Conventional weight loss interventions across the different BMI obesity classes: A systematic review and quantitative comparative analysis

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Abstract
Objective: The recommendation for conventional body weight loss (BWL) treatment in obesity is 5–10%. It is not clear whether BWL is similar across the three different body mass index (BMI) obesity classes. The aim was to provide an overview on BWL across these classes in moderate lifestyle/diet intervention programs.

Method: A systematic literature search was conducted and the evidence of randomized controlled trials (RCTs) and pre-post design studies synthesized. The outcome was BWL.

Results: For RCTs, mean BWL in the intervention group was 3.6 kg (class I) and 5.3 kg (class II), which equates to 4 and 5% BWL, respectively. None of the assessed class III obesity studies met the inclusion criteria. For pre-post design studies, mean BWL was 5.4 kg (class I), 5.5 kg (class II) and 7.9 kg (class III), with high variation within and across studies in the latter. This equates to 6, 5 and, 6% BWL, respectively.

Conclusions: BWL of moderate BWL programs are similar across the different obesity classes. For class I obesity, the results differ between RCT and pre-post design studies by 2% BWL. The high variation of BWL in class III obesity might reflect different states of motivation such as the attitude towards bariatric surgery.

Keywords
adults, obesity, review, treatment, weight loss

1 | INTRODUCTION

Obesity and its associated comorbidities are a serious public health problem (Blüher, 2019). The underlying cause of obesity is a chronic imbalance between energy intake and energy expenditure in favour of the former, leading to an accumulation of body weight and in particular body fat mass (Hruby & Hu, 2015).
The body mass index (BMI) is globally used for classifying body weight (Nuttall, 2015). It is calculated as body weight in kg divided by squared height in meters. A BMI between 18.5 and 24.9 kg/m² is categorized as normal weight, a BMI between 25–29.9 kg/m² as overweight and a BMI ≥30 kg/m² as obese. Furthermore, obesity is subdivided into three BMI classes: class I, 30–34.9 kg/m²; class II, 35–39.9 kg/m²; and class III, ≥40 kg/m² (Deitel & Rossner, 2003).

Obesity is associated with a variety of comorbidities such as type 2 diabetes and cardiovascular diseases (Apovian, 2016). Their risks increase continuously with the degree of obesity compared to normal weight, particularly in class III obesity (World Health Organization [WHO], 2000). Besides the individual burden at physiological and psychological levels (Dixon, 2010), obesity leads to high direct and indirect costs for healthcare systems (European Commission, 2006).

The underlying mechanism for obesity treatment is reduced energy intake to promote body weight loss (BWL). This can be mainly achieved through conservative weight-management programs and/or bariatric surgery. Conservative weight-management programs focus on reducing energy intake, improving eating behaviour and increasing physical activity. Ideally, psychological and psychosocial factors are also addressed (Jensen et al., 2014; Yumuk et al., 2015). Pharmacotherapy is another option in obesity management, but is only used as an adjuvant treatment component in certain situations (Lagerros & Rossner, 2013). Bariatric surgery becomes the method of choice in either severe obesity or obesity with comorbidities, when conservative methods have failed (De Luca et al., 2016; Lagerros & Rossner, 2013; WHO, 2000).

There is currently an ongoing debate as to whether or not conservative weight-management programs are still the first treatment option in individuals with a BMI ≥35 kg/m², as surgical procedures have proven to be highly effective and safe, even in lower obesity classes (Feng, Andalib, Brethauer, Schauer, & Aminian, 2019). For conservative weight management programs realistic BWL goals are important to avoid disappointment. In practice, participants often have unrealistic BWL goals, up to one third of his or her initial body weight (Foster, Wadden, Vogt, & Brewer, 1997). In contrast, the common recommended weight reduction goal ranges between 5 and 10% of initial body weight within 6 months (Jensen et al., 2014; WHO, 2000).

Interestingly, it is not clear whether reduction in body weight is similar across the different obesity classes, when conservative BWL programs are used. To our knowledge, only one systematic review has compared BWL data across obesity classes (Barte, Veldwijk, Teixeira, Sacks, & Bemelmans, 2014). In this review, the inclusion criteria were 1-year weight change after an intervention, consisting of diet and physical activity, in Caucasian adults with a BMI ranging from 25 to 39.9 kg/m² (overweight to class obesity II). In this analysis, comparison of BWL was only based on a pre-post design without control groups, and no randomized controlled trial (RCT) studies were included. The results of the 13 included trials depicted a lower weight change for overweight in contrast to obese participants and no significant weight change differences between class I and class II obesity (Barte et al., 2014).

Therefore, the aim of this systematic review was to compare body weight change by moderate lifestyle and diet intervention programs in patients with obesity separately across the different BMI obesity classes including class III. Initially, we had planned to perform a meta-analysis. However, due to high heterogeneity, which will be discussed later in the manuscript, and no class III obesity RCTs found for analysis, we changed our first intention of doing a meta-analysis. Instead, we decided to do a thorough review on this topic by analysing RCTs in the first step and pre-post trials, which were not necessarily randomized and/or controlled, in the second step.

Our first hypothesis was that BWL depends on the baseline obesity class, with greater BWL expected in individuals with a higher initial BMI category. The rationale for the hypothesis is that resting energy expenditure increases with body weight resulting in larger amounts of energy intake needed to stabilize body weight (Elbelt et al., 2010). Thus, during BWL intervention (diet), the energy deficit might be larger in patients with higher body weight. Our second hypothesis was that BWL in class III obesity shows a large range of variation within and across studies. The rationale for the second hypothesis is that with increasing BMI and comorbidities the wish for a surgical approach might increase in many

### Highlights

- Body weight loss across the different obesity classes in moderate lifestyle/diet intervention programs is similar.
- For class I obesity, the results differ by 2% total BWL between RCTs and pre-post design studies.
- The variation of BWL within and across studies in class III obesity is high and might reflect different states of motivation.
patients, leading to less motivation and subsequently less adherence in a conservative treatment setting.

2 | METHODS

2.1 | Literature information sources and search strategy

The literature search process was divided into two parts. First, a database search was conducted to systematically identify review articles and meta-analyses from the last 5 years which deal with the results of BWL programs according to the search strategy which is recommended for the development of evidence-based guidelines (Ball C; Phillips, 2004). Therefore, a PubMed search was conducted using the following search term: weight loss (title/abstract) AND (review[title] OR meta-analysis [title] AND ["January 1, 2014"[PDAT];"April 11, 2019"[PDAT]). Additionally, hand-searched reviews were included.

In a second step, original articles were systematically extracted from the review articles and meta-analyses and reported on the basis of the PRISMA statement (Liberati et al., 2009; Moher, Liberati, Tetzlaff, Altman, & PRISMA Group, 2009). Additionally, a hand-search for original articles was performed. The review protocol was registered in the International Prospective Register of Systematic Reviews (PROSPERO; CRD42020132766).

2.2 | Eligibility criteria

In the first part of the search, all peer-reviewed review articles and meta-analyses dealing with BWL of conservative programs in overweight and obesity written in German or English and published from January 2014 to April 11th of 2019 were eligible.

Eligibility criteria for the second part of the search were based on the five PICOS dimensions, that is, Participants, Interventions, Comparators, Outcome, and Study design (da Costa Santos, de Mattos Pimenta, & Nobre, 2007).

Participants: A mixed collective of patients with obesity defined as BMI ≥30 kg/m² and aged ≥18 years. Studies exclusively conducted in specific patient groups with for example, type 2 diabetes, metabolic syndrome (=central obesity, high blood pressure, high serum triglyceride and low high-density lipoprotein), polycystic ovary syndrome, pregnancy, mobility limitations, mental illness were excluded to avoid selection bias of specific groups. No restrictions were made regarding ethnicity and sex status.

Interventions: BWL programs for patients with obesity consisting of a moderate standard behavioural and nutritional intervention with or without physical activity and a duration of at least 6 months but not longer than 36 months, were included. BWL interventions (a) following extreme dietary approaches such as ketogenic diet, meal replacement, diets with an energy content of less than 1,000 kcal per day or (b) focusing on methodologies such as eHealth programs to increase comparability between intervention methods were excluded.

Comparators: For group 1, a control group from RCTs was necessary. For group 2, studies with control groups were allowed but not necessary since before-and-after comparisons were conducted.

Outcomes: The primary outcome was BWL in % or kg, secondary outcomes included change of BMI or other weight-related parameters.

Study design: For group 1, only RCTs were included. For group 2, additionally, randomized non-controlled trials (RTs) and uncontrolled pre-post intervention without group comparison (BA) were included.

2.3 | Study selection, data collection and organization

A modified PICOS-scheme was applied for study selection and data collection reference (da Costa Santos et al., 2007).

The first and the last author (K.B. and I.M.) independently screened titles and abstracts to identify relevant reviews and meta-analyses after the removal of duplicates. Full-text reviews and meta-analysis were evaluated regarding their eligibility and disagreement concerning eligibility was resolved by discussion. Based on the included reviews RCTs, RTs and BAs studies were extracted and a second search process was performed similarly to the first search. Again, after removing duplicates of the original RCTs, RTs and BAs, the studies were screened by abstract and title. The remaining trials were then tested for eligibility by full-text and were either analysed quantitatively as RCTs (group 1) or pre-post analysis (group 2). The results for both groups were separately presented by BMI obesity classes. Studies were categorized into class I obesity if the mean BMI of participants was between 30 and 34.9 kg/m², into class II obesity if the mean BMI of participants was between 35 and 39.9 kg/m² and into class III obesity if the mean BMI of participants was ≥40 kg/m².

In the case of missing data, the authors of the RCTs, RTs and BAs were contacted by email with a response rate of 35%.
2.4 | Data items and statistics

The following information was extracted from each included article for groups 1 and 2 and for the different obesity classes: year of publication, sample size, age, sex distribution, intervention design and duration, initial BMI and BWL in kg or body weight after intervention. For group 1, BWL in kg is reported as total BWL (total BWL) and as relative BWL (relative BWL) of the intervention group. The latter was calculated as BWL of the intervention group minus BWL of the corresponding control group. Results across studies are presented by calculating the median [interquartile range], minimum and maximum for: study length, sample size, age and sex for the different obesity classes.

For the quantitative analysis of RCT studies, the sample size, mean and SD are reported separately for the intervention and control group. For both groups the mean difference and 95% CI intervals, as well as the summary of these data across the studies, were calculated using the software package Review Manager 5.3.

Initially, we had planned to perform a meta-analysis. However, the heterogeneity of the studies was too high and not meeting the criteria for a meta-analysis even when applying a random effect model (DerSimonian & Laird, 1986; Normand, 1999). Hence, we performed subgroup analysis for study length (6 months, 7–12 months, 13–36 months) which improved heterogeneity, but still remained high. We did not perform further subgroup analysis to reduce heterogeneity (e.g., according to sex, age etc.) because the majority of studies did not deliver all relevant information needed (DerSimonian & Laird, 1986; Normand, 1999). This would have resulted in the reduction of the studies included leading to a considerable selection bias. Nevertheless, we performed a funnel plot to detect publication bias.

For the quantitative analysis of pre-post studies, the sample size, BWL in kg and the SD were extracted. If BWL was not reported explicitly, the average pre and post body weight data (kg) were used for BWL calculation in Microsoft Excel™. In order to provide a summary of the pre-post data across the studies, BWL of each study was multiplied with the number of participants of the respective study and divided by the total number of participants. Finally, the total mean was calculated as a weighted sum of BWL from the individual studies.

BWL in % was calculated using the fraction mean BWL (kg) divided by mean baseline body weight (kg).

2.5 | Risk of bias

A risk of bias score was assessed based on “The Office of Health Assessment and Translation (OHAT) Risk of Bias Rating tool for Human and Animal Studies” (Rooney, Boyles, Wolfe, Bucher, & Thayer, 2014) for studies which were originally thought to be included in a meta-analysis (group 1). The following items were applied: “Was administered dose or exposure level adequately randomized?”, “Was allocation to study groups adequately concealed?”, “Can we be confident in the exposure characterization?”, “Can we be confident in the outcome assessment?”, “Were all measured outcomes reported?”, “Were statistical methods appropriate?”, “Did researchers adhere to the study protocol?” and “Did the study design or analysis account for important confounding and modifying variables in (including unintended co-exposures) in experimental studies?” The rating ranged between: definitely low (“+++”), probably low (“+”), probably high (“–” or “NR”: not reported), or definitely high risk of bias (“- -”).

Risk of bias for group 1 was analysed within and across studies and no final scores were calculated, pursuant with the PRISMA statement (Moher et al., 2009). Studies were only excluded in case that all questions were of probably high and/or definitely high risk of bias.

3 | RESULTS

3.1 | Study selection and categorization

An overview of the dualistic search process is depicted in Figure 1. A total number of 1,218 RCTs, RTs and BAs were extracted from review articles and meta-analyses. For analysis 91 RTs and non-randomized trials were eligible. From these 91 trials, 83 trials were analysed since eight studies utilized the same participants (Appel et al., 2003; Friedman et al., 2012; Heshka et al., 2003; Runhaar et al., 2015; Samaha et al., 2003; Sarwer et al., 2013; Silva et al., 2010; Truby et al., 2006).

For the quantitative analysis of RCTs (group 1) 32 trials were included. Of these trials, 24 were categorized into class I obesity and 8 into class II obesity. No RCT studies were found for class III obesity. Therefore, the primary analysis of RCTs was complemented by quantitative pre-post analysis including RT, BA and RCT studies, which did not fulfill the criteria for the quantitative analysis of RCTs. A detailed description of the studies is given in Table 1 and Data S1.

For the quantitative pre-post analysis (group 2) 51 trials were included. Of these trials, 27 were categorized into class I obesity, 16 into class II obesity and 7 into class III obesity. Of these studies, 12 were RCTs and originally selected for group 1: However, they were included in group 2 for analysis due to missing data. Here, only the intervention group could be investigated. The remaining trials were either RTs or BAs. Eight trials only provided BWL averaged over all interventions rather than for each intervention
Records identified through database search (n=318) → Reviews after duplicates removed (n=316) → Reviews screenend (n=316) → Reviews excluded by abstract and title (n=271) → Full-text reviews assessed for eligibility (n=45) → Full-text reviews excluded (n=14) → Reviews included for original article screening (n=31) → Additional reviews identified through hand-search (n=8) → Reviews included for original article screening (n=4)

(a)

Records identified through review articles (n=1218) → Records after duplicates removed (n=866) → Records screenend (n=866) → Reviews excluded by abstract and title (n=536) → Full-text articles assessed for eligibility (n=330) → Studies included in qualitative synthesis (n=91) → Studies included in qualitative synthesis of RCTs (n=32) → Studies included in quantitative pre-post analysis (n=51) → Additional original article identified through hand-search (n=2) → Full-text reviews assessed for eligibility (n=45) → Full-text reviews excluded, with reasons n=239:
- DM/IGT/metabolic syndrome: n=11
- eHealth: n=4
- Medical Treatment: n=2
- <6 Mo weight loss Intervention: n=25
- Wrong Topic/Weight Maintenance/no defined intervention: n=54
- BMI <30, missing or not distinct: n=104
- Data not reported: n=19
- Meal Replacement: n=4
- <1000kcal/d: n=7
- mobility limitations of whole group n=1
- ≥ 2 exclusion criteria: n=8

(b)

FIGURE 1 Flow diagram of systematic literature search. Legend A systematic search of review articles through database search was conducted (A), followed by a systematic search of original articles through review articles (B). Abbreviations n: Number; DM: Diabetes mellitus; IGT: impaired glucose tolerance; Mo: Month; BMI: Body mass index; kcal Kilocalorie; d: Day
| Author, Year                  | Study length Months | Sample size and characterization | Country  |
|------------------------------|--------------------|----------------------------------|----------|
| Ahern et al., 2017           | 24                 | 1. C: n = 211; age: 51.9 (14.1); 68% female; BMI: 34.4 (4.6) | UK       |
|                             |                    | 1. I: n = 528; age: 53.3 (14); 68% female; BMI: 34.5 (5.1)  |          |
| Blumenthal et al., 2000      | 6                  | 1. C: n = 24; age: 47.2 (1.8); 46% female; BMI: 32.6 (5.1) | US       |
|                             |                    | 1. I: n = 55; age: 48.5 (1.2); 62% female; BMI: 32.1 (4)  |          |
| Cohen, D’Amico, & Merenstein, 1991 | 12              | 1. C: n = 15; age: 59.7; 73% female; BMI: 34.2 | US       |
|                             |                    | 1. I: n = 15; age: 59.7; 73% female; BMI: 34  |          |
| de Vos, Runhaar, & Bierma-Zeinstra, 2014 | 30             | 1. C: n = 204; age: 55.7 (3.2); 100% female; BMI: 32.5 (4.5) | NL       |
|                             |                    | 1. I: n = 203; age: 55.7 (3.2); 100% female; BMI: 32.2 (4.1)  |          |
| Elmer et al., 2006           | 18                 | 1. C: n = 241; age: 49.5 (8.8); 63% female; BMI: 32.9 (5.6) | US       |
|                             |                    | 1. I: n = 269; age: 50.2 (9.3); 57.2% female; BMI: 33.3 (6.3) |          |
| Greaves et al., 2015         | 12                 | 1. C: n = 53; age: 63.7 (7.4); 73.6% female; BMI: 32.3 (3) | UK       |
|                             |                    | 1. I: n = 55; age: 66.6 (6.4); 65.5% female; BMI: 33 (3.2)  |          |
| Hardcastle, Taylor, Bailey, & Castle, 2008 | 6              | 1. C: n = 131; age: 50.4 (0.9); 67% female; BMI: 34.3 (0.6) | UK       |
|                             |                    | 1. I: n = 203; age: 50.1 (0.7); 67% female; BMI: 33.7 (0.4) |          |
| Heshka et al., 2000          | 24                 | 1. C: n = 212; age: 44 (10); 87% female; BMI: 33.6 (3.7)  | US       |
|                             |                    | 1. I: n = 211; age: 45 (10); 82% female; BMI: 33.8 (3.4)  |          |
| Jansson, Engfeldt, Magnuson, Pt, & Liljegren, 2013 | 24         | 1. C: n = 66; age: 45 (13); 77% female; BMI: 33.6  | SW       |
|                             |                    | 1. I: n = 67; age: 49 (13); 67% female BMI: 33.8  |          |
| Jebb et al., 2011            | 12                 | 1. C: n = 395; age: 48.2 (12.2); 86% female; BMI: 31.3 (2.6)  | MULTI    |
|                             |                    | 1. I: n = 377; age: 48.2 (12.2); 88% female; BMI: 31.5 (2.6) |          |
| Jenkins et al., 2017         | 6                  | 1. C: n = 486; age: 44.7; 77%; female; BMI: 32.5 (32 to 33) | CAN      |
|                             |                    | 1. I: n = 145; age: 44.7; 77%; female; BMI: 31.7 (30.8 to 32.7) |          |
| Jones et al., 1999           | 6                  | 1. C: n = 51; age: 59 (7); 55% female; BMI: 34 (6) | US       |
|                             |                    | 1. I: n = 51; age: 57 (6); 55% female; BMI: 34 (6)  |          |
| Morgan et al., 2009          | 6                  | 1. C: n = 61; age: 40.8 (9.6); 75.4% female; BMI: 31.5 (2.9) | UK       |
|                             |                    | 1. I: n = 47; age: 39.9 (10.9); 72.4% female; BMI: 31.2 (2.7) |          |
| Nanchahal et al., 2012       | 12                 | 1. C: n = 190; age: 49.4 (15.5); 73% female; BMI: 33 (5.4) | UK       |
|                             |                    | 1. I: n = 191; age: 48.2 (14.1); 72% female; BMI: 33.9 (5.6) |          |
| Ockene et al., 2012          | 12                 | 1. C: n = 150; age: 52.4 (11.6); 77% female; BMI: 34.2 (5.9) | US       |
|                             |                    | 1. I: n = 162; age: 51.4 (10.9); 72% female; BMI: 33.6 (5.1) |          |
| Puhkala et al., 2015         | 12                 | 1. C: n = 58; age: 46.5 (8.6); male 100%; BMI: 33.1 (4.7) | F        |
|                             |                    | 2. I: n = 55; age: 47.6 (7.9); male 100%; BMI: 32.9 (4.3) |          |
| Rock, Pakiz, Flatt, & Quintana, 2007 | 6             | 1. C: n = 35; age: 40 (12); 100% female; BMI: 33.8 (3.4) | US       |
|                             |                    | 1. I: n = 35; age: 42 (11); 100% female; BMI: 34.2 (3.7)  |          |
| Rock et al., 2010            | 24                 | 1. C: n = 111; age: 45 (11); 100% female; BMI: 34 (3.2) | US       |
|                             |                    | 1. I: n = 151; age: 44 (10); 100% female; BMI: 33.8 (3.1)  |          |
| Rodriguez-Cristobal et al., 2017 | 24           | 1. C: n = 446; age: 55.5 (11.5); 73% female; BMI: 34.1 (4.8) | SP       |
|                             |                    | 2. I: n = 400; age: 57.7 (22.1); 82% female; BMI: 34.1 (4.8) |          |
| Ross et al., 2012            | 24                 | 1. C: n = 241; age: 52.4 (11.8); 70% female; BMI: 32 (4.2) | US       |
|                             |                    | 2. I: n = 249; age: 51.3 (11); 70% female; BMI: 32.6 (4.1) |          |
individually. In some cases, not all intervention groups of one trial matched our eligibility criteria. If so, only the eligible intervention groups were examined. A detailed description of the single studies is given in Table 2 and Data S1.

### 3.2 Summary of study characteristics

#### 3.2.1 Quantitative analysis of RCTs (group 1)

Out of the 32 trials, most of the studies ($n = 20$) were conducted in the US. The rest took place in the UK, Sweden, Finland, Netherlands, Belgium, Canada, Spain and as a multicentre worldwide cooperation. The original studies were published between 1991 and 2017 (class I obesity from 1991 to 2017; class II obesity from 2006 to 2011).

The eligible number of trials for this quantitative analysis of RCTs included 9,730 participants in total, 8,787 participants for BMI I, and 943 participants for BMI II. In class I obesity the median for age was 49 [44.95–53.85] years and for weight 91.8 [88.4–94.3] kg. In class II obesity the median for age was 55.3 [47.3–65] years and for weight 100.9 [98.8–103.4] kg. The proportion of female sex ranged between 0% to 100% and the mean proportion was 69.6%. A detailed description of the table.

**Table 1** (Continued)

| BMI 1 | Study length Months | Sample size and characterization N; age (SD); sex (%), BMI (kg/m$^2$) (SD) | Country |
|-------|---------------------|-------------------------------------------------|---------|
| **Shea et al., 2011** | 8 | 1. C: $n = 294$; age: 65.6 (4.5); 57% female; BMI: 31.1 (2.4) | US |
| | | 2. I: $n = 291$; age: 65.6 (4.5); 47% female; BMI: 31.2 (2.2) | |
| **Shuger et al., 2011** | 9 | 1. C: $n = 50$; age: 47.2 (8.9); 84% female; BMI: 33.7 (5.5) | US |
| | | 2. I: $n = 49$; age: 46.8 (12.4); 80% female; BMI: 33.1 (4.8) | |
| **Stevens et al., 2001** | 36 | 1. C: $n = 596$; age: 43.2 (6.1); 68% male; BMI (female): 30.8 (3.5); BMI (male): 31 (2.9) | US |
| | | 2. I: $n = 595$; age: 43.4 (6.1); 78% male; BMI (female): 31 (3.6); BMI (male): 31 (2.9) | |
| **Vissers et al., 2010** | 6 | 1. C: $n = 21$; age: 44.8 (11.4); 75% female; BMI 30.8 (3.4) | BL |
| | | 2. I: $n = 20$; age: 44.7 (13.0); 75% female; BMI: 33.1 (3.4) | |

**BMI 2**

| **Anton et al., 2011** | 6 | 1. C: $n = 17$; age: 63.7 (6.7); 100% female; BMI: 35.8 (6.8) | US |
| | | 2. I: $n = 17$; age: 63.7 (6.5); 100% female; BMI: 37.8 (5.5) | |
| **Davis Martin et al., 2006** | 6 | 1. C: $n = 73$; age: 43 (11.4); 100% female; BMI: 39.6 (7.7) | US |
| | | 2. I: $n = 71$; age: 40.7 (12.6); 100% female; BMI: 38.1 (7.5) | |
| **Perri et al., 2008** | 6 | 1. C: $n = 79$; age: 58.6 (6); 100% female; BMI: 36.2 (4.3) | US |
| | | 2. I: $n = 83$; age: 59.2 (6.2); 100% female; BMI: 37.1 (4.5) | |
| **Stolley et al., 2009** | 6 | 1. C: $n = 106$; age: 45.5 (8.4); 100% female; BMI: 39.6 (5.8) | US |
| | | 2. I: $n = 107$; age: 46.4 (8.4); 100% female; BMI: 38.8 (5.5) | |
| **Tsai et al., 2010** | 6 | 1. C: $n = 26$; age: 47.6 (2.5); 88% female; BMI: 37.6 (1.1) | US |
| | | 2. I: $n = 24$; age: 51.3 (2.3); 88% female; BMI: 35.4 (1.2) | |
| **Villareal et al., 2006** | 6 | 1. C: $n = 10$; age: 71 (4); 60% female; BMI: 39 (5) | US |
| | | 2. I: $n = 17$; age: 69 (5); 71% female; BMI: 39 (5) | |
| **Villareal et al., 2011** | 12 | 1. C: $n = 27$; age: 69 (4); 67% female; BMI: 37.3 (4.7) | US |
| | | 2. I: $n = 28$; age: 70 (4); 57% female; BMI: 37.2 (5.4) | |
| **Wadden et al., 2011** | 24 | 1. C: $n = 130$; age: 51.7 (12.1); 75% female; BMI 39 (4.8) | US |
| | | 2. I: $n = 131$; age: 52 (12.2); 84% female; BMI: 38.5 (4.6) | |

Abbreviations: BL, Belgium; BMI, Body mass index; C, Control Group; CAN, Canada; d, Day; F, Finland; I, Intervention Group; kcal, Kilocalorie; kg, Kilogram; m, Meter; min(s), Minute(s); MULTI, Multicenter worldwide cooperation; N, Number; NL, Netherlands.; RCT, Randomized controlled trial; SD, Standard deviation; SP, Spain; SW, Sweden; UK, United Kingdom; US, United States.
characteristics for the single RCTs is given in Table 1 and Data S1 and across the RCTs in Data S2.

### 3.2.2 Quantitative pre-post analysis (group 2)

The trials for the quantitative pre-post analysis were conducted mainly in the US \( (n = 34) \). The rest of the studies took place in Spain, Italy, Portugal, Australia, Canada, Ireland, the UK, Finland, Sweden, Germany and Iran; the studies were published between 1992 to 2016 (class I obesity: 1992 to 2016; class II obesity: 2003 to 2014; class III obesity: 1993 to 2016).

For this quantitative pre-post analysis 11,942 participants were analysed, with 4,869 participants representing the class I obesity subgroup, 6,381 the class II obesity subgroup and 692 the class III obesity subgroup. The median weight was 89 \([84.1–93.1]\) kg for class I obesity, 101.6 \([99–103.4]\) kg for class II obesity and, 123.6 \([120.2–133.3]\) kg for class III obesity. A mean of 73.4% of the participants were female and total median age was 47.3 \([44.1–53]\) years. A detailed description of the characteristics is given in Table 2 and Data S1 and across the studies in Data S2.

### 3.3 Risk of bias

The risk of bias for the studies included in the quantitative analysis of RCTs was assessed according to the OHAT criteria for each trial individually and is presented in Data S3. The randomization of trials was definitely or probably of low risk of bias. The allocation to the intervention groups were in large parts not reported. If it was reported, the risk of bias was mostly of low or probably low risk of bias. For blinding participants and research personnel, the risk of bias was high in every trial. However, this is a common bias for nutritional studies as blinding is difficult or even impossible to perform. The detection bias was mostly of low or probably low risk of bias, as well as the attrition and reporting bias. Furthermore, the adherence to study protocols was probably of low risk of bias.

The trial dropout rate ranged from 0 to 46% with a median of 13.8% \([8–28.5%]\). Eight out of the 32 trials had a dropout rate \(\geq30%\).

### 3.4 Summary of study outcome

#### 3.4.1 Quantitative analysis of RCT studies (group 1)

An overview of the quantitative analysis of RCT studies is depicted in Figure 2. In comparison to the control group (relative BWL), the participants of the intervention group of class I obesity lost on average 2.78 kg \((CI 95% -3.41\text{ to }-2.15)\) and in class II obesity 4.08 kg \((CI 95% -5.89\text{ to }-2.27)\). In total relative BWL was 3.03 kg \((CI 95% -3.59\text{ to }-2.47)\). Thus, on average, the intervention group of class I obesity lost 3% and class II obesity 4% of their body weight.

The total amount of BWL (total BWL) for the intervention group of class I obesity was 3.6 kg and of class II obesity 5.3 kg, which equates to 3.8 and 5.3% total BWL, respectively.

The funnel plot depicted in Data S4 shows an asymmetry with a deficiency in the lower corner on the right and may implicate a reporting bias (Sterne et al., 2011).

Initially, we had planned to perform a meta-analysis. However, the heterogeneity was too high and not meeting the criteria for a meta-analysis even when applying a random effect model (DerSimonian & Laird, 1986; Normand, 1999). We performed a subgroup analysis for the duration of the programs \((6, 7–12 \text{ and } 13–36 \text{ months})\) and the heterogeneity improved but remained high. The results are presented in Data S5. Across the duration of the programs, total BWL in kg decreased over time for class I obesity. For class II obesity the number of studies were too small to draw any conclusions.

We did not perform further subgroup analysis to reduce heterogeneity \(\text{(e.g., according to sex, age etc.)} \) because most of the studies did not deliver the relevant information needed. This would have resulted in a reduction of studies included leading to a considerable selection bias (DerSimonian & Laird, 1986; Normand, 1999). In addition, no class III obesity RCT studies were found for analysis. However, our intention of this review was to provide an overview of body weight change by moderate lifestyle and diet intervention programs in patients with obesity separately across the different BMI obesity classes including class III. Therefore, we changed our first intention of doing a meta-analysis on this subject and decided to do a thorough review including quantitative analysis and including pre-post studies.

#### 3.4.2 Quantitative analysis of pre-post studies (group 2)

A summary of the pre-post quantitative analysis is presented in Figure 3. Mean BWL for class I obesity was 5.4 kg \([\text{range: } -0.67 \text{ to } -13.7]\), for class II obesity, 5.5 kg \([\text{range: } 0 \text{ to } -15]\) and, for class III obesity 7.9 kg \([\text{range of: } -3.1 \text{ to } -18.1]\). For class III obesity the analysis is based on less than 700 participants in total and the range of BWL between the studies but also the range within the studies was extremely high. BWL of the three obesity classes equates to 6, 5.3 and 6.3% of baseline weight, respectively. Altogether, the participants achieved a mean BWL of 5.6 kg.
| Author, Year                  | Study type | Study length Months | Sample size and characterization | Country |
|------------------------------|------------|---------------------|----------------------------------|----------|
| Abedi et al., 2010           | RCT        | 6                   | I: n = 35; age: 51.4 (4.9); 100% female; BMI: 30.1 (6.2) | IRA      |
| Acharya et al., 2009         | RT         | 6                   | I: n = 151; age: 44.4 (8.6); 87% female; BMI: 34 | US       |
| Allen, Stephens, Dennison Himmelfarb, Stewart, & Hauck, 2013 | RT         | 6                   | I: n = 18; age: 42.5 (12.1); 78% female; BMI: 34.1 (4.1) | US       |
| Arrebola et al., 2011        | BA         | 6                   | I: n = 60; age: 40 (9); 71% female; BMI: 32.1 (3) | SP       |
| Brinkworth, Noakes, Buckley, Keogh, & Clifton, 2009 | RT         | 12                  | I1: n = 55; age: 50.3 (8.4), 69% female; BMI: 33.9 (4.3) | AUS      |
|                             |            |                     | I2: n = 52; age: 51.0 (7.5); 60% female; BMI: 33.5 (4.1) |          |
| Brochu et al., 2009         | RT         | 6                   | I1: n = 89; age: 58 (4.7); 100% female; BMI: 32.3 (4.6) | CAN      |
|                             |            |                     | I2: n = 48; age: 57.2 (5); 100% female; BMI: 32.6 (4.9) |          |
| Cousins et al., 1992        | RCT        | 6                   | I1: n = 32; age: 33.6 (6.4); 100% female; BMI: 31.7 (5) | US       |
|                             |            |                     | I2: n = 27; age: 32.8 (6.1); 100% female; BMI: 30.3 (4.5) |          |
| Ello-Martin, Roe, Ledikwe, Beach, & Rolls, 2007 | RT         | 12                  | I1: n = 49; age: 44.5 (1.3); 100% female; BMI: 33.3 (0.4) | US       |
|                             |            |                     | I2: n = 48; age: 45.3 (1.4); 100% female; BMI: 33.4 (0.5) |          |
| Foster et al., 2012         | RT         | 18                  | I1: n = 61; age: 47.0 (12.02); 89% female; BMI: 33.9 (3.5) | US       |
|                             |            |                     | I2: n = 62; age: 46.7 (13.0); 94% female; BMI: 34.0 (3.7) |          |
| Foster-Schubert et al., 2012 | RCT        | 12                  | I: n = 117; age: 58.0 (4.5); 100% female; BMI: 31.0 (4.3) | US       |
| Griffin et al., 2013        | RT         | 12                  | I1: n = 36; age: 22.4 (2.4); 100% female; BMI: 34.1 (4.1) | AUS      |
|                             |            |                     | I2: n = 35; age: 22.5 (2.3); 100% female; BMI: 33.8 (4.9) |          |
| Hollis et al., 2008         | BA         | 6                   | I: n = 1,685; age: 54.8 (9.1); 67% female; BMI: 34.3 (4.8) | US       |
| Jakicic et al., 2012        | RT         | 12                  | I1: n = 165; age: 42.4 (9.2); 82% female; BMI: 33 (3.9) | US       |
|                             |            |                     | I2: n = 198; age: 42 (8.9); 83% female; BMI: 33.4 (4.3) |          |
| Jeffery, Wing, Sherwood, & Tate, 2003 | RT         | 18                  | I1: n = 109; age: 42.2 (6.4); 58% female; BMI: 31 (2.6) | US       |
|                             |            |                     | I2: n = 93; age: 42.2 (6.4); 58% female; BMI: 31 (2.6) |          |
| C. A. Johnston, Rost, Miller-Kovach, Moreno, & Foreyt, 2013 | RCT        | 6                   | I: n = 147; age: 47.5 (11.7); 89% female; BMI: 33.1 (3.7) | US       |
| Kirby et al., 2011          | RCT        | 12                  | I: n = 54; age: 47 (10); 81% female; BMI: 34.9 (6.1) | IRL      |
| Koniak-Griffin et al., 2015  | RCT        | 6                   | I: n = 111; age: 43.3 (7.4); 100% female; BMI: 32.37 (5) | US       |
| Laatikainen et al., 2007    | BA         | 12                  | I: n = 237; age: Completers 56.7 (8.7); 73% female; BMI: Completers 33.5 (5.9); non-completers 34.7 (6.9) | AUS      |
| McManus, Antinoro, & Sacks, 2001 | RT         | 18                  | I1: n = 50; age: 44 (10); 88% female; BMI: 34 (5) | US       |
|                             |            |                     | I2: n = 51; age: 44 (10); 92% female; BMI: 33 (3) |          |
| Mellberg et al., 2014       | RT         | 24                  | I: n = 35; age: 59.5 (5.5); 100% female; BMI: 32.7 (3.6) | SW       |

(Continues)
| Author, Year                        | Study type | Study length | Sample size and characterization N; age (SD); sex (%), BMI (kg/m²) (SD) | Country |
|------------------------------------|------------|--------------|--------------------------------------------------------------------------|---------|
| Pellegrini et al., 2012            | RT         | 6            | I2: n = 35; age: 60.3 (5.9); 100% female; BMI: 32.6 (3.3)                | US      |
| Rolls, Roe, Beach, & Kris-Etherton, 2005 | RT         | 6            | I: n = 17; age: 45.1 (9.4); 100% female; BMI: 33.1 (3.8)                | US      |
| Ryan, Nicklas, Berman, & Elahi, 2003 | RT         | 6            | I1: n = 15; age: 56 (1); 100% female; BMI: 33.6 (1.2)                  | US      |
| Ryan & Harduarsingh-Permaul, 2014  | NRT        | 6            | I1: n = 16; age: 59 (1); 100% female; BMI: 31.1 (1.0)                  | US      |
| Sacks et al., 2009                 | RT         | 24           | I1: n = 204; age: 51 (9); 62% female; BMI: 33 (4)                      | US      |
| Ebbeling, Leidig, Feldman, Lovesky, & Ludwig, 2007 | RT       | 6            | I1: n = 37; age: 28.2 (3.8); 81% female; BMI: 37.5                   | US      |
| Esposito et al., 2004              | RCT        | 24           | I: n = 55; age: 43.5 (4.8); 100% male; BMI: 36.9 (2.5)                 | IT      |
| Foster et al., 2010                | RT         | 24           | I: n = 154; age: 44.9 (10.2); 67% female; BMI: 36.1 (3.5)             | US      |
| Frimel, Sinacore, & Villareal, 2008 | RT         | 6            | I1: n = 15; age: 70.3 (4.8); 60% female; BMI: 37.5                    | US      |
| Gorin et al., 2013                 | RT         | 18           | I: n = 99; age: 50.4 (9.3); 79% female; BMI: 36.1 (6.2)               | US      |
| Kumanyika et al., 2012             | RT         | 12           | I1: n = 137; age: 46.8 (11.6); 83% female; BMI: 37.3 (6.4)            | US      |

**TABLE 2 (Continued)**

| Author, Year                        | Study type | Study length | Sample size and characterization N; age (SD); sex (%), BMI (kg/m²) (SD) | Country |
|------------------------------------|------------|--------------|--------------------------------------------------------------------------|---------|
| Carels, Darby, Cacciapaglia, & Douglass, 2004 | RT         | 6            | I1: n = 21; age: 54.7 (7.9); 100% female; BMI: 37.8 (5.9)              | US      |
| Damschroder et al., 2014           | RT         | 12           | I1: n = 160; age: 54.9 (9.5); 84% male; BMI: 36.4 (6.4)               | US      |
| Ebbeling, Leidig, Feldman, Lovesky, & Ludwig, 2007 | RT       | 6            | I1: n = 159; age: 54.6 (10.5); 88% male; BMI: 36.8 (6.4)             | US      |
| Esposito et al., 2004              | RCT        | 24           | I: n = 106; age: 38.1 (7); 100%; female BMI: 31.7 (4.2)               | POR     |
| Toobert, Glasgow, & Radcliffe, 2000 | RCT        | 24           | I: n = 14; age: 64 (10); 100% female BMI: 32 (4.2)                    | US      |

**BMI 2**

| Author, Year                        | Study type | Study length | Sample size and characterization N; age (SD); sex (%), BMI (kg/m²) (SD) | Country |
|------------------------------------|------------|--------------|--------------------------------------------------------------------------|---------|
| Carols, Darby, Cacciapaglia, & Douglass, 2004 | RT         | 6            | I2: n = 23; age: 54.7 (7.9); 100% female; BMI: 35.1 (5)              | US      |
| Damschroder et al., 2014           | RT         | 12           | I2: n = 160; age: 54.9 (9.5); 84% male; BMI: 36.4 (6.4)               | US      |
| Ebbeling, Leidig, Feldman, Lovesky, & Ludwig, 2007 | RT       | 6            | I2: n = 159; age: 54.6 (10.5); 88% male; BMI: 36.8 (6.4)             | US      |
| Esposito et al., 2004              | RCT        | 24           | I2: n = 55; age: 43.5 (4.8); 100% male; BMI: 36.9 (2.5)               | IT      |
| Foster et al., 2010                | RT         | 24           | I2: n = 154; age: 44.9 (10.2); 67% female; BMI: 36.1 (3.5)            | US      |
| Frimel, Sinacore, & Villareal, 2008 | RT         | 6            | I2: n = 15; age: 70.3 (4.8); 60% female; BMI: 37.5                    | US      |
| Gorin et al., 2013                 | RT         | 18           | I2: n = 99; age: 50.4 (9.3); 79% female; BMI: 36.1 (6.2)              | US      |
| Kumanyika et al., 2012             | RT         | 12           | I2: n = 137; age: 46.8 (11.6); 83% female; BMI: 37.3 (6.4)            | US      |
| Author, Year               | Study type | Study length Months | Sample size and characterization N, age (SD); sex (%), BMI (kg/m²) (SD) | Country |
|---------------------------|------------|---------------------|-------------------------------------------------------------------------|---------|
| Lagerstrom, Berg, & Haas, 2013 | BA         | 12                  | I: n = 5,025; age:48.6 (11.3); female: 74.7%; BMI: 35.7 (3)             | GER     |
| Latner, Ciao, Wendicke, Murakami, & Durso, 2013 | RT         | 6                   | I1: n = 52; age: 49.7 (12.3); 64% female; BMI: 35.6 (8.1)             | US      |
|                          |            |                     | I2: n = 38; age: 49.7 (12.3); 64% female; BMI: 36.1 (7.7)             |         |
| Moore et al., 2003       | RCT        | 18                  | I: n = 415; age: 48.4 (10.9); 75% female; BMI: 37 (5.7)               | UK      |
| Nackers et al., 2013     | RT         | 6                   | I: n = 60; age: 52.5 (9.8); 100% female; BMI: 37.6 (3.8)              | US      |
| Perri et al., 2014       | RCT        | 6                   | I: n = 161; age: 53.2 (12.0); 75% female; BMI: 36.7 (4.0)            | US      |
| Pinto, Fava, Hoffmann, & Wing, 2013 | RT         | 12                  | I1: n = 48; age: 49.2 (9.8); 89.1% female; BMI: 36.4 (5)             | US      |
|                          |            |                     | I2: n = 49; age: 49 (9.2); 89.8% female; BMI: 35.5 (5.3)             |         |
|                          |            |                     | I3: n = 47; age: 50.9 (8.8); 91.3% female; BMI: 36.6 (6.1)           |         |
| Wadden et al., 2004      | RCT        | 10                  | I: n = 43; age: 45.6 (9.2); 100% female; BMI: 36.3 (4.9)              | US      |
| Yancy Jr. et al., 2010   | RT         | 12                  | I: n = 72; age: 52.9 (10.2); 28% female; BMI: 39.9 (6.9)             | US      |
| Yeh et al., 2003         | RT         | 6                   | I1: n = 40; age: 48 (9); 100% female; BMI: 37.9 (6.7)                 | US      |
|                          |            |                     | I2: n = 40; age: 51 (11); 100% female; BMI: 36.3 (5.4)               |         |
| Dalle Grave, Calugi, Gavasso, El Ghoch, & Marchesini, 2013 | RT         | 12                  | I1: n = 43; age: 46.7 (10.3); 61% female; BMI: 45.8 (6.5)             | IT      |
|                          |            |                     | I2: n = 45; age: 46.6 (12.0); 56% female; BMI: 45.4 (7)              |         |
| Goodpaster et al., 2010  | RT         | 12                  | I1: n = 67; age: 46.1 (6.5); 85% female; BMI: 43.5 (4.8)             | US      |
|                          |            |                     | I2: n = 67; age: 47.5 (6.2); 92% female; BMI: 43.7 (5.9)             |         |
| Hakala, Karvetti, & Ronnemaa, 1993 | RT       | 24                  | I1: n = 30; age: Women: 41 (8), men: 39 (9)                           | F       |
|                          |            |                     | 75% female; BMI: Women 43.6 (4.8), men 42.7 (4)                      |         |
|                          |            |                     | I2: n = 30; age: Women: 37 (6),men 40 (10); 75% female; BMI: Women 43.4 (5.4), men 41.7 (3.1) |         |
| Mingrone et al., 2002    | RT         | 12                  | I: n = 33; age: 30–45; sex: No data; BMI: Women: 48.4 (8.9), men: 47.8 (8.8) | IT      |
| Rudolph, Hellhardt, Baldofski, de Zwaan, & Hilbert, 2016 | BA         | 12                  | I: n = 190; age: 44.9 (11.4); 90.9% female; BMI: 44.1 (6.2)          | GER     |
| Stern et al., 2004       | RT         | 6                   | I1: n = 64; age: 53 (9); 20% female; BMI: 42.9 (6.6)                 | US      |
|                          |            |                     | I2: n = 68; age: 54 (9); 15% female; BMI: 42.9 (7.7)                 |         |
| Torgerson, Lissner, Lindroos, Kruijer, & Sjostrom, 1997 | RT         | 24                  | I: n = 55; age: 46.9 (5.8); 70% female; BMI: 40.5 (4.3)              | SW      |

**Abbreviations:** AUS, Australia; BA, Before-and-after comparison (without control); BMI, Body mass index; C, Control Group; CAN, Canada; d, Day; F, Finland; GER, Germany; I, Intervention Group; IRA, Iran; IRL, Ireland; IT, Italy; kcal, Kilocalorie; kg, Kilogram; m, Meter; min (s), Minute(s); N, Number; NRT, Nonrandomized controlled trial; POR, Portugal; RCT, Randomized controlled trial; RT, Randomized Trial; SD, Standard deviation; SP, Spain; SW, Sweden; UK, United Kingdom; US, United States of America.
The aim of this systematic review is to compare body weight change by moderate lifestyle and diet intervention programs in patients with obesity separately across the different BMI obesity classes including class III.

4.1 Hypothesis 1 rejected: “BWL is greater in individuals with a higher initial obesity class”

To test hypothesis 1, BWL was presented as a stratified overview across the different obesity classes. For RCTs, stratification was only possible for class I and class II obesity, showing a relative BWL of the intervention groups (compared to the control groups) by 3% and 4% and absolute BWL by 3.8 and 5.3%, respectively. These results indicate that the recommended 5–10% BWL is frequently not achieved (Jensen et al., 2014; WHO, 2000).

The meta-analysis from Johnston et al. depicted a BWL after a 6-months intervention of 8.73 kg (CI 95% 7.27–10.2) for low-carbohydrate diets and 7.99 kg (95% CI 6.01–9.92) for low-fat diets (B. C. Johnston et al., 2014). In contrast to these trials, the 83 trials described here ranged from 6 to 36 months. This corresponds directly to the LOOK AHEAD study, which described an initial greater BWL for the first year, followed by a decreased amount of BWL in the following years (Look AHEAD...
In addition, Leblanc et al. analysed RCTs with a mean baseline BMI ranging from 24 to 42 kg/m² and over a period of 12–18 months. Out of 67 behaviour modification-based trials, the mean BWL in comparison to the control groups was 2.39 kg (95% CI, −2.86 to −1.93) (LeBlanc et al., 2018). Therefore, our results are comparable to these outcomes.

The analyses of the RCTs were extended to pre-post comparisons where a stratified overview across all three different obesity classes was possible. BWL was 6% for
class I obesity, 5.5% for class II obesity and 6.3% for class III obesity. All obesity classes achieved the recommended BWL of 5–10%.

Thus, for class II obesity the data synthesis of RCTs versus pre-post design studies was similar. For class III obesity this comparison was not possible due to the lack of RCTs. Interestingly, for class I obesity the synthesis of data for the different study types differed by 2% BWL, with the greater BWL achieved in pre-post studies (6% BWL in pre-post, 3.8% BWL in RCTs). This could be attributed to the weight-management programs conducted in the included pre-post studies being more effective for BWL. However, there may be some influencing factors regarding motivation or placebo effect. In the pre-post studies, all participants were aware that they received an intervention. This may have resulted in higher expectations and greater motivations for lifestyle change, in comparison with those in RCTs where participants are already aware at study inclusion that they may only receive the less effective intervention status (Enck, Klosterhalfen, Weimer, Horing, & Zipfel, 2011; Sneed et al., 2008; Weimer, Colloca, & Enck, 2015). This principle is also known from drug trials.

Overall, hypothesis 1 was rejected since BWL was rather similar across the three obesity classes for pre-post design studies.

4.2 | Hypothesis 2 confirmed: “BWL in class III obesity shows a large range of variation within and across studies”

Interestingly, the conventional treatment program for patients with class III obesity varied extremely. This aspect contributes to the large range of variations in BWL outcome (%) in class III obesity, thus confirming the second hypothesis. Several factors interfere with BWL, both negatively and positively. On the one hand, there was a trend that BWL increased with the intensity. In detail, class III obesity study designs and treatments differed in contrast to class I and II with partly higher intensities and longer durations (Dalle Grave et al., 2013; Hakala et al., 1993) as well as modified designs regarding outpatient interventions with individual meetings (Hakala et al., 1993) or group meetings (Rudolph et al., 2016; Torgerson et al., 1997). Nevertheless, the factors of personal motivation and comorbidities affect BWL and may lead to a great variety within and between studies (Williams, Grow, Freedman, Ryan, & Deci, 1996). Therefore, further insights into motivation for BWL in class III obesity could help to improve conservative BWL treatment. For example, the personal intention against or for bariatric surgery could have great impact on BWL: Intention to bariatric surgery may lower BWL during a conservative BWL program.

4.3 | Implications for class III obesity

BWL in people with class III obesity was not higher than in those with class I or II obesity and, the variation of BWL was high within and across class III obesity studies. This emphasizes that for these patients bariatric surgery is a good alternative if not even first choice treatment since greater BWL results can be achieved (Wolfe, Kvach, & Eckel, 2016). Restrictive dietary programs such as total meal replacements are used more frequently in class III obesity. These programs, which are commonly very low caloric, are more effective than food-based or low caloric diets (Ard et al., 2019) but drop-out rates are also often high (>30%) in these programs (Bischoff et al., 2012).

However, not all patients wish to undergo either bariatric surgery or a formula based or other extreme diet. Although anthropometric changes are small in moderate conservative BWL programs, it is extremely important to continue to offer this treatment option for these patients and undecided patients in order to promote the stabilisation and/or improvement of physiological and psychological factors (Fabricatore & Wadden, 2004; Lasikiewicz, Myrissa, Hoyland, & Lawton, 2014). These programs are also important for the prevention of continued weight gain and halting the progression of comorbidities, which are the likely outcomes if untreated (Anderson & Konz, 2001). These programs also instil skills surrounding goal setting, motivation and decision making, which consequently can assist in the stabilisation of physiological and psychological factors (Fabricatore & Wadden, 2004; Lasikiewicz et al., 2014). Therefore, moderate conservative BWL programs as a treatment option for patients with obesity should not be undervalued, and the decision for the specific treatment pathway should be based on the personal situation and desires of the patient.

In order to avoid disappointment and to achieve the best results, it is necessary to treat the patients by a multidisciplinary team as recommended by the current guidelines (Fitzpatrick et al., 2016).

4.4 | Strengths and limitations

Overall, this systematic review has its limitations and strengths. A common problem with studies offering diets
and behavioural changes is that blinding of the participants and research personnel is impossible. Therefore, the risk of performance bias may be high. Finally, although not scope of this review, we like to mention that this review is not considering the long-term effects of the interventions and therefore no statement about BWL maintenance can be made for the different obesity classes.

Furthermore, as the aim of this analysis was to compare the BWL in moderately intensive BWL programs, the search was not limited to specific standardized treatment programs such as Weight Watchers. This procedure may have contributed to the observed high heterogeneity across the studies (Normand, 1999). Besides, the funnel plot suggests that there might be a publication bias, since studies with small effects or no effects are short-handed. This appears to be a common bias in publications (Dickersin, Min, & Meinert, 1992). In addition, for the statistics of BWL aggregated BMI data were used. Therefore, the accuracy of the data is not as high as possible. Indeed, the analysed group consists in large parts of the described BMI class, but there are almost always other BMI classes represented. This leads to a bias of results. In consequence, out of these results only a trend can be deduced. To minimize this effect, we excluded studies with no distinct participants’ characteristics.

To deal with the increasing amount of published studies regarding BWL programs (37,164 hits in PubMed since the last 5 years) we have chosen a search strategy which is common in the development process of evidence-based guidelines. In this case the evidence level is highest in meta-analyses followed by RCTs and non-controlled studies (Ball, Sackett, Phillips, Straus, & Haynes, 2009; Phillips, 2004).

Finally, a limitation of this analysis is that the comparison across all obesity classes based only on RCTs could not be performed due to the lack of studies in class III obesity. A reason could be that the study designs examining conservative treatments often ab initio exclude participants with a BMI greater than 39.9 kg/m². A rationale behind this procedure is that these patients may frequently use medications or have mobility limitations, for example, due to knee osteoarthritis.

A special strength of this review is that we aggregated a great amount of RCTs, RTs and BAs, to create a large data basis. In total, 83 original articles (RCTs, RTs and BAs) were included in this analysis, leading to high external validity. Eventually, we were able to provide a stratified overview across the different obesity classes as intended. In addition, we followed a conservative approach and investigated a mixed obesity population.

5 Conclusion

When comparing the results across the different obesity classes undergoing a moderate BWL program, there are hardly any differences between the individual classes for BWL in %. To achieve greater BWL than the reached 4–6% from baseline body weight, more intensive program regimes (or bariatric surgery) are probably necessary.

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Conflict of Interest

The authors declare no conflicts of interest.

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References

Abedi, P., Lee, M. H., Kandiah, M., Yassin, Z., Shojaeezade, D., Hosseini, M., & Malihi, R. (2010). Diet intervention to improve cardiovascular risk factors among Iranian postmenopausal women. Nutrition Research and Practice, 4(6), 522–527. https://doi.org/10.4162/nrp.2010.4.6.522

Acharya, S. D., Elci, O. U., Sereika, S. M., Music, E., Styn, M. A., Turk, M. W., & Burke, L. E. (2009). Adherence to a behavioral weight loss treatment program enhances weight loss and improvements in biomarkers. Patient Preference and Adherence, 3, 151–160 Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/19936157

Ahern, A. L., Wheeler, G. M., Aveyard, P., Boyland, E. J., Halford, J. C. G., Mander, A. P., ... Jebb, S. A. (2017). Extended and standard duration weight-loss programme referrals for adults in primary care (WRAP): A randomised controlled trial. Lancet, 389(10085), 2214–2225. https://doi.org/10.1016/S0140-6736(17)30647-5

Allen, J. K., Stephens, J., Dennison Himmelfarb, C. R., Stewart, K. J., & Hauck, S. (2013). Randomized controlled pilot study testing use of smartphone technology for obesity treatment. Journal of Obesity, 2013, 1–7. https://doi.org/10.1155/2013/151597

Anderson, J. W., & Konz, E. C. (2001). Obesity and disease management: Effects of weight loss on comorbid conditions. Obesity Research, 9(Suppl 4), 326S–334S. https://doi.org/10.1038/oby.2001.138

Anton, S. D., Manini, T. M., Milsom, V. A., Dubyak, P., Cesari, M., Cheng, J., ... Perri, M. G. (2011). Effects of a weight loss plus exercise program on physical function in overweight, older women: A randomized controlled trial. Clinical Interventions in Aging, 6, 141–149. https://doi.org/10.2147/CIA.S17001
Apovian, C. M. (2016). Obesity: Definition, comorbidities, causes, and burden. The American Journal of Managed Care, 22(7 Suppl), s176-s185. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/27356115

Appel, L. J., Champagne, C. M., Harsha, D. W., Cooper, L. S., Obarzanek, E., Elmer, P. J., ... Writing Group of the PREMIER Collaborative Research Group. (2003). Effects of comprehensive lifestyle modification on blood pressure control: Main results of the PREMIER clinical trial. JAMA, 289(16), 2083–2093. https://doi.org/10.1001/jama.289.16.2083

Ard, J. D., Lewis, K. H., Rothberg, A., Auriemma, A., Coburn, S. L., Cohen, S. S., ... Periman, S. (2019). Effectiveness of a total meal replacement program (OPTIFAST program) on weight loss: Results from the OPTIFAST study. Obesity (Silver Spring), 27(1), 22–29. https://doi.org/10.1002/oby.22303

Arrebola, E., Gomez-Candela, C., Fernandez-Fernandez, C., Loria, V., Munoz-Perez, E., & Bermejo, L. M. (2011). Evaluation of a lifestyle modification program for treatment of overweight and nonmorbid obesity in primary healthcare and its influence on health-related quality of life. Nutrition in Clinical Practice, 26(3), 316–321. https://doi.org/10.1177/0884536611405993

Ball, C., Sackett, S., Phillips, B., Straus, S., Haynes, B. (2009). Oxford Centre for Evidence-based Medicine–Levels of Evidence (March 2009). Retrieved from https://www.cebm.net/2009/06/oxford-centre-evidence-based-medicine-levels-evidence-march-2009/

Barte, J. C., Veldwijk, J., Teixeira, P. J., Sacks, F. M., & Bemelmans, W. J. (2014). Differences in weight loss across different BMI classes: A meta-analysis of the effects of interventions with diet and exercise. International Journal of Behavioral Medicine, 21(5), 784–793. https://doi.org/10.1007/s12529-013-9355-5

Bischoff, S. C., Damms-Machado, A., Betz, C., Herpertz, S., Legenbauer, T., Low, T., ... Ellrott, T. (2012). Multicenter evaluation of an interdisciplinary 52-week weight loss program for obesity with regard to body weight, comorbidities and quality of life—a prospective study. International Journal of Obesity, 36(4), 614–624. https://doi.org/10.1038/ijo.2011.107

Blaue, M. (2019). Obesity: Global epidemiology and pathogenesis. Nature Reviews. Endocrinology, 15(5), 288–298. https://doi.org/10.1038/s41574-019-0176-8

Blumenthal, J. A., Sherwood, A., Gullette, E. C., Babyak, M., Waugh, R., Georgiades, A., ... Hinderliter, A. (2000). Exercise and weight loss reduce blood pressure in men and women with mild hypertension: Effects on cardiovascular, metabolic, and hemodynamic functioning. Archives of Internal Medicine, 160(13), 1947–1958. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/10888969

Brinkworth, G. D., Noakes, M., Buckley, J. D., Keogh, J. B., & Clifton, P. M. (2009). Long-term effects of a very-low-carbohydrate weight loss diet compared with an isocaloric low-fat diet after 12 mo. The American Journal of Clinical Nutrition, 90(1), 23–32. https://doi.org/10.3945/ajcn.2008.27326

Brochu, M., Malita, M. F., Messier, V., Doucet, E., Strychar, I., Lavoie, J. M., ... Rabasa-Lhoret, R. (2009). Resistance training does not contribute to improving the metabolic profile after a 6-month weight loss program in overweight and obese postmenopausal women. The Journal of Clinical Endocrinology and Metabolism, 94(9), 3226–3233. https://doi.org/10.1210/jc.2008-2706

Carels, R. A., Darby, L. A., Cacciapaglia, H. M., & Douglass, O. M. (2004). Reducing cardiovascular risk factors in postmenopausal women through a lifestyle change intervention. Journal of Women's Health (2002), 13(4), 412–426. https://doi.org/10.1089/15409904323087105

Cohen, M. D., D’Amico, F. J., & Merenstein, J. H. (1991). Weight reduction in obese hypertensive patients. Family Medicine, 23(1), 25–28. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/2001777

Cousins, J. H., Rubovits, D. S., Dunn, J. K., Reeves, R. S., Ramirez, A. G., & Foreyt, J. P. (1992). Family versus individually oriented intervention for weight loss in Mexican American women. Public Health Reports, 107(5), 549–555. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/1410236

da Costa Santos, C. M., de Mattos Pimenta, C. A., & Nobre, M. R. (2007). The PICO strategy for the research question construction and evidence search. Revista Latino-Americana de Enfermagem, 15(3), 508–511. https://doi.org/10.1590/s0104-11692007000300023

Dalle Grave, R., Calugi, S., Gavasso, I., El Ghoch, M., & Marchesini, G. (2013). A randomized trial of energy-restricted high-protein versus high-carbohydrate, low-fat diet in morbid obesity. Obesity (Silver Spring), 21(9), 1774–1781. https://doi.org/10.1002/oby.20320

Damschroder, L. J., Lutes, L. D., Kirsh, S., Kim, H. M., Gillon, L., Holleman, R. G., ... Richardson, C. R. (2014). Small-changes obesity treatment among veterans: 12-month outcomes. American Journal of Preventive Medicine, 47(5), 541–553. https://doi.org/10.1016/j.amepre.2014.06.016

Davis Martin, P., Rhode, P. C., Dutton, G. R., Redmann, S. M., Ryan, D. H., & Brantley, P. J. (2006). A primary care weight management intervention for low-income African-American women. Obesity (Silver Spring), 14(8), 1412–1420. https://doi.org/10.1080/0606160

De Luca, M., Angrisani, L., Himpens, J., Busetto, L., Scopinaro, N., Weiner, R., ... Shikora, S. (2016). Indications for surgery for obesity and weight-related diseases: Position statements from the international federation for the surgery of obesity and metabolic disorders (IFSO). Obesity Surgery, 26(8), 1659–1696. https://doi.org/10.1007/s11695-016-2271-4

de Vos, B. C., Runhaar, J., & Bierma-Zeinstra, S. M. (2014). Effectiveness of a tailor-made weight loss intervention in primary care. European Journal of Nutrition, 53(1), 95–104. https://doi.org/10.1007/s00394-013-0505-y

Deitel, M., & Greenstein, R. J. (2003). Recommendations for reporting weight loss. Obesity Surgery, 13(2), 159–160. https://doi.org/10.1081/096089203764467117

DerSimonian, R., & Laird, N. (1986). Meta-analysis in clinical trials. Controlled Clinical Trials, 7(3), 177–188. https://doi.org/10.1016/0197-2456(86)90046-2

Dickerson, K., Min, Y. I., & Meinert, C. L. (1992). Factors influencing publication of research results. Follow-up of applications submitted to two institutional review boards. JAMA, 267(3), 374–378. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/1727960
Dixon, J. B. (2010). The effect of obesity on health outcomes. Molecular and Cellular Endocrinology, 316(2), 104–108. https://doi.org/10.1016/j.mce.2009.07.008

Ebbeling, C. B., Leidig, M. M., Feldman, H. A., Lovesky, M. M., & Ludwig, D. S. (2007). Effects of a low-glycemic load vs low-fat diet in obese young adults: A randomized trial. JAMA, 297(19), 2092–2102. https://doi.org/10.1001/jama.297.19.2092

Eilert, U., Schuetz, T., Hoffmann, L., Pirlich, M., Strasburger, C. J., & Lochs, H. (2010). Differences of energy expenditure and physical activity patterns in subjects with various degrees of obesity. Clinical Nutrition, 29(6), 766–772. https://doi.org/10.1016/j.cnu.2010.05.003

Ello-Martin, J. A., Roe, L. S., Ledikwe, J. H., Beach, A. M., & Bauer et al. (2004). Psychological aspects of European Commission, (2006). D. G. f. H. a. C. P. Nutrition & obesity prevention. Retrieved from https://ec.europa.eu/health/archive/ph_determinants/life_style/nutrition/documents/nut_obe_prevention.pdf

Elmiger, P., Obarzanek, E., Vollmer, W. M., Simons-Morton, D., Stevens, V. J., Young, D. R., ... PREMIER Collaborative Research Group. (2006). Effects of comprehensive lifestyle modification on diet, weight, physical fitness, and blood pressure control: 18-month results of a randomized trial. Annals of Internal Medicine, 144(7), 485–495. https://doi.org/10.7326/0003-4819-144-7-200604040-00007

Enck, P., Klosterhalfen, S., Weimer, K., Horing, B., & Zipfel, S. (2011). The placebo response in clinical trials: More questions than answers. Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences, 366(1572), 1889–1895. https://doi.org/10.1098/rstb.2010.0384

Esposito, K., Giugliano, F., Di Palo, C., Giugliano, G., Marfella, R., D’Andrea, F., ... Giugliano, D. (2004). Effect of lifestyle changes on erectile dysfunction in obese men: A randomized controlled trial. JAMA, 291(24), 2978–2984. https://doi.org/10.1001/jama.291.24.2978

European Commission, (2006). D. G. f. H. a. C. P. Nutrition & obesity prevention. Retrieved from https://ec.europa.eu/health/archive/ph_determinants/life_style/nutrition/documents/nut_obe_prevention.pdf

Fabricatore, A. N., & Wadden, T. A. (2004). Psychological aspects of obesity. Clinics in Dermatology, 22(4), 332–337. https://doi.org/10.1016/j.clindermatol.2004.01.006

Feng, X., Andalib, A., Brethauer, S. A., Schauer, P. R., & Aminian, A. (2019). How safe is bariatric surgery in patients with class I obesity (body mass index 30-35 kg/m²)? Surgery for Obesity and Related Diseases, 15(2), 253–260. https://doi.org/10.1016/j.soard.2018.12.006

Fitzpatrick, S. L., Wischenka, D., Appelhans, B. M., Pfert, L., Wang, M., Wilson, D. K., ... Society of Behavioral Medicine. (2016). An evidence-based guide for obesity treatment in primary care. The American Journal of Medicine, 129(1), 115.e1–115.e7. https://doi.org/10.1016/j.amjmed.2015.07.015

Foster, G. D., Shantz, K. L., Vander Veur, S. S., Oliver, T. L., Lent, M. R., Virus, A., ... Gilden-Tsai, A. (2012). A randomized trial of the effects of an almond-enriched, hypocaloric diet in the treatment of obesity. The American Journal of Clinical Nutrition, 96(2), 249–254. https://doi.org/10.3945/ajcn.112.037895

Foster, G. D., Wadden, T. A., Vogt, R. A., & Brewer, G. (1997). What is a reasonable weight loss? Patients' expectations and evaluations of obesity treatment outcomes. Journal of Consulting and Clinical Psychology, 65(1), 79–85 Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/9103737

Foster, G. D., Wyatt, H. R., Hill, J. O., Makris, A. P., Rosenbaum, D. L., Brill, C., ... Klein, S. (2010). Weight and metabolic outcomes after 2 years on a low-carbohydrate versus low-fat diet: A randomized trial. Annals of Internal Medicine, 153(3), 147–157. https://doi.org/10.7326/0003-4819-153-3-20100830-00005

Foster-Schubert, K. E., Alfano, C. M., Duggan, C. R., Xiao, L., Campbell, K. L., Kong, A., ... McFarland, A. (2012). Effect of diet and exercise, alone or combined, on weight and body composition in overweight-to-obese postmenopausal women. Obesity (Silver Spring), 20(8), 1628–1638. https://doi.org/10.1038/oby.2011.76

Friedman, A. N., Ogden, L. G., Foster, G. D., Klein, S., Stein, R., Miller, B., ... Wyatt, H. R. (2012). Comparative effects of low-carbohydrate high-protein versus low-fat diets on the kidney. Clinical Journal of the American Society of Nephrology, 7(7), 1103–1111. https://doi.org/10.2215/CJN.11741111

Frimel, T. N., Sinacore, D. R., & Villareal, D. T. (2008). Exercise attenuates the weight-loss-induced reduction in muscle mass in frail obese older adults. Medicine and Science in Sports and Exercise, 40(7), 1213–1219. https://doi.org/10.1249/MSS.0b013e3181a685ce

Goodpaster, B. H., Delany, J. P., Otto, A. D., Kuller, L., Vockley, J., South-Paul, J. E., ... Jakicic, J. M. (2010). Effects of diet and physical activity interventions on weight loss and cardiometabolic risk factors in severely obese adults: A randomized trial. JAMA, 304(16), 1795–1802. https://doi.org/10.1001/jama.2010.1505

Gorin, A. A., Raynor, H. A., Fava, J., Maguire, K., Robichaud, E., Trautvetter, J., ... Wing, R. R. (2013). Randomized controlled trial of a comprehensive home environment-focused weight-loss program for adults. Health Psychology, 32(2), 128–137. https://doi.org/10.1037/a0026959

Greaves, C., Gillison, F., Stathi, A., Bennett, P., Reddy, P., Dunbar, J., ... Taylor, G. (2015). Waste the waist: A pilot randomised controlled trial of a primary care based intervention to support lifestyle change in people with high cardiovascular risk. International Journal of Behavioral Nutrition and Physical Activity, 12, 1. https://doi.org/10.1186/s12966-014-0159-z

Griffin, H. J., Cheng, H. L., O’Connor, H. T., Rooney, K. B., Petocz, P., & Steinbeck, K. S. (2013). Higher protein diet for weight management in young overweight women: A 12-month randomized controlled trial. Diabetes, Obesity & Metabolism, 15 (6), 572–575. https://doi.org/10.1111/dom.12056

Hakala, P., Karvetti, R. L., & Ronnemaa, T. (1993). Group vs. individual weight reduction programmes in the treatment of severe obesity—A five year follow-up study. International Journal of Obesity and Related Metabolic Disorders, 17(2), 97–102 Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/8384171

Hardcastle, S., Taylor, A., Bailey, M., & Castle, R. (2008). A randomised controlled trial on the effectiveness of a primary health care based counselling intervention on physical activity, diet and CHD risk factors. Patient Education and Counseling, 70(1), 31–39. https://doi.org/10.1016/j.pec.2007.09.014
Heshka, S., Anderson, J. W., Atkinson, R. L., Greenway, F. L., Hill, J. O., Phinney, S. D., ... Pi-Sunyer, F. X. (2003). Weight loss with self-help compared with a structured commercial program: A randomized trial. JAMA, 289(14), 1792–1798. https://doi.org/10.1001/jama.289.14.1792

Heshka, S., Greenway, F., Anderson, J. W., Atkinson, R. L., Hill, J. O., Phinney, S. D., ... Xavier Pi-Sunyer, F. (2000). Self-help weight loss versus a structured commercial program after 26 weeks: A randomized controlled study. The American Journal of Medicine, 109(4), 282–287. https://doi.org/10.1016/s0002-9343(00)00494-0

Hollis, J. F., Gullion, C. M., Stevens, V. J., Brantley, P. J., Appel, L. J., Ard, J. D., ... Weight Loss Maintenance Trial Research Group. (2008). Weight loss during the intensive intervention phase of the weight-loss maintenance trial. American Journal of Preventive Medicine, 35(2), 118–126. https://doi.org/10.1016/j.amepre.2008.04.013

Hruby, A., & Hu, F. B. (2015). The epidemiology of obesity: A big picture. Pharmacoeconomics, 33(7), 673–689. https://doi.org/10.1007/s40273-014-0243-x

Jakicic, J. M., Tate, D. F., Lang, W., Davis, K. K., Polzien, K., Rickman, A. D., ... Finkelstein, E. A. (2012). Effect of a stepped-care intervention approach on weight loss in adults: A randomized clinical trial. JAMA, 307(24), 2617–2626. https://doi.org/10.1001/jama.2012.6866

Jansson, S. P., Engfeldt, P., Magnuson, A., Pt, G. L., & Liljegren, G. (2013). Interventions for lifestyle changes to promote weight reduction, a randomized controlled trial in primary health care. BMC Research Notes, 6, 213. https://doi.org/10.1186/1756-0500-6-213

Jebb, S. A., Ahern, A. L., Olson, A. D., Aston, L. M., Holzapfel, C., Stoll, J., ... Caterson, I. D. (2011). Primary care referral to a commercial provider for weight loss treatment versus standard care: A randomised controlled trial. Lancet, 378(9801), 1485–1492. https://doi.org/10.1016/S0140-6736(11)6344-5

Jeffery, R. W., Wing, R. R., Sherwood, N. E., & Tate, D. F. (2003). Physical activity and weight loss: Does prescribing higher physical activity goals improve outcome? The American Journal of Clinical Nutrition, 78(4), 684–689. https://doi.org/10.1093/ajcn/78.4.684

Jenkins, D. J. A., Boucher, B. A., Ashbury, F. D., Sloan, M., Brown, P., El-Sohemy, A., ... Kreiger, N. (2017). Effect of current dietary recommendations on weight loss and cardiovascular risk factors. Journal of the American College of Cardiology, 69(9), 1103–1112. https://doi.org/10.1016/j.jacc.2016.10.089

Jensen, M. D., Ryan, D. H., Apovian, C. M., Ard, J. D., Comuzzie, A. G., Donato, K. A., ... Obesity, S. (2014). 2013 AHA/ACC/TOS guideline for the management of overweight and obesity in adults: A report of the American College of Cardiology/American Heart Association task force on practice guidelines and the obesity society. Journal of the American College of Cardiology, 63(25 Pt B), 2985–3023. https://doi.org/10.1016/j.jacc.2013.11.004

Johnston, B. C., Kanters, S., Bandayrel, K., Wu, P., Naji, F., Siemieniuk, R. A., ... Mills, E. J. (2014). Comparison of weight loss among named diet programs in overweight and obese adults: A meta-analysis. JAMA, 312(9), 923–933. https://doi.org/10.1001/jama.2014.10397

Johnston, C. A., Rost, S., Miller-Kovach, K., Moreno, J. P., & Foreyt, J. P. (2013). A randomized controlled trial of a community-based behavioral counseling program. The American Journal of Medicine, 126(12), 1143.e19–1143.e24. https://doi.org/10.1016/j.amjmed.2013.04.025

Jones, D. W., Miller, M. E., Wofford, M. R., Anderson, D. C., Jr., Cameron, M. E., Willoughby, D. L., ... King, N. S. (1999). The effect of weight loss intervention on antihypertensive medication requirements in the hypertension optimal treatment (HOT) study. American Journal of Hypertension, 12(12 Pt 1-2), 1175–1180. https://doi.org/10.1016/s0895-7061(99)00123-5

Kirby, M. L., Beatty, S., Stack, J., Harrison, M., Greene, I., McBrinn, S., ... Nolan, J. M. (2011). Changes in macular pigment optical density and serum concentrations of lutein and zeaxanthin in response to weight loss. The British Journal of Nutrition, 105(7), 1036–1046. https://doi.org/10.1017/S0007114510004721

Koniak-Griffin, D., Brecht, M. L., Takayanagi, S., Villegas, J., Melendez, M., & Balcazar, H. (2015). A community health worker-led lifestyle behavior intervention for Latina (Hispanic) women: Feasibility and outcomes of a randomized controlled trial. International Journal of Nursing Studies, 52(1), 75–87. https://doi.org/10.1016/j.ijnurstu.2014.09.005

Kumanyika, S. K., Fassbender, J. E., Sarver, D. B., Phipps, E., Allison, K. C., Localio, R., ... Wadden, T. A. (2012). One-year results of the think health! Study of weight management in primary care practices. Obesity (Silver Spring), 20(6), 1249–1257. https://doi.org/10.1038/oby.2011.329

Laatikainen, T., Dunbar, J. A., Chapman, A., Kilkkinen, A., Vartiainen, E., Heistaro, S., ... Janus, E. D. (2007). Prevention of type 2 diabetes by lifestyle intervention in an Australian primary health care setting: Greater green triangle (GGT) diabetes prevention project. BMC Public Health, 7, 249. https://doi.org/10.1186/1471-2458-7-249

Lagerros, Y. T., & Rossner, S. (2013). Obesity management: What brings success? Therapeutic Advances in Gastroenterology, 6(1), 77–88. https://doi.org/10.1177/1756283X12459413

Lagerstrom, D., Berg, A., & Haas, U. (2013). Das M.O.B.I.L.I.S.-Schulungs programm bewegungstherapie und lebensstilintervention bei adipositas und diabetes. Diabetes Aktuell, 11(1), 10–16.

Lasikiewicz, N., Myrissa, K., Hoyland, A., & Lawton, C. L. (2014). Psychological benefits of weight loss following behavioural and/or dietary weight loss interventions. A Systematic Research Review. Appetite, 72, 123–137. https://doi.org/10.1016/j.appet.2013.09.017

Latner, J. D., Ciao, A. C., Wendedic, A. U., Murakami, J. M., & Durso, L. E. (2013). Community-based behavioral weight-loss treatment: Long-term maintenance of weight loss, physiological, and psychological outcomes. Behaviour Research and Therapy, 51(8), 451–459. https://doi.org/10.1016/j.brat.2013.04.009

LeBlanc, E. S., Patnode, C. D., Webber, E. M., Redmond, N., Rushkin, M., & O’Connor, E. A. (2018). Behavioral and pharmacotherapy weight loss interventions to prevent obesity-related morbidity and mortality in adults: Updated evidence report and systematic review for the US preventive services task force. JAMA, 320(11), 1172–1191. https://doi.org/10.1001/jama.2018.7777

Liberati, A., Altman, D. G., Tetzlaff, J., Mulrow, C., Gotzsche, P. C., Ioannidis, J. P., ... Moher, D. (2009). The PRISMA statement for
reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: Explanation and elaboration. BMJ, 339, b2700. https://doi.org/10.1136/bmj.b2700

Look AHEAD Research Group. (2010). Long-term effects of a lifestyle intervention on weight and cardiovascular risk factors in individuals with type 2 diabetes mellitus: Four-year results of the Look AHEAD trial. Archives of Internal Medicine, 170(17), 1566–1575. https://doi.org/10.1001/archinternmed.2010.334

McManus, K., Antinoro, L., & Sacks, F. (2001). A randomized controlled trial of a moderate-fat, low-energy diet compared with a low fat, low-energy diet for weight loss in overweight adults. International Journal of Obesity and Related Metabolic Disorders, 25(10), 1503–1511. https://doi.org/10.1038/sjijo.0801796

Mellberg, C., Sandberg, S., Ryberg, M., Eriksson, M., Brage, S., Larsson, C., ... Lindahl, B. (2014). Long-term effects of a Palaeolithic-type diet in obese postmenopausal women: A 2-year randomized trial. European Journal of Clinical Nutrition, 68(3), 350–357. https://doi.org/10.1038/ejcn.2013.290

Mingrone, G., Greco, A. V., Giancaterini, A., Scarfone, A., Castagneto, M., & Pugate, M. (2002). Sex hormone-binding globulin levels and cardiovascular risk factors in morbidly obese subjects before and after weight reduction induced by diet or malabsorptive surgery. Atherosclerosis, 161(2), 455–462. https://doi.org/10.1016/s0021-9150(01)00667-0

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & PRISMA Group. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. BMJ, 339, b2535. https://doi.org/10.1136/bmj.b2535

Moore, H., Summerbell, C. D., Greenwood, D. C., Tovey, P., Griffiths, J., Henderson, M., ... Adamson, A. J. (2003). Improving management of obesity in primary care: Cluster randomised trial. BMJ, 327(7423), 1085–1080. https://doi.org/10.1136/bmj.327.7423.1085

Morgan, L. M., Griffin, B. A., Millward, D. J., DeLoopy, A., Fox, K. R., Baic, S., ... Truby, H. (2009). Comparison of the effects of four commercially available weight-loss programmes on lipid-based cardiovascular risk factors. Public Health Nutrition, 12(6), 799–807. https://doi.org/10.1017/S136898008003236

Nackers, L. M., Middleton, K. R., Dubyak, P. J., Daniels, M. J., Anton, S. D., & Perri, M. G. (2013). Effects of prescribing 1,000 versus 1,500 kilocalories per day in the behavioral treatment of obesity: A randomized trial. Obesity (Silver Spring), 21(12), 2481–2487. https://doi.org/10.1002/oby.20439

Nanchahal, K., Power, T., Holdsworth, E., Hession, M., Sorhaiendo, A., Griffiths, U., ... Haines, A. (2012). A pragmatic randomised controlled trial in primary care of the Camden weight loss (CAMWEL) programme. BMJ Open, 2(3), e000793. https://doi.org/10.1136/bmjopen-2011-000793

Normand, S. L. (1999). Meta-analysis: Formulating, evaluating, combining, and reporting. Statistics in Medicine, 18(3), 321–359. https://doi.org/10.1002/(sici)1097-0258(19990215)18:3<321::aid-sim28>3.0.co;2-p

Nuttall, F. Q. (2015). Body mass index: Obesity, BMI, and health: A critical review. Nutrition Today, 50(3), 117–128. https://doi.org/10.1097/NT.0000000000000092

Ockene, I. S., Tellez, T. L., Rosal, M. C., Reed, G. W., Mordes, J., Merriam, P. A., ... Ma, Y. (2012). Outcomes of a Latino community-based intervention for the prevention of diabetes: The Lawrence Latino diabetes prevention project. American Journal of Public Health, 102(2), 336–342. https://doi.org/10.2105/ AJPH.2011.300357

Pellegrini, C. A., Verba, S. D., Otto, A. D., Helsel, D. L., Davis, K. K., & Jakicic, J. M. (2012). The comparison of a technology-based system and an in-person behavioral weight loss intervention. Obesity (Silver Spring), 20(2), 356–363. https://doi.org/10.1038/oby.2011.13

Perri, M. G., Limacher, M. C., Durning, P. E., Janicke, D. M., Lutes, L. D., Bobroff, L. B., ... Martin, A. D. (2008). Extended-care programs for weight management in rural communities: The treatment of obesity in underserved rural settings (TOURS) randomized trial. Archives of Internal Medicine, 168(21), 2347–2354. https://doi.org/10.1001/archinte.168.21.2347

Perri, M. G., Limacher, M. C., von Castel-Roberts, K., Daniels, M. J., Durning, P. E., Janicke, D. M., ... Martin, A. D. (2014). Comparative effectiveness of three doses of weight-loss counseling: Two-year findings from the rural LITE trial. Obesity (Silver Spring), 22(11), 2293–2300. https://doi.org/10.1002/oby.20832

Phillips, B. (2004). GRADE: Levels of evidence and grades of recommendation. Archives of Disease in Childhood, 89(5), 489–490. https://doi.org/10.1136/adc.2004.050898

Pinto, A. M., Fava, J. L., Hoffmann, D. A., & Wing, R. R. (2013). Combining behavioral weight loss treatment and a commercial program: A randomized clinical trial. Obesity (Silver Spring), 21(4), 673–680. https://doi.org/10.1002/oby.20044

Pulkala, J., Kuukonen-Harjula, K., Mansikkamaki, K., Aittasalo, M., Hulin, C., Karmeniemi, P., ... Fogelholm, M. (2015). Lifestyle counseling to reduce body weight and cardiometabolic risk factors among truck and bus drivers—A randomized controlled trial. Scandinavian Journal of Work, Environment & Health, 41(1), 54–64. https://doi.org/10.5271/sjweh.3463

Rock, C. L., Flatt, S. W., Sherwood, N. E., Karanja, N., Pakiz, B., & Thomson, C. A. (2010). Effect of a free prepared meal and incentivized weight loss program on weight loss and weight loss maintenance in obese and overweight women: A randomized controlled trial. JAMA, 304(16), 1803–1810. https://doi. org/10.1001/jama.2010.1503

Rock, C. L., Pakiz, B., Flatt, S. W., & Quintana, E. L. (2007). Randomized trial of a multifaceted commercial weight loss program. Obesity (Silver Spring), 15(4), 939–949. https://doi.org/10.1080/oby.2007.614

Rodriguez-Cristobal, J. J., Alonso-Villaverde, C., Panisello, J. M., Trave-Mercade, P., Rodriguez-Cortes, F., Marsal, J. R., & Pena, E. (2017). Effectiveness of a motivational intervention on overweight/obese patients in the primary healthcare: A cluster randomized trial. BMC Family Practice, 18(1), 74. https://doi.org/10.1186/s12875-017-0644-y

Rolls, B. J., Roe, L. S., Beach, A. M., & Kris-Etherton, P. M. (2005). Provision of foods differing in energy density affects long-term weight loss. Obesity Research, 13(6), 1052–1060. https://doi.org/10.1038/oby.2005.123

Rooney, A. A., Boyles, A. L., Wolfe, M. S., Bucher, J. R., & Thayer, K. A. (2014). Systematic review and evidence integration for literature-based environmental health science assessments. Environmental Health Perspectives, 122(7), 711–718. https://doi.org/10.1289/ehp.1307972
Snee'd, J. R., Rutherford, B. R., Rindskopf, D., Lane, D. T., Sackheim, H. A., & Roose, S. P. (2008). Design makes a difference: A meta-analysis of antidepressant response rates in placebo-controlled versus comparator trials in late-life depression. The American Journal of Geriatric Psychiatry, 16(1), 65–73. https://doi.org/10.1097/JGP.0b013e3181256b1d

Sten, L., Iqbal, N., Seshadri, P., Chicano, K. L., Daily, D. A., McGrory, J., ... Samaha, F. F. (2004). The effects of low-carbohydrate versus conventional weight loss diets in severely obese adults: One-year follow-up of a randomized trial. Annals of Internal Medicine, 140(10), 778–785. https://doi.org/10.7326/0003-4819-140-10-200405180-00007

Sterne, J. A., Sutton, A. J., Ioannidis, J. P., Terrin, N., Jones, D. R., Lau, J., ... Higgins, J. P. (2011). Recommendations for examining and interpreting funnel plot asymmetry in meta-analyses of randomised controlled trials. BMJ, 343, d4002. https://doi.org/10.1136/bmj.d4002

Stevens, V. J., Obarzanek, E., Cook, N. R., Lee, I. M., Appel, L. J., Smith West, D., ... Trials for the Hypertension Prevention Research Group. (2001). Long-term weight loss and changes in blood pressure: Results of the trials of hypertension prevention, phase II. Annals of Internal Medicine, 134(1), 1–11. https://doi.org/10.1037/0003-4819-134-1-200101020-00007

Stolley, M. R., Fitzgibbon, M. L., Schiffer, L., Sharp, L. K., Singh, V., Van Horn, L., & Dyer, A. (2009). Obesity reduction black intervention trial (ORBIT): Six-month results. Obesity (Silver Spring), 17(1), 100–106. https://doi.org/10.1038/oby.2008.488

Teixeira, P. J., Silva, M. N., Coutinho, S. R., Palmeira, A. L., Mata, J., Vieira, P. N., ... Sardinia, L. B. (2010). Mediators of weight loss and weight loss maintenance in middle-aged women. Obesity (Silver Spring), 18(4), 725–735. https://doi.org/10.1038/oby.2009.281

Toobert, D. J., Glasgow, R. E., & Radcliffe, J. L. (2000). Physiologic and related behavioral outcomes from the Women's lifestyle heart trial. Annals of Behavioral Medicine, 22(1), 1–9. https://doi.org/10.1007/BF02895162

Torgerson, J. S., Lissner, L., Lindroos, A. K., Kruijer, H., & Sjostrom, L. (1997). VLCD plus dietary and behaviourial support versus support alone in the treatment of severe obesity. A randomised two-year clinical trial. International Journal of Obesity and Related Metabolic Disorders, 21(11), 987–994 Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/9368821

Truby, H., Baic, S., deLooy, A., Fox, K. R., Livingstone, M. B., Logan, C. M., ... Millward, D. J. (2006). Randomised controlled trial of four commercial weight loss programmes in the UK: Initial findings from the BBC “diet trials”. BMI, 332(7553), 1309–1314. https://doi.org/10.1136/bmj.38833.411204.80

Tsai, A. G., Wadden, T. A., Rogers, M. A., Lane, D. T., Sackheim, H. A., ... & Islam, B. R. (2010). A primary care intervention for weight loss: Results of a randomized controlled pilot study. Obesity (Silver Spring), 18(8), 1614–1618. https://doi.org/10.1038/oby.2009.457

Villareal, D. T., Chode, S., Parimi, N., Sinacore, D. R., Hilton, T., Armamento-Villareal, R., ... Shah, K. (2011). Weight loss, exercise, or both and physical function in obese older adults. The New England Journal of Medicine, 364(13), 1218–1229. https://doi.org/10.1056/NEJMoa1008234

Villareal, D. T., Miller, B. V., 3rd, Banks, M., Fontana, L., Sinacore, D. R., & Klein, S. (2006). Effect of lifestyle
