

Third-wave cognitive behaviour therapies for weight management: a systematic review and network meta-analysis

Emma R Lawlor¹, Nazrul Islam¹, Sarah Bates², Simon J Griffin^{1,3}, Andrew J Hill⁴, Carly A Hughes^{5,6}, Stephen J. Sharp¹, Amy L Ahern¹

1. MRC Epidemiology Unit, University of Cambridge, Cambridge, United Kingdom
2. School of Health and Related Research, Faculty of Medicine, Dentistry and Health, University of Sheffield, Sheffield, United Kingdom
3. Primary Care Unit, Institute of Public Health, University of Cambridge, Cambridge, United Kingdom
4. Division of Psychological & Social Medicine, School of Medicine, University of Leeds, Leeds, United Kingdom
5. Fakenham Medical Practice, Norfolk, United Kingdom.
6. Norwich Medical School, University of East Anglia, Norwich, United Kingdom.

* Joint contribution.

Corresponding author: Dr Emma R Lawlor

Address: MRC Epidemiology Unit, University of Cambridge, School of Clinical Medicine, Box 285 Institute of Metabolic Science, Cambridge Biomedical Campus, Cambridge, CB2 0QQ, United Kingdom.

Email: emma.lawlor@mrc-epid.cam.ac.uk

Running title: Third-wave cognitive behaviour therapies for weight management

Keywords: Weight loss; Obesity; Network meta-analysis; Third-wave behavioural therapy

Acknowledgements: This study is funded by the National Institute for Health Research (NIHR) Programme Grants for Applied Research RP-PG-0216-20010. The views expressed are those of the authors and not necessarily those of the NIHR or the Department of Health and Social Care. ALA and SJG are supported by the Medical Research Council (MC_UU_12015/4). SJG is an NIHR senior investigator. The University of Cambridge has received salary support in respect of SJG from the National Health Service in the East of England through the Clinical

Academic Reserve. We want to thank the patient user group panel for assisting with the refinement of the research question, and interpretation of results. We would like to thank individuals within the unit that assisted with article language translation, Eleanor Barker for help in developing the search strategy and Rebecca Jones for assisting with database searches. We would also like to thank all corresponding authors of articles that provided additional information or clarity on their studies.

Conflicts of interest:

AA is the Chief Investigator on two publically funded (MRC, NIHR) trials where the intervention is provided by WW (formerly Weight Watchers) at no cost outside the submitted work. AJH reports receiving personal fees from Slimming World, outside the submitted work. CAH reports education work and consultancy Oviva, Orexigen Therapeutics, Kastech, Ethicon, Mundipharma, Consilient Health, Nestle, and Novo Nordisk, outside the submitted work. ERL, NI, SB and SJG have no conflicts of interest.

Abbreviations:

BMI: Body mass index; CBT: Cognitive behaviour therapy; SBT: Standard behavioural treatment; SMD: Standardised mean difference; 3wCBT: Third-wave cognitive behaviour therapy; DBT: Dialectical behaviour therapy; ACT: Acceptance and commitment therapy; MBCT: Mindfulness-based cognitive behavioural treatment; CFT: Compassion focused therapy; RCT: Randomised controlled trial; SD: Standard deviation; CI: Confidence intervals.

1 **ABSTRACT**

2 This systematic review and network meta-analysis synthesised evidence on the
3 effects of third-wave cognitive behaviour therapies (3wCBT) on body weight,
4 psychological and physical health outcomes in adults with overweight or obesity.
5 Studies that included a 3wCBT for the purposes of weight management and
6 measured weight or BMI pre-intervention and ≥ 3 months post-baseline were
7 identified through database search [MEDLINE, CINAHL, Embase, Cochrane
8 database (CENTRAL), PsycINFO, AMED, ASSIA and Web of Science]. Thirty-seven
9 studies were eligible; 21 were randomised controlled trials (RCT) and included in the
10 network meta-analyses. Risk of bias was assessed using RoB2 and evidence quality
11 was assessed using GRADE.

12 Random-effects pairwise meta-analysis found moderate to high quality evidence
13 suggesting that 3wCBT had greater weight loss than standard behavioural treatment
14 (SBT) at post-intervention (SMD: -0.09, 95% CI: -0.22, 0.04; N=19; $I^2=32\%$), 12-
15 months (SMD: -0.17, 95% CI: -0.36, 0.02; N=5; $I^2=33\%$) and 24-months (SMD: -0.21,
16 95% CI: -0.42, 0.00; N=2; $I^2=0\%$). Network meta-analysis compared the relative
17 effectiveness of different types of 3wCBT that were not tested in head-to-head trials
18 up to 18 months. Acceptance and commitment therapy (ACT)-based interventions
19 had the most consistent evidence of effectiveness. Only ACT had RCT evidence of
20 effectiveness beyond 18 months. Meta-regression did not identify any specific
21 intervention characteristics (dose, duration, delivery) that were associated with
22 greater weight loss.

23 Evidence supports the use of 3wCBT for weight management, specifically ACT.
24 More large trials with long-term follow-up are needed to identify who these

1 interventions work for, their most effective components, and the most cost-effective
2 method of delivery.

3

4 **BACKGROUND**

5 Although behavioural interventions are effective at helping people to lose weight,
6 many people struggle to sustain effective weight management behaviours over
7 extended periods due to a combination of biological, psychological, social and
8 environmental factors that drive weight gain.^{1,2} Standard behavioural programmes
9 can be effective in the short-term, but less so in the longer term.³⁻⁶ These usually
10 combine diet and physical activity advice with core behavioural change techniques
11 including goal setting, self-monitoring, problem solving, and planned social support.⁷

12 It has been proposed that third-wave cognitive behaviour therapies (3wCBT),
13 including acceptance and commitment therapy (ACT), dialectical behaviour therapy
14 (DBT), mindfulness-based cognitive behavioural therapy (MBCT) and compassion-
15 focused therapy (CFT),⁸⁻¹⁰ may have better short- and long-term outcomes.²

16 The theoretical case for 3wCBT for weight management has been well articulated.²

17 In brief, these therapies encourage people to accept aversive internal experiences
18 (e.g., food cravings, physical discomfort) rather than avoid them. Increased present-
19 moment, non-judgemental awareness and psychological flexibility may assist an
20 individual in recognizing internal and external cues to overeat, and alter behavioural
21 responses to be more in line with their values. Fostering a compassionate attitude
22 towards the self could also help prevent discouragement following minor lapses.^{2,8,9}

23 However, the evidence of their superior effectiveness is less clear. Previous
24 systematic reviews and meta-analyses primarily focused on mindfulness and/or
25 acceptance-based interventions.¹¹⁻¹⁸ Three reviews^{13,15,16} have reported a

1 quantitative synthesis of pre-post change without comparing the effect against a
2 comparator. Two of these three reviews reported a 'small' pre-to-post change in
3 weight¹⁵ or BMI¹³ while the other study¹⁶ reported a null effect on BMI. Critically, only
4 one review¹⁴ reported a meta-analytic synthesis that compared the effectiveness of
5 mindfulness and acceptance-based interventions to those in other active
6 interventions and control arms using appropriate statistical methods. A small but
7 significant difference in weight or BMI was reported at post-intervention, favouring
8 mindfulness and acceptance-based interventions over comparator arms. Subgroup
9 analysis suggested that the effect may only hold when the comparator is waitlist
10 control. In that review, there was no restriction on the minimum follow-up duration
11 and outcomes were analysed at one month post intervention (or the closest
12 measurement to this). Thus, the pooled estimates reflected a mix of very short-term
13 and longer-term effects. Moreover, without a restriction on minimum BMI, these
14 findings are less relevant from a policy perspective since behavioural weight
15 management programmes are intended for adults with overweight/obesity.^{19,20} This
16 concern is compounded by the finding that a lower BMI was associated with a larger
17 effect size.

18 To our knowledge, no head-to-head trial exists that has compared the effectiveness
19 of different types of 3wCBT on weight management. In the absence of head-to-head
20 trials, network meta-analysis can estimate the indirect evidence on the comparative
21 effectiveness of different types of 3wCBT. The proposed mechanism for the superior
22 effects of 3wCBT is through improvements in eating behaviour and psychological
23 outcomes, so it is also important to synthesise evidence on the impact of 3wCBT on
24 these outcomes. In addition, evidence synthesis of the effect of 3wCBT on eating

1 behaviour and psychological outcomes has been limited to pre-post change^{13,15,16}
2 and has not considered longer follow-up periods.

3 To address these knowledge gaps, we conducted the most comprehensive,
4 inclusive, and relevant review and quantitative synthesis of available evidence to
5 date. We included different types of 3wCBT beyond mindfulness and acceptance-
6 based interventions. Our main objectives were (i) to evaluate the effectiveness of
7 3wCBTs on weight management by pooling the pre-post change effect estimates
8 across all study types, (ii) to compare the effectiveness of 3wCBTs on weight
9 management against no/minimal interventions and standard behavioural treatment
10 separately using random-effects pairwise meta-analysis of RCTs, (iii) to estimate the
11 comparative effectiveness of different types of 3wCBTs on weight management
12 using random-effects network meta-analysis of RCTs, (iv) to evaluate the impact of
13 3wCBT on eating behaviour and psychological and physical health outcomes, and
14 (v) to provide a detailed description of intervention characteristics and to identify
15 whether any of these are associated with better weight change outcomes by using
16 meta-regression.

17

18 **METHODS**

19 **Protocol and registration**

20 The protocol was registered on Prospero (CRD42018088255) prior to article
21 screening.²¹

22 **Eligibility criteria**

23 Participants were community-dwelling adults (≥ 18 years) with overweight or obesity
24 ($\text{BMI} \geq 25 \text{ kg/m}^2$) seeking assistance with weight management. Studies had to include

1 a 3wCBT intervention for the purpose of weight management. Multi-component
2 interventions (e.g. including diet and PA advice) were acceptable, with no restriction
3 placed on the proportion of the intervention using 3wCBT. Interventions could be of
4 any duration. Comparisons were (1) no/minimal intervention, (2) standard
5 behavioural treatment (SBT) or (3) no comparator (single-arm pre-post studies). We
6 defined SBT as structured programmes providing diet and/or physical activity advice
7 and standard behaviour change techniques (e.g. goal setting, self-monitoring,
8 problem solving, social support). The primary outcome was body weight or BMI.
9 Studies needed to measure this pre-intervention and at least 3-months post-
10 baseline. Secondary outcomes were stress, anxiety, depression, meta-cognition,
11 eating attitudes, eating behaviours, body satisfaction, quality of life, blood pressure,
12 lipids, glycaemia and adherence to treatment. All outcomes reported at 3-months
13 from baseline and beyond were extracted. All settings apart from laboratories were
14 eligible. We included research articles, theses and dissertations reporting
15 randomised control trials (RCTs), non-RCTs, prospective cohort and case series
16 studies.

17 **Information sources**

18 Databases (MEDLINE, CINAHL, EMBASE, Cochrane database (CENTRAL),
19 PsycINFO, AMED, ASSIA and Web of Science) were searched by ERL from
20 inception with no restrictions, using keywords and subject heading searches relating
21 to the concepts: (1) Third-wave CBTs AND (2) Overweight, obesity or weight
22 management (see Table S1). The initial search was conducted on the 16th January
23 2018, and an updated search was conducted on 25th September 2019. Reference
24 lists of eligible studies and relevant reviews were searched and authors of relevant

1 abstracts were contacted to identify whether findings had been accepted for
2 publication.

3 **Study selection**

4 Titles and abstracts, then full texts, were screened independently by two of three
5 researchers, with a third reviewer adjudicating uncertainty or disagreement. Study
6 authors were contacted to resolve any questions about eligibility. Non-English
7 language texts were translated into English by colleagues who were fluent in that
8 language.

9 **Data collection process**

10 Data were extracted independently by two of four researchers using a form based on
11 the Cochrane data extraction form,²² the Consolidated Standards of Reporting Trials
12 2010 statement²³ and the Template for Intervention Description and Replication
13 checklist,²⁴ and cross-checked for consistency. Attempts were made to contact
14 authors to retrieve missing data. If there was no response after two attempts, we
15 used the data available in the published work.

16 **Risk of bias**

17 Two researchers assessed studies independently using the Risk of Bias 2 tool²⁵ or
18 the Risk of Bias in Non-randomised studies of Interventions tool,²⁶ dependent upon
19 study design. A third reviewer adjudicated inconsistency. The quality of evidence
20 was assessed using the Grading of Recommendations Assessment, Development
21 and Evaluation approach, which classifies studies as 'high', 'moderate', 'low' or 'very
22 low' quality.²⁷

23

24

1 **Missing data**

2 For the primary outcomes, where SDs for mean change were missing and not
3 provided following author correspondence, these were imputed using the following
4 methods, in order of prioritisation: i) imputed from other time-points within same
5 study, ii) estimated from t-statistics, Cohen's d, p-values or confidence intervals,²⁸⁻³²
6 iii) estimated using a correlation coefficient of 0.97, based on empirical data from
7 seven studies^{28,30,33-37} (17 estimates) that reported SDs for baseline, follow-up, and
8 mean change.³⁸⁻⁴⁶ Insufficient data prevented this approach for secondary
9 outcomes, so we used a correlation of 0.7 as in previous studies.^{47,48}

10 **Synthesis of results**

11 Stata/SE v.14.2⁴⁹ was used for all the statistical analyses. Following guidance,⁵⁰ we
12 focused on 95% confidence intervals (CI), rather than statistical significance. For
13 example, unlike conventional interpretations, we did not outright interpret an effect
14 estimate 'non-significant' if the lower or upper bound of the 95% CI was slightly
15 above/below the null value; we interpreted them as 'suggestive' of an effect.

16 *Pooled estimates of intervention-specific effects from all study types*

17 Intervention-specific effects (post-intervention minus pre-intervention) were
18 estimated by pooling effect estimates from all study designs. Due to heterogeneity in
19 outcome measurement, effect estimates were reported as standardised mean
20 change from the random-effects meta-analysis.⁵¹ Effect estimates were reported at
21 the earliest measurement post-intervention (≥ 3 months from baseline) and at 3-, 6-,
22 9-, 12-, 18-, 24-, and 36-months from baseline. Outcomes falling between these
23 time-points were included with the closest time-point.

24

1 *Intervention comparisons: Direct evidence from pairwise meta-analysis of RCTs*

2 The direct effect comparing 3wCBT against (i) no/minimal intervention and (ii) SBT
3 was estimated using random-effects⁵¹ pairwise meta-analysis of RCTs. The
4 standardised mean difference (SMD) calculated using Hedges' method and 95% CI
5 were reported.⁵²

6 *Intervention comparisons: Indirect and mixed evidence from network meta-analysis*
7 *of RCTs*

8 To compare types of 3wCBT, random-effects network meta-analysis of RCTs was
9 conducted to estimate the indirect and mixed (direct plus indirect) evidence.⁵³ Basic
10 assumptions were checked conceptually and statistically.⁵³ For example, to avoid
11 violating the transitivity assumption, which requires the comparator arm (e.g., the
12 waitlist control) is comparable across the trials, the comparators (SBT and
13 no/minimal intervention) were not pooled/used together. Similarly, the intervention
14 arms were dropped (namely resistance exercise³⁵ and food environment
15 modification⁵⁴) if they were not comparable with other intervention arms. The
16 consistency assumption was checked statistically to see if the direct and indirect
17 effect estimates were comparable enough to pool them together into the mixed
18 evidence.^{55,56} Effect estimates were reported as SMD and 95% CIs. The relative
19 ranking probability of each intervention being the best treatment was estimated using
20 Rankograms.⁵⁷

21 *Sensitivity analysis*

22 The influence of individual studies on weight change of 3wCBT compared to
23 no/minimal intervention or SBT was examined using influence plots, where one study
24 was removed at a time to see its effect on the overall estimate⁵⁸.

1 *Meta-regression on intervention and study characteristics*

2 Where at least 10 studies provided relevant data,⁵⁹ meta-regression was used to
3 identify potential sources of heterogeneity for pre-specified characteristics: number
4 of sessions (continuous; <12 vs. ≥12 sessions), duration of intervention (<3 months
5 vs. ≥3 months, <6 months vs. ≥6-months), method of delivery (face-to-face vs.
6 remote; group vs. individual) and risk of bias (low, some concerns, high).

7 *Secondary outcomes*

8 Only a small number of studies reported the secondary outcomes at each follow-up
9 time-point, so the first time-point post-intervention was used and network meta-
10 analysis was not conducted. Pooled and pairwise meta-analyses were conducted for
11 secondary outcomes reported in ≥2 studies.

12 For consistency, we defined ‘change’ as post-intervention minus pre-intervention
13 values; so a negative ‘change’ estimate indicates that the outcome decreased after
14 the intervention.

15

16 **RESULTS**

17 After duplicate removal, 8755 titles and abstracts were screened and 215 full text
18 articles were assessed. Two additional studies and four articles related to already
19 included studies were identified from reference lists,^{60–64} and contacting an author.⁶⁵
20 Fifty articles reporting 37 studies met the inclusion criteria (Figure 1). Two studies
21 were excluded from the meta-analyses due to co-interventions (pharmacotherapy⁶⁶
22 and bariatric surgery³⁹). 35 studies were used in the pooled-effects meta-analysis of
23 pre-post changes and the 21 RCT design studies were used in the network meta-
24 analysis that compared different interventions.

1 Figure 1: PRISMA flow diagram

2

3 **Study characteristics**

4 Seventeen studies^{30–33,36,41,45,46,66–74} used a two group RCT, four^{35,40,44,54} used a
5 three group RCT and one used a two group cluster RCT design.⁴² Fourteen
6 studies^{28,29,34,38,43,64,65,75–80} used a pre-post one group design, and one study was a
7 non-randomised three group study.³⁹ The majority of studies were conducted in the
8 USA (n=28). The other studies were conducted in New Zealand,³⁴ Italy,³⁹ UK,^{41,42,77}
9 the Netherlands,^{43,64} Finland⁴⁴ and Portugal⁷⁰ (Table 1).

10

11 *Table 1: Characteristics of included studies*

12

13 *Participant characteristics*

14 Studies included 2726 participants and the sample size ranged from ten^{29,64} to 283.⁵⁴
15 Seventy-five percent of participants were female (n=2035/2726), with twelve
16 studies^{28,32–34,38,45,64,65,67,70,80} focusing exclusively on females. Mean age was 46
17 years (ranged from 21³³ to 58 years⁴⁵), and mean BMI was 35.6 kg/m² (Table 1 &
18 Table S2a&b).

19 *Intervention Characteristics*

20 Twenty-two studies evaluated MBCT^{28,29,31–33,35,36,38,40,42,45,46,64,65,67–70,74,77,78}, eleven
21 evaluated ACT-based interventions^{30,34,44,54,71–73,75,76,79,80}, three evaluated DBT^{39,43,66}
22 (one⁶⁶ in combination with pharmacotherapy), and one evaluated CFT.⁴¹ Twenty-
23 seven studies^{28–33,35,36,40,44–46,64,65,67–73,75,77,78,80,81} used primarily face to face, group

1 format delivery. One study⁴³ had an initial individual face to face session before
2 delivery of group sessions. Five other studies^{38,39,41,42,66} used face to face group
3 sessions along with another mode: emails,⁴² telephone calls,^{39,41} individual diet
4 counselling³⁸ and a website for pharmacology support.⁶⁶ One study⁷⁶ used individual
5 face to face lifestyle counselling and telephone delivery. Three delivered
6 interventions on an individual, remote basis using email⁷⁴ and online website,^{34,79} two
7 of these included telephone support.^{74,79} One study⁴⁴ had two intervention arms with
8 the same content delivered face to face or through mobile telephone. Most
9 interventions include home-based skills practice between sessions.

10 Intervention duration varied, with two lasting less than a week,^{28,30} twelve studies
11 between one and 3 months,^{29,32,33,36,42,44,65,66,77,79,80} and nine
12 studies^{31,34,40,43,67,68,70,76,78} between 3½ and 5½ months in length. Thirteen studies
13 lasted for 6 months or more, with five of these being 12 months in length.^{39,45,54,72,73}
14 Hamel et al⁶⁴ did not report intervention length.

15 All studies were delivered on a weekly or alternating weekly basis, apart from two: a
16 one-off one day workshop and 5-day residential retreat.^{28,30} Several interventions
17 had an “active phase”, then an extended period with less regular sessions or
18 telephone follow-up.^{38,40,45,54,68–73} Most interventions were implemented at a
19 university,^{30,35,36,40,42,45,46,54,66,68} with other venues including primary care units and
20 hospitals,^{41,70,76,77} yoga retreat centres,^{28,65} a community and oncology practice,³⁸
21 YMCA,²⁹ and participants’ place of employment⁸⁰ (Table 1 and Table S3a&b).

22

23 Risk of bias

1 Of the RCTs, the risk of bias was rated as 'high' in four,^{36,41,42,74} 'some concern' in
2 eleven^{30,31,33,35,40,45,46,66,69-71} and 'low' in seven studies^{32,44,54,67,68,72,73} (Table S4a). Of
3 the 15 non-RCTs, the risk of bias was rated as 'serious' in nine,^{28,38,39,64,65,78-80} and
4 'moderate' in six^{29,34,43,75-77} studies (Table S4b). The quality of the evidence was
5 different for different comparisons, dependent on studies included. For the
6 comparison between 3wCBT and no/minimal intervention at post-intervention the
7 quality of evidence was high (3 studies);^{40,44,67} for the comparison between 3wCBT
8 and SBT, the quality of evidence was moderate at post-intervention (19 studies),³⁰⁻
9 ^{33,35,36,40-42,45,46,54,68-74} and high at 12 months (5 studies),^{45,54,68,72} 18 months (3
10 studies),^{68,71,73} 24 months (2 studies)^{72,73} and 36 months (1 study,⁷² direct evidence
11 only) from baseline. Details of study quality for all comparisons are reported Table
12 S5a-c.

13 **Intervention effects on body weight or BMI**

14 Twenty five studies^{28-33,35,36,38,42,44-46,54,65,67-69,73-78} reported an absolute weight
15 change (kg or lb), four studies^{71,72,79,80} reported percent change from baseline
16 weight, and six studies^{34,40,41,43,64,70} reported BMI change.

17 ***Pooled estimates of intervention-specific effects from all study types***

18 Standardised mean change in weight or BMI for 3wCBT was -0.84 (95% CI: -1.06, -
19 0.62; N=35; $I^2=93\%$) from baseline to post-intervention (equating an absolute weight
20 change of 5.5kg). Weight change by types of 3wCBT at different time-points is
21 reported in Table S6. There was a pattern of weight loss (relative to baseline) for
22 DBT up to 12-months, for MBCT up to 18-months, and for ACT up to 36-months.
23 However, there was high heterogeneity and few studies at later time points. There

1 was no evidence of weight loss following CFT, but this was based on one poor
2 quality study⁴¹ at a single 3 month follow-up from baseline

3 ***Intervention comparisons: Direct evidence***

4 Figure 2 summarises the results of the pairwise random-effects meta-analysis, and
5 Table S5a presents the quality of evidence for all direct comparisons using
6 GRADE.²⁷ Most individual studies were small and did not find evidence of a
7 difference between interventions. However, when findings were meta-analysed,
8 there was high quality evidence to suggest greater weight loss for 3wCBT compared
9 to no/minimal intervention at post-intervention and 9-months follow-up from baseline.
10 There was moderate quality evidence based on 19 studies^{30–33,35,36,40–42,45,46,54,68–74}
11 suggesting that 3wCBT had greater weight loss than SBT at post-intervention, and
12 high quality evidence suggesting that 3wCBT had greater weight loss than SBT at
13 12-months (5 studies^{45,54,68,72}), and 24-months (2 studies^{72,73}). Only ACT
14 interventions provided data for the 24-month comparison. Estimates at 6- and 18-
15 months also suggested greater weight loss for 3wCBT vs. SBT, but there was no
16 evidence of a difference between the two groups at 3- and 9-months.

17 ***Sensitivity Analysis***

18 In the influence plot analysis, removal of one study at a time did not have any effect
19 on the overall effects estimates from the pairwise meta-analysis of weight change.

20

21 *Figure 2: Weight change comparing third-wave CBT and no/minimal or standard*
22 *behavioural treatment from random-effects pairwise meta-analysis*

23

1 ***Intervention comparisons: Indirect and mixed evidence***

2 Network meta-analysis was conducted up to 18-months post-baseline, as only a
3 single pairwise comparison (ACT vs. SBT) was reported at 24- and 36-months.
4 Intervention networks at each time-point are summarised in Figure 3. Estimates from
5 the network meta-analysis are summarised in Figure 4. ACT produced greater
6 weight loss than no/minimal intervention at post-intervention and 9-months;
7 comparisons at 3- and 6-months, however, did not provide evidence of superior
8 effectiveness of ACT. Comparisons between ACT and SBT suggested greater
9 weight loss for ACT post-intervention; there was no evidence of a difference at other
10 time-points. Compared to MBCT, ACT had greater weight loss at 9-months;
11 comparisons at other time-points did not show evidence of a difference.
12 Comparisons between no/minimal intervention and MBCT did not provide evidence
13 of a difference at any time-point and there was no consistent pattern of effects.
14 Comparisons between MBCT and SBT suggested that SBT was more effective at 9-
15 months, but estimates at 12- and 18-months suggested MBCT was favoured. When
16 CFT was compared to the other interventions, confidence intervals were wide with
17 no comparisons favouring CFT.

18 When interventions were relatively ranked, ACT was the best intervention post-
19 intervention and at 3-, 6- and 9-months post-baseline. MBCT was the best-ranking
20 intervention at 12- and 18-months post-baseline, however this was based on only 5
21 studies (2 MBCT) and 3 studies (1 MBCT) respectively (Figure S1).

22 *Figure 3: Network of interventions at different follow-up time*

23

24 *Figure 4: Summary of weight change from network meta-analysis*

25

1 In terms of absolute weight change, for example, the SMD in weight between 3wCBT
2 and SBT equates to a difference of 0.6kg post-intervention and 1.4kg at 24 month
3 follow-up from baseline.

4

5 **Interventions effects on secondary outcomes**

6 Pooled arm-specific estimates (standardised mean change) of the effect of 3wCBT
7 (combined) on secondary outcomes are presented in Figure S2. Pairwise estimates
8 (SMD) from RCTs comparing 3wCBT and no/minimal intervention are presented in
9 Figure S3; those comparing 3wCBT and SBT are presented in Figure 5 (a, b and c).

10 **Psychological outcomes**

11 Pooled arm-specific estimates showed a reduction in anxiety (N=7),^{29,30,32,33,67,69,74}
12 depression (N=9),^{29,30,32,33,40,43,69,74,78} and stress (N=8)^{28-30,32,36,67,74,78} following
13 3wCBT. When compared to no/minimal intervention, estimates suggested greater
14 reductions in anxiety for 3wCBT (N=1)⁶⁷, a greater reduction in depression for
15 3wCBT (N=1),⁴⁰ but found no evidence of a difference in stress (N=1)⁶⁷. Pairwise
16 comparisons found no evidence of differences between 3wCBT and SBT for anxiety
17 (N=5),^{30,32,33,69,74} depression (N=6)^{30,32,33,40,69,74} or stress (N=4).^{30,32,36,74}

18 Pooled arm-specific estimates (N=4)^{64,70,78,80} suggested an increase in quality of life
19 (QoL) following 3wCBT. One study⁷⁰ reported a greater increase in QoL in 3wCBT
20 vs. SBT.

21 Pooled arm-specific estimates (N=9)^{32,35,36,42,44,46,69,70,80} showed an increase in
22 mindfulness with 3wCBT. The estimate from one study⁴⁴ suggested a greater
23 increase in mindfulness for 3wCBTs vs. no/minimal intervention. Pairwise estimates
24 (N=7)^{32,35,36,42,46,69,70} suggested a greater increase in mindfulness in 3wCBT vs. SBT.

1 Pooled arm-specific estimates (N=5)^{30,34,44,74,75} showed that psychological flexibility
2 increased after 3wCBT. One study⁴⁴ showed a greater increase in psychological
3 flexibility for 3wCBT vs. no/minimal intervention. Pairwise estimates (N=2)^{30,74} found
4 no evidence of a difference between 3wCBT and SBT.

5 **Eating behaviour**

6 Pooled arm-specific estimates showed a decrease in binge eating (N=6),^{29,33,40,45,74,78}
7 disinhibition (N=14),^{29,35,40,41,43,44,46,67,69,70,73,75,78,80} and hunger (N=7)^{29,35,40,46,69,75,78}
8 and suggested a decrease in emotional eating (N=13)^{31,35,41,43,44,64,65,67,70,74,77,80}
9 following 3wCBT. Compared to no/minimal intervention, three studies showed a
10 greater decrease in disinhibition favouring 3wCBT,^{40,44,67} one study⁴⁰ reported a
11 greater decrease in binge eating and hunger favouring 3wCBT, and two studies^{44,67}
12 showed a greater decrease in emotional eating favouring 3wCBT. Pairwise
13 estimates comparing 3wCBT and SBT found a greater decrease in disinhibition for
14 3wCBT (N=7),^{35,40,41,46,69,70,73} but no evidence of a difference between the groups in
15 binge eating (N=4),^{33,40,45,74} hunger (N=4)^{35,40,46,69} or emotional eating
16 (N=5).^{31,35,41,70,74} Pooled arm-specific estimates showed an increase in dietary
17 restraint (N=12),^{29,35,40,41,43,44,46,67,69,75,78,80} intuitive eating (N=2),^{34,44} and mindful
18 eating (N=6)^{36,38,64,65,74} following 3wCBT. Pairwise estimates comparing 3wCBT and
19 no/minimal intervention showed a greater increase in dietary restraint (N=3)^{40,44,67}
20 and a greater increase in intuitive eating (N=1)⁴⁴ in the 3wCBT group. Pairwise
21 estimates comparing 3wCBT and SBT found a greater increase in mindful eating for
22 3wCBT (N=2)^{36,74} but no evidence of a difference in dietary restraint (N=5).^{35,40,41,46,69}
23 No studies compared intuitive eating in 3wCBT vs. SBT.

1 Pooled estimates (N=6)^{33,35,43,65,78} showed no evidence of a change in body
2 dissatisfaction following 3wCBT; pairwise comparisons showed no evidence of a
3 difference between 3wCBT and SBT (N=2).^{33,35}

4 **Physical health outcomes**

5 Pooled arm-specific estimates (N=4)^{30,32,36,68} suggested a reduction in diastolic blood
6 pressure and systolic blood pressure following 3wCBT, but pairwise estimates
7 showed no evidence of differences between 3wCBT and SBT. Pooled arm-specific
8 estimates (N=3)^{32,68,69} suggested a reduction in fasting glucose and HbA_{1c} following
9 3wCBT, and pairwise estimates suggested greater reductions in fasting glucose and
10 HbA_{1c} for 3wCBT vs. SBT. There was no evidence of changes in high density
11 lipoprotein cholesterol (N=1),⁶⁸ low density lipoprotein cholesterol (N=2),^{32,68} or total
12 cholesterol (N=1) following 3wCBT,⁷⁰ and no evidence of differences between
13 3wCBT and SBT in any of these outcomes. One study⁶⁸ reported a decrease in
14 triglyceride and triglyceride-to-HDL ratio following 3wCBT, and a greater decrease of
15 triglyceride in 3wCBT compared to SBT with no evidence of a change for
16 triglyceride-to-HDL ratio between 3wCBT and SBT. Pooled arm-specific estimates
17 (N=6)^{36,42,68-70,76} showed a decrease in waist circumference following 3wCBT, but
18 pairwise comparisons found no evidence of a difference between 3wCBT and SBT.

19 *Figure 5: Changes in secondary outcomes comparing third-wave cognitive behaviour*
20 *therapy and standard behavioural treatment at earliest time point post-intervention*
21 *using random-effects pairwise meta-analysis*

22 *5a: Psychological outcomes*

23 *5b: Eating behaviours*

24 *5c: Physical health outcomes*

1 **Meta-regression of intervention characteristics**

2 A sufficient number of studies for meta-regression ($N \geq 10$) was only available at post-
3 intervention and at 3- and 6-months since baseline for 3wCBTs vs. SBT. Pre-
4 specified study and intervention characteristics were examined in the meta-
5 regression at these time-points including number of sessions, duration of
6 intervention, method of delivery and risk of bias (Table S7) and none were found to
7 have any impact on the effect estimates on weight or BMI reported in the pairwise
8 meta-analysis. There were too few studies in each stratum to analyse the potential
9 effects of comorbidities (e.g., diabetes). Due to the small number of studies,
10 subgroup analysis was not conducted.

11 **Intervention adherence**

12 There was substantial heterogeneity and poor reporting of attendance and
13 adherence outcomes, limiting our ability to conduct any meaningful quantitative
14 analysis (Table S8). Only 22 studies reported any attendance information, but, for all
15 these studies, attendance was at least 60% at group sessions overall, and eight
16 ^{31,35,42,46,54,69,71,72} out of 11 RCTs reporting attendance information for each group had
17 a 3wCBT group with higher attendance than the control arm. Information provided on
18 adherence included minutes of home meditation practice, number of mindful meals
19 per week, food and exercise diaries, and completion of online modules. Generally,
20 within each study, there seemed to be a spread of engagement in the home practice
21 aspect of interventions. This also varied with interventions delivered via internet: one
22 study⁴⁴ found a median completion of all modules was 91%, and another³⁴ found a
23 mean of 32%.

24

1 **DISCUSSION**

2 This comprehensive systematic review and network meta-analysis found high quality
3 evidence suggesting that 3wCBT results in greater weight loss than no/minimal
4 intervention. Importantly, it also found moderate quality evidence that suggests
5 3wCBT results in greater weight loss than SBT at post-intervention and high quality
6 evidence from a small number of studies indicating that 3wCBT results in greater
7 weight loss than SBT at longer-term follow-up. However, it is important to note that
8 3wCBTs did not consistently outperform other interventions across shorter follow-up
9 times (e.g. 3- and 9-months) and that differences in weight change between 3wCBT
10 and SBT were small (approximately 0.6kg difference post-intervention and 1.4kg
11 difference at 24 months). Future research is needed to establish the clinical
12 significance of these small differences in weight change.

13 The finding that 3wCBT is potentially more effective than SBT contrasts with the
14 report by Roche et al.¹⁴ that acceptance- and mindfulness-based interventions were
15 only more effective than waitlist control arms. Conversely, estimates for the
16 difference in weight loss between CBT and no/minimal intervention in our analysis
17 are slightly smaller. This may be because Roche et al.¹⁴ merged short and long-term
18 follow-up data, and included participants with a BMI <25 kg/m², either of which may
19 be associated with larger effects. Comparisons with other reviews that purport to
20 have compared 3wCBT with other approaches are more challenging because of less
21 appropriate statistical approaches. Both Carrière et al.¹⁵ and Rogers et al.¹³
22 combined the estimates from both RCTs and single-arm pre-post studies. While the
23 analytic methods used in Carrière et al.¹⁵ is unclear, Rogers et al.¹³ used only the
24 post-intervention estimates for the RCTs (which ignores baseline differences
25 between groups that may be influential in smaller studies),⁸² and effect estimates

1 were weighted by sample size, not SD. Consequently, the reported study-specific
2 estimates are different between Rogers et al.¹³ and Roche et al.¹⁴ even though both
3 label the effect as Hedges g.^{15,59}

4 Our statistical approach was more rigorous. In the pairwise meta-analysis we only
5 included RCTs, we applied a consistent definition of 'change' estimate as pre-minus-
6 post estimates, we used appropriate methods for pairwise comparisons, and we
7 further separated the effectiveness against no/minimal control or standard
8 behavioural treatments. We reported the effect estimates by follow-up times to have
9 more insights of the short- and longer-term effects, and we restricted our analytic
10 population to those with a BMI ≥ 25 kg/m² as this is more relevant from a clinical and
11 policy perspective.

12 To our knowledge, this is also the first review to report on the comparative
13 effectiveness of individual 3wCBT types, which have never been tested in head-to-
14 head trials. Network meta-analysis found that ACT-based interventions had the most
15 consistent evidence of effectiveness indicating greater weight loss compared to SBT
16 at post-intervention and 12- and 24-month follow-up from baseline; comparisons at
17 other time-points or with other 3wCBT types either appeared to favour ACT or did
18 not show evidence of a difference. ACT was ranked as the best intervention up to 12
19 months and was the only 3wCBT to have outcomes at 24 months and 36 months.
20 Network estimates suggested MBCT resulted in greater weight loss than SBT at 12-
21 and 18-months, but favoured SBT at 9 months and there was no evidence that
22 MBCT was more effective than no/minimal intervention. This suggests that we
23 should interpret the finding that MBCT was the highest-ranking intervention at 12-
24 and 18-months with some caution. Only four studies evaluated a 3wCBT approach
25 other than acceptance or mindfulness and these were of low quality and short follow-

1 up. Although we identified three studies using DBT, all used non-randomised pre-
2 post design and one was combined with pharmacotherapy; therefore they were not
3 included in the pairwise or network meta-analysis, limiting conclusions on DBT
4 effectiveness. CFT was found to have no evidence for weight loss; however, this
5 finding is based upon one unpublished thesis⁴¹ which was deemed to be of high risk
6 of bias, and of very low quality. To date, the evidence provides strongest support for
7 the superiority of acceptance-based interventions. It is possible that the superiority of
8 the acceptance-based programmes in this context is due to its focus on values and
9 willingness to reduce experiential avoidance. However, more research is needed to
10 confirm these differences and identify the mechanisms of action.

11 Changes in secondary outcomes were generally in the desired direction. Following
12 3wCBT there was evidence suggestive of reductions in depression, anxiety and
13 stress, and increases in quality of life, mindfulness and psychological flexibility.
14 There were similar reductions in binge eating, dietary disinhibition, hunger and
15 emotional eating, and increases in dietary restraint, intuitive eating and mindful
16 eating following 3wCBT. This is consistent with previous reviews that have reported
17 on these outcomes.^{13,15,16} Pairwise comparisons suggest that most improvements in
18 these outcomes were greater than for no/minimal intervention. Focusing on
19 comparisons of 3wCBT vs. SBT, pairwise comparisons showed that reductions in
20 disinhibition and increases in mindful eating were greater for 3wCBT but no
21 differences in other psychological factors. These could represent important
22 mechanisms by which 3wCBT has a greater effect on weight control than SBT and
23 warrant further investigation. Few studies reported changes in blood pressure,
24 glycaemia, lipid profile, and waist circumference, and pairwise comparisons only
25 suggested greater reductions in glycaemia.

1 Meta-regression did not identify any specific intervention characteristics (e.g.,
2 duration, mode of delivery, number of sessions) that were more effective than others.
3 This may have been due to the small number of studies. Similar to traditional
4 behavioural weight management programmes, the majority of interventions were
5 delivered in a group face to face format. Such delivery has often been found to be
6 effective in weight loss,⁸³ with the group providing peer support and regular
7 encouragement, particularly for those experiencing social isolation. However, closed
8 group programmes led by clinical psychologists can be logistically difficult and costly
9 to deliver, particularly in the context of national health services providing free or
10 discounted healthcare. Increasingly, standard behavioural weight management
11 interventions are moving to more scalable methods of delivery to increase reach and
12 reduce cost. Only four interventions^{34,44,74,79} in our review used remote delivery
13 through internet or mobile phone. Similarly, a review of online mindful eating
14 interventions¹⁸ found only two studies focusing on weight loss, and none were
15 delivered through mobile telephone, highlighting a dearth of investigation into this
16 research area. Greater consideration may need to be given to the use of digital
17 technology to facilitate intervention delivery, with its 24-hour accessibility, improved
18 scalability and increased reach.⁸⁴

19 **Strengths and limitations**

20 The study of 3wCBT for weight management is in its relative infancy, with the earliest
21 included RCTs from 2008³³ (MBCT) and 2011³⁰ (ACT). While a number of RCTs
22 have been conducted, most have had small samples, short follow-up and few
23 provide high quality evidence. Only three RCTs reported outcomes beyond 12-
24 months despite 3wCBT being hypothesised to have particular benefit for long-term
25 outcomes. However, these studies with longer term follow-up had low risk of bias

1 and provided high quality evidence. The small number of studies limited our network
2 meta-analysis to up to 18-months post-baseline and meant that there were
3 insufficient studies to conduct meaningful meta-regression on the most effective
4 intervention components and characteristics beyond 6 months. Many studies also
5 had very small sample sizes. The small number of studies and small sample sizes
6 meant that many of our estimates had wide confidence intervals, thereby limiting the
7 power to detect a difference. Many of the studies included in this review had high or
8 serious risk of bias. However, it should be noted that we used a stringent
9 assessment tool, and heterogeneity for many outcomes was low. For some studies
10 this may also reflect the slowness of the obesity field to adopt standards for trial
11 reporting (e.g., CONSORT),²³ rather than the quality of the research itself. It is also
12 important to note that the studies with longer-term follow-up (i.e. 12 and 24 months
13 from baseline) were of high quality, based upon the GRADE assessment tool,²⁷ so
14 we can have greater confidence in the findings at these time points.

15 There was heterogeneity in the content of 3wCBT programmes, with a combination
16 of standardised, modified and novel programmes that varied in length and practice
17 time. Some studies evaluated interventions that used combinations of different third-
18 wave therapies, which may obscure potential differences between types of therapy.
19 However, this is a reflection of how these interventions are used. In attempting to
20 collate adherence and attendance data, we found a low number of studies reporting
21 intervention fidelity information and substantial variability in reporting. 3wCBTs seem
22 to have comparable attendance and attrition rates to standard behavioural
23 programmes,⁸⁵ suggesting they are an acceptable and feasible option. Lack of
24 information stopped us from conducting a meta-regression to try to identify sources
25 of heterogeneity in attendance or adherence.

1 Studies in our review had a high proportion of female participants; this is typical in
2 weight loss programmes and mindfulness interventions.⁸⁶ This limits generalisability
3 of findings to males,⁸³ and warrants purposive recruitment of males to studies and
4 weight loss programmes per se. Furthermore, several studies lacked detail of
5 participant demographics such as ethnicity and socio-economic status; more
6 complete reporting would enable us to understand the extent of the generalisability
7 of results.

8 There are several strengths to this review. RCTs and pre-post studies were included
9 in our pooled estimates, but only RCTs were included in pairwise and network meta-
10 analysis to provide the estimates of the comparative effectiveness against a
11 comparator. By conducting a network analysis, we could estimate comparisons
12 between different types of 3wCBT that have not been directly compared,
13 incorporating direct, indirect and mixed evidence in our evaluations of the evidence.
14 To maximise on relevant research, we included unpublished theses and contacted
15 authors regarding abstracts in conference proceedings. Unlike previous reviews,¹⁴
16 we restricted our analytic population to those with a BMI ≥ 25 kg/m² to make our
17 results more relevant to healthcare policies that recommend weight management
18 interventions for people with overweight/obesity.

19 **Conclusions**

20 This systematic review and network meta-analysis found moderate quality evidence
21 suggesting that third wave cognitive behavioural therapy results in a small increase
22 in weight loss compared to standard behavioural treatment at post-intervention. It
23 found high quality evidence from a small number of studies suggesting that third
24 wave cognitive behavioural therapy results in greater weight loss than standard
25 behavioural treatment at 12 and 24 month follow-up from baseline. Evidence

1 specifically appears to support the use of acceptance-based programmes. More
2 large, high-quality trials are needed in this area to better understand who these
3 interventions work for and how they work, so that we can target these interventions
4 appropriately and identify the most crucial components and “active ingredients”.
5 Future research should also consider how we deliver these interventions in a cost-
6 effective way that maximises scalability while maintaining effectiveness.

7

8 REFERENCES

- 9 1. Curioni CC, Lourenc PM. Long-term weight loss after diet and exercise: a systematic
10 review. *Int J Obes*. 2005;29:1168-1174. doi:10.1038/sj.ijo.0803015
- 11 2. Forman EM, Butryn ML, Manasse M, Bradley LE. Acceptance-based behavioral
12 treatment for weight control: a review and future directions. *Curr Opin Psychol*.
13 2015;2:87-90. doi:10.1016/j.copsyc.2014.12.020.
- 14 3. Hartmann-Boyce J, Johns DJ, Jebb SA, Summerbell C, Aveyard P. Behavioural
15 weight management programmes for adults assessed by trials conducted in everyday
16 contexts: systematic review and meta-analysis. *Obes Rev*. 2014;15(11):920-932.
17 doi:10.1111/obr.12220
- 18 4. Barte JCM, Ter Bogt NCW, Bogers RP, et al. Maintenance of weight loss after
19 lifestyle interventions for overweight and obesity, a systematic review. *Obes Rev*.
20 2010;11:899-906. doi:10.1111/j.1467-789X.2010.00740.x
- 21 5. Dombrowski S, Knittle K, Avenell a, Araujo-Soares V, Sniehotta F. Long term
22 maintenance of weight loss with non-surgical interventions in obese adults: systematic
23 review and meta-analyses of randomised controlled trials. *BMJ*. 2014;348:g2646.
24 doi:10.1136/bmj.g2646
- 25 6. Dietz WH, Baur LA, Hall K, et al. Management of obesity: improvement of health-care

- 1 training and systems for prevention and care. *Lancet*. 2015;385:2521-2533.
2 doi:10.1016/S0140-6736(14)61748-7
- 3 7. NICE guideline. Obesity: identification, assessment and management. Clinical
4 guideline [CG189]. 2014.
- 5 8. Hayes SC, Villatte M, Levin M, Hildebrandt M. Open, Aware, and Active: Contextual
6 Approaches as an Emerging Trend in the Behavioral and Cognitive Therapies. *Annu*
7 *Rev Clin Psychol*. 2011;7:141-168. doi:10.1146/annurev-clinpsy-032210-104449
- 8 9. Hayes SC. Acceptance and commitment therapy, relational frame theory, and the
9 third wave of behavioral and cognitive therapies. *Behav Ther*. 2004;35(4):639-665.
10 doi:10.1016/S0005-7894(04)80013-3
- 11 10. Linardon J, Fairburn CG, Fitzsimmons-Craft EE, Wilfley DE, Brennan L. The empirical
12 status of the third-wave behaviour therapies for the treatment of eating disorders: A
13 systematic review. *Clin Psychol Rev*. 2017;58:125-140. doi:10.1016/j.cpr.2017.10.005
- 14 11. Olson KL, Emery CF. Mindfulness and weight loss: A systematic review. *Psychosom*
15 *Med*. 2015;77(1):59-67. doi:10.1097/PSY.0000000000000127
- 16 12. O'Reilly GA, Cook L, Spruijt-Metz D, Black DS. Mindfulness-based interventions for
17 obesity-related eating behaviours: A literature review. *Obes Rev*. 2014;15(6):453-461.
18 doi:10.1111/obr.12156
- 19 13. Rogers JM, Ferrari M, Mosely K, Lang CP, Brennan L. Mindfulness-based
20 interventions for adults who are overweight or obese: a meta-analysis of physical and
21 psychological health outcomes. *Obes Rev*. 2017;18(1):51-67. doi:10.1111/obr.12461
- 22 14. Roche AI, Kroska EB, Denburg NL. Acceptance- and mindfulness-based interventions
23 for health behavior change: Systematic review and meta-analyses. *J Context Behav*
24 *Sci*. 2019;13:74-93. doi:10.1016/j.jcbs.2019.06.002
- 25 15. Carrière K, Khoury B, Günak MM, Knäuper B. Mindfulness-based interventions for

- 1 weight loss: a systematic review and meta-analysis. *Obes Rev.* 2018;19(2):164-177.
2 doi:10.1111/obr.12623
- 3 16. Ruffault A, Czernichow S, Hagger MS, et al. The effects of mindfulness training on
4 weight-loss and health-related behaviours in adults with overweight and obesity: A
5 systematic review and meta-analysis. *Obes Res Clin Pract.* 2017;11:90-111.
6 doi:10.1016/j.orcp.2016.09.002
- 7 17. Katterman SN, Kleinman BM, Hood MM, Nackers LM, Corsica JA. Mindfulness
8 meditation as an intervention for binge eating, emotional eating, and weight loss: A
9 systematic review. *Eat Behav.* 2014;15(2):197-204. doi:10.1016/j.eatbeh.2014.01.005
- 10 18. Lyzwinski LN, Caffery L, Bambling M, Edirippulige S. A Systematic Review of
11 Electronic Mindfulness-Based Therapeutic Interventions for Weight, Weight-Related
12 Behaviors, and Psychological Stress. *Telemed e-Health.* 2018;24(3).
13 doi:10.1089/tmj.2017.0117
- 14 19. Public Health England. *National Mapping of Weight Management Services; Provision*
15 *of Tier 2 and Tier 3 Services in England.* 2015.
- 16 20. Curry SJ, Krist AH, Owens DK, et al. Behavioral weight loss interventions to prevent
17 obesity-related morbidity and mortality in adults US preventive services task force
18 recommendation statement. *JAMA.* 2018;320(11):1163-1171.
19 doi:10.1001/jama.2018.13022
- 20 21. Lawlor ER, Islam N, Griffin SJ, Hill AJ, Hughes CA, Ahern AL. Third-wave cognitive
21 behaviour therapies for weight management: Systematic review and network meta-
22 analysis protocol. *BMJ Open.* 2018;8:e023425. doi:10.1136/bmjopen-2018-023425
- 23 22. The Cochrane Public Health Group. Cochrane Public Health Group Data Extraction
24 and Assessment Template. 2011:1-22.
- 25 23. Schulz KF, Altman DG, Moher D, et al. CONSORT 2010 Statement: updated
26 guidelines for reporting parallel group randomised trials. *BMC Med.* 2010;8:18.

- 1 doi:10.1186/1741-7015-8-18
- 2 24. Hoffmann TC, Glasziou PP, Boutron I, et al. Better reporting of interventions:
3 Template for intervention description and replication (TIDieR) checklist and guide.
4 *BMJ*. 2014;348:g1687. doi:10.1136/bmj.g1687
- 5 25. Higgins JPT, Sterne JAC, Savović J, Page MJ, Hróbjartsson A, Boutron I, Reeves
6 B, Eldridge S. A revised tool for assessing risk of bias in randomized trials In:
7 Chandler J, McKenzie J, Boutron I, Welch V (editors). *Cochrane Methods*.
8 *Cochrane Database of Systematic Reviews* 2016, Issue 10 (Suppl 1).
9 dx.doi.org/10.1002/14651858.CD201601.
- 10 26. Sterne JA, Hernán MA, Reeves BC, et al. ROBINS-I: A tool for assessing risk of bias
11 in non-randomised studies of interventions. *BMJ*. 2016;355:i4919.
12 doi:10.1136/bmj.i4919
- 13 27. Guyatt GH, Oxman A, Vist G, et al. GRADE an emerging consensus on rating quality
14 of evidence and stren. *BMJ*. 2008;336:924. doi:10.1136/bmj.39489.470347.AD
- 15 28. Braun TD, Park CL, Conboy LA. Psychological Well-Being, Health Behaviors, and
16 Weight Loss Among Participants in a Residential Kripalu Yoga-Based Weight Loss
17 Program. *Int J Yoga Therap*. 2012;22:9-22.
- 18 29. Dalen J, Smith BW, Shelley BM, Sloan AL, Leahigh L, Begay D. Pilot study: Mindful
19 Eating and Living (MEAL): Weight, eating behavior, and psychological outcomes
20 associated with a mindfulness-based intervention for people with obesity.
21 *Complement Ther Med*. 2010;18:260-264. doi:10.1016/j.ctim.2010.09.008
- 22 30. Fletcher LB. A Mindfulness and Acceptance-based Intervention for Increasing
23 Physical Activity and Reducing Obesity. *Dissertation*. 2011.
- 24 31. Goldbacher E, La Grotte C, Komaroff E, Vander Veur S, Foster GD. An initial
25 evaluation of a weight loss intervention for individuals who engage in emotional

- 1 eating. *J Behav Med.* 2016;39:139-150. doi:10.1007/s10865-015-9678-6
- 2 32. Raja-Khan N, Agito K, Shah J, et al. Mindfulness-Based Stress Reduction in Women
3 with Overweight or Obesity: A Randomized Clinical Trial. *Obesity.* 2017;25:1349-
4 1359. doi:10.1002/oby.21910
- 5 33. Blevins NC. Mindfulness meditation as an intervention for body image and weight
6 management in college women: A pilot study. *Dissertation.* 2008.
- 7 34. Boucher S, Gray A, Lillis J, et al. Teaching Intuitive Eating and Acceptance and
8 Commitment Therapy Skills Via a Web-Based Intervention: A Pilot Single-Arm
9 Intervention Study. *JMIR Res Protoc.* 2016;5(4):e180. doi:10.2196/resprot.5861
- 10 35. Davis KK. Effect of Mindfulness Meditation and Home-Based Resistance Exercise on
11 Weight Loss, Weight Loss Behaviors, and Psychosocial Correlates in Overweight
12 Adults. *Dissertation.* 2008.
- 13 36. Lee TM. Comparing mindfulness-enriched weight management to current standard
14 practices. *Dissertation.* 2017. doi:https://doi.org/10.13023/ETD.2017.054
- 15 37. Palmeira L, Cunha M, Pinto-Gouveia J. Processes of change in quality of life, weight
16 self-stigma, body mass index and emotional eating after an acceptance-, mindfulness-
17 and compassion-based group intervention (Kg-Free) for women with overweight and
18 obesity. *J Health Psychol.* 2017:1-14. doi:10.1177/1359105316686668
- 19 38. Chung S, Zhu S, Friedmann E, et al. Weight loss with mindful eating in African
20 American women following treatment for breast cancer: a longitudinal study. *Support*
21 *Care Cancer.* 2016;24:1875-1881. doi:10.1007/s00520-015-2984-2
- 22 39. Gallé F, Cirella A, Salzano AM, Onofrio V Di, Belfiore P, Liguori G. Analyzing the
23 Effects of Psychotherapy on Weight Loss after Laparoscopic Gastric Bypass or
24 Laparoscopic Adjustable Gastric Banding in Patients with Borderline Personality
25 Disorder: A Prospective Study. *Scand J Surg.* 2017;106(4):299-304.
26 doi:10.1177/1457496917701670

- 1 40. Kristeller J, Wolever RQ, Sheets V. Mindfulness-Based Eating Awareness Training
2 (MB-EAT) for Binge Eating: A Randomized Clinical Trial. *Mindfulness*. 2014;5(3):282-
3 297. doi:10.1007/s12671-012-0179-1
- 4 41. Loader KA. A compassionate mind approach to self-help for treatment seeking obese
5 adults: A randomised controlled trial. *Dissertation*. 2013.
- 6 42. McKee HC, Ntoumanis N. Developing self-regulation for dietary temptations:
7 intervention effects on physical, self-regulatory and psychological outcomes. *J Behav*
8 *Med*. 2014;37:1075-1081. doi:10.1007/s10865-014-9557-6
- 9 43. Roosen MA, Safer D, Adler S, Cebolla A, van Strien T. Group dialectical behavior
10 therapy adapted for obese emotional eaters; a pilot study. *Nutr Hosp*.
11 2012;27(4):1141-1147. doi:10.3305/nh.2012.27.4.5843
- 12 44. Sairanen E, Tolvanen A, Karhunen L, et al. Psychological flexibility mediates change
13 in intuitive eating regulation in acceptance and commitment therapy interventions.
14 *Public Health Nutr*. 2017;20(9):1681-1691. doi:10.1017/s1368980017000441
- 15 45. Smith BW, Shelley BM, Sloan AL, Colleran K, Erickson K. A Preliminary Randomized
16 Controlled Trial of a Mindful Eating Intervention for Post-menopausal Obese Women.
17 *Mindfulness*. 2018;9(3):836-849. doi:10.1007/s12671-017-0824-9
- 18 46. Spadaro KC, Davis KK, Sereika SM, Gibbs BB, Jakicic JM, Cohen SM. Effect of
19 mindfulness meditation on short-term weight loss and eating behaviors in overweight
20 and obese adults: A randomized controlled trial. *J Complement Integr Med*.
21 2017;15(2). doi:10.1515/jcim-2016-0048
- 22 47. Godfrey KM, Gallo LC, Afari N. Mindfulness-based interventions for binge eating: a
23 systematic review and meta-analysis. *J Behav Med*. 2015;38:348-362.
24 doi:10.1007/s10865-014-9610-5
- 25 48. Vocks S, Tuschen-Caffier B, Pietrowsky R, Rustenbach SJ, Kersting A, Herpertz S.
26 Meta-analysis of the effectiveness of psychological and pharmacological treatments

- 1 for binge eating disorder. *Int J Eat Disord*. 2010;43:205-217. doi:10.1002/eat.20696
- 2 49. StataCorp. Stata Statistical Software. 2015.
- 3 50. Wasserstein RL, Lazar NA. The ASA's Statement on p -Values: Context, Process,
4 and Purpose. *Am Stat*. 2016;70(2):129-133. doi:10.1080/00031305.2016.1154108
- 5 51. DerSimonian R, Laird N. Meta-analysis in clinical trials. *Control Clin Trials*.
6 1986;7:177-188. doi:10.1016/0197-2456(86)90046-2
- 7 52. Hedges, LV; Olkin I. *Statistical Methods for Meta-Analysis*. Academic Press; 2014.
- 8 53. Salanti G, Giovane C Del, Chaimani A, Caldwell DM, Higgins JPT. Evaluating the
9 quality of evidence from a network meta-analysis. *PLoS One*. 2014;9(7):e99682.
10 doi:10.1371/journal.pone.0099682
- 11 54. Butryn ML, Forman EM, Lowe MR, Gorin AA, Zhang F, Schaumberg K. Efficacy of
12 environmental and acceptance-based enhancements to behavioral weight loss
13 treatment: The ENACT trial. *Obesity*. 2017;25:866-872. doi:10.1002/oby.21813
- 14 55. Higgins JPT, Jackson D, Barrett JK, Lu G, Ades AE, White IR. Consistency and
15 inconsistency in network meta-analysis: concepts and models for multi-arm studies.
16 *Res Synth Methods*. 2012;3:98-110. doi:10.1002/jrsm.1044
- 17 56. Dias S, Welton NJ, Caldwell DM, Ades AE. Checking consistency in mixed treatment
18 comparison meta-analysis. *Stat Med*. 2010;29:932-944. doi:10.1002/sim.3767
- 19 57. Salanti G, Ades AE, Ioannidis JPA. Graphical methods and numerical summaries for
20 presenting results from multiple-treatment meta-analysis: An overview and tutorial. *J*
21 *Clin Epidemiol*. 2011;64(2):163-171. doi:10.1016/j.jclinepi.2010.03.016
- 22 58. Tobias A. Assessing the influence of a single study in the meta-analysis estimate.
23 *Stata Tech Bull*. 1999:15-17. [https://www.stata-](https://www.stata-press.com/journals/stbcontents/stb47.pdf)
24 [press.com/journals/stbcontents/stb47.pdf](https://www.stata-press.com/journals/stbcontents/stb47.pdf).
- 25 59. Higgins JPT , Green S, ed. *Cochrane Handbook for Systematic Reviews of*

- 1 *Interventions Version 5.1.0 (Updated March 2011)*. The Cochrane Collaboration;
2 2011. www.handbook.cochrane.org.
- 3 60. Lappalainen R, Sairanen E, Järvelä E, et al. The effectiveness and applicability of
4 different lifestyle interventions for enhancing wellbeing: the study design for a
5 randomized controlled trial for persons with metabolic syndrome risk factors and
6 psychological distress. *BMC Public Health*. 2014;14:310. doi:10.1186/1471-2458-14-
7 310
- 8 61. Raja-Khan N, Agito K, Shah J, et al. Mindfulness-based stress reduction for
9 overweight/obese women with and without polycystic ovary syndrome: Design and
10 methods of a pilot randomized controlled trial. *Contemp Clin Trials*. 2015;41:287-297.
11 doi:10.1016/j.cct.2015.01.021
- 12 62. Lillis J, Niemeier HM, Ross KM, et al. Weight loss intervention for individuals with high
13 internal disinhibition: design of the Acceptance Based Behavioral Intervention (ABBI)
14 randomized controlled trial. *BMC Psychol*. 2015;3:17. doi:10.1186/s40359-015-0075-2
- 15 63. Mattila E, Lappalainen R, Väikkynen P, Sairanen E, Lappalainen P. Usage and Dose
16 Response of a Mobile Acceptance and Commitment Therapy App: Secondary
17 Analysis of the Intervention Arm of a Randomized Controlled Trial. *JMIR Mhealth*
18 *Uhealth*. 2016;4(3):e90. doi:10.2196/mhealth.5241
- 19 64. Hamel REG. Weight loss and psychosocial effects of a mindfulness-based
20 intervention in overweight adults: a pilot study. *Dissertation*. 2010.
- 21 65. Braun TD, Noggle JJ, Gorin AA, Garivaltis H, Conboy LA, Park CL. Group-Based
22 Yogic Weight Loss with Ayurveda-Inspired Components: A Pilot Investigation of
23 Female Yoga Practitioners and Novices. *Int J Yoga Therap*. 2016;26:55-72.
24 doi:10.17761/1531-2054-26.1.55
- 25 66. Adler S. Orlistat/Alli compared to Orlistat/Alli plus dialectical behavior therapy in
26 overweight binge eaters: A randomized control trial. *Dissertation*. 2008.

- 1 67. Daubenmier J, Kristeller J, Hecht FM, et al. Mindfulness Intervention for Stress Eating
2 to Reduce Cortisol and Abdominal Fat among Overweight and Obese Women: An
3 Exploratory Randomized Controlled Study. *J Obes.* 2011:1-13.
4 doi:10.1155/2011/651936
- 5 68. Daubenmier J, Moran PJ, Kristeller J, et al. Effects of a mindfulness-based weight
6 loss intervention in adults with obesity: A randomized clinical trial. *Obesity.*
7 2016;24:794-804. doi:10.1002/oby.21396
- 8 69. Miller CK, Kristeller JL, Headings A, Nagaraja H, Miser WF. Comparative
9 Effectiveness of a Mindful Eating Intervention to a Diabetes Self-Management
10 Intervention among Adults with Type 2 Diabetes: A Pilot Study. *J Acad Nutr Diet.*
11 2012;112:1835-1842. doi:10.1016/j.jand.2012.07.036
- 12 70. Palmeira L, Pinto-Gouveia J, Cunha M. Exploring the efficacy of an acceptance,
13 mindfulness & compassionate-based group intervention for women struggling with
14 their weight (Kg-Free): A randomized controlled trial. *Appetite.* 2017;112:107-116.
15 doi:10.1016/j.appet.2017.01.027
- 16 71. Forman EM, Butryn ML, Juarascio AS, et al. The Mind Your Health project: A
17 randomized controlled trial of an innovative behavioral treatment for obesity. *Obesity.*
18 2013;21(6):1119-1126. doi:10.1002/oby.20169
- 19 72. Forman EM, Butryn ML, Manasse SM, et al. Acceptance-based versus standard
20 behavioral treatment for obesity: Results from the Mind Your Health randomized
21 controlled trial. *Obesity.* 2016;24(10):2050-2056. doi:10.1002/oby.21601
- 22 73. Lillis J, Niemeier HM, Thomas JG, et al. A randomized trial of an acceptance-based
23 behavioral intervention for weight loss in people with high internal disinhibition.
24 *Obesity.* 2016;24(12):2509-2514. doi:10.1002/oby.21680
- 25 74. Carpenter KM, Vickerman KA, Salmon EE, Javitz HS, Epel ES, Lovejoy JC. A
26 Randomized Pilot Study of a Phone-Based Mindfulness and Weight Loss Program.

- 1 *Behav Med.* 2017;6:1-11. doi:10.1080/08964289.2017.1384359
- 2 75. Niemeier HM, Leahey T, Palm Reed K, Brown RA, Wing RR. An Acceptance-Based
3 Behavioral Intervention for Weight Loss: A Pilot Study. *Behav Ther.* 2012;43(2):427-
4 435. doi:10.1016/j.beth.2011.10.005
- 5 76. Andalcio AA. Implementation of a Lifestyle Intervention Program in the Primary Care
6 Setting to Decrease Body Mass Indices in Obese Adults. *Dissertation.* 2018.
- 7 77. Hanson P, Shuttlewood E, Halder L, et al. Application of Mindfulness in a Tier 3
8 Obesity Service Improves Eating Behavior and Facilitates Successful Weight Loss. *J*
9 *Clin Endocrinol Metab.* 2019;104(3):793-800. doi:10.1210/jc.2018-00578.
- 10 78. Lundgren JD. A mindfulness-based behavioral treatment for weight loss. *Dissertation.*
11 2003.
- 12 79. Bradley LE, Forman EM, Kerrigan SG, et al. Project HELP: a Remotely Delivered
13 Behavioral Intervention for Weight Regain after Bariatric Surgery. *Obes Surg.*
14 2017;27(3):586-598. doi:10.1007/s11695-016-2337-3
- 15 80. Forman EM, Butryn ML, Hoffman KL, Herbert JD. An Open Trial of an Acceptance-
16 Based Behavioral Intervention for Weight Loss. *Cogn Behav Pract.* 2009;16(2):223-
17 235. doi:10.1016/j.cbpra.2008.09.005
- 18 81. Butryn ML, Phelan S, Hill JO, et al. Consistent Self-monitoring of Weight : A Key
19 Component of Successful Weight Loss Maintenance. *Obesity.* 2007;15(12):3091-
20 3096. doi:10.1038/oby.2007.368.
- 21 82. Johnsen TJ, Friborg O. The effects of cognitive behavioral therapy as an anti-
22 depressant treatment is falling: A meta-analysis. *Psychol Bull.* 2015;141(4):747-768.
23 doi:http://dx.doi.org/10.1037/bul0000015.
- 24 83. Borek AJ, Abraham C, Greaves CJ, Tarrant M. Group-Based Diet and Physical
25 Activity Weight-Loss Interventions : A Systematic Review and Meta-Analysis of

- 1 Randomised Controlled Trials. *Appl Psychol Heal Well-Being*. 2018;10(1):62-86.
2 doi:10.1111/aphw.12121
- 3 84. Beleigoli AM, Andrade AQ, Cançado AG, et al. Web-Based Digital Health
4 Interventions for Weight Loss and Lifestyle Habit Changes in Overweight and Obese
5 Adults : Systematic Review and Meta-Analysis. *J Med Internet Res*. 2019;8(21):e298.
6 doi:10.2196/jmir.9609
- 7 85. Caplan W, Bowman JD, Pronk NP. Weight-Loss Outcomes: A Systematic Review and
8 Meta-Analysis of Weight-Loss Clinical Trials with a Minimum 1-Year Follow-Up. *J Am
9 Diet Assoc*. 2007;107:1755-1767. doi:10.1016/j.jada.2007.07.017.
- 10 86. Pagoto SL, Schneider KL, Oleski JL, Luciani JM, Bodenlos JS, Whited MC. Male
11 inclusion in randomized controlled trials of lifestyle weight loss interventions. *Obesity*.
12 2012;20(6):1234-1239. doi:10.1038/oby.2011.140
- 13 87. Daubenmier J, Lin J, Blackburn E, et al. Changes in stress, eating, and metabolic
14 factors are related to changes in telomerase activity in a randomized mindfulness
15 intervention pilot study. *Psychoneuroendocrinology*. 2012; 37:917-928.
16 doi:10.1016/j.psyneuen.2011.10.008.
- 17 88. Mason AE, Epel ES, Aschbacher K, et al. Reduced reward-driven eating accounts for
18 the impact of a mindfulness-based diet and exercise intervention on weight loss: Data
19 from the SHINE randomized controlled trial. *Appetite*. 2016; 100: 86-93.
20 <http://dx.doi.org/10.1016/j.appet.2016.02.009>.
- 21 89. Miller CK, Kristeller JL, Headings A, Nagaraja H. Comparison of a Mindful Eating
22 Intervention to a Diabetes Self-Management Intervention Among Adults with Type 2
23 Diabetes: A Randomized Controlled Trial. *Health Educ Behav*. 2014; 41(2):145-154.
24 doi:10.1177/1090198113493092
- 25 90. Spadaro KC. Weight loss: Exploring self-regulation through mindfulness meditation.
26 *Dissertation*. 2008.

- 1 91. Schumacher LM, Godfrey KM, Forman EM, Butryn ML. Change in domain-specific but
2 not general psychological flexibility relates to greater weight loss in acceptance-based
3 behavioral treatment for obesity. *J Contextual Behav Sci.* 2019;12:59-65.
4 <https://doi.org/10.1016/j.jcbs.2019.01.008>
- 5 92. Forman EM, Manasse SM, Butryn ML, et al. Long-term Follow-up of the Mind Your
6 Health Project: Acceptance-Based versus Standard Behavioral Treatment for Obesity.
7 *Obesity.* 2019; 27(4):565-571. doi:10.1002/oby.22412.
- 8 93. Lillis J, Thomas JG, Niemeier HM, Wing RR. Exploring process variables through
9 which acceptance-based behavioral interventions may improve weight loss
10 maintenance. *J Contextual Behav Sci.* 2017; 6: 398-403.
11 <http://dx.doi.org/10.1016/j.jcbs.2017.07.005>
- 12 94. Järvelä-Reijonen E, Karhunen L, Sairanen E, et al. The effects of acceptance and
13 commitment therapy on eating behaviour and diet delivered through face-to-face
14 contact and a mobile app: a randomized controlled trial. *Int J Behav Nutr Phys Act.*
15 2018;15:22. doi: 10.1186/s12966-018-0654-8.
- 16 95. Bradley LE. A remote, acceptance-based intervention for weight regain after bariatric
17 surgery. *Dissertation.* 2015.

18

Figure 1: PRISMA flow diagram

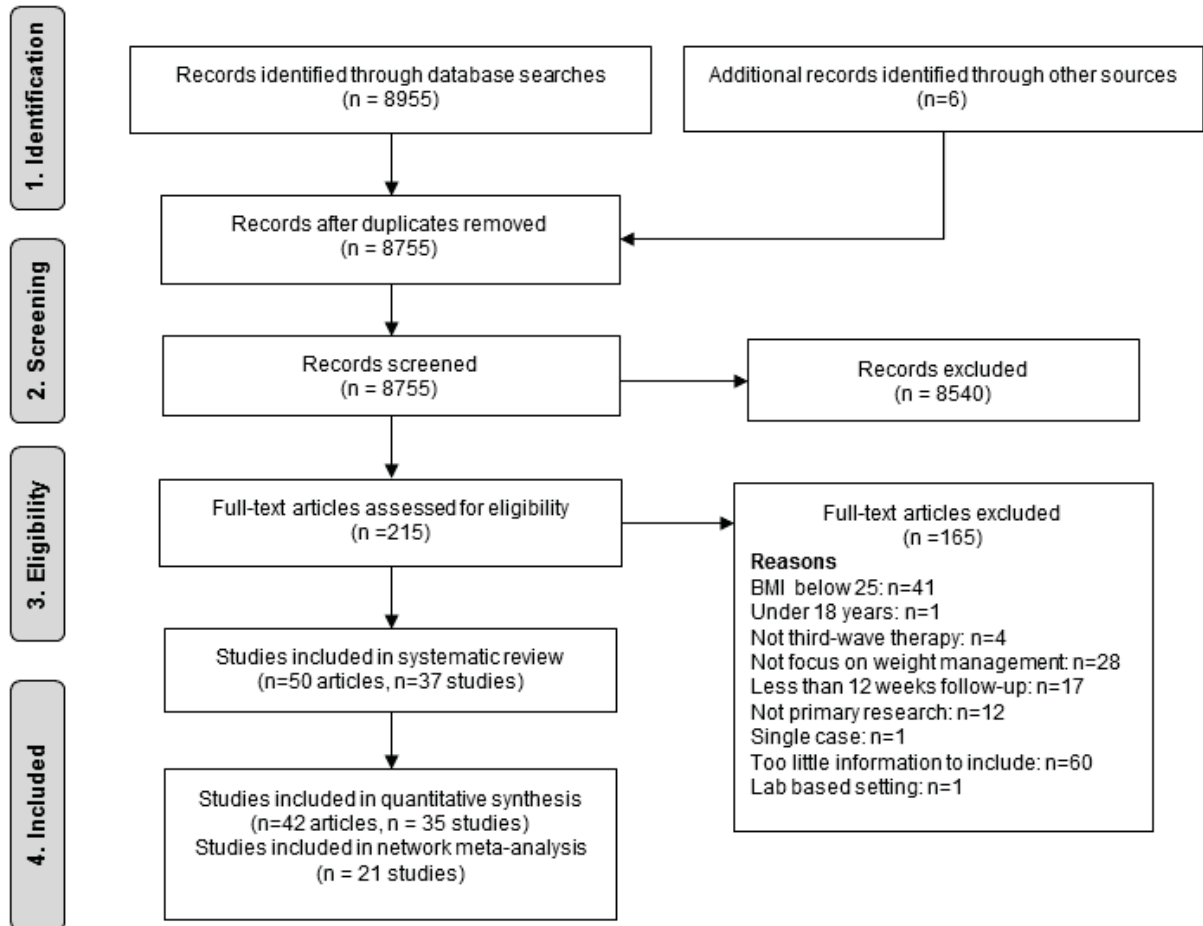


Figure 2: Weight change comparing third-wave CBT and no/minimal or standard behavioural treatment from random-effects pairwise meta-analysis

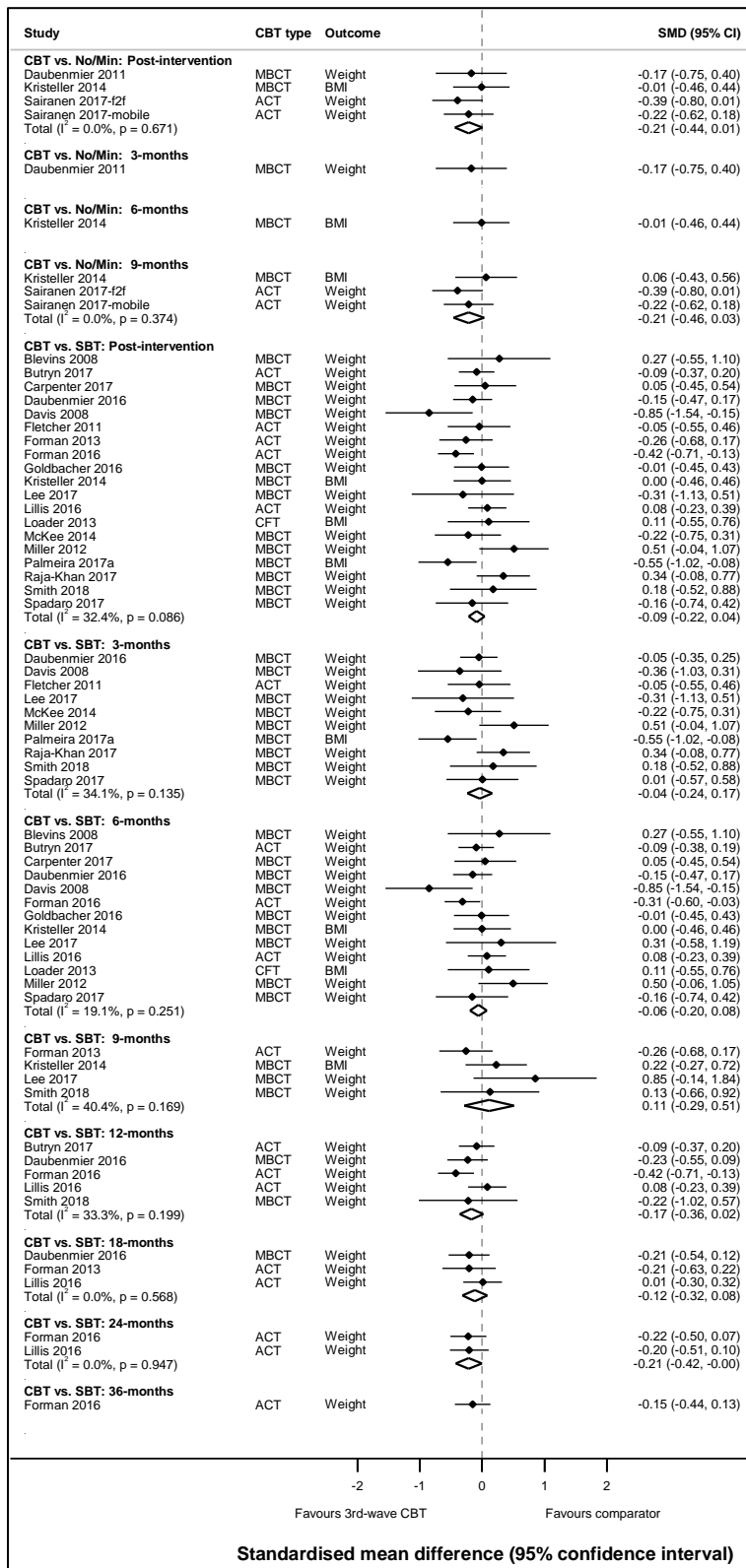


Figure 2 legends: Time-points are months since baseline unless otherwise specified; No/min: No/minimal intervention; SBT: Standard behavioural treatment; CBT: Cognitive behaviour therapy; MBCT: Mindfulness-based cognitive behaviour treatment;

ACT: Acceptance and commitment therapy; CFT: Compassion-focussed therapy; BMI: Body mass index; SMD: Standardised mean difference; CI: Confidence interval.

Figure 3: Network of interventions at different follow-up from baseline time points

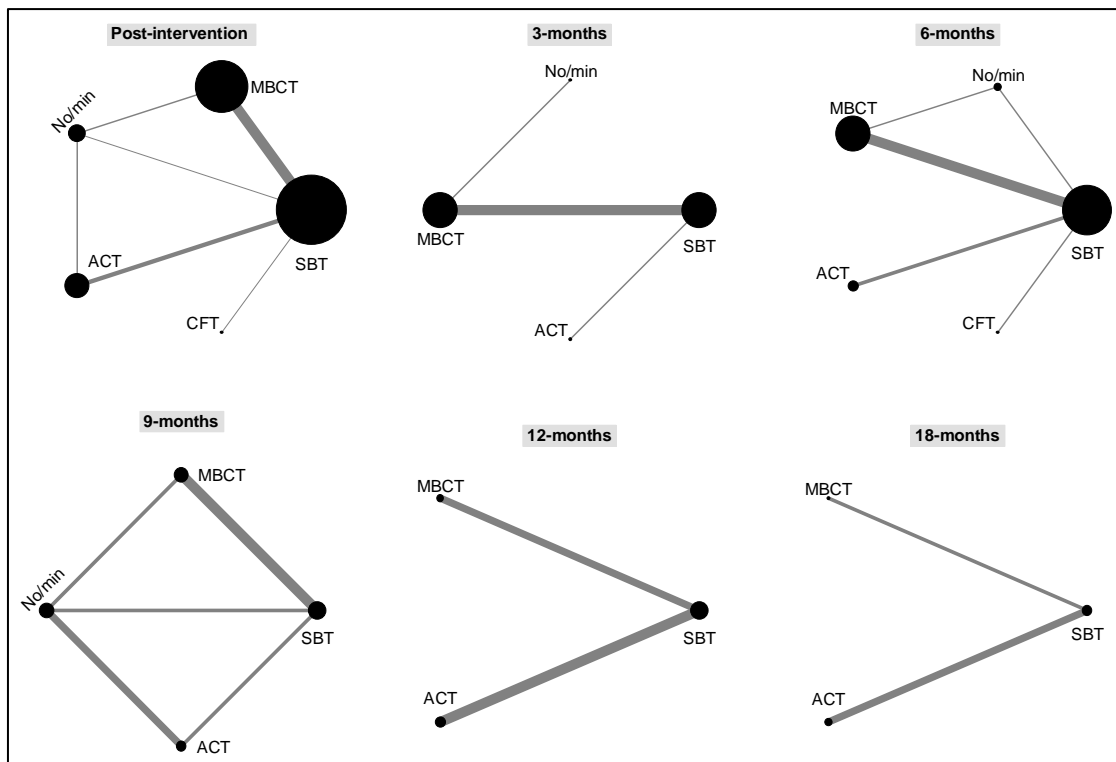


Figure 3 legends: No/min: No/minimal intervention; SBT: Standard behavioural treatment; MBCT: Mindfulness-based cognitive behaviour treatment; ACT: Acceptance and commitment therapy; CFT: Compassion-focussed therapy
 Nodes are weighted by the number of studies involved in each intervention while the edges are weighted by the number of studies involved in each comparison. Time-points are months since randomisation unless otherwise specified.

Figure 4: Summary of weight change from network meta-analysis at different follow-up from baseline time points

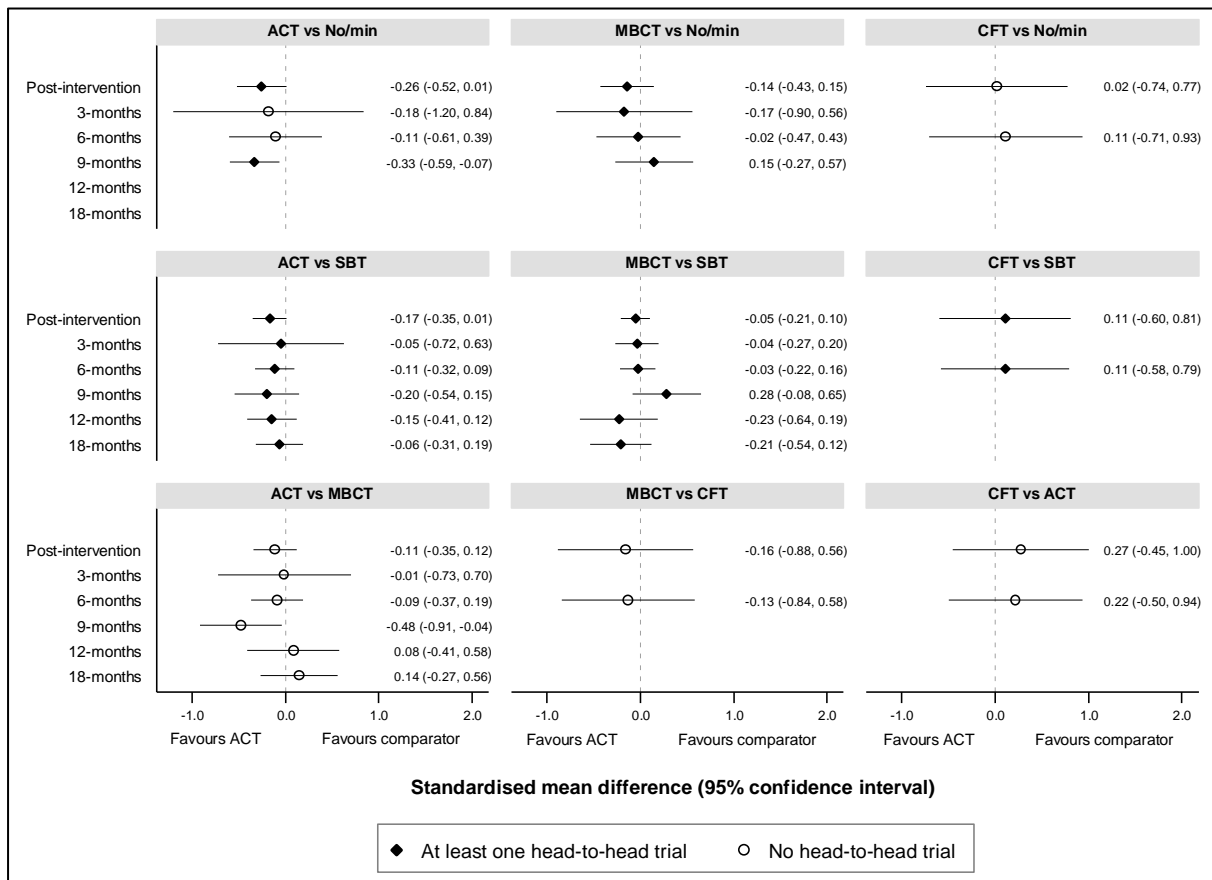
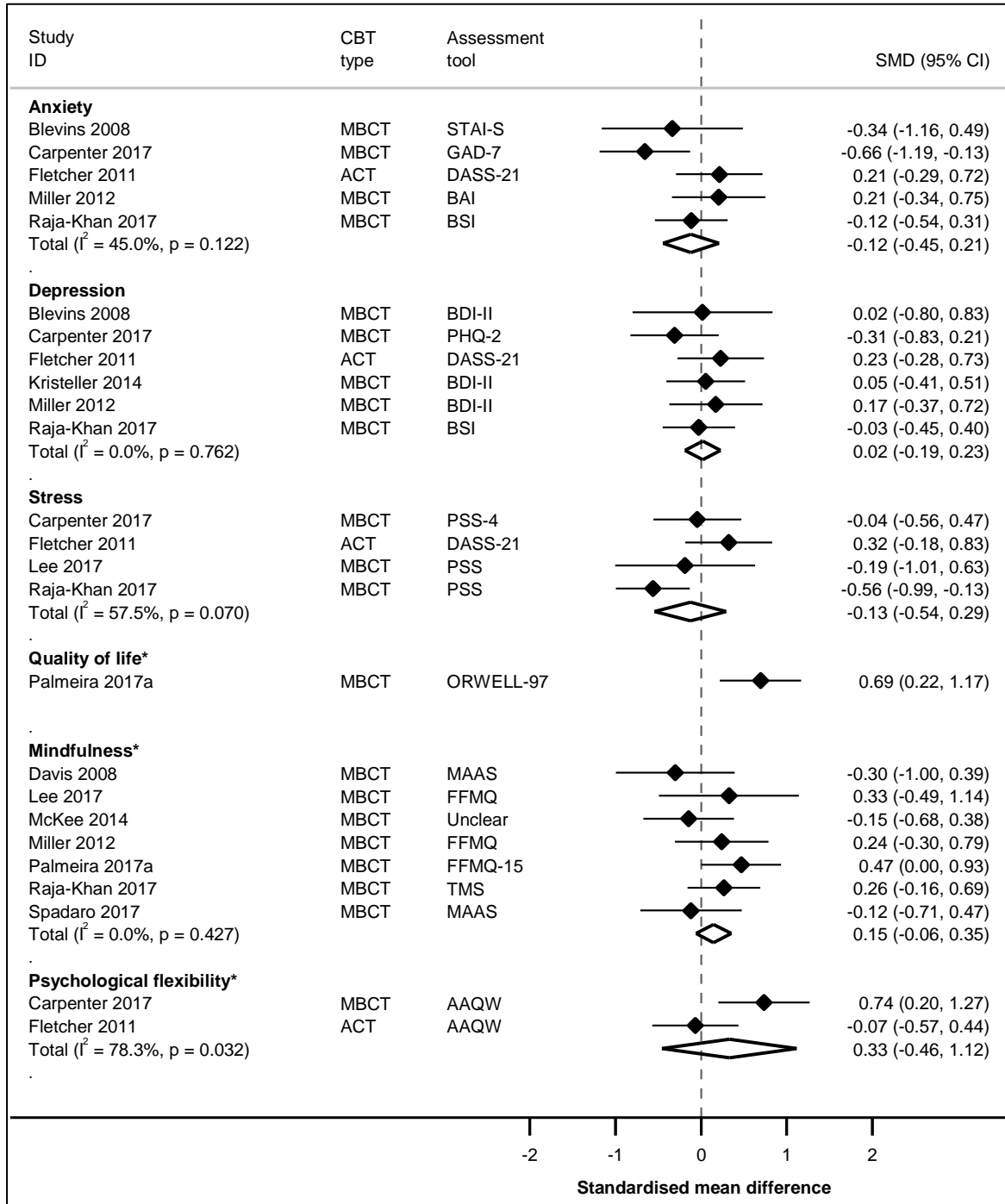


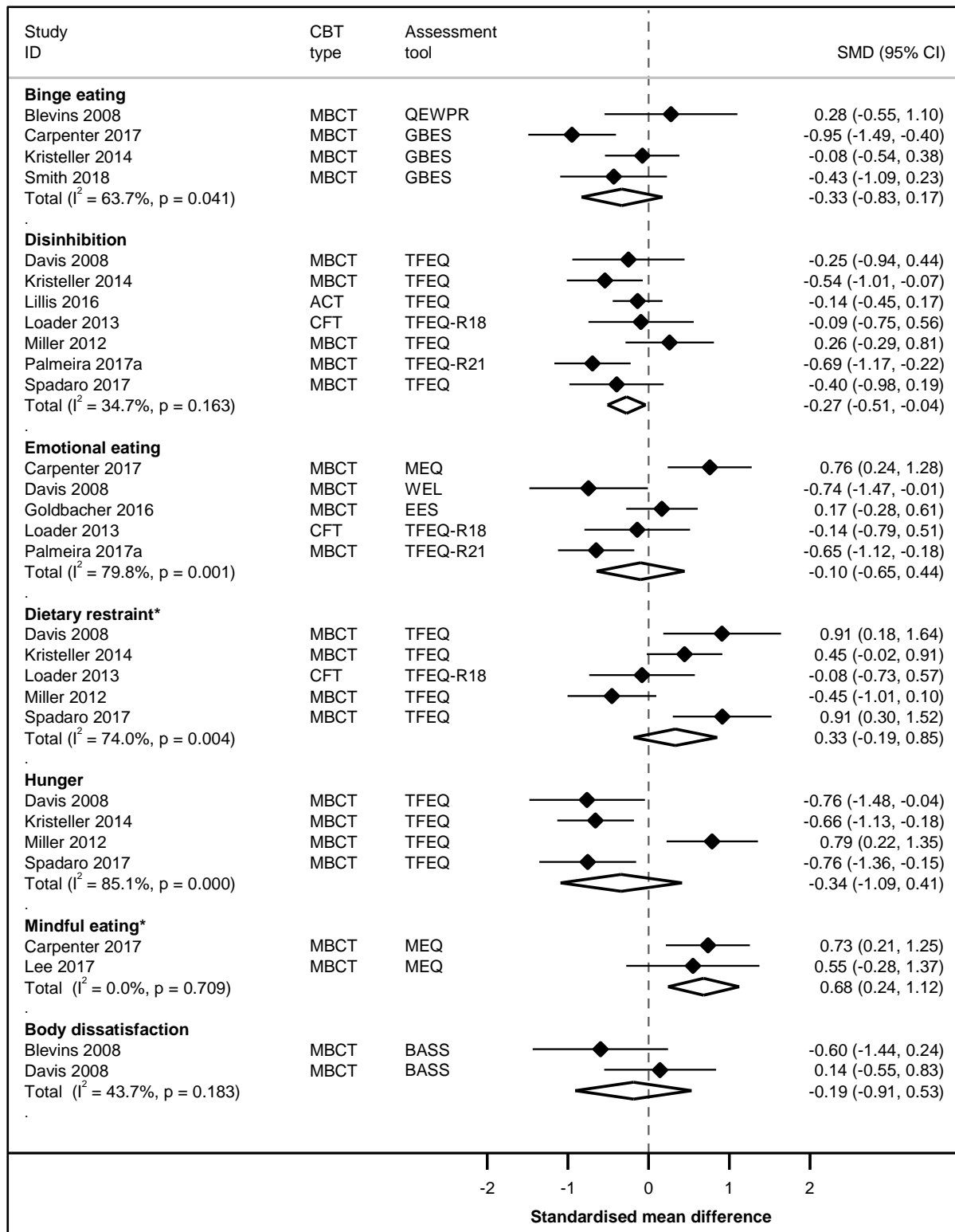
Figure 4 legends: No/min: No/minimal intervention; SBT: Standard behavioural treatment; MBCT: Mindfulness-based cognitive behaviour treatment; ACT: Acceptance and commitment therapy; CFT: Compassion-focussed therapy. Time-points are months since baseline unless otherwise specified.

Figure 5: Changes in secondary outcomes comparing third-wave cognitive behaviour therapy and standard behavioural treatment at earliest time point post-intervention using random-effects pairwise meta-analysis

5a: Psychological outcomes



5b: Eating behaviours



5c: Physical health outcomes

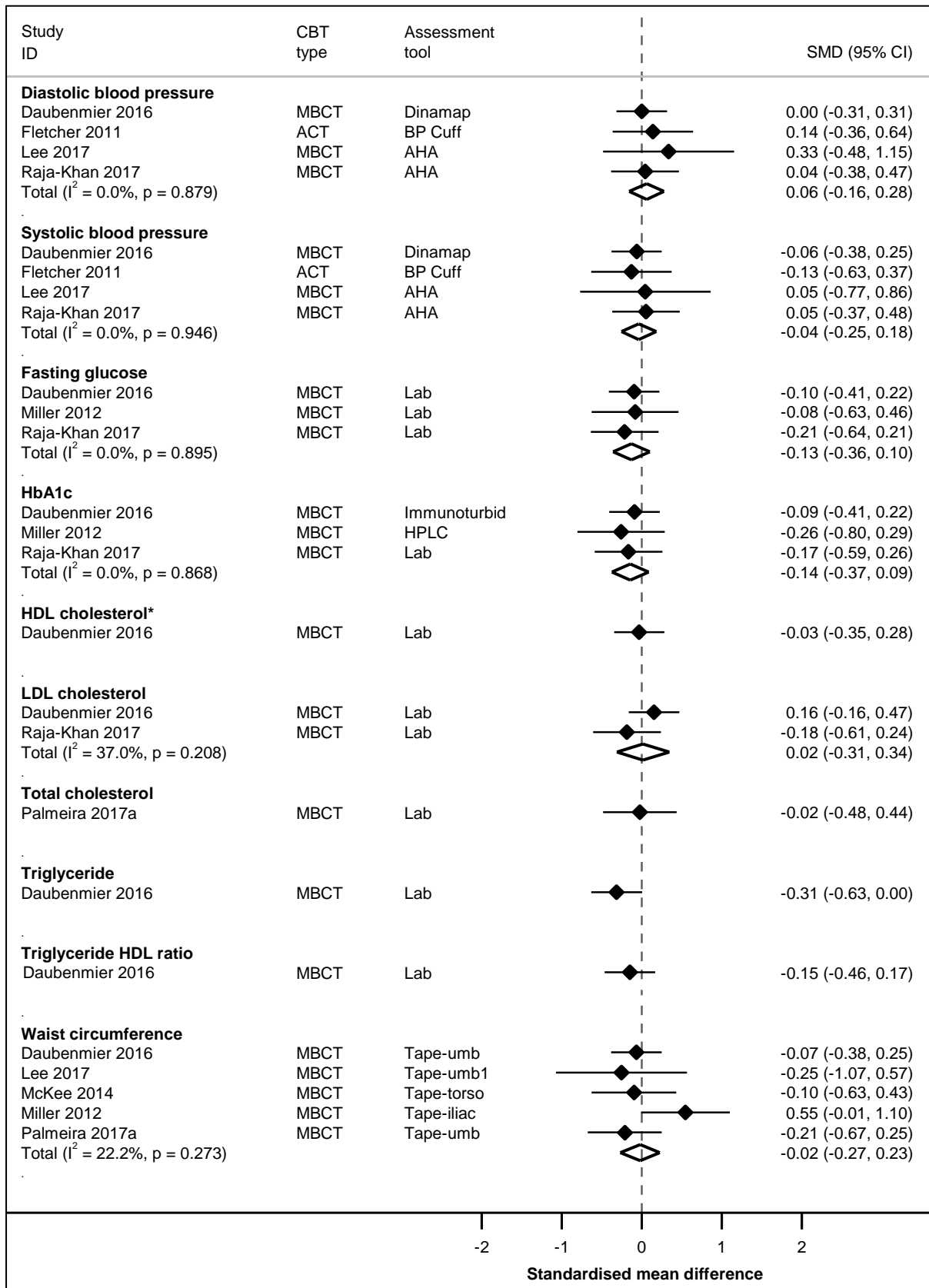


Figure 5a-c legends: * For these variables, estimates to the right of the dotted line indicate a desired change in favour of third-wave CBTs; for all other variables, it is to the left of the dotted line.

CBT: Cognitive behaviour therapy; MBCT: Mindfulness-based cognitive behaviour treatment; ACT: Acceptance and commitment therapy; CFT: Compassion-focussed therapy; CI: Confidence interval.

AAQ-2: Acceptance and Action Questionnaire-2; AAQW: Acceptance and Action Questionnaire for Weight; AHA: American Heart Association guidelines; BAI: Beck Anxiety Inventory (21-item); BASS: Body Areas Satisfaction Scale; BDI: Beck Depression Inventory (1961); BDI-II: Beck Depression Inventory-II (1996); BIA-O: Body Image Assessment-Obesity; BP Cuff: Digital blood pressure cuff; BSI: Brief Symptom Inventory; DASS-21: Depression Anxiety Stress Scales (21-item); DEBQ: Dutch Eating Behavior Questionnaire; Dinamap: GE/Critikon Dinamap Pro 300; EDI-II: Revised Eating Disorder Inventory-Body Dissatisfaction Subscale; EES: Emotional Eating Scale; FFMQ: Five Facets of Mindfulness Questionnaire; FFMQ-15: Five Facet Mindfulness Questionnaire-15; GAD-7: Generalized anxiety disorder-7; GBES: Gormally Binge Eating Scale; HPLC: High performance liquid chromatography; HPLP-II: Health-Promoting Lifestyle Profile II; IES: Intuitive Eating Scale scores; IES-2: Intuitive Eating Scale scores-2; Immunoturbid: Immunoturbidimetry ; IWQOL-Lite: The Impact of Weight on Quality of Life-Lite; Lab: Standard laboratory procedure; MAAS: Mindfulness Attention Awareness Scale; MEQ: Mindful Eating Questionnaire; MEQ-Dutch: Mindful Eating Questionnaire-Dutch version; ORWELL-97: Obesity Related Well-Being Questionnaire; PHQ-2: Patient Health Questionnaire-2; PMS: Philadelphia Mindfulness Scale; PSS: Perceived Stress Scale; PSS-4: Perceived Stress Scale-4; QEWPR: Questionnaire of Eating and Weight Patterns-Revised; QoLI: Quality of Life Inventory; RAND-36: RAND-36; SCL-90: Hopkins Symptom Checklist-90; SIBID-S: Situational Inventory of Body Image Dysphoria-Short Form; STAI-S: State-Trait Anxiety Inventory-State Scale; STAI-T: State-Trait Anxiety Inventory-Trait Scale; Tape-iliac: Tape measure, just above the right iliac crest at the mid-axillary line; Tape-torso: Tape measure, at the narrowest part of the torso between the iliac crest and the xiphoid process; Tape-umb: Tape measure, at the umbilicus; Tape-umb1: Tape measure, 1-inch above umbilicus; TFEQ: Three-Factor Eating Questionnaire; TFEQ-R18: Three-Factor Eating Questionnaire-R18; TFEQ-R21: Three Factor Eating Questionnaire-R21; TMS: Toronto Mindfulness Scale; Unclear: Not clear; WEL: Weight Efficacy Lifestyle Questionnaire (20-item).

Table 1: Characteristics of included studies

1st author, year	Population				Intervention			Comparison		Outcomes	
	N	Age (years)*	BMI (kg/m2)*	Female; N (%)	Intervention(s)	Primary delivery mode	Group or individual	Length (months)	Comparison	Measurements	Time points**
Randomised controlled trials											
Blevins, 2008 (33)	41	20.7 (1.4)	29.6 (1.9)	41 (100)	MBCT	Face to face	Group	2m	SBT	Weight; Anxiety; Depression; Binge eating; Body dissatisfaction	2m, 5m
Carpenter, 2017 (74)	75	47.3 (10.0)	31.5 (2.3)	69 (92)	MBCT	Telephone & email	Individual	6m	SBT	Weight; Anxiety; Depression; Stress; Psychological flexibility; Binge eating; Emotional eating; Mindful eating	6m
Daubenmier, 2011 (67; 87)	47	MBCT: 40.4 (8.0); No/Min: 41.4 (6.7)	31.2 (4.8)	47 (100)	MBCT	Face to face	Group	4m	No/Min	Weight; Anxiety; Stress; Disinhibition; Emotional eating; Dietary restraint;	4m
Daubenmier, 2016 (68; 88)	194	MBCT: 47.2 (13.0); SBT: 47.8 (12.4)	MBCT: 35.4 (3.5); SBT: 35.6 (3.8)	MBCT: 79 (79); SBT: 81 (86)	MBCT	Face to face	Group	5½m	SBT	Weight; DBP; SBP; Fasting glucose; HbA1c; HDL; LDL; TG; TG HDL ratio; Waist circumference	3m, 6m, 12m, 18m
Davis, 2008 (35)	71	45.1 (8.3)	32.9 (3.7)	63 (89)	MBCT	Face to face	Group	6m	SBT, SBT+RE	Weight; Mindfulness; Disinhibition; Emotional eating; Dietary restraint; Hunger; Body dissatisfaction	3m, 6m
Goldbacher, 2016 (31)	79	45.6 (10.5)	36.2 (4.1)	75 (95)	MBCT	Face to face	Group	5m	SBT	Weight; Emotional eating	5m
Kristeller, 2014 (40)	150	46.6	40.3	132 (88)	MBCT	Face to face	Group	5¼m	SBT, No/Min	BMI; Depression; Binge eating; Disinhibition; Dietary restraint; Hunger	6m, 9m
Lee, 2017 (36)	53	47.7 (11.3)	34.5 (4.8)	48 (91)	MBCT	Face to face	Group	3m	SBT	Weight; Stress; Mindfulness; Mindful eating ; DBP; SBP; Waist circumference	3m, 6m, 9m
McKee, 2014 (42)	60	37.6 (13.5)†	32.6 (4.9)†	40 (72)†	MBCT	Face to face & email	Group & individual	2m	SBT	Weight; Mindfulness; Waist circumference	2m, 3m
Miller, 2012 (69; 89)	68	MBCT: 53.9 (8.2); SBT: 54.0 (7.0)†	MBCT: 36.2 (1.2); SBT: 36.1 (1.2)†	33 (63.5)†	MBCT	Face to face	Group	6m	SBT	Weight; Anxiety; Depression; Mindfulness; Disinhibition; Dietary restraint; Hunger; Fasting glucose; HbA1c; Waist circumference	3m, 4m, 6m
Palmeira, 2017 (37; 70)	73	MBCT: 42.0 (8.8) SBT: 42.7 (8.4)	MBCT: 34.8 (5.26) SBT: 33.7 (4.8)	73 (100)	MBCT	Face to face	Group	3½m	SBT	BMI; QoL; Mindfulness; Disinhibition; Emotional eating; Total cholesterol; Waist circumference	3.5m
Raja-Khan, 2017 (32; 61)	86	44.5 (12.5)	38.9 (8.7)	86 (100)	MBCT	Face to face	Group	2m	SBT	Weight; Anxiety; Depression; Stress; Mindfulness; DBP; SBP; Fasting glucose; HbA1c; LDL	2m, 4m
Smith, 2017 (45)	40	MBCT: 58.6 (4.7); SBT: 58.6 (5.2)†	MBCT: 34.7 (4.3); SBT: 38.2 (7.1)†	36 (100)†	MBCT	Face to face	Group	12m	SBT	Weight; Binge eating	1½m, 4m, 9m, 12m
Spadaro, 2017 (46; 90)	49	45.2 (8.2)†	32.5 (3.7)†	40 (87)†	MBCT	Face to face	Group	6m	SBT	Weight; Mindfulness; Disinhibition; Dietary restraint; Hunger	3m, 6m

Butryn, 2017 (54; 91)	283	ACT: 53.2 (9.4); SBT: 53.0 (9.3); BT+E: 53.4 (10.3)	ACT: 35.2 (4.6); SBT: 35.0 (5.2); BT+E: 35.4 (5.2)	ACT: 84 (82); SBT: 67 (76); BT+E: 72 (77)	ACT	Face to face	Group	12m	SBT, BT+E	Weight	6m, 12m
Fletcher, 2011 (30)	72	ACT: 53.1 (11.1); SBT: 52.1 (12.6)	ACT: 36.2 (0.6); SBT: 34.7 (0.6)	60 (83)	ACT	Face to face	Group	1 day	SBT	Weight; Anxiety; Depression; Stress; Psychological flexibility; DBP; SBP	1w (not weight/BMI), 3m
Forman, 2013 (71)	128	45.7 (12.8)	34.1 (3.6)	NR	ACT	Face to face	Group	10m	SBT	Weight	2½m, 5m, 10m,12m
Forman, 2016 (72; 92)	190	51.6 (10.1)	36.9 (5.8)	156 (82)	ACT	Face to face	Group	12m	SBT	Weight	6m, 12m
Lillis, 2016 (62; 73; 93)	162	50.2 (10.9)	37.6 (5.3)	138 (85)	ACT	Face to face	Group	12m	SBT	Weight; Disinhibition	6m, 12m, 18m, 24m
Sairanen, 2017 (44; 60; 63; 94)	219	49.5 (7.4)	31.3 (2.9)	185 (85)	ACT	Face to face Mobile	Group Individual	2m	No/Min	Weight; Mindfulness; Psychological flexibility; Disinhibition; Emotional eating; Dietary restraint; Intuitive eating	2½m, 9m
Loader, 2013 (41)	36	45.4 (9.5)	46.7 (0.3)	25 (69)	CFT	Face to face & telephone	Group & individual	6m	SBT	BMI; Disinhibition; Emotional eating; Dietary restraint	6m, 9m
Adler, 2008 (66)	17	49.4 (11.4)	37.7 (10.1)	15 (88)	DBT+O	Face to face & website	Group & individual	3m	SBT+O		3m, 4.5m
Pre-post studies											
Braun, 2012 (28)	37	Range: 32-65	NR	NR	MBCT	Face to face	Group	5 days	N/A	Weight; Mindfulness; Stress	5d, 3m, 12m [†]
Braun, 2016 (65)	S1: 22; S2: 21	S1: 48.2 (14.3); S2: 49.4 (10.7)	S1: 30.8 (4.2); S2: 35.5 (6.8)	S1: 22 (100); S2: 21 (100)	MBCT	Face to face	Group	2½m	N/A	Weight; Emotional eating; Mindful eating	2.5m, 5½m
Chung, 2016 (38)	26	50.1 (9.0) [†]	35.1 (4.0) [†]	22 (100) [†]	MBCT	Face to face & telephone	Group & individual	6m	N/A	Weight; Mindful eating	3¼m, 6m
Dalen, 2010 (29)	10	44 (8.7)	36.9 (6.2)	7 (70)	MBCT	Face to face	Group	1½m	N/A	Weight; Anxiety; Binge eating; Depression; Dietary restraint; Disinhibition; Stress	1½, 3m
Hamel 2010 (64)	10	50.4 (13.2)	29.1 (3.2)	9 (90)	MBCT	Face to face	Group	NR	N/A	BMI; Emotional eating; Hunger; Mindful eating ; QoL	3.25m
Hanson 2019 (77)	53	45.6 (11.3)	48.5 (9.2)	16 (30.2)	MBCT	Face to face	Group	2m	SBT	Weight; Emotional eating	½m,1m,1½ m,2m,8m
Lundgren, 2005 (78)	33	44.8 (9.0) [†]	31.1 (3.6) [†]	16 (84) [†]	MBCT	Face to face	Group (unclear)	5m	N/A	Weight; QoL	5m
Andalcio 2018 (76)	23	NR	39.9	21 (91.3)	ACT	Face to face & telephone	Individual	4m	N/A	Weight; Waist circumference	2m, 4m
Boucher, 2016 (34)	40	44.8 (3.1)	32.9 (6.0)	40 (100)	ACT	Website	Individual	3½m	N/A	BMI; Intuitive eating	3½m, 6.5m
Bradley, 2017 (79; 95)	20	54.3 (12.1)	NR	17 (85)	ACT	Website & telephone	Individual	2½m	N/A	Weight	1¼m, 2½m, 5½m
Forman, 2009 (80)	29	43.7 (9.8)	35.8 (5.4)	29 (100)	ACT	Face to face	Group	3m	N/A	Weight; Dietary restraint; Disinhibition; Emotional eating; Mindfulness; QoL	3m, 6m
Niemeier, 2012 (75)	21	52.2 (7.6)	32.8 (3.4)	19 (91)	ACT	Face to face	Group	6m	N/A	Weight; Dietary restraint; Disinhibition; Hunger	6m, 9m
Gallé, 2017 (39)	153	DBT:34 (3.8) IIT: 33 (4.2)	45.8 (6.4)	153 (100)	DBT	Face to face	Group & individual	12m	IIT, SBT	Weight	12m

Roosen, 2012 (43)	35	SBT: 32 (5.1) 39.2 (11.0)	35.4 (2.6)	30 (86)	DBT	Face to face	Group & individual	5m	N/A	BMI; Depression; Dietary restraint; Disinhibition; Emotional eating	5m, 11m
-------------------	----	------------------------------	------------	---------	-----	--------------	--------------------	----	-----	---	---------

*Mean (SD) or range; **Time since randomisation/baseline (m= months); †Among completers/participants included in analysis; ‡6- & 9-months recorded but not reported in the article. No/Min= No/minimal intervention; RE= Resistance exercise; BT+E= Behaviour therapy with environmental change; NL= Netherlands; NZ= New Zealand; IIT= Interpersonal individual treatment; S1= Study 1; S2= Study 2; MBCT= Mindfulness-based cognitive behavioural treatment; ACT= Acceptance and commitment therapy; CFT= Compassion-focussed therapy; DBT= Dialectical behavioural therapy; SBT= Standard behavioural treatment; NR= Not reported; DBT+O= DBT+Orlistat; SBT+O= SBT+Orlistat; QoL= Quality of life; BMI= Body Mass Index