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

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Funding information
Australian National Health, Grant/Award Number: APP1156909; Fundação de Amparo à Pesquisa do Estado de São Paulo, Grant/Award Numbers: 2018/19183-1, 2019/24124-7; Medical Research Council, Grant/Award Numbers: MC_UU_12015/4, Grant MC_UU_12015/7

Summary

There is good evidence that behavioural weight management interventions improve physical health; however, the impact on mental health remains unclear. We evaluated the impact of behavioural weight management interventions on mental health-related outcomes in adults with overweight or obesity at intervention-end and 12 months from baseline. Eligible studies were randomized controlled trials (RCTs) or cluster RCTs of adult behavioural weight loss interventions reporting affect, anxiety, binge eating, body image, depression, emotional eating, quality of life, self-esteem and stress. We searched seven databases from inception to 7 May 2019 and included 43 articles reporting 42 RCTs. Eighteen studies were deemed to be at high risk of bias. We conducted random-effects meta-analyses, stratified analyses and meta-regression using Stata. Interventions generated greater improvements than comparators for depression, mental health-related quality of life and self-efficacy at intervention-end and 12 months from baseline. There was no difference between groups for anxiety, overall quality of life, self-esteem or stress at intervention-end. There was insufficient evidence to assess the impact on anxiety, binge eating, body image, emotional eating, affect, life satisfaction, self-esteem or stress at intervention-end and/or 12 months from baseline. Although evidence suggests that interventions benefit some aspects of mental health, high-quality, transparently reported RCTs measuring a range of mental health outcomes over longer durations are required to strengthen the evidence base.

KEYWORDS
interventions, mental health, obesity, weight management

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1 | INTRODUCTION

Overweight and obesity are associated with increased risk of conditions such as cardiovascular disease, type 2 diabetes, stroke, osteoarthritis and some cancers, as well as greater all-cause mortality.[1–6] Additionally, obesity is related to an increased risk of poor mental health including mood disorders, anxiety and psychiatric disorders.[7,8] There is good evidence that behavioural weight management interventions can improve physical health in people with overweight and obesity.[9,10] However, the evidence for their impact on mental health is less clear.

Some studies have reported mental health improvements with weight loss.[11–15] However, qualitative evidence suggests that there is inadequate support for mental health and emotional well-being in weight management interventions.[16] Some studies also report concerns that a focus on dietary restriction may influence disordered eating and increase psychological distress.[17–20] 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, optimizing care and minimizing the risk of harm.

Previous systematic reviews have aimed to synthesize evidence for the impact of behavioural weight management interventions on various aspects of mental health; however, findings have been limited and conflicting.[17,21–26] For example, Warkentin et al.[23] concluded that weight loss may be associated with improved physical health but not mental health, Fabricatore et al.[25] reported statistically significant reductions in depressive symptoms following behavioural weight loss interventions, and Lasikiewicz et al.[24] concluded that weight management interventions are associated with improvements in multiple mental health outcomes including self-esteem, body image, quality of life and depressive symptoms.

Previous reviews have also highlighted the breadth of mental health outcomes that could be affected by attending a weight management intervention; however, the majority of reviews have focused on a limited number of outcomes.[17,21–26] 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 another. Previous 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).[17,27] Overweight and obesity are associated with increased risk of a wide range of comorbidities[28]; therefore, the exclusion of these participants limits the representativeness of findings.

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. 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 or obesity, or investigating whether particular intervention or study characteristics are more supportive of mental health. Therefore, we aimed to:

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

2 | METHODS

This review adheres to Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) reporting.[29] Full details of the methods were reported in the published protocol.[30]

2.1 | Eligibility criteria

1. Participants: Community-dwelling adults (≥ 18 years) with overweight or obesity (body mass index [BMI] ≥ 25 kg/m^2) seeking intentional weight loss. To increase the generalizability of the findings, we included studies that included people 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. Interventions: Behavioural weight management interventions in community-based settings aiming to achieve weight loss through changes in diet and/or physical activity. Interventions treating eating disorders or involving surgical and/or pharmacological intervention were excluded.
3. Comparators: Inactive/minimal intervention (e.g., information leaflet) or usual care.
4. Outcomes: Affect/mood, anxiety, binge eating, body image, depression, emotional eating, quality of life, self-esteem and stress. Outcomes reported at intervention-end and at 12 months from baseline were extracted, regardless of intervention duration. We chose these a priori defined outcomes as they were deemed to be the most relevant, were most frequently reported in 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.
5. Study designs: Individual or cluster randomized controlled trials (RCTs). Non-English language publications were excluded.

2.2 | Information sources and search

We searched seven databases (AMED, ASSIA, CINAHL, Cochrane database (CENTRAL), Embase, MEDLINE and PsycINFO) from database inception to 7 May 2019. The search strategy was based on the

concepts: (1) adults with overweight/obesity and (2) behavioural weight management interventions and (3) mental health outcomes and (4) study designs (Table S1). The search was restricted to English-language papers, with no other restrictions applied. To augment the results of the database search, we hand searched the reference lists of included studies and previous relevant reviews.[10,17,21–27,31–34]

2.3 | Study selection

Two-stage screening was completed in duplicate, with a third reviewer resolving discrepancies.[30] We contacted study authors (n = 2) to resolve any uncertainties about eligibility. Where studies were reported in more than one publication, all articles that met eligibility criteria were included and combined to make best use of the data available.

2.4 | Data collection

Data extraction was completed by one investigator with full checking by one further investigator. Discrepancies were resolved through discussion, with use of a third investigator where necessary. We contacted study authors (n = 26) to request missing data. If there was no response, authors were sent two email reminders. 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.

2.5 | RoB in individual studies

Risk of bias (RoB) appraisal was completed by one investigator using the Cochrane RoB tool,[35] with full checking by one further investigator. 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' RoB dependent on the ratings for individual domains. Ratings given to 'blinding of participants and personnel' and 'blinding of outcome assessment' were excluded from overall assessment of RoB because of the behavioural nature of the interventions and self-reported assessment of outcomes.

2.6 | Synthesis of results

Stata v.16 was used for all statistical analyses.[36] Unstandardized mean differences between the intervention and comparator groups and 95% confidence intervals (CIs) were calculated for continuous outcomes and standardized mean differences (Hedges' g) if different measurement tools were reported in the individual studies. Effect sizes for each outcome were combined across studies using random effects meta-analysis. When studies had multiple interventions meeting the inclusion 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). When studies reported multiple measures for the same outcome, the measure deemed by the authorship team to be most valid and precise was prioritized and used. Meta-analyses examined effectiveness at intervention-end and 12 months from baseline, regardless of intervention duration. These time points 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 unstandardized mean differences, effect sizes based either on post-intervention or change from baseline results were combined in a single forest plot. Separate forest plots were produced for post-intervention and change from baseline when standardized mean differences were used in the meta-analyses.[35]

Heterogeneity was assessed using the I^2 statistic and interpreted according to Cochrane recommendations.[35] Contour-enhanced funnel plots of individual study effect sizes were produced for all outcomes to assess the risk of publication bias.

2.7 | Additional analyses

Sensitivity analysis was conducted by removing studies judged to be high RoB 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 and age).

3 | RESULTS

3.1 | Study selection

Following deduplication, 31,390 articles were identified for 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).[37–79] Three studies were excluded from the meta-analyses as data were incomplete or unable to be pooled.[45,52,67]

3.2 | Study characteristics

Table 1 provides an overview of included studies, and Table S2 presents detailed characteristics for each study. Briefly, studies included a total of
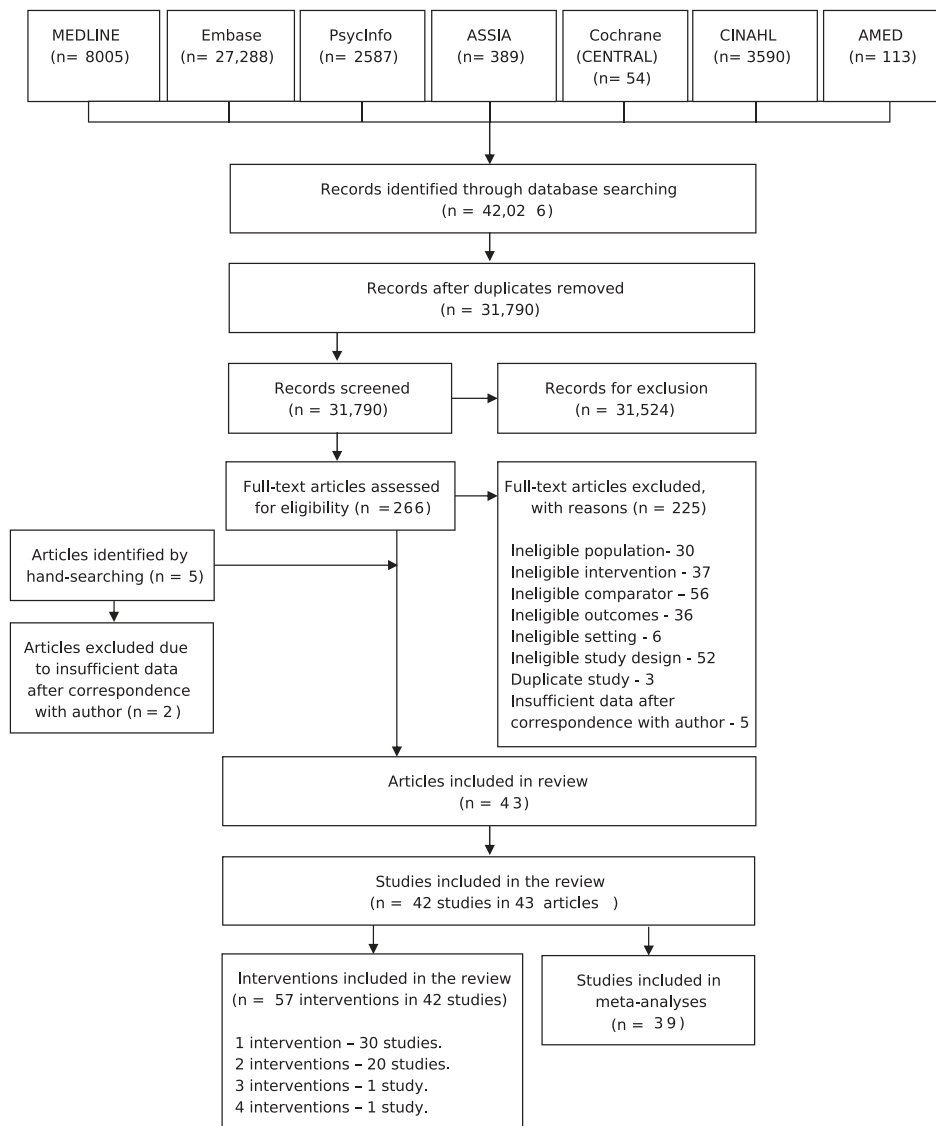
FIGURE 1 Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) flow diagram for the inclusion of studies

9,385 participants, with the sample size ranging from 23[40] to 1,269.[37] Intervention were compared with no intervention, minimal intervention (e.g., leaflet) or usual care (ranging from minimal to delivery of an intervention). One study did not define what usual care entailed.[71]

Overall, the majority of interventions were education based (n = 33),[37,39,41,43,45–55,57–61,63–72,74,77,79] delivered face to face (n = 23)[37–40,42,44,47,49,53,57,58,60–62,64,68–70,72,73,75,78] and provided to individuals only (n = 25).[38,39,41,43,45,48–52,54–58,60,63,65–67,69–71,76,77,79]

Twenty-nine studies[37,42,44,45,47,48,50–62,64–66,69,71,73,75,77–79] provided interventions lasting between 2 to 11 months, whereas 12 studies provided interventions lasting greater than 12 months.[37–39,41,43,46,61,63,67,68,72,74] Three studies were less than 2 months in duration.[40,49,70] 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,[37,49,53,60,65,73] and eight interventions were 12 months in duration.[37,39,43,46,68,74]

Seven outcomes were positively scaled, defined as measured on a numeric scale where a positive effect size represented a 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 a 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.

3.3 | Risk of bias

Forty-two percent of studies received an overall rating of high RoB,[38,43,50,51,54,55,57–59,62,63,65,68–71,74,75] 35% received an unclear RoB rating,[30,39–41,44,45,48,49,64,66,67,72,76,78,79] and 23% received a low RoB rating[42,46,47,52,53,56,60,61,73,77] (Table 1). Table S3 reports the domain ratings for all included studies, and Figure S1 presents the summary of RoB domain ratings across studies.

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

	Number of studies	Citations
Study characteristics		
Study design		
RCTs	43 (100%)	37–79
Year of publication		
≥2019	1	77
2017–2018	8	37,48,60,61,67,70,74,76
2015–2016	11	38,40,41,45,47,53,58,59,62,78,79
≤2014	23	39,42–44,46,49–52,54–57,63–66,68,69,71–73,75
Overall risk of bias rating		
Low risk of bias	10	42,46,47,52,53,56,60,61,73,77
Unclear risk of bias	15	30,39–41,44,45,48,49,64,66,67,72,76,78,79
High risk of bias	18	38,43,50,51,54,55,57–59,62,63,65,68–71,74,75
Study location		
United States	15	38,39,41,45,46,50–52,59,63,64,66,71,75,79
United Kingdom	10	37,40,42,44,53,57,60,69,72,73
Australia	8	48,49,54–56,67,72,77
Portugal	2	68,76
Finland	2	43,58
Germany	2	72,78
Malaysia	1	47
Canada	1	61
Greece	1	70
India	1	62
New Zealand	1	74
Not reported	1	65
Participant characteristics		
Sample size		
≤50 participants	3	40,44,59
50–200	25	42,43,45,48,49,51,52,54–58,61,62,64,66,69–71,74–79
≥200	15	37–39,41,46,47,50,53,60,63,65,67,68,72,73
Mean age (years)		
18–30	2	41,75
31–50	32	40,42–45,47,49–58,60–62,66–74,76–79
51–70	9	37–39,46,48,59,63–65
Proportion female		
0% (all male)	8	42,54–56,61,62,73,79
50–99%	27	37–39,41,43–45,47–53,57,58,60,63,65–67,70–72,74,76,77
100% (all female)	8	40,46,59,64,68,69,75,78
Participant BMI (kg/m^2)		
25–29.9	2	40,41
30–34.9	23	37,42,43,46–49,51,52,54–56,59,64–68,72,75,77–79
35–39.9	13	38,39,45,53,57,58,60,61,63,69–71,73
≥40	4	44,50,74,76
Not reported	1	62

TABLE 1 (Continued)

	Number of studies	Citations
Intervention characteristics		
Intervention type		
Education only	33	37,39,41,43,45–55,57–61,63–72,74,77,79
Physical activity only	4	40,44,46,78
Education and physical activity	8	42,46,56,57,61,62,73,75
Delivery mode		
Face to face	23	37–40,42,44,47,49,53,57,58,60–62,64,68–70,72,73,75,78
Online	6	48,51,52,59,66,77
Resources	4	48,56,65,77
Telephone	2	39,45
Mixture of modes	11	41,43,46,50,54–56,63,71,74,79
Delivery format		
Individuals only	25	38,39,41,43,45,48–52,54–58,60,63,65–67,69–71,76,77,79
Groups only	16	37,39,40,42,44,47,49,53,61,62,64,68,72,73,75,78
Groups and individuals	4	46,59,63,74
Intervention duration		
≤2 months	3	40,49,70
>2–6 months	25	37,42,44,45,47,48,51–57,59–62,64,65,69,71,73,75,77,78
>6–11 months	4	50,58,66,79
>12–23 months	9	37,39,43,46,61,67,68,72,74
>24 months	3	38,41,63
Comparator characteristics		
Type of control group		
No intervention	16	40,43,46,51,54–56,61,65,66,69,73,75,77–79
Minimal intervention	14	37,42,47–49,58,59,62–64,67,68,70,76
Usual care	13	38,39,41,44,45,50,52,53,57,60,71,72,74
Outcome characteristics		
Mental health outcomes reported at intervention-end		
Anxiety	6	37,44,46,48,57,77
Binge eating	1	66
Body image concerns	2	66,68
Depression	14	37,38,41,44,46,48,50,57,63,64,66,70,71,77
Emotional eating	4	53,58,68,72
Negative affect	4	42,47,61,73
Psychological distress	1	74
Quality of life (global)	12	37,39,41,48,53,57,60,61,63,69,74,77
Quality of life (mental health-related)	13	40,42,46,47,54–56,63,64,67,73,74,79
Quality of life (obesity-related)	4	51,60,72,76
Satisfaction with life	2	37,39
Self-efficacy (general)	2	49,65
Self-efficacy (diet-related)	9	39,43,45,47,52,59,68,75,79
Self-efficacy (exercise-related)	7	39,44,54,55,68,75,79
Self-esteem	5	42,57,61,73,78
Stress	6	46,48,62,70,75,78
Mental health outcomes reported at 12 months from baseline		
Anxiety	0	—

TABLE 1 (Continued)

	Number of studies	Citations
Body image concerns	1	68
Depression	2	37,46
Emotional eating	2	53,68
Negative affect	1	73
Psychological distress	0	—
Quality of life (global)	5	37,39,53,60,74
Quality of life (mental health-related)	5	46,67,73,74
Quality of life (obesity-related)	1	60
Satisfaction with life	1	39
Self-efficacy (general)	2	49,65
Self-efficacy (diet-related)	3	39,43,68
Self-efficacy (exercise-related)	2	39,68
Self-esteem	1	73
Stress	0	—

Note: Number of studies per characteristic may sum greater than 43 because of studies contributing multiple intervention arms.

Abbreviation: BMI, body mass index; RCT, randomized controlled trial.

3.4 | Intervention effects on mental health

3.4.1 | Anxiety

There was no evidence of a difference between intervention and comparator for anxiety at intervention-end (post-intervention: standardized 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 RoB ($n = 2$),[57] there was still no evidence of a difference between groups at intervention-end (Figures S42 and S43). No studies reported anxiety at 12 months from baseline.

Meta-regression identified that the substantial heterogeneity at intervention-end was explained by one study[48] where the intervention consisted solely of provision of resources (Table S4). After removing this study, there was a suggestion of an effect in favour of the intervention (SMD −0.10 [95% CI −0.22, 0.02; $n = 10$; $I^2 = 0\%$]) (Figure S49).

3.4.2 | Binge eating

Only one study[66] reported results for binge eating at intervention-end, so this could not be included in the meta-analysis, despite being a prespecified 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.

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; $n = 2$; $I^2 = 54\%$]), 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]),[68] so no meta-analysis was possible.

3.4.4 | Depression

There was some evidence of an effect in favour of interventions for depression at intervention-end (post-intervention: SMD −0.19 [95% CI −0.29, −0.10; $n = 15$; $I^2 = 2\%$]; change from baseline: SMD −0.41 [95% CI −1.06, 0.24; $n = 7$; $I^2 = 1\%$]) (Figure 2) and at 12 months from baseline (post-intervention: SMD −0.19 [95% CI −0.34, −0.04; $n = 5$; $I^2 = 0\%$]) (Figure S41).

After removal of interventions from studies deemed to be high RoB ($n = 8$),[38,50,57,63,70,71] 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; $n = 11$; $I^2 = 0\%$]; change from baseline: SMD −0.17 [95% CI −0.51, 0.18; $n = 3$; $I^2 = 19\%$]) (Figures S42 and S43).

3.4.5 | Emotional eating

There was no evidence of a difference between intervention and comparator for emotional eating (post-intervention: SMD −0.12 [95%

CI −0.30, 0.06; n = 3; I^2 = 21%]) (Figure 2). Only one study reported change from baseline results for emotional eating at intervention-end[53] (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]),[71] so no meta-analysis was possible.

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; I^2 = 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]),[42] and one study reported results at 12 months from baseline (SMD −0.21 [95% CI −0.36, −0.06]),[73] so no meta-analysis was possible.

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]),[74] and no studies reported psychological distress data at 12 months from baseline, so no meta-analysis was possible for this outcome.

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; I^2 = 94%]; change from baseline: SMD 0.19 [95% CI −0.03, 0.40; n = 8; I^2 = 60%]) (Figure 3) or at 12 months from baseline (post-intervention: SMD 0.12 [95% CI −0.04, 0.28; n = 4; I^2 = 0%]; change from baseline: SMD 0.00 [95% CI −0.16, 0.16; n = 3; I^2 = 0%]) (Figure S41). After excluding studies deemed to be at high RoB (n = 7),[57,63,69,74] there was still no evidence of a difference between intervention and comparator for global quality of life at intervention-end (Figures S44 and S45).

Meta-regression identified that the substantial heterogeneity at intervention-end was explained by three interventions[48,69] where 90–100% of intervention participants were women or where the intervention consisted solely of provision of resources (Table S5). After exclusing of 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; I^2 = 0%]) (Figure S50).

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; I^2 = 15%]; change from baseline:

SMD 0.03 [95% CI −0.14, 0.20; n = 5; I^2 = 45%]) (Figure 3) and at 12 months from baseline (post-intervention: SMD 0.29 [95% CI 0.09, 0.50; n = 4; I^2 = 0%]) (Figure S41). After excluding studies deemed to be at high RoB (n = 4),[54,55,63,74] 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; I^2 = 14%]; change from baseline: SMD 0.15 [95% CI 0.03, 0.28; n = 3; I^2 = 0%]) (Figures S44 and S45).

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]),[73] so meta-analysis was not possible.

3.4.10 | Quality of life (obesity-related)

Only one study[60] 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 RoB (n = 1),[51] 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%]) (Figures S42 and S43). No studies reported negatively scaled obesity-related quality of life at 12 months from baseline, so meta-analysis was not possible.

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%]) (Figure S41). No studies measuring satisfaction with life were deemed to be at high RoB.

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; I^2 = 0%]) (Figure 3) and at 12 months from baseline (post-intervention: SMD 0.35 [95% CI 0.13, 0.57; n = 6; I^2 = 0%]) (Figure S41).

After excluding studies deemed to be at high RoB (n = 4),[65] 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^2 = 0%]) (Figures S44 and S45).

Study	Assessment tool		Hedges's g with 95% CI
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 $\theta_i = \theta_j$: 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]
Alfaris et al. (2015)	PHQ−8		−0.16 [−0.40, 0.09]
Heterogeneity: $\tau^2 = 0.69$, $I^2 = 94.57\%$, $H^2 = 18.43$			−0.41 [−1.06, 0.24]
Test 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: $\tau^2 = 0.00$, $I^2 = 1.54\%$, $H^2 = 1.02$			−0.19 [−0.29, −0.10]
Test of $\theta_i = \theta_j$: Q(14) = 8.63, p = 0.85			

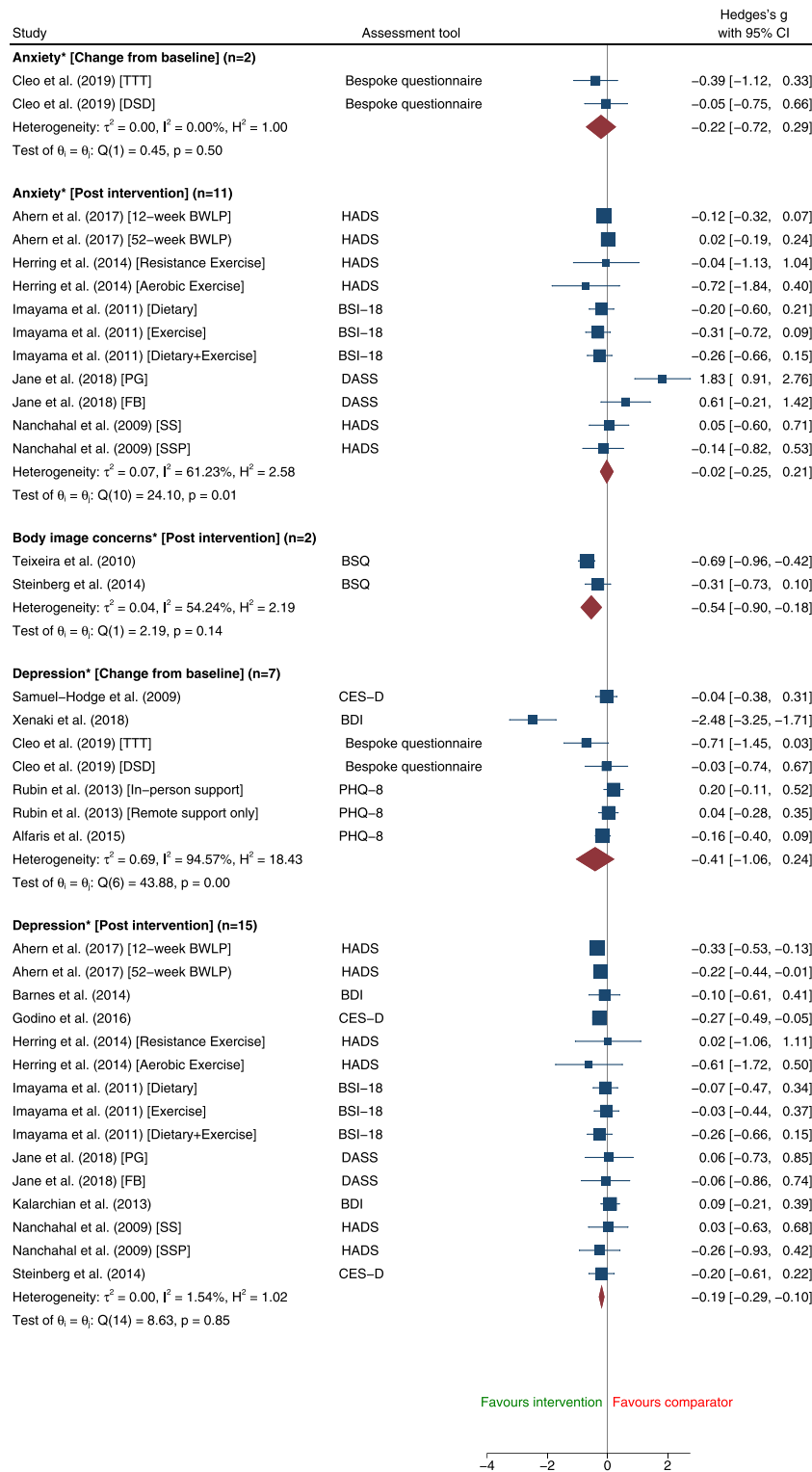Favours intervention | Favours comparator

−4   −2   0   2

FIGURE 2 Changes in negatively scaled mental health outcomes at intervention-end comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis. Abbreviations: ATQ, Automatic Thoughts Questionnaire; BDI, Beck Depression Inventory; BSQ, Body Shape Questionnaire; BWLP, Behavioural Weight Loss Programme; CES-D, Center for Epidemiologic Studies Depression Scale; DASS, Depression Anxiety Stress Scales; DEBQ, Dutch Eating Behaviour Questionnaire; DSD, Do Something Different; FB, Facebook Group; HADS, Hospital Anxiety and Depression Scale; BSI, Brief Symptom Inventory; HPLP II, Health Promoting Lifestyle Profile; IWOQOL, Impact of Weight on Quality of Life; ORWELL-R, Obesity Related Well-being Questionnaire; PANAS/PNAS, Positive and Negative Affect Schedule; PG, Pamphlet Group; PHQ, Patient Health Questionnaire; PSS, Perceived Stress Scale; SS, Structured Support; SSP, Structured Support and Physical Activity; TFEQ, Three Factor Eating Questionnaire; TTT, Ten Top Tips
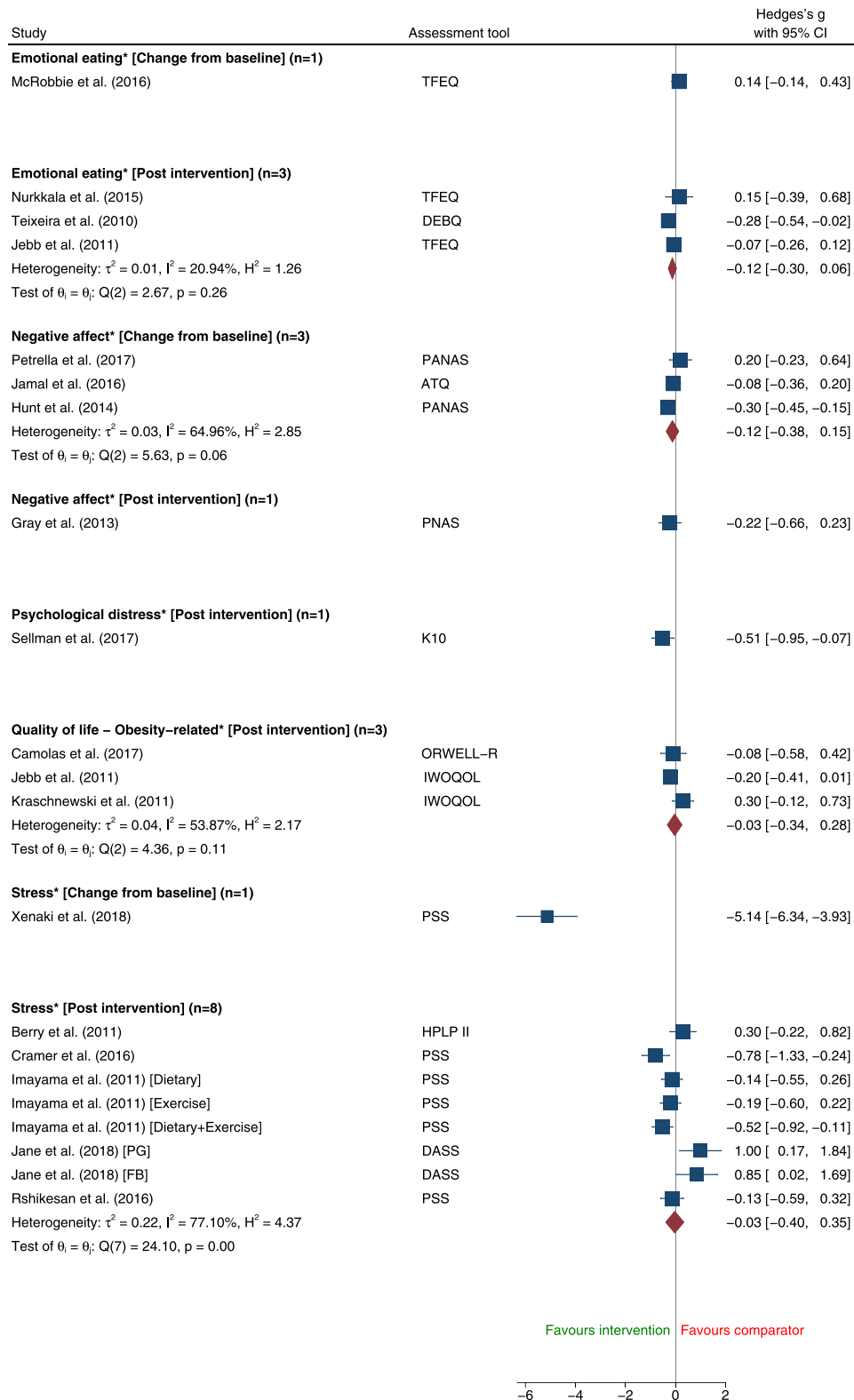
Study	Assessment tool	Hedges's g with 95% CI
Emotional eating* [Change from baseline] (n=1)		
McRobbie et al. (2016)	TFEQ	0.14 [−0.14, 0.43]
Emotional eating* [Post intervention] (n=3)		
Nurkkala et al. (2015)	TFEQ	0.15 [−0.39, 0.68]
Teixeira et al. (2010)	DEBQ	−0.28 [−0.54, −0.02]
Jebb et al. (2011)	TFEQ	−0.07 [−0.26, 0.12]
Heterogeneity: $\tau^2 = 0.01$, $I^2 = 20.94\%$, $H^2 = 1.26$		−0.12 [−0.30, 0.06]
Test of $\theta_i = \theta_j$: 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)	ATQ	−0.08 [−0.36, 0.20]
Hunt et al. (2014)	PANAS	−0.30 [−0.45, −0.15]
Heterogeneity: $\tau^2 = 0.03$, $I^2 = 64.96\%$, $H^2 = 2.85$		−0.12 [−0.38, 0.15]
Test of $\theta_i = \theta_j$: Q(2) = 5.63, p = 0.06		
Negative affect* [Post intervention] (n=1)		
Gray et al. (2013)	PNAS	−0.22 [−0.66, 0.23]
Psychological distress* [Post intervention] (n=1)		
Sellman 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   Favours comparator

−6   −4   −2   0   2
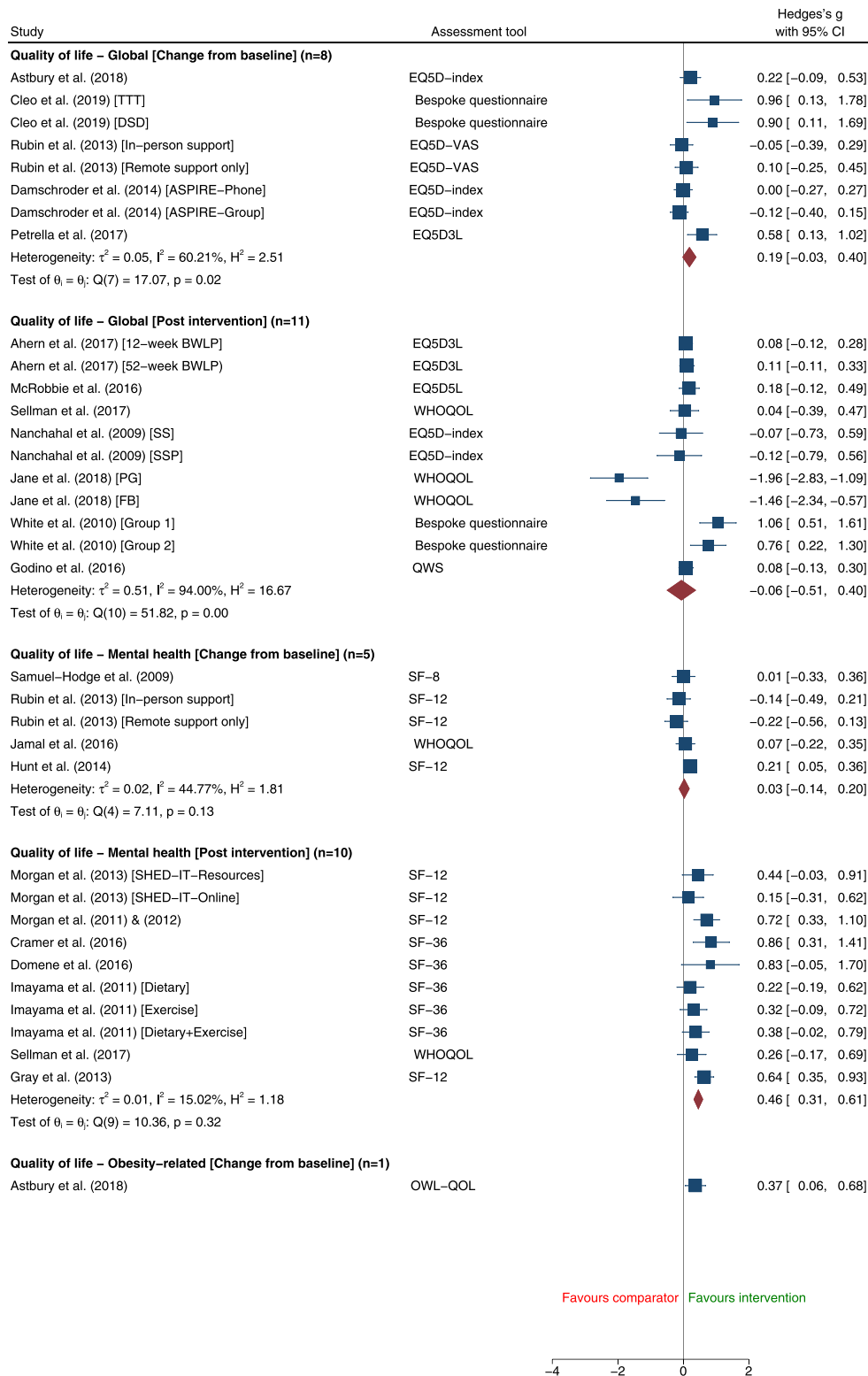
FIGURE 2   (Continued)

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

Study	Assessment tool	Hedges's g with 95% CI
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 $\theta_i = \theta_j$: 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]
Self efficacy – Diet [Post intervention] (n=7)		
Berry et al. (2011)	ESES	−0.28 [−0.80, 0.24]
Crane et al. (2016)	WEL	0.41 [0.02, 0.79]
Damschroder et al. (2014) [ASPIRE–Phone]	SOCQ	0.26 [−0.06, 0.58]
Damschroder et al. (2014) [ASPIRE–Group]	SOCQ	0.17 [−0.15, 0.48]
Haapala et al. (2009)	Bespoke questionnaire	−0.13 [−0.56, 0.31]
Teixeira et al. (2010)	WMEQ	0.63 [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 $\theta_i = \theta_j$: Q(6) = 16.83, 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

FIGURE 3   (Continued)

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; I^2 = 65%]) (Figure 3) and at 12 months from baseline (post-intervention: SMD 0.26 [95% CI −0.04, 0.56; n = 4; I^2 = 71%]) (Figure S41), but there was substantial heterogeneity. Findings were unchanged following exclusion of studies deemed to be at high RoB (n = 5)[43,59,68,75,79] (Figures S44 and S45). 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]),[47] so meta-analysis was not possible.

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; I^2 = 60%]) (Figure 3) and at 12 months from baseline (post-intervention: SMD 0.47 [95% CI 0.15, 0.79; n = 3; I^2 = 71%]), but there was substantial heterogeneity. Findings were unchanged after exclusion of studies deemed to be at high RoB (n = 4).[54,55,68,75,79] There were insufficient studies to conduct meta-regression to identify sources of heterogeneity.

3.4.15 | Self-esteem

There was no evidence of a difference between intervention and comparator groups for self-esteem at intervention-end (MD 0.95 [95% CI −0.25, 2.15; n = 6; I^2 = 77%]) (Figure 4). Findings were unchanged following exclusion of studies deemed to be at high RoB (n = 2)[57] (Figure S46). 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]),[73] so meta-analysis was not possible.

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; I^2 = 77%]) (Figure 2). Findings were unchanged following exclusion of studies deemed to be at high RoB (n = 3) (Figures S42 and S43). Only one study reported change from baseline results for stress at intervention-end (SMD −5.14 [95% CI −6.34, −3.93]),[70] and no studies reported stress at 12 months from baseline, so meta-analysis was not possible.

3.5 | Additional analyses

Figures S51–S85 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 high risk of publication bias across all outcomes (Figures S3–S40).

Study	Assessment tool	Mean Diff. with 95% CI
Self–esteem (n=6)		
Cramer et al. (2016)	RSES	4.30 [1.23, 7.37]
Gray et al. (2013)	RSES	2.90 [1.11, 4.69]
Hunt et al. (2014)	RSES	0.20 [0.14, 0.26]
Nanchahal et al. (2009) [SSP]	RSES	−0.07 [−2.03, 1.89]
Nanchahal et al. (2009) [SS]	RSES	0.23 [−1.80, 2.26]
Petrella et al. (2017)	RSES	−0.01 [−1.38, 1.36]
		0.95 [−0.25, 2.15]

Favours comparator   Favours intervention

Heterogeneity: τ^2 = 1.48, I^2 = 76.71%, H^2 = 4.29

Test of $\theta_i = \theta_j$: Q(5) = 15.73, p = 0.01

FIGURE 4 Changes in (positively scaled) self-esteem at intervention-end comparing adult behavioural weight management interventions with inactive, minimal or usual care comparator using random-effects pairwise meta-analysis. Abbreviations: RSES, Rosenberg self-esteem scale; SS, Structured Support; SSP, Structured Support and Physical Activity

4 | DISCUSSION

This comprehensive systematic review and meta-analysis found evidence suggesting that behavioural weight loss interventions result in greater improvements for a number of 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.[25] and Peckmezian et al.[17] A previous review by Baillot et al.[22] 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[22] and improvements in mental health-related quality of life for male-only interventions.[33] We found evidence to suggest improvements in mental health-related quality of life at intervention-end and at 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 Balliot et al.[22] Contrasting with previous evidence,[22,27] we 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., ≥25 vs. ≥30 kg/m^2), study designs (e.g., inclusion of non-RCTs) or interventions studied (e.g., behavioural intervention vs. cognitive behaviour interventions). Consistent with previous reviews,[22,27] we found no evidence of an effect of interventions on anxiety. However, there was significant heterogeneity for this outcome, and after removal of a single study[48] identified as the source of heterogeneity, the behavioural interventions were associated with a reduction in anxiety. This highlights the potential influence 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 our knowledge, this is the first review 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 RoB. Common underlying reasons included selective reporting, allocation concealment and incomplete data. Although sensitivity analyses showed minimal impact of high RoB 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 health care. 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,[80] to improve study validity and credibility.[81]

Substantial heterogeneity was present for many outcomes in this review, hypothesized to be due to diversity in intervention types, populations under study and measurement tools. Although 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.[80]

Despite previous reviews highlighting a need for more research,[17,21–25,27,33] there remains a lack of high-quality behavioural weight loss intervention studies measuring and reporting mental health outcomes. Systematic reviews of effectiveness of behavioural weight loss intervention identified 58 RCTs[82] in 2014 and 89 RCTs[10] in 2018, whereas we 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 with inactive comparison groups.

It is also important to note that we 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.

4.1 | Strengths and limitations

To our 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 who 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.[83] In particular, the review protocol was preregistered and published, data and methods are comprehensively reported, PRISMA reporting guidelines were adhered to,[29] 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 RoB 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, investigators conducted extensive hand searching of reviews assessing other outcomes and study reference lists to maximize 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.[84,85] 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.

5 | CONCLUSION

This comprehensive and inclusive systematic review suggests that behavioural weight management interventions result in improvements in a number of 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 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.

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