be linked to other data sources for analysis using a link file stored in the study database.

The SWiM web-platform has been developed by Cauldron Science Ltd and is stored securely on Microsoft Azure which is a secure cloud based web host. All data is stored in a Microsoft Azure SQL database; this is stored in two different data centres both located within the European Union. Data inputted into the SWiM web-platform, including name and email address are stored securely in the Azure SQL database, which is encrypted at rest and only accessible with both the correct credentials and a whitelisted IP address. The University of Cambridge and Cauldron Science Ltd hold a data confidentiality agreement. The web platform is stored in accordance with the University of Cambridge data standards and such data is only accessible to the study team and Cauldron as the technical providers. All content is the intellectual property of the University of Cambridge. The study team at MRC Epidemiology will be responsible for downloading the research data via a secure download directly from the SWiM platform.

The qualitative interviews will be carried out by phone or using zoom (chats will be password protected to ensure privacy) and will be recorded using an Epidemiology Unit Dictaphone. The recordings will be transferred to the Unit's secure network as soon as they have been recorded.

Recordings will be transcribed by an experienced external agency and checked for accuracy by the research team. Verbatim transcripts will be coded using NVivo software, retaining a focus on narrative sequences and transitions as well as salient themes. This will help us understand participants' accounts of what mattered for their weight control and how these aspects fit within the context of their everyday lives. A dual coding approach will be used: a first inductive round based on emerging themes relating to the research questions; a second round sensitised by quantitative findings. In the first inductive stage, open codes will be generated based on line-by-425 line scrutiny of verbatim transcripts uploaded into NVivo. Inconsistencies between coders will be resolved through discussion.

## Link Anonymisation

Participants will complete an online screening questionnaire and will be assigned an anonymised participant ID number which will be unique to them. The Database Manager will have programmed a series of ID numbers into the database which will be assigned to participants in sequence. The ID number and participant's personal details will need to be linked in a separate database to enable us to contact participants for further follow up visits, but access to this information will be restricted to the database manager and the study coordinator. At the point the participant has been assigned an ID number, this will be used thereafter on all Case Report Forms and questionnaires; the only form to include the participants name will be the consent form which will be kept separately to the other study documents. Link-anonymised ID numbers will also be used to access online questionnaires.

Participant details will only be used when we mail out study information (eg. Newsletters) and questionnaires.

## Data Sharing during the Trial

Data sharing will be kept to the minimum required for the trial conduct and patient safety. Personal identifying information and outcome data will be kept separate at all times. Any data transfer will be encrypted and shared via a secure FTP server with appropriate data sharing agreements and consent in place.

Anonymised data sets may be shared with collaborators for research purposes. Each data request from outside the research team undergoes review by the PIs for scientific merit and integrity before any releases are made.

#### Data Forms and Data Entry

Online questionnaires will be completed via a dedicated programme that has been set up by the Data Team at the University of Cambridge. Online questionnaires will be exact copies of the paper forms. Data will be exported from the software programme by the study coordinator and saved on the secure network where 10% sense checks will be carried out. The Database Manager and the Study Coordinator will be responsible for data entry, quality and checking procedures.

#### Data Storage and Archiving

The Principal Investigators and Sponsor will take overall responsibility for data archiving with day to day responsibility delegated to the Database Manager and Study Coordinator. All data sets will be kept securely with no access from unauthorised personnel. Data will be stored so that it can be accessed, used and understood by subsequent users. When the investigators have completed their planned analyses, the anonymised data will be made available for use by others and will be shared under appropriate data sharing agreements. Primary data and the Trial Master File will be retained securely in their original form for a minimum of 10 years.

The MRC Epidemiology Unit will be responsible for archiving all documentation relating to the trial which will include consent forms, participant forms (screening questionnaires, CRFs, questionnaires), data, the study database, and results and associated files.

MRC policy is that: (i) primary research data are kept in original form for a minimum of 10 years from study end after which review will be carried out regularly to review retention; (ii) where consent has been taken, the original records covering the protocol, consent procedure, recruitment log and adverse event reports will be kept for 30 years after the end of the study in both digital and original form; and (iii) for clinical or public health studies, all records (other than those relating to consent) will be kept for 20 years to enable review and / or re-appraisal.

#### ADVERSE EVENTS

It is unlikely that we will experience adverse events as this is an online randomised controlled trial but in the event that we do, they will be reported according to unit policy and CETU SOP015 (Recording and reporting adverse events).

#### **RESEARCH GOVERNANCE AND APPROVALS**

The investigators will ensure that the trial conduct conforms to the principles of the Declaration of Helsinki (2008), ICH notes for Guidance on Good Clinical Practice and the Data Protection Act. All research participation will be done under written informed consent.

The protocol, participant information sheets, and e-consent form will be submitted for to the University of Cambridge Psychology Research Ethics Committee (PREC). No participants will be recruited until relevant approvals have been received. Where needed, the Investigators will submit any proposed substantial and non-substantial amendments to the protocol or other approved documents to the PREC for approval. Substantial amendments will not be implemented until relevant approvals have been given.

#### **ROLES AND RESPONSIBILITIES**

The MRC Epidemiology Unit, University of Cambridge is the lead institution. All Investigators contributed to the design of the protocol and the application for funding.

As Joint Principal Investigators, Dr Amy Ahern and Professor Simon Griffin have joint responsibility for the design and conduct of the trial and for the analysis and dissemination of results.

As the Study Coordinator, Jenny Woolston will take responsibility for the day-to-day management of the trial at the MRC Epidemiology Unit. This will include day-to-day responsibility for: recruiting participants, monitoring recruitment and uptake, retention and online study completion; creating standard operating procedures; preparing reports for the sponsor, ethics committees and funders as appropriate; ensuring that the trial is running in a timely manner and in accordance with good clinical practice guidelines.

The Trial Statistician, Mr Stephen Sharp, is responsible for overseeing the work of a dedicated Research Associate who will write and implement the statistical analysis plan.

Professor Stephen Morris is responsible for leading the economic evaluation, including the establishment of the data collection methods used, conducting the quantitative analyses and publication and appropriate dissemination of findings.

Dr Robbie Duschinsky and Ms Rebecca Jones will lead the qualitative evaluation, including the establishment of the data collection methods used, conducting the qualitative analyses outlined in Section 9, and publication and appropriate dissemination of findings.

#### PATIENT AND PUBLIC INVOLVEMENT

The ideas for this study were developed in response to requests for support with eating behaviour and weight management from the European Patient Council on Obesity, who then reviewed the initial outline of the study and strongly supported its aims. Substantial PPI input was included in the development of the SWiM intervention. The initial ideas and research proposal were reviewed by 22 men and women attending the Fakenham Weight Management Service in Norfolk and 6 members of the University of Cambridge PPI Panel. Once funding was awarded a Patient User Group Panel (PUGP) was formed, comprising members with diverse experiences of weight loss and weight maintenance. This group helped in development and refinement of the logic model, the intervention outline, and different prototype iterations. Regular meetings were convened during the development phase, in order to consult on progress and to feedback to the panel on how their input was incorporated. A series of 'Think aloud' user testing sessions were completed for the alpha version of the web platform with feedback requested on content, design and functionality. To get feedback on the content from a wider and more diverse audience, remote user testing of the web platform has been conducted with the PUGP members and participants from the WRAP study from around the UK.

To maximise participant engagement and retention, and minimise burden, PPI representatives have also reviewed the content, design, and delivery of participant-facing materials. They will also advise on the content and methods of qualitative interviews and focus groups to ensure sensitivity and to maximise participant engagement.

A member of the PUGP will review the transcripts of the qualitative interviews, providing input to the analysis and interpretation of the findings. They will be included as a co-author on the qualitative results paper. A PPI representative (Jennifer Bostock) is a member of our Investigator team and has contributed to the design of the protocol and chairs the PUGP. She will also contribute to designing and delivering PPI training, preparing ethics and R&D submissions, co-authoring journal articles and the final report, disseminating findings to a wide range of audiences, and supporting other PPI members.

Two PPI representatives are members of the Trial Steering Committee. They will review the final study reports and contribute to the writing of specific sections, such as the lay summary.

Including PPI perspectives in plans for dissemination will ensure that we access an appropriate range of audiences and communicate messages effectively. PPI representatives will advise on content and methods of dissemination and will review public facing documents such as newsletters and press releases.

PPI representatives will be reimbursed for their time and expenses in a timely manner and tailored PPI training will be provided to suit the specific needs of the individual and their role. We will use the INVOLVE Standards for PPI as a guide. All meetings will be virtual and tailored to individual needs as Covid-19 recommendations and regulations dictate.

#### **PROGRAMME STEERING COMMITTEE**

An independent trial steering committee will be established to ensure that the project is conducted to the rigorous standards set out in the UK Policy Framework for Health and Social Care Research and the Guidelines for Good Clinical Practice. The TSC will consist of at least 3 independent academics with relevant experience and 2 patient and public representatives. They will provide advice to the Investigators on all aspects of the trial and will review and agree the trial protocol, the statistical analysis plan, and any amendments to the protocol. This is a low risk trial with no rules for early stopping and participants and study coordinators are not blind to intervention allocation. Thus a separate data monitoring committee was not deemed to be necessary.

## DISSEMINATION

At the end of the trial we will present the findings to our PPI representatives and our stakeholder panel and to identify appropriate ways to communicate findings to participants and other nonacademic audiences. Co-authorship & co-presenting with our PUGP members will be sought where possible and the results will be made available to participations.

All specified analyses will be written up as scientific papers and submitted for publication in peerreviewed open-access journals. Members of the research team will be involved in reviewing drafts of the manuscripts, abstracts, and any other publications arising from the trial. The Principal Investigators will have final approval on all publications and press releases. Authorship will be determined using ICMJE criteria.

In all papers or reports for publication the following statement (which incorporates a disclaimer in view of the independence of the research) should be used, amended accordingly, depending on the type of output:

"This paper/article/abstract presents independent research funded by the National Institute for Health Research (NIHR) under its Programme Grants for Applied Research Programme (Reference Number RP-PG-0216-20010) and the MRC Epidemiology Unit. The views expressed are those of the author(s) and not necessarily those of the NHS, the NIHR or the Department of Health."

As a condition of NIHR funding, the Investigators must give 28 days' notice of intention to NIHR prior to submitting a research paper and 14 days' notice prior to the host institution or publisher or collaborator issuing a press release together with the draft manuscript.

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## A7.2 Consent form

## Supporting Weight Management during COVID-19 (SWiM-C) Study

Participant study number:



# CONSENT FORM

| Version 3 (                                       | 10/08/2020)                      |   |
|---|----------------------------------|---|
| REC Ref: PRE.2020.049                             | Chief Investigator: Dr Amy Ahern |   |
|   | Please initial each box          |   |
| 1. I confirm that I have read and underst         | tood the information sheet       | _ |
| version 3.0, 10/08/2020 for the above study a     | and have had the opportunity     |   |
| to consider the information, ask questions and    | I have had these answered        |   |
| satisfactorily.                                   |                                  |   |
| <b>2.</b> I understand that my participation is v | voluntary and that I am free     |   |
| to withdraw at any time, without giving any re    | eason and without my             |   |
| medical care being negatively affected or my l    | legal rights.                    |   |
|   |                                  |   |

3. I understand that the information collected about me can be stored by the MRC Epidemiology Unit, University of Cambridge.

4. To access the SWiM intervention, I give permission for my name and email address to be provided to Cauldron, the website developer, to create an account for me to access the web-based programme.

5. I understand that I will not benefit financially if this research leads to the development of a new treatment or test.

6. I agree to take part in the above study

| OP <sup>-</sup> | ГIО | NA | L: |
|-----------------|-----|----|----|
| •.              |     |    |    |

8. I agree to take part in a semi-structured interview

9. I understand that my anonymised data will be used to support other research in the future, and may be shared anonymously with other researchers. This could include collaborators overseas or in the commercial sector.

10. I am willing to be contacted again in the future beyond this study and any follow up from it.



No

Yes







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| Full name of Participant |  | D | ate | (DD | י אף | YYYY | () | Signature |
|--------------------------|--|---|-----|-----|------|------|----|-----------|

## A7.3 Participant interview schedule

## Weight loss journey

- 1. Before we talk about the SWiM programme, can you briefly describe your weight management journey before beginning the programme?
- 2. People join these programmes for many different reasons.

Can you tell me what were your main motivations for joining the SWiM programme?

- 3. What were your hopes or expectations for the programme?
  - a. To what extent do you feel your hopes/expectations were met?

## Programme acceptability

- 4. How did you find using SWiM website?
  - a. Prompt: How easy or difficult and why, any technical issues, finding the time/privacy
- 5. Can you tell me about the information delivered in the SWiM sessions?
  - a. What did you find most useful?
  - b. What did you find least useful?
  - c. Is there anything you would have liked to have more support with?
  - d. Is there anything you feel is missing from the programme?
  - e. Is there anything you feel shouldn't be included in the programme?
- 6. The programme provided information on skills and strategies for weight management and emotional well-being.
  - a. How easy or difficult did you find it to understand the strategies or exercises? Did anything help or hinder your understanding?
  - b. Which strategies, exercises or SWiM Aids did you find most useful?

- c. Which strategies, exercises or SWiM Aids did you find least useful?
- 7. How useful did you find your conversations with the coach?
  - d. What did you find most useful?
  - e. What did you find least useful?
  - f. Is there anything you would have liked to have more support with?

#### Benefits and disadvantages

- 8. Can you tell me about any positive experiences, or benefits, you have experienced as a result of the SWiM programme?
- 9. Can you tell me about any negative experiences, or difficulties, you have experienced as a result of the SWiM programme?

#### Mental health/emotional well-being

- 1. I'd be interested to know more about what your mood was like during the programme?
  - a. For example, to what extent have you experienced...
    - i. feelings of stress?
    - ii. conflict at home/at work?
    - iii. financial concerns?
    - iv. loneliness?
    - v. feeling not sufficiently supported?
    - vi. not feeling fully satisfied with your life?
- 2. In what ways do you feel that your mood affects your health behaviours, such as your diet, movement, or sleep? For example, if you are feeling low, stressed, lonely, or having a bad day?

- a. How is your diet affected? How is your physical activity affected? How is your sleep affected?
- 3. To what extent did participating in the SWiM programme affect your mood and emotions? How? Why?
  - a. Did the programme provide sufficient support?
  - b. What additional support do you think may be helpful? Anything else?
- 4. Before I ask my final question, I'm going to ask you to take a moment to reflect on your time taking part in the SWiM programme. When you reflect back on your time as a SWiM participant, can you describe kind of feelings emerge for you? Anything else?

# A8. Appendices for Chapter Eight

# A8.1 Joint display: Integrated results table

| Chapter Two                     | Chapter Four                 | Chapter Seven                 | Chapter Five (Quantitative)       | Chapter Six (Quantitative)  |
|---------------------------------|------------------------------|-------------------------------|-----------------------------------|-----------------------------|
| (Quantitative)                  | (Quantitative)               | (Qualitative)                 |                                   |                             |
| Behavioural weight loss         | Adults with obesity          | Many experienced              | There was no meaningful           | Higher levels of anxiety at |
| interventions result in small   | attending a behavioural      | improvements to their         | change in depression and          | baseline were associated    |
| improvements to some            | weight management            | mental health associated      | anxiety symptoms at 5             | with decreases in anxiety   |
| aspects of mental health at     | programme are less likely    | with the intervention, but    | years after beginning the         | and increases in            |
| the end of an intervention      | to attend programme          | some experienced a            | behavioural weight                | depression symptoms up      |
| and 12-months after the         | sessions or engage with      | decline that they at least in | management intervention           | to 5 years from beginning a |
| intervention began              | programme resources if       | part attributed to the        |                                   | behavioural weight          |
|                                 | they report poorer mental    | intervention                  |                                   | management intervention.    |
|                                 | health at baseline           |                               |                                   |                             |
| There was <b>no evidence</b> to | Adults with obesity          | Participants were exposed     | There was <b>no evidence of a</b> | Higher levels of depression |
| suggest that interventions      | attending a behavioural      | to a range of experiences     | difference between the            | at baseline were associated |
| negatively impacted             | weight management            | related to and external to    | behavioural weight                | with <b>decreases in</b>    |
| mental health                   | programme are less likely    | the SWiM-C intervention       | management                        | depression and increases    |
|                                 | to attend study follow-up    | that negatively impacted      | interventions and control         | in anxiety symptoms up to   |
|                                 | visits if they report poorer | their mental health.          | group for changes in              | 5 years from beginning a    |
|                                 | mental health at baseline    |                               | depression and anxiety at 5       | behavioural weight          |
|                                 |                              |                               | years from baseline.              | management intervention.    |

#### BEHAVIOURAL WEIGHT MANAGEMENT INTERVENTIONS

| There was insufficient    | Participants perceived to    |
|---------------------------|------------------------------|
| evidence to assess the    | make trade-offs between      |
| impact on a large number  | the SWiM-C intervention      |
| of mental health outcomes | and the external factors in  |
| at intervention-end and   | their lives - intervention   |
| beyond                    | was often deemed to be a     |
|                           | lesser priority resulting in |
|                           | reduced intervention         |
|                           | engagement.                  |
|                           | Participants described their |
|                           | decline in intervention      |
|                           | engagement to lead to        |
|                           | feeling self-blame, shame,   |
|                           | guilt, and disappointment    |
|                           | in themselves.               |
|                           | Participants described       |
|                           | using maladaptive coping     |
|                           | responses to manage          |
|                           | mental health declines       |
|                           | with the aim to improve      |
|                           | mood - more often their      |
|                           | mental health was further    |
|                           | damaged via feelings of      |
|                           | regret, self-blame, and      |
|                           | shame                        |

| Aspects of the intervention  |  |
|------------------------------|--|
| appeared to help             |  |
| participants to respond in   |  |
| an adaptively, rather than   |  |
| maladaptively , to a decline |  |
| in mental health             |  |
| Participants suggest that    |  |
| intervention                 |  |
| personalisation could help   |  |
| to individualise the         |  |
| amount and type of           |  |
| psychological support        |  |
| received                     |  |