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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 (Bluher, 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/m^2 is categorized as normal weight, a BMI between 25–29.9 kg/m^2 as overweight and a BMI ≥30 kg/m^2 as obese. Furthermore, obesity is subdivided into three BMI classes: class I, 30–34.9 kg/m^2; class II, 35–39.9 kg/m^2; and class III, ≥40 kg/m^2 (Deitel & Greenstein, 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/m^2, 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/m^2 (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, *P*articipants, *I*nterventions, *C*omparators, *O*utcome, and *S*tudy design (da Costa Santos, de Mattos Pimenta, & Nobre, 2007).

Participants: A mixed collective of patients with obesity defined as BMI ≥30 kg/m^2 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/m^2, into class II obesity if the mean BMI of participants was between 35 and 39.9 kg/m^2 and into class III obesity if the mean BMI of participants was ≥40 kgm^2.

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 fulfil 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

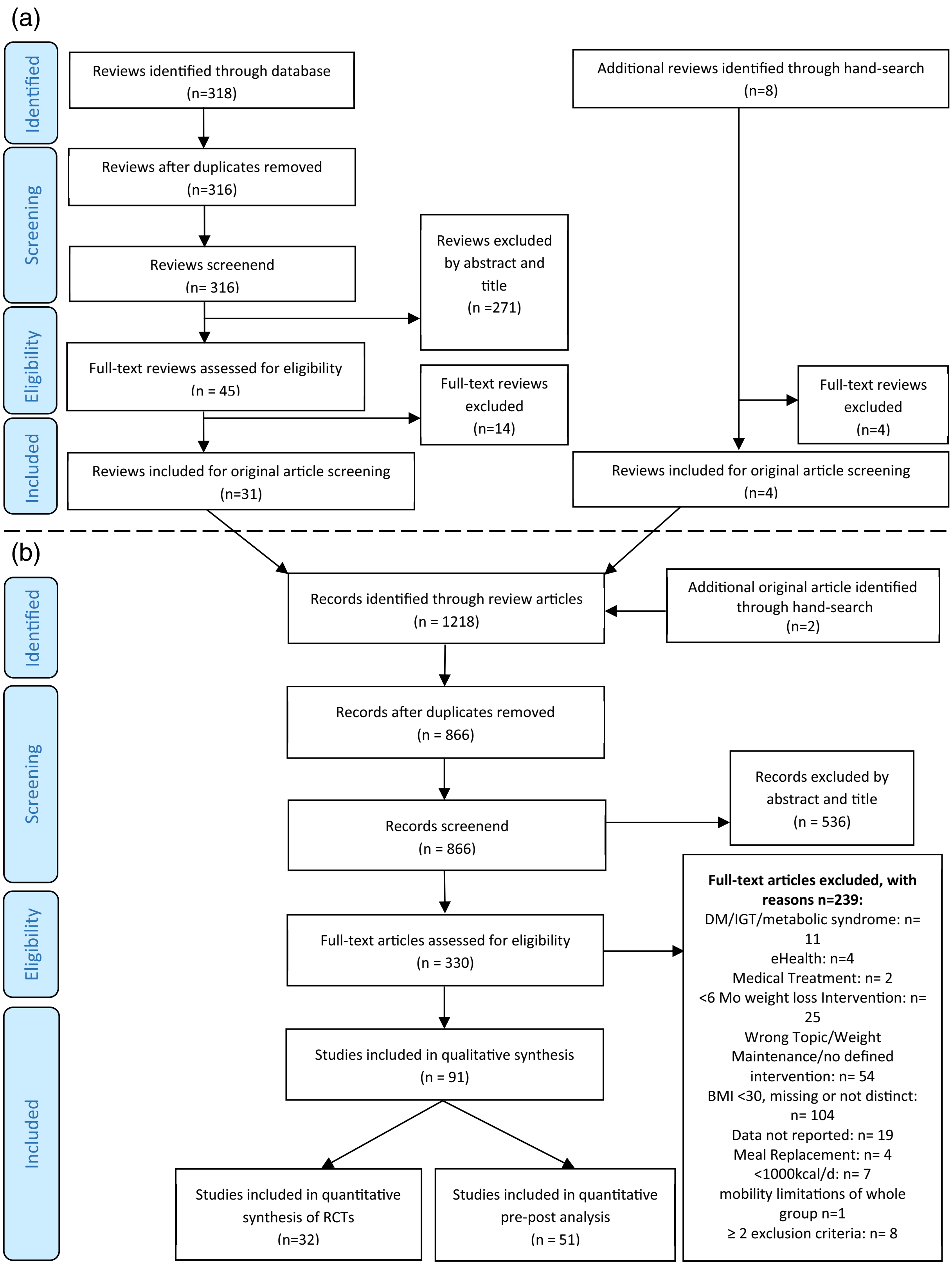


FIGURE 1 Flow diagram of systematic literature search. Legend A systematic search of review articles through database search was conducted (A), followed by a systematic search of original articles through review articles (B). Abbreviations n: Number; DM: Diabetes mellitus; IGT: impaired glucose tolerance; Mo: Month; BMI: Body mass index; kcal Kilocalorie; d: Day

TABLE 1 Characterization of RCTs by obesity class

BMI 1			
Author, Year	**Study length Months**	**Sample size and characterization N; age (SD); sex (%), BMI (kg/m^2) (SD)**	**Country**
Ahern et al., 2017	24	**1. C:** n = 211; age: 51.9 (14.1); 68% female; BMI: 34.4 (4.6) **2. I:** n = 528; age: 53.3 (14); 68% female; BMI: 34.5 (5.1)	UK
Blumenthal et al., 2000	6	**1. C:** n = 24; age: 47.2 (1.8); 46% female; BMI: 32.6 (5.1) **2. I:** n = 55; age: 48.5 (1.2); 62% female; BMI: 32.1 (4)	US
Cohen, D'Amico, & Merenstein, 1991	12	**1. C:** n = 15; age: 59.7; 73% female; BMI: 34.2 **2. I:** n = 15; age: 59.7; 73% female; BMI: 34	US
de Vos, Runhaar, & Bierma-Zeinstra, 2014	30	**1. C:** n = 204; age: 55.7 (3.2); 100% female; BMI: 32.5 (4.5) **2. I:** n = 203; age: 55.7 (3.2); 100% female; BMI: 32.2 (4.1)	NL
Elmer et al., 2006	18	**1. C:** n = 241; age: 49.5 (8.8); 63% female; BMI: 32.9 (5.6) **2. I:** n=269; age: 50.2 (9.3); 57.2% female; BMI: 33.3 (6.3)	US
Greaves et al., 2015	12	**1. C:** n = 53; age: 63.7 (7.4); 73.6% female; BMI: 32.3 (3) **2. I:** n = 55; age: 66.6 (6.4); 65.5% female; BMI: 33 (3.2)	UK
Hardcastle, Taylor, Bailey, & Castle, 2008	6	**1. C:** n = 131; age: 50.4 (0.9); 67% female; BMI: 34.3 (0.6) **2. I:** n = 203; age: 50.1 (0.7); 67% female; BMI: 33.7 (0.4)	UK
Heshka et al., 2000	24	**1. C:** n = 212; age: 44 (10); 87% female; BMI: 33.6 (3.7) **2. I:** n = 211; age: 45 (10); 82% female; BMI: 33.8 (3.4)	US
Jansson, Engfeldt, Magnuson, Pt, & Liljegren, 2013	24	**1. C:** n = 66; age: 45 (13); 77% female; BMI: 33.6 **2. I:** n = 67; age: 49 (13); 67% female BMI: 33.8	SW
Jebb et al., 2011	12	**1. C:** n = 395; age: 48.2 (12.2); 86% female; BMI: 31.3 (2.6) **2. I:** n = 377; age: 48.2 (12.2); 88% female; BMI: 31.5 (2.6)	MULTI
Jenkins et al., 2017	6	**1. C:** n = 486; age: 44.7; 77%; female; BMI: 32.5 (32 to 33) **2. I:** n = 145; age: 44.7; 77%; female; BMI: 31.7 (30.8 to 32.7)	CAN
Jones et al., 1999	6	**1. C:** n = 51; age: 59 (7); 55% female; BMI: 34 (6) **2. I:** n = 51; age: 57 6); 55% female; BMI: 34 (6)	US
Morgan et al., 2009	6	**1. C:** n = 61; age: 40.8 (9.6); 75.4% female; BMI: 31.5 (2.9) **2. I:** n = 47; age: 39.9 (10.9); 72.4% female; BMI: 31.2 (2.7)	UK
Nanchahal et al., 2012	12	**1. C:** n = 190; age: 49.4 (15.5); 73% female; BMI: 33 (5.4) **2. I:** n = 191; age: 48.2 (14.1); 72% female; BMI: 33.9 (5.6)	UK
Ockene et al., 2012	12	**1. C:** n = 150; age: 52.4 (11.6); 77% female; BMI: 34.2 (5.9) **2. I:** n = 162; age: 51.4 (10.9); 72% female; BMI: 33.6 (5.1)	US
Puhkala et al., 2015	12	**1. C:** n = 58; age: 46.5 (8.6); male 100%; BMI: 33.1 (4.7) **2. I:** n = 55; age: 47.6 (7.9); male 100%; BMI: 32.9 (4.3)	F
Rock, Pakiz, Flatt, & Quintana, 2007	6	**1. C:** n = 35; age: 40 (12); 100% female; BMI: 33.8 (3.4) **2. I:** n = 35; age: 42 (11); 100% female; BMI: 34.2 (3.7)	US
Rock et al., 2010	24	**1. C:** n = 111; age: 45 (11); 100% female; BMI: 34 (3.2) **2. I:** n = 151; age: 44 (10); 100% female; BMI: 33.8 (3.1)	US
Rodriguez-Cristobal et al., 2017	24	**1. C:** n = 446; age: 55.5 (11.5); 73% female; BMI: 34.1 (4.8) **2. I:** n = 400; age: 57.7 (22.1); 82% female: BMI: 34.1 (4.8)	SP
Ross et al., 2012	24	**1. C:** n = 241; age: 52.4 (11.8); 70% female; BMI: 32 (4.2) **2. I:** n = 249; age: 51.3 (11); 70% female; BMI: 32.6 (4.1)	US

TABLE 1 (Continued)

Author, Year	Study length Months	Sample size and characterization N; age (SD); sex (%), BMI (kg/m^2) (SD)	Country
BMI 1			
Shea et al., 2011	8	**1. C:** n = 294; age: 65.6 (4.5); 57% female; BMI: 31.1 (2.4) **2. I:** n = 291; age: 65.6 (4.5); 47% female; BMI: 31.2 (2.2)	US
Shuger et al., 2011	9	**1. C:** n = 50; age: 47.2 (8.9); 84% female; BMI: 33.7 (5.5) **2. I: n** = 49; age: 46.8 (12.4); 80% female; BMI: 33.1 (4.8)	US
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) **2. I:** n = 595; age: 43.4 (6.1); 78% male; BMI (female): 31 (3.6); BMI (male): 31 (2.9)	US
Vissers et al., 2010	6	**1. C:** n = 21; age: 44.8 (11.4); 75% female; BMI 30.8 (3.4) **2. I:** n = 20; age: 44.7 (13.0); 75% female; BMI: 33.1 (3.4)	BL
BMI 2			
Anton et al., 2011	6	**1. C:** n = 17; age: 63.7 (6.7); 100% female; BMI: 35.8 (6.8) **2. I:** n = 17; age: 63.7 (4.5); 100% female; BMI: 37.8 (5.5)	US
Davis Martin et al., 2006	6	**1. C:** n = 73; age: 43 (11.4); 100% female; BMI: 39.6 (7.7) **2. I:** n = 71; age: 40.7 (12.6); 100% female; BMI: 38.1 (7.5)	US
Perri et al., 2008	6	**1. C:** n = 79; age: 58.6 (6); 100% female; BMI: 36.2 (4.3) **2. I:** n = 83; age: 59.2 (6.2); 100% female; BMI: 37.1 (4.5)	US
Stolley et al., 2009	6	**1. C:** n = 106; age: 45.5 (8.4); 100% female; BMI: 39.6 (5.8) **2. I:** n = 107; age: 46.4 (8.4); 100% female; BMI: 38.8 (5.5)	US
Tsai et al., 2010	6	**1. C:** n = 26; age: 47.6 (2.5); 88% female; BMI: 37.6 (1.1) **2. I:** n = 24; age: 51.3 (2.3); 88% female; BMI 35.4 (1.2)	US
Villareal et al., 2006	6	1. **C:** n = 10; age: 71 (4); 60% female; BMI: 39 (5) **2. I:** n = 17; age: 69 (5); 71% female; BMI: 39 (5)	US
Villareal et al., 2011	12	**1. C:** n = 27; age: 69 (4); 67% female; BMI: 37.3 (4.7) **2. I:** n = 28; age: 70 (4); 57% female; BMI: 37.2 (5.4)	US
Wadden et al., 2011	24	**1. C:** n = 130; age: 51.7 (12.1); 75% female; BMI 39 (4.8) **2. I:** n = 131; age: 52 (12.2); 84% female; BMI: 38.5 (4.6)	US

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, Netherland.; RCT, Randomized controlled trial; SD, Standard deviation; SP, Spain; SW, Sweden; UK, United Kingdom; US, United States.

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 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 ≥30%.

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 to −2.15) and in class II obesity 4.08 kg (CI 95% −5.89 to −2.27). In total relative BWL was 3.03 kg (CI 95% −3.59 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 and 13–36 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 (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 [range: −0.67 to −13.7], for class II obesity, 5.5 kg [range: 0 to −15] and, for class III obesity 7.9 kg [range of: −3.1 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.

TABLE 2 Characterization of pre-post trials by obesity class

Author, Year	Study type	Study length Months	Sample size and characterization N; age (SD); sex (%), BMI (kg/m^2) (SD)	Country
BMI 1				
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) **I2**: n = 52; age: 51.0 (7.5); 60% female; BMI: 33.5 (4.1)	AUS
Brochu et al., 2009	RT	6	**I1:** n = 89; age: 58 (4.7); 100% female; BMI: 32.3 (4.6) **I2:** n = 48; age: 57.2 (5); 100% female; BMI: 32.6 (4.9)	CAN
Cousins et al., 1992	RCT	6	**I1:** n = 32; age: 33.6 (6.4); 100% female; BMI: 31.7 (5) **I2:** n = 27; age: 32.8 (6.1); 100% female; BMI: 30.3 (4.5)	US
Ello-Martin, Roe, Ledikwe, Beach, & Rolls, 2007	RT	12	**I1:** n = 49; age: 44.5 (1.3); 100% female; BMI: 33.3 (0.4) **I2**: n = 48; age: 45.3 (1.4); 100% female; BMI: 33.4 (0.5)	US
Foster et al., 2012	RT	18	**I1:** n = 61; age: 47.0 (12.02); 89% female; BMI: 33.9 (3.5) **I2:** n = 62; age: 46.7 (13.0); 94% female; BMI: 34.0 (3.7)	US
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) **I2:** n = 35; age:22.5 (2.3); 100% female; BMI: 33.8 (4.9)	AUS
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) **I2:** n = 198; age: 42 (8.9); 83% female; BMI: 33 (4.3)	US
Jeffery, Wing, Sherwood, & Tate, 2003	RT	18	**I1:** n = 109; age: 42.2 (6.4); 58% female; BMI: 31 (2.6) **I2:** n = 93; age: 42.2 (6.4); 58% female; BMI: 31 (2.6)	US
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) **I2:** n = 51; age: 44 (10); 92% female; BMI: 33 (3)	US
Mellberg et al., 2014	RT	24	**I1:** n = 35; age: 59.5 (5.5); 100% female; BMI: 32.7 (3.6)	SW

(Continues)

TABLE 2 (Continued)

Author, Year	Study type	Study length Months	Sample size and characterization N; age (SD); sex (%), BMI (kg/m^2) (SD)	Country
BMI 1				
			I2: n = 35; age: 60.3 (5.9); 100% female; BMI: 32.6 (3.3)	
Pellegrini et al., 2012	RT	6	**I:** n = 17; age: 45.1 (9.4); 100% female; BMI:33.1 (3.8)	US
Rolls, Roe, Beach, & Kris-Etherton, 2005	RT	6	**I1:** n = 50; age: 44.5 (1.2); 77% female; BMI: 31.4 (0.4)	US
			I2: n = 50; age: 45.1 (1.2); 77% female; BMI: 30.9 (0.5)	
			I3: n = 50; age: 43.8 (1.2); 77% female; BMI: 30.8 (0.5)	
			I4: n = 50; age: 45.2 (1.2); 77%; female; BMI: 31.3 (0.4)	
Ryan, Nicklas, Berman, & Elahi, 2003	RT	6	**I1:** n = 15; age: 56 (1); 100% female; BMI: 33.6 (1.2)	US
			I2: n = 16; age: 59 (1); 100% female; BMI: 31.1 (1.0)	
			I3: n = 9; age: 57 (2); 100% female; BMI: 31.4 (1.2)	
Ryan & Harduarsingh-Permaul, 2014	NRT	6	**I1:** n = 22; age: 50–76 years; 100% female; BMI: 34 (1)	US
			I2: n = 43; age: 50–76 years; 100% female: BMI: 32 (1)	
Sacks et al., 2009)	RT	24	**I1:** n = 204; age: 51 (9); 62% female; BMI: 33 (4)	US
			I2: n = 202; age: 50 (10); 67% female; BMI: 33 (4)	
			I3: n = 204; age: 52 (9); 61% female; BMI: 32 (4)	
			I4: n = 201; age: 51 (9); 64% female; BMI: 33 (4)	
			all: Age: 51 (9); 64% female; BMI: 33 (4)	
Teixeira et al., 2010	RCT	12	**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				
Carels, Darby, Cacciapaglia, & Douglass, 2004	RT	6	**I1:** n = 21; age: 54.7 (7.9); 100% female; BMI: 37.8 (5.9)	US
			I2: n = 23; age: 54.7 (7.9); 100% female; BMI: 35.1 (5)	
Damschroder et al., 2014	RT	12	**I1:** n = 160; age: 54.9 (9.5); 84% male; BMI: 36.4 (6.4)	US
			I2: n = 159; age: 54.6 (10.5); 88% male; BMI: 36.8 (6.4)	
Ebbeling, Leidig, Feldman, Lovesky, & Ludwig, 2007	RT	6	**I1:** n = 37; age: 28.2 (3.8); 81% female; BMI: 37,5	US
			I2: n = 36; age: 26.9 (4.2); 78% female; BMI: 36,6	
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
			I2: n = 15; age: 68.7 (4.3); 60% female; BMI: 37.5	
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
			I2: n = 124; age: 47.6 (11.9); 86% female; BMI: 37.2 (6.5)	

TABLE 2 (Continued)

Author, Year	Study type	Study length Months	Sample size and characterization N; age (SD); sex (%), BMI (kg/m^2) (SD)	Country
BMI 1				
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)	
BMI 3				
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, Hellbardt, 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.

Study or Subgroup	Intervention Mean	Intervention SD	Intervention Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Random, 95% CI
4.1.1 BMI 1								
Ahern 2017	-6.8	9.2	528	-3.3	10.2	211	3.2%	-3.50 [-5.08, -1.92]
Blumenthal 2000	-7.9	6	55	0.7	3.3	24	2.8%	-8.60 [-10.66, -6.54]
Cohen 1991	-0.9	4	15	1.3	3	15	2.5%	-2.20 [-4.73, 0.33]
de Vos 2014	-0.6	5.7	203	0.6	5.7	204	3.6%	-1.20 [-2.31, -0.09]
Elmer 2006	-4.3	7.4	269	-1.5	5	241	3.6%	-2.80 [-3.89, -1.71]
Greaves 2015	-4.3	5.5	55	-2	6.9	55	2.6%	-2.30 [-4.63, 0.03]
Hardcastle 2008	-0.7	3.6	203	0.1	3.3	131	3.8%	-0.80 [-1.55, -0.05]
Heshka 2000	-2.9	7.3	211	-0.2	5.8	212	3.5%	-2.70 [-3.96, -1.44]
Jansson 2013	-1.9	8.6	67	-1.2	6.9	66	2.4%	-0.70 [-3.35, 1.95]
Jebb 2011	-5.1	6	377	-2.3	4.2	395	3.8%	-2.80 [-3.53, -2.07]
Jenkins 2017	-1.2	7.3	145	-1	5.6	486	3.4%	-0.20 [-1.49, 1.09]
Jones 1999	-3.2	4.3	51	-1.8	2.7	51	3.4%	-1.40 [-2.79, -0.01]
Morgan 2009	-6.2	6.2	58	-0.6	2.7	61	3.1%	-5.60 [-7.33, -3.87]
Nanchahal 2012	-2.4	7.5	191	-1.3	6.4	190	3.4%	-1.10 [-2.50, 0.30]
Ockene 2012	-1.1	4.4	162	0.3	4.7	150	3.6%	-1.40 [-2.41, -0.39]
Puhkala 2015	-3.4	6.6	55	0.7	3.9	58	2.9%	-4.10 [-6.11, -2.09]
Rock 2007	-7.8	7.2	35	-0.3	4.5	35	2.3%	-7.50 [-10.31, -4.69]
Rock 2010	-7.4	8.5	167	-2	6.7	103	3.0%	-5.40 [-7.23, -3.57]
Rodriguez-Cristobal 2017	-2.5	10	400	-1	8.4	446	3.5%	-1.50 [-2.75, -0.25]
Ross 2012	-2.4	3.9	249	-0.7	3.8	241	3.8%	-1.70 [-2.38, -1.02]
Shea 2011	-5	4.5	291	-1.1	3.4	294	3.8%	-3.90 [-4.55, -3.25]
Shuger 2011	-1.7	6.5	49	-0.9	7.4	50	2.3%	-0.80 [-3.54, 1.94]
Stevens 2001	-0.2	6.2	595	1.8	6.2	596	3.8%	-2.00 [-2.70, -1.30]
Vissers 2010	-7	5.6	20	0.9	3.4	21	2.2%	-7.90 [-10.75, -5.05]
Subtotal (95% CI)			**4451**			**4336**	**76.2%**	**-2.81 [-3.49, -2.13]**
4.1.2 BMI 2								
Anton 2011	-5.8	3.8	17	-0.4	3.9	16	2.4%	-5.40 [-8.03, -2.77]
Martin 2006	-2	3.2	73	0.2	2.9	71	3.6%	-2.20 [-3.20, -1.20]
Perri 2008	-10.1	5.5	83	-10.5	5.3	101	3.2%	0.40 [-1.17, 1.97]
Stolley 2009	-3	4.9	107	0.2	3.7	106	3.5%	-3.20 [-4.37, -2.03]
Tsai 2010	-4.4	2.9	24	-0.9	3.1	26	3.1%	-3.50 [-5.16, -1.84]
Villareal 2006	-8.2	5.7	17	0.7	2.7	10	2.0%	-8.90 [-12.08, -5.72]
Villareal 2011	-8.6	3.8	28	-0.1	3.5	27	2.9%	-8.50 [-10.43, -6.57]
Wadden 2011	-4.6	8	129	-1.7	8	130	2.9%	-2.90 [-4.85, -0.95]
Subtotal (95% CI)			**478**			**487**	**23.8%**	**-4.07 [-5.90, -2.25]**
Total (95% CI)			**4929**			**4823**	**100.0%**	**-3.10 [-3.74, -2.45]**

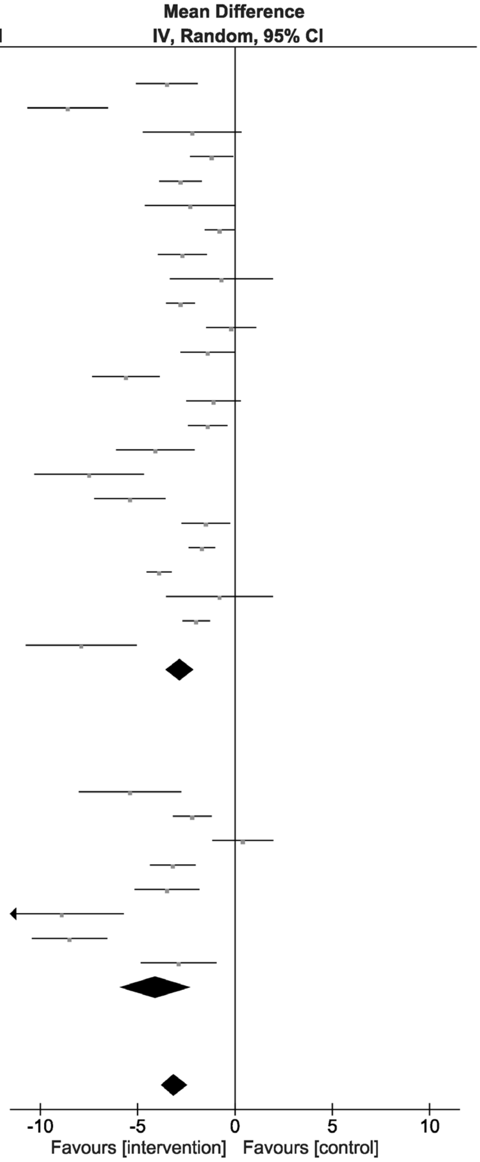


FIGURE 2 Quantitative analysis of randomized controlled trials

4 | DISCUSSION

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"

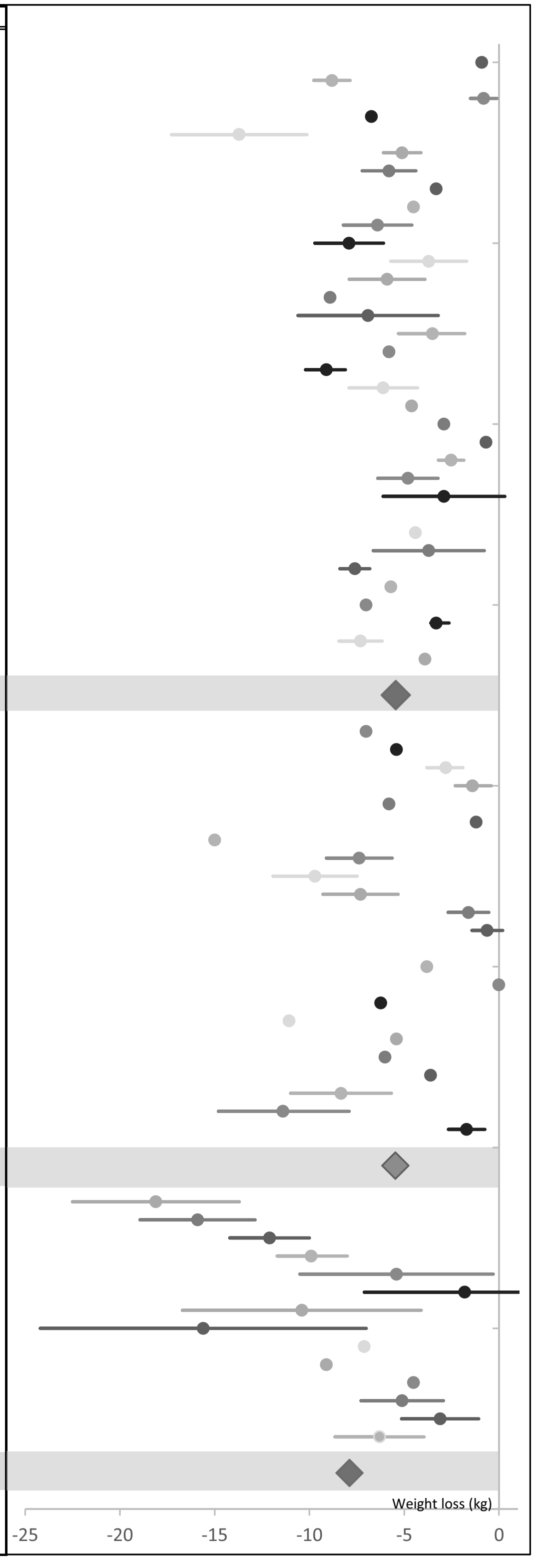
To test hypothesis 1, BWL was presented as a stratified overview across the different obesity classes. For RCTs, stratification was only possible for class I and class II obesity, showing a relative BWL of the intervention groups (compared to the control groups) by 3 and 4% and absolute BWL by 3.8 and 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

FIGURE 3 Quantitative pre-post analysis (weight loss [kg] with 95% CI)

Author (Year)	Weight loss (kg)	SD	Total
Abedi (2010)	-0.90	NR	35
Acharya (2009)	-8.81	5.96	151
Allen (2013)	-0.80	1.40	18
Arrebola (2011)	-6.73	NR	60
Brinkworth (2009)	-13.70	1.80	106
Brochu (2009): I1	-5.10	4.70	89
Brochu (2009): I2	-5.80	4.90	48
Cousins (1992): I2	-3.30	NR	32
Cousins (1992): I2	-4.50	NR	27
Ello-Martin (2007): I1	-6.40	6.30	49
Ello-Martin (2007): I2	-7.90	6.24	48
Foster (2012): I1	-3.70	-7.81	61
Foster (2012): I2	-5.90	-7.87	62
Foster-Schubert (2012)	-8.91	NR	117
Griffin (2013): I1	-6.90	NR	36
Griffin (2013): I2	-3.50	NR	35
Hollis (2008)	-5.80	4.40	1685
Jakicic (2012	-9.10	NR	165
Jeffery (2003)	-6.10	8.80	93
Johnston (2013)	-4.60	NR	147
Kirby (2011)	-2.90	NR	54
Koniak-Griffin (2015)	-0.67	NR	111
Laatikainen (2007)	-2.52	NR	237
McManus (2001): I1	-4.80	5.60	50
McManus (2001): I2	-2.90	8.60	30
Melberg (2014): I1	-8.70	NR	35
Melberg (2014): I2	-4.40	NR	35
Pellegrini (2012)	-3.70	5.70	17
Rolls (2005)	-7.60	5.66	200
Ryan (2003)	-5.70	NR	40
Ryan (2014)	-7.00	NR	65
Sacks (2009):	-3.31	6.95	811
Teixeira (2010)	-7.30	5.90	106
Toobert (2000)	-3.90	NR	14
BMI 1 Total	**-5.4**		**4869**
Carels (2004): I1	-7.00	NR	21
Carels (2004): I2	-5.40	NR	23
Damschroder (2014): I1	-2.80	NR	160
Damschroder (2014): I2	-1.40	NR	159
Ebbeling (2007): I1	-5.80	NR	37
Ebbeling (2007): I2	-1.20	NR	36
Esposito (2004)	-15.00	NR	55
Foster (2010)	-7.37	NR	154
Frimel (2008)	-9.70	4.00	15
Gorin (2013):	-7.30	9.95	99
Kumanyika (2012): I1	-1.61	NR	124
Kumanyika (2012): I2	-0.62	NR	137
Lagerstrom (2013)	-6	NR	4336
Latner (2013)	-3.80	NR	90
Moore (2003)	0.00	NR	415
Nackers (2013)	-6.23	0.94	60
Perri (2014)	-11.07	NR	161
Pinto (2013): I1	-5.40	0.80	48
Pinto (2013): I2	-6.00	0.80	49
Pinto (2013): I3	-3.60	0.80	47
Wadden (2004)	-8.33	8.63	43
Yancy (2010)	-11.40	NR	72
Yeh (2003)	-1.70	3.00	40
BMI 2 Total	**-4.3**		**6381**
Dalle Grave (2013): I1	-18.10	14.30	43
Dalle Grave (2013): I2	-15.90	10.10	45
Goodpaster (2010): I1	-12.10	NR	67
Goodpaster (2010): I2	-9.90	NR	67
Hakala (1993): I1 F	-15.70	9.00	20
Hakala (1993): I1 M	-13.10	8.80	10
Hakala (1993): I2 F	-10.40	13.40	20
Hakala (1993): I2 M	-15.60	12.00	10
Mingrone (2002): F	-7.10	NR	22
Mingrone (2002): M	-9.10	NR	11
Rudolph (2016)	-4.5	NR	190
Stern (2004): I1	-5.10	8.70	64
Stern (2004): I2	-3.10	8.440	68
Torgerson (1997)	-6.30	8.70	55
BMI 3 Total	**-7.9**		**692**

Abbrevations: *BMI: Body mass index; NR: not reported; I1: Intervention group 1; I2: Intervention group 2; kg: Kilogram; CI: Confidence interval*



Research Group, 2010). In addition, Leblanc et al. analysed RCTs with a mean baseline BMI ranging from 24 to 42 kg/m^2 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/m^2. 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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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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