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Differences in Weight Loss Across Different BMI Classes: A Meta-analysis of the Effects of Interventions with Diet and Exercise

Jeroen C. M. Barte · Jorien Veldwijk · Pedro J. Teixeira · Frank M. Sacks · Wanda J. E. Bemelmans

Abstract

Background Lifestyle interventions are effective for weight loss and are recommended for persons with a body mass index (BMI) of 25–40 kg m^{-2}. However, this group is very heterogeneous, which could influence outcomes from lifestyle interventions.

Purpose In this systematic review, differences in 1-year weight change and percentage weight change after lifestyle interventions were investigated for participants varying in initial BMI using meta-analyses.

Method Twenty-two interventions with healthy Caucasian adults, a mean BMI between 25 and 40 kg m^{-2}, a dietary as well as a physical activity component aiming at weight loss, and at least five contact sessions guided by a professional health care provider were selected from a systematic search in the MEDLINE database. Participants in each intervention were divided into one of the three BMI classes: overweight (BMI of 25–29.99 kg m^{-2}), class-I obesity (BMI of 30–34.99 kg m^{-2}), and class-II obesity (BMI of 35–39.99 kg m^{-2}). Differences in weight change and percentage weight change were analyzed and compared among different BMI classes within the same intervention by calculating standardized mean differences.

Results Overweight participants lost 1.1 kg less ($p<0.01$) than participants with class-I obesity and 1.5 kg less ($p<0.01$) than participants with class-II obesity. For percentage weight change, no significant differences were found among the BMI classes.

Conclusion Average weight change during lifestyle interventions only differs to a small extent among people with BMI between 25 and 40 kg m^{-2}. This implies that these interventions are equally appropriate for these BMI classes.

Keywords Baseline BMI · Initial BMI · Lifestyle intervention · Overweight · Obesity

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Introduction

Changes in lifestyle are needed, on an individual level, to counteract the current overweight and obesity problem. Lifestyle interventions aiming at changes in dietary and physical activity behavior are effective in causing weight loss in the short term [1, 2], and it has been shown that participants maintain on average more than half of their weight loss even after an unsupervised follow-up period of 1 year [3]. Furthermore, these interventions are relatively inexpensive [4], less invasive compared to surgery or weight loss medication, and may bring about a range of other physical and mental health benefits [5–7]. Hence, guidelines for the management of overweight and obesity advise the use of lifestyle interventions to lose weight for participants with a body mass index (BMI) of 25–40 kg m^{-2} [8–10].

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However, effects of lifestyle interventions differ per individual. Often, it is not clear which factors determine the effect of a treatment. Patients within the BMI range of 25–40 kg m^{-2} are heterogeneous, i.e., their characteristics such as co-morbidity, weight history, and psychological and behavioral variables may vary. BMI scores have been shown to be related to a lower self-esteem [11] and to a higher dropout rate [12, 13], which lead to lower weight loss outcomes [14]. Furthermore, variables that may be associated with BMI scores such as diet attempts, self-efficacy, and body image are also related to weight loss outcomes [15–17]. This may result in different effects of lifestyle interventions for patients with a different BMI. In contrast, a previous review on pretreatment predictors of success did not find BMI as a predictor of subsequent weight loss [18]. However, this review was limited in the number of studies covered, and more recent studies [19–21] have suggested that initial BMI class does matter. Thus, lifestyle interventions may be more effective for participants in specific BMI classes, which would implicate that interventions should be adjusted or tailored per BMI class or even that other treatments may be preferred per BMI class. Nevertheless, effects of lifestyle interventions on BMI classes (i.e., 25–29.99 kg m^{-2}, 30–34.99 kg m^{-2}, and 35–39.99 kg m^{-2}) are rarely reported, and the effect of initial BMI on weight change has never been systematically investigated. Therefore, the aim of this study was to systematically study differences in the effects of lifestyle interventions on overweight and obese participants across different BMI classes, within the same interventions, using meta-analyses.

Methods and Procedures

Search and Selection

The literature search of this study is an extension of a previously performed search [4]. Relevant articles were selected from the MEDLINE database and from the references of reviews that gave insight on interventions aiming at weight loss. For the present study, the search was extended from August 2007 to January 2011 (see Fig. 1). Two authors independently screened the identified records, and disagreement concerning eligibility was resolved by discussion.

To narrow our review and reduce heterogeneity, it was chosen to examine the effects only within lifestyle interventions with a mainly Caucasian population because in terms of weight loss, different races may respond differently to lifestyle interventions [22]. Other inclusion criteria for the interventions were as follows: an adult population with a mean BMI between 25 and 40 kg m^{-2}, a dietary as well as a physical activity component aiming at weight loss, at least five contact sessions guided by a professional health care provider, BMI measured on baseline, weight measured on baseline and in the period between 1 and 1.5 years after the start of the intervention, at least 20 participants, and published in English after 1 January 2000. Exclusion criteria were a population with serious diseases (e.g., diabetes mellitus, cardiovascular disease, and cancer), musculoskeletal complaints, or pregnancy. In addition, interventions targeting health care providers, interventions with weight loss medication, and interventions with surgery were excluded. No criteria on randomized or controlled trials were set because the outcome measures were not compared between intervention groups but within the intervention group (as described below).

Data Collection

Within the selected interventions, participants who were measured at baseline and follow-up were divided into three different groups based on their initial BMI. These groups were classified according to the WHO weight classifications [23]: overweight (BMI of 25–29.99 kg m^{-2}), class-I obesity (BMI of 30–34.99 kg m^{-2}), and class-II obesity (BMI of 35–39.99 kg m^{-2}). For the participants who completed the 1-year follow-up, their mean and standard deviation for weight change, BMI change, and percentage weight change at 1 year follow-up were gathered by contacting the authors of each individual study (at least twice) by e-mail. These data were requested separately for participants in the three different BMI classes of each selected intervention. If no data of a 1-year follow-up were available, data for follow-ups between 1 and 1.5 years were also accepted. Furthermore, authors were requested to run some additional statistical tests (t tests, chi-square tests) to determine whether there were any differences in age, gender, and socioeconomic status between the BMI classes of the interventions.

Statistical Analyses

Only studies of which the authors provided full data on weight change, BMI change, and percentage weight change could be included in the analyses. Characteristics (age, gender, baseline weight, baseline BMI, number of participants, duration of the intervention, and dropout percentage) of responding and non-responding studies were compared using independent t test. For the selected interventions, mean effects of weight change, BMI change, and percentage weight change were calculated and weighted to inverse variance.

Furthermore, weight change, BMI change, and percentage weight change were compared among the different BMI classes (i.e., 25–29.99 kg m^{-2}, 30–34.99 kg m^{-2}, and 35–39.99 kg m^{-2}) within the same intervention. Using the means, standard deviations, and group sizes of the BMI classes, the standardized mean differences between BMI classes (where a positive mean difference indicates more (percentage) weight loss for the patients in a higher BMI group) were calculated. Statistical heterogeneity across interventions was assessed by calculating I^2 [24, 25]. If

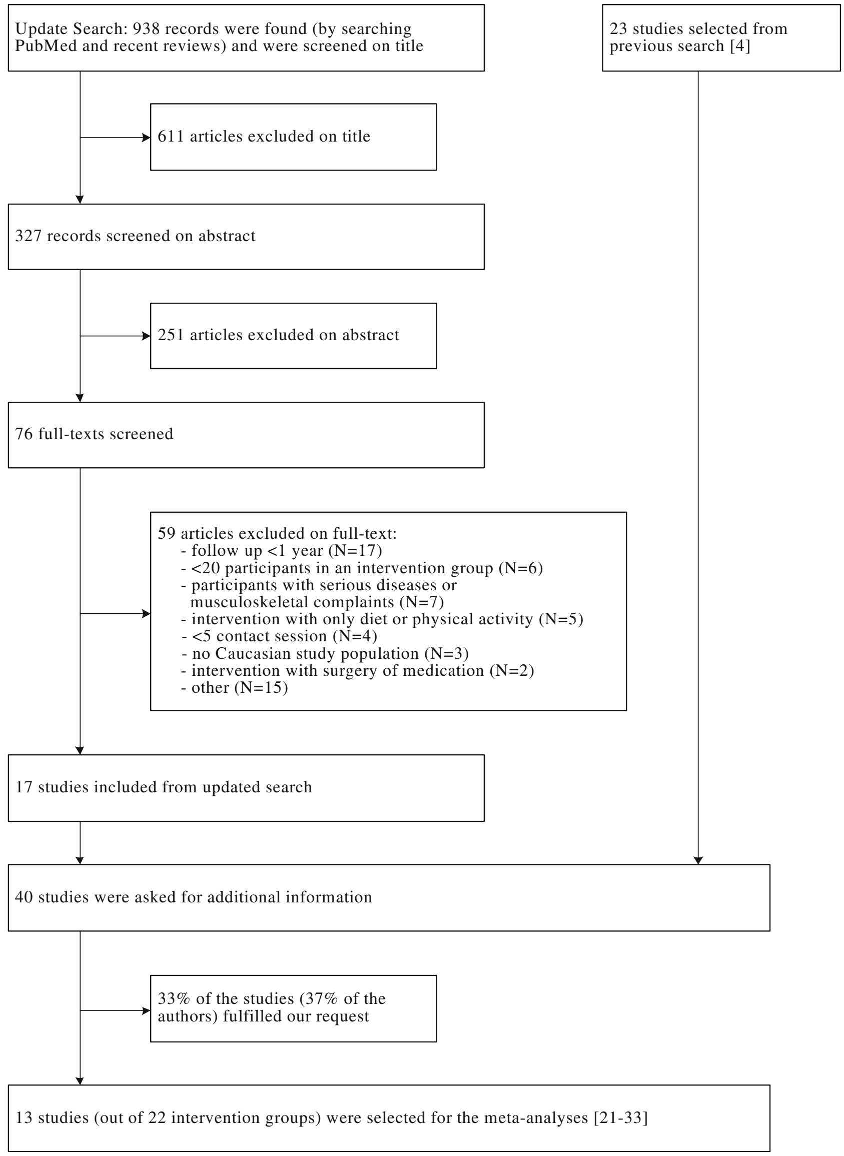


Fig. 1 Flowchart of search and study selection for the meta-analyses

heterogeneity existed, a random effects model was used. Publication bias was assessed by interpreting the funnel plots and by conducting the Egger regression test [26, 27]. Furthermore, sensitivity analyses were performed by evaluating the standardized mean differences in weight change, BMI change, and percentage weight change for three subgroups. These three subgroups consisted of only the interventions with a study population that did not differ significantly in age, gender, or socioeconomic status between the BMI classes. A p value below 0.05 was considered statistically significant. Mix 1.7 was used to perform all statistical analyses.

Results

In total, 40 studies contained intervention groups which fulfilled the inclusion criteria (see Fig. 1). Of these 40 studies, 13 studies (37 % of the contacted authors) responded positively to the data request [28–40]. There were no differences in age, gender, baseline weight, baseline BMI, number of participants, duration of the intervention, or dropout between responding and non-responding studies. Out of the 13 studies that responded, 22 intervention groups were included in the analyses. Twelve of these interventions included participants in all three BMI groups, and one study [30] did not include participants with a BMI above 35 kg m^{-2} and was only taken into account in the comparisons between participants with overweight and class-I obesity. Table 1 describes the characteristics of the included interventions. Although all interventions had a dietary and physical activity component, the content of the interventions was diverse. In general, interventions contained caloric restriction, a physical activity goal, and (behavioral) group sessions led by health care professionals such as dietitians, exercise specialists, or behavioral interventionists. Some

Table 1 Characteristics of the selected interventions

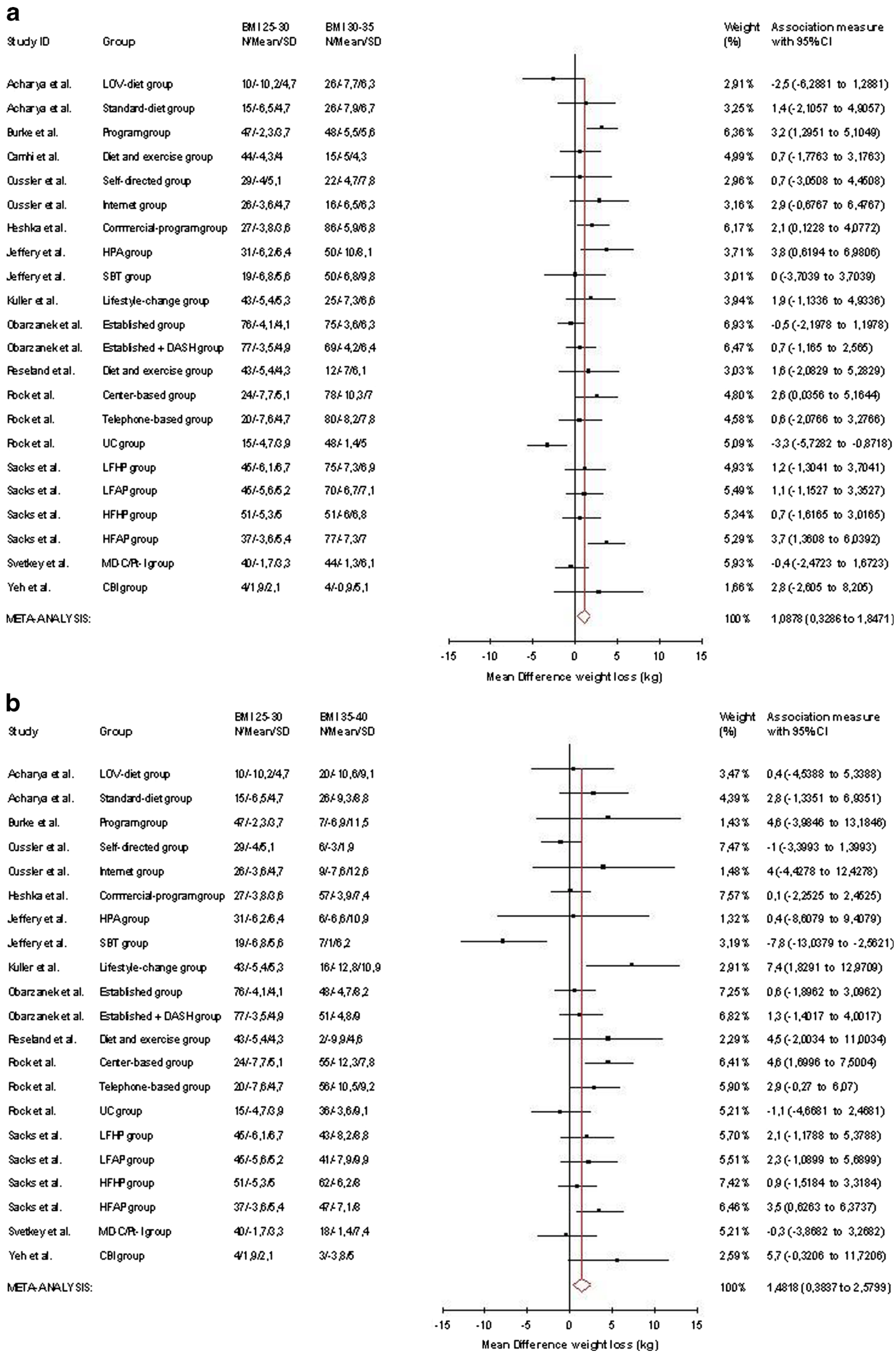
Author	Year	Group	*N* baseline	*N* BMI 25–30 kg m^{-2}	*N* BMI 30–35 kg m^{-2}	*N* BMI 35–40 kg m^{-2}	Duration of intervention	Mean age (years)	Gender (%male)	Follow-up	Dropout at follow-up (%)	Intervention
Acharya [21]	2009	Lacto-ovo-vegetarian diet group	80	10	26	20	12 months	44	14	12 months	25	Standard behavioral therapy in groups, calorie restriction, reduce fat intake to 25 %, vegetarian diet, increase physical activity to 150 min $week^{-1}$
		Standard diet group	96	15	26	26	12 months	43	13	12 months	27	Standard behavioral therapy in groups, calorie restriction, reduce fat intake to 25 %, increase physical activity to 150 min $week^{-1}$
Burke [22]	2005	Program group	123	47	48	7	16 months	57	46	16 months	17	Group sessions, low-sodium DASH diet, encouraged to exercise 30 min day^{-1}, telephone contact, individual sessions if needed
Camhi [23]	2010	Diet and exercise group	94	44	15	0	9–11 months	57 (F), 48 (M)[a]	54	12 months	3	An individual counseling session, group lessons on diet, supervised exercise sessions, NCEP Step 2 diet
Cussler [24]	2008	Self-directed group	69	29	22	6	4 months	48	0	16 months	14	Group sessions, caloric restriction, exercise plan
		Internet group	66	26	16	9	16 months	48	0	16 months	21	Group sessions, caloric restriction, exercise plan, website including chat room sessions
Heshka [25]	2003	Commercial program	211	27	86	57	2 years	45	18	12 months	17	Weight watchers: group meetings, food plan, activity plan and a behavior modification plan
Jeffery [26]	2003	HPA group	109	31	50	6	18 months	42[a]	42[a]	12 months	21	Group sessions, caloric restriction, <20 % fat, energy expenditure goal of 2,500 kcal $week^{-1}$, exercise coach, financial incentives for reached goals
		SBT group	93	19	50	7	18 months	42[a]	42[a]	12 months	18	Group sessions, caloric restriction, <20 % fat, instructed to initiate physical activity (1,000 kcal $week^{-1}$)
Kuller [27]	2007	Lifestyle change group (without hormone therapy at baseline and follow-up)	N/A	43	25	16	5 years	57[a]	0	18 months	N/A	Group sessions, caloric restriction, low fat, activity goal of 150 min $week^{-1}$ moderate intensity
Obarzanek [28]	2007	Established group	257	76	75	48	18 months	50[a]	38[a]	18 months	4	Group sessions and individual visits, individual caloric restriction goal, a target of 180 min $week^{-1}$ of physical activity
		Established+DASH group	261	77	69	51	18 months	50[a]	38[a]	18 months	2	Group sessions and individual visits, DASH diet, a target of 180 min $week^{-1}$ of physical activity
Reseland [29]	2001	Diet and exercise group	67	43	12	2	12 months	45[a]	90[a]	12 months	3	Individual dietary counseling, supervised exercise program

Table 1 (continued)

Author	Year	Group	*N* baseline	*N* BMI 25–30 kg m^{-2}	*N* BMI 30–35 kg m^{-2}	*N* BMI 35–40 kg m^{-2}	Duration of intervention	Mean age (years)	Gender (%male)	Follow-up	Dropout at follow-up (%)	Intervention
Rock [30]	2010	Center-based group	169	24	78	55	2 years	44	0	12 months	6	Individual (in person) contact, follow-up with telephone and e-mail, website available, calorie restriction, low fat, prepackaged prepared food available, a physical activity goal of 30 min day^{-1}
		Telephone-based group	164	20	80	56	2 years	44	0	12 months	4	Individual (telephone) contact, follow-up with telephone and e-mail, website available, calorie restriction, low fat, prepackaged prepared food available, a physical activity goal of 30 min day^{-1}
		Usual-care group	113	15	48	36	2 years	45	0	12 months	11	An individual session, check-ins by e-mail or telephone, caloric restriction, recommendations to increase physical activity
Sacks [31]	2009	LFHP group	202	45	75	43	2 years	50	33	12 months	22[b]	Low-fat high-protein diet, caloric restriction, group sessions and individual sessions, physical activity goal of 90 min $week^{-1}$
		HFAP group	204	45	70	41	2 years	52	39	12 months	26[b]	High-fat average-protein diet, caloric restriction, group sessions and individual sessions, physical activity goal of 90 min $week^{-1}$
		HFHP group	201	51	51	62	2 years	51	36	12 months	16[b]	High-fat high-protein diet, caloric restriction, group sessions and individual sessions, physical activity goal of 90 min $week^{-1}$
		LFAP group	204	37	77	47	2 years	51	38	12 months	17[b]	Low-fat average-protein diet, caloric restriction, group sessions and individual sessions, physical activity goal of 90 min $week^{-1}$
Svetkey [32]	2009	MD-C Pt-I group	140	40	44	18	18 months	59	34	18 months	11	Group sessions, DASH diet, goal to increase physical activity
Yeh [33]	2003	Counseling-based intervention group	40	4	4	3	10 months	48	0	12 months	65	Individual sessions, low-caloric meal plan, instructions regarding physical activity

[a] Data for all participants in the study, not for the intervention groups separately

[b] Data of 2-year follow-up


a
Study ID
Group
BMI 25-30 N/Mean/SD
BMI 30-35 N/Mean/SD
Weight (%)
Association measure with 95%CI
Acharya et al. LOV-diet group 10/-10,2/4,7 26/-7,7/6,3 2,91% -2,5 (-6,2881 to 1,2881)
Acharya et al. Standard-diet group 15/-6,5/4,7 26/-7,9/6,7 3,25% 1,4 (-2,1057 to 4,9057)
Burke et al. Program group 47/-2,3/3,7 48/-5,5/5,6 6,36% 3,2 (1,2951 to 5,1049)
Camhi et al. Diet and exercise group 44/-4,3/4 15/-5/4,3 4,99% 0,7 (-1,7763 to 3,1763)
Cussler et al. Self-directed group 29/-4/5,1 22/-4,7/7,8 2,96% 0,7 (-3,0508 to 4,4508)
Cussler et al. Internet group 26/-3,6/4,7 16/-6,5/6,3 3,16% 2,9 (-0,6767 to 6,4767)
Heshka et al. Commercial-program group 27/-3,8/3,6 86/-5,9/6,8 6,17% 2,1 (0,1228 to 4,0772)
Jeffery et al. HPA group 31/-6,2/6,4 50/-10/8,1 3,71% 3,8 (0,6194 to 6,9806)
Jeffery et al. SBT group 19/-6,8/5,6 50/-6,8/9,8 3,01% 0 (-3,7039 to 3,7039)
Kuller et al. Lifestyle-change group 43/-5,4/5,3 25/-7,3/6,6 3,94% 1,9 (-1,1336 to 4,9336)
Obarzanek et al. Established group 76/-4,1/4,1 75/-3,6/6,3 6,93% -0,5 (-2,1978 to 1,1978)
Obarzanek et al. Established + DASH group 77/-3,5/4,9 69/-4,2/6,4 6,47% 0,7 (-1,165 to 2,565)
Reseland et al. Diet and exercise group 43/-5,4/4,3 12/-7/6,1 3,03% 1,6 (-2,0829 to 5,2829)
Rock et al. Center-based group 24/-7,7/5,1 78/-10,3/7 4,80% 2,6 (0,0356 to 5,1644)
Rock et al. Telephone-based group 20/-7,6/4,7 80/-8,2/7,8 4,58% 0,6 (-2,0766 to 3,2766)
Rock et al. UC group 15/-4,7/3,9 48/-1,4/5 5,09% -3,3 (-5,7282 to -0,8718)
Sacks et al. LFHP group 45/-6,1/6,7 75/-7,3/6,9 4,93% 1,2 (-1,3041 to 3,7041)
Sacks et al. LFAP group 45/-5,6/5,2 70/-6,7/7,1 5,49% 1,1 (-1,1527 to 3,3527)
Sacks et al. HFHP group 51/-5,3/5 51/-6/6,8 5,34% 0,7 (-1,6165 to 3,0165)
Sacks et al. HFAP group 37/-3,6/5,4 77/-7,3/7 5,29% 3,7 (1,3608 to 6,0392)
Svetkey et al. MD C/R-I group 40/-1,7/3,3 44/-1,3/6,1 5,93% -0,4 (-2,4723 to 1,6723)
Yeh et al. CBI group 4/1,9/2,1 4/-0,9/5,1 1,66% 2,8 (-2,605 to 8,205)
META-ANALYSIS: 100% 1,0878 (0,3286 to 1,8471)
-15 -10 -5 0 5 10 15
Mean Difference weight loss (kg)
b
Study
Group
BMI 25-30 N/Mean/SD
BMI 35-40 N/Mean/SD
Weight (%)
Association measure with 95%CI
Acharya et al. LOV-diet group 10/-10,2/4,7 20/-10,6/9,1 3,47% 0,4 (-4,5388 to 5,3388)
Acharya et al. Standard-diet group 15/-6,5/4,7 26/-9,3/8,8 4,39% 2,8 (-1,3351 to 6,9351)
Burke et al. Program group 47/-2,3/3,7 7/-6,9/11,5 1,43% 4,6 (-3,9846 to 13,1846)
Cussler et al. Self-directed group 29/-4/5,1 6/-3/1,9 7,47% -1 (-3,3993 to 1,3993)
Cussler et al. Internet group 26/-3,6/4,7 9/-7,6/12,6 1,48% 4 (-4,4278 to 12,4278)
Heshka et al. Commercial-program group 27/-3,8/3,6 57/-3,9/7,4 7,57% 0,1 (-2,2525 to 2,4525)
Jeffery et al. HPA group 31/-6,2/6,4 6/-6,6/10,9 1,32% 0,4 (-8,6079 to 9,4079)
Jeffery et al. SBT group 19/-6,8/5,6 7/1/6,2 3,19% -7,8 (-13,0379 to -2,5621)
Kuller et al. Lifestyle-change group 43/-5,4/5,3 16/-12,8/10,9 2,91% 7,4 (1,8291 to 12,9709)
Obarzanek et al. Established group 76/-4,1/4,1 48/-4,7/8,2 7,25% 0,6 (-1,8962 to 3,0962)
Obarzanek et al. Established + DASH group 77/-3,5/4,9 51/-4,8/9 6,82% 1,3 (-1,4017 to 4,0017)
Reseland et al. Diet and exercise group 43/-5,4/4,3 2/-9,9/4,6 2,29% 4,5 (-2,0034 to 11,0034)
Rock et al. Center-based group 24/-7,7/5,1 55/-12,3/7,8 6,41% 4,6 (1,6996 to 7,5004)
Rock et al. Telephone-based group 20/-7,6/4,7 56/-10,5/9,2 5,90% 2,9 (-0,27 to 6,07)
Rock et al. UC group 15/-4,7/3,9 36/-3,6/9,1 5,21% -1,1 (-4,6681 to 2,4681)
Sacks et al. LFHP group 45/-6,1/6,7 43/-8,2/8,8 5,70% 2,1 (-1,1788 to 5,3788)
Sacks et al. LFAP group 45/-5,6/5,2 41/-7,9/9,9 5,51% 2,3 (-1,0899 to 5,6899)
Sacks et al. HFHP group 51/-5,3/5 62/-6,2/8 7,42% 0,9 (-1,5184 to 3,3184)
Sacks et al. HFAP group 37/-3,6/5,4 47/-7,1/8 6,46% 3,5 (0,6263 to 6,3737)
Svetkey et al. MD C/R-I group 40/-1,7/3,3 18/-1,4/7,4 5,21% -0,3 (-3,8682 to 3,2682)
Yeh et al. CBI group 4/1,9/2,1 3/-3,8/5 2,59% 5,7 (-0,3206 to 11,7206)
META-ANALYSIS: 100% 1,4818 (0,3837 to 2,5799)
-15 -10 -5 0 5 10 15
Mean Difference weight loss (kg)

◀ **Fig. 2** **a** Meta-analysis of weight change for overweight participants and class-I obese participants. **b** Meta-analysis of weight change for overweight participants and class-II obese participants

interventions had individual sessions and/or contact by telephone, and additionally, contact by e-mail was possible or a website was available.

In total, weight change data of 2,431 participants who completed the 1-year follow-up were available. At baseline, the mean initial BMI was 32.2 kg m^{-2}, 768 participants were overweight (mean BMI, 27.9 kg m^{-2}), 1,047 participants were class-I obese (mean BMI, 32.3 kg m^{-2}), and 616 participants were class-II obese (mean BMI, 37.2 kg m^{-2}). The mean effects of weight change, BMI change, and percentage weight change were −4.3 kg (95 % confidence interval (CI), −3.0 to −5.6 kg), −1.6 kg m^{-2} (95 % CI, −1.1 to −2.0 kg m^{-2}), and −5.0 % (95 % CI, −3.6 to −6.5 %), respectively.

The results of the funnel plots and the Egger regression tests showed no evidence of publication bias. The I^2 tests showed that there was low to moderate heterogeneity (range 17–46 %), and therefore randomized effect models were used for the analyses.

Overweight participants lost 1.1 kg (95 % CI, 0.3–1.8 kg; $p<0.01$) less than participants with class-I obesity and 1.5 kg (95 % CI, 0.4–2.6 kg; $p<0.01$) less than participants with class-II obesity (see Fig. 2). Differences in BMI change were 0.4 kg m^{-2} (95 % CI, 0.1–0.6 kg m^{-2}; $p<0.01$) between overweight participants and class-I obese participants, and 0.5 kg m^{-2} (95 % CI, 0.1–0.9 kg m^{-2}; $p<0.01$) between overweight participants and class-II obese participants. The difference in weight change and BMI change between participants with class-I obesity and class-II obesity was not significant (0.6 kg, 95 % CI −0.3 to 1.5 kg, $p=0.21$; and 0.2 kg m^{-2}, 95 % CI −0.1 to 0.5 kg m^{-2}, $p=0.20$).

Figure 3 shows no significant differences for percentage weight change between overweight participants and class-I obese participants (0.6 %, 95 % CI −0.3 to 1.4 kg m^{-2}; $p=0.18$), and between the overweight participants and those with class-II obesity (0.1 %, 95 % CI −1.0 to 1.1 kg m^{-2}; $p=0.85$). Between the participants with class-I obesity and class-II obesity, there were also no significant differences (−0.3 %, 95 % CI −1.1 to 0.6 kg m^{-2}; $p=0.52$).

The three sensitivity analyses, which included only the subgroups of interventions without statistically significant differences in age, gender, or socioeconomic status between the BMI classes, showed similar differences in weight change, BMI change, and percentage weight change between the BMI classes as compared to the analyses using the full dataset (data not shown).

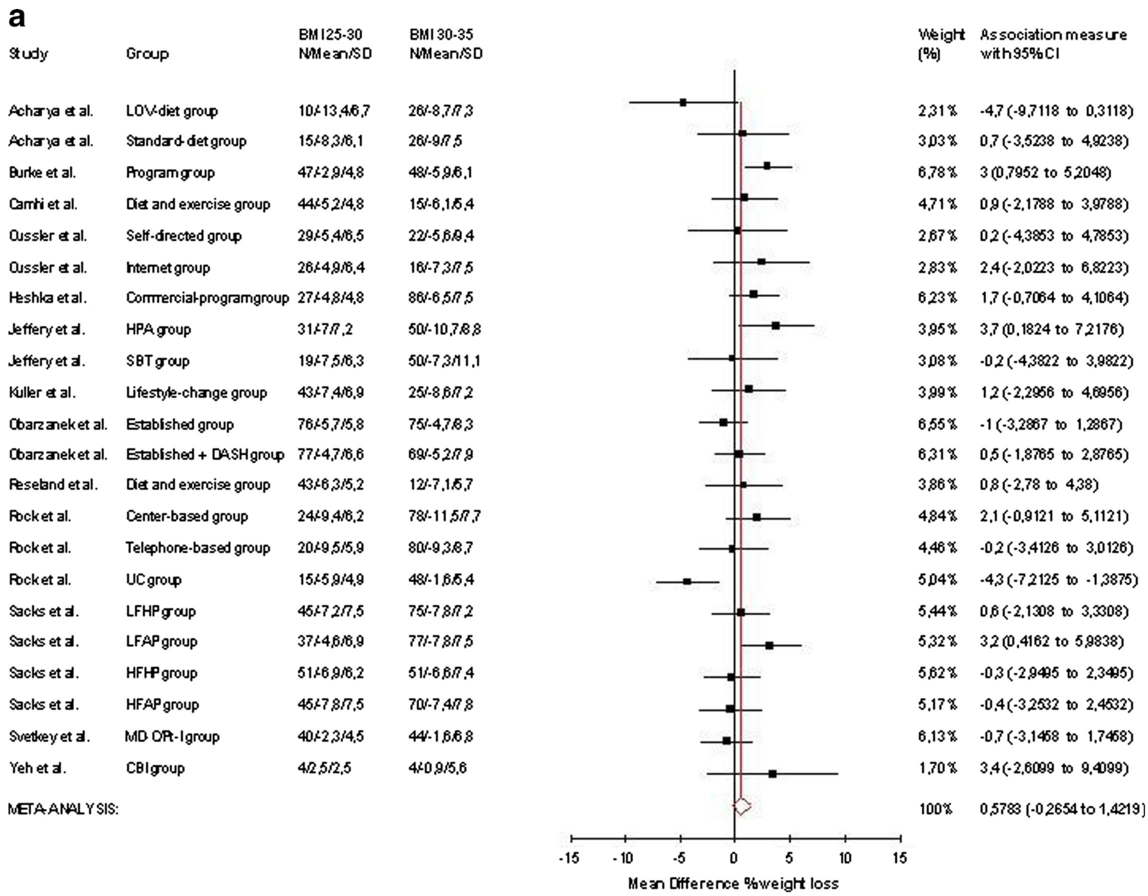
Discussion

This study investigated possible differences in weight change after at least 1 year for participants in different BMI classes within lifestyle weight management interventions. The results show that overweight participants on average lose less weight than participants with class-I and class-II obesity, but the differences were small and hardly clinically significant (1.1 and 1.5 kg, respectively). The mean difference in weight change between participants with class-I obesity and class-II obesity was not significant. Furthermore, no statistical differences were found in percentage weight change across the three BMI classes. These results are in line with a previous review [18] that indicated that initial weight or BMI is generally not related to weight loss during a lifestyle intervention. Despite the heterogeneity of participants, differences in weight change across the BMI classes defined by the World Health Organization are small after participating in a lifestyle program. Therefore, initial BMI is not a good indicator of success in lifestyle interventions and lifestyle interventions appear equally effective for participants within a BMI range of 25–40 kg m^{-2}.

The primary foci of this study were on weight change, BMI change, and percentage weight change across the BMI classes; and therefore, other outcome variables were not taken into account. However, besides effects on weight, lifestyle interventions may also lead to improvements in blood pressure, lipid profiles, and glucose levels [41–43]. In line with the hypothesis tested in the present study, the effects of lifestyle interventions on these outcomes might differ for the different BMI classes and more research is needed on this topic.

Within the selected interventions, there was some variation in the intensity and the content of the interventions. Different intensities and contents of an intervention may give different results for different groups of patients, e.g., information on a healthy diet may add less knowledge to highly educated patients or to females [44]. It would be interesting to investigate which intervention components work better for the different BMI classes. Unfortunately, in this study we were not able to do so because in general the content of the interventions was not described sufficiently and because the number of included interventions was too low to compare intensity or components among the interventions. Further research on this specific topic is recommended and may lead to tailoring interventions for specific target populations to a larger extent.

Several points have to be kept in mind when interpreting the results of this study. First, the response of the authors to the request for participants' data was only 37 %. Despite this response rate, this study still contains a large sample of 22 interventions and 2,431 participants. Furthermore, no differences in characteristics were found between responding and non-responding studies. Therefore, there is no indication that reasons for not responding have biased the results. Second, only data for completers of the 1-year follow-up were used, and therefore, no information on dropouts was available and a possible relation between initial BMI and dropout rate could not be investigated. However, a recent review shows no clear


a
Study
Group
BMI25-30 N/Mean/SD
BMI30-35 N/Mean/SD
Weight (%)
Association measure with 95%CI
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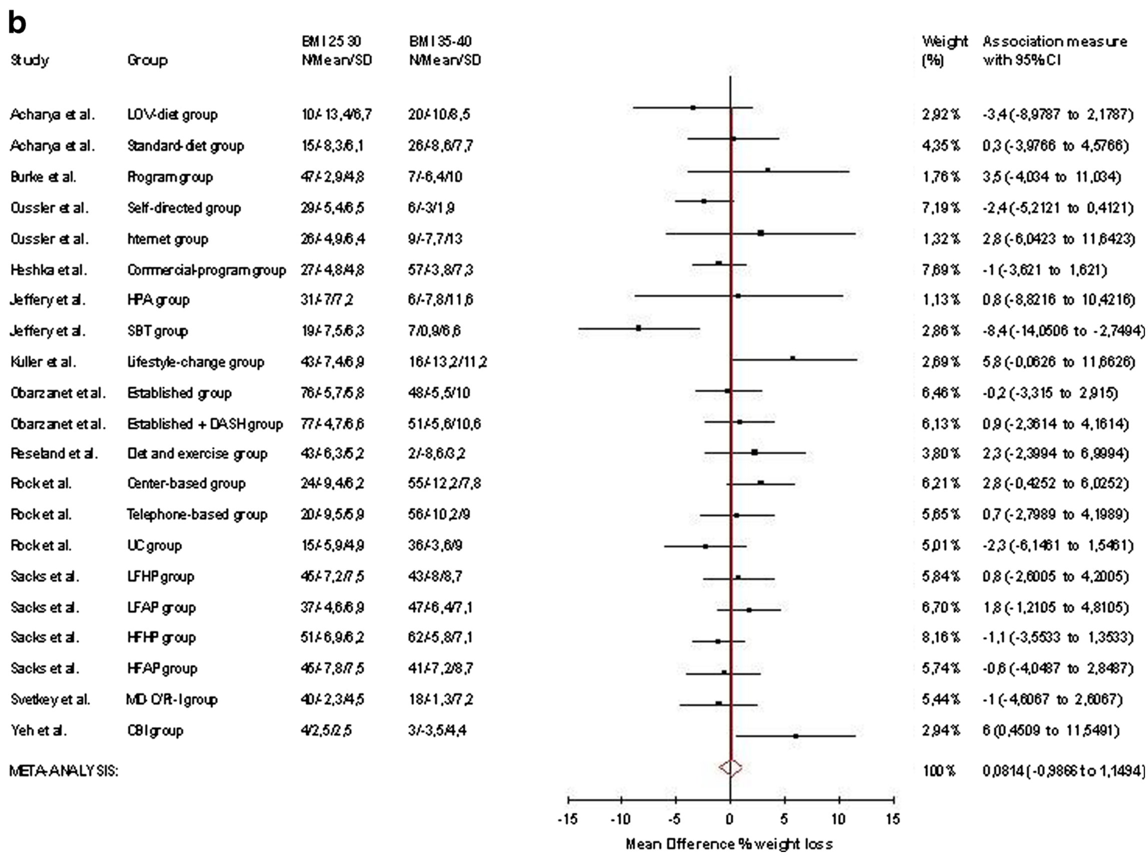
Acharya et al. Standard-diet group 15/-8,3/6,1 26/-9/7,5 3,03% 0,7 (-3,5238 to 4,9238)
Burke et al. Program group 47/-2,9/4,8 48/-5,9/6,1 6,78% 3 (0,7952 to 5,2048)
Camhi et al. Diet and exercise group 44/-5,2/4,8 15/-6,1/5,4 4,71% 0,9 (-2,1788 to 3,9788)
Cussler et al. Self-directed group 29/-5,4/6,5 22/-5,6/9,4 2,67% 0,2 (-4,3853 to 4,7853)
Cussler et al. Internet group 26/-4,9/6,4 16/-7,3/7,5 2,83% 2,4 (-2,0223 to 6,8223)
Heshka et al. Commercial-program group 27/-4,8/4,8 86/-6,5/7,5 6,23% 1,7 (-0,7064 to 4,1064)
Jeffery et al. HPA group 31/-7/7,2 50/-10,7/8,8 3,95% 3,7 (0,1824 to 7,2176)
Jeffery et al. SBT group 19/-7,5/6,3 50/-7,3/11,1 3,08% -0,2 (-4,3822 to 3,9822)
Kuller et al. Lifestyle-change group 43/-7,4/6,9 25/-8,6/7,2 3,99% 1,2 (-2,2956 to 4,6956)
Obarzanek et al. Established group 76/-5,7/5,8 75/-4,7/8,3 6,55% -1 (-3,2867 to 1,2867)
Obarzanek et al. Established + DASH group 77/-4,7/6,6 69/-5,2/7,9 6,31% 0,5 (-1,8765 to 2,8765)
Reseland et al. Diet and exercise group 43/-6,3/5,2 12/-7,1/6,7 3,86% 0,8 (-2,78 to 4,38)
Rock et al. Center-based group 24/-9,4/6,2 78/-11,5/7,7 4,84% 2,1 (-0,9121 to 5,1121)
Rock et al. Telephone-based group 20/-9,5/5,9 80/-9,3/8,7 4,46% -0,2 (-3,4126 to 3,0126)
Rock et al. UC group 15/-5,9/4,9 48/-1,6/5,4 5,04% -4,3 (-7,2125 to -1,3875)
Sacks et al. LFHP group 45/-7,2/7,5 75/-7,8/7,2 5,44% 0,6 (-2,1308 to 3,3308)
Sacks et al. LFAP group 37/-4,6/6,9 77/-7,8/7,5 5,32% 3,2 (0,4162 to 5,9838)
Sacks et al. HFHP group 51/-6,9/6,2 51/-6,6/7,4 5,62% -0,3 (-2,9495 to 2,3495)
Sacks et al. HFAP group 45/-7,8/7,5 70/-7,4/7,8 5,17% -0,4 (-3,2532 to 2,4532)
Svetkey et al. MD C/R-I group 40/-2,3/4,5 44/-1,6/6,8 6,13% -0,7 (-3,1458 to 1,7458)
Yeh et al. CBI group 4/2,5/2,5 4/-0,9/5,6 1,70% 3,4 (-2,6099 to 9,4099)
META-ANALYSIS: 100% 0,5783 (-0,2654 to 1,4219)
-15 -10 -5 0 5 10 15
Mean Difference % weight loss


b
Study
Group
BMI25-30 N/Mean/SD
BMI35-40 N/Mean/SD
Weight (%)
Association measure with 95%CI
Acharya et al. LOV-diet group 10/-13,4/6,7 20/-10/8,5 2,92% -3,4 (-8,9787 to 2,1787)
Acharya et al. Standard-diet group 15/-8,3/6,1 26/-8,6/7,7 4,35% 0,3 (-3,9766 to 4,5766)
Burke et al. Program group 47/-2,9/4,8 7/-6,4/10 1,76% 3,5 (-4,034 to 11,034)
Cussler et al. Self-directed group 29/-5,4/6,5 6/-3/1,9 7,19% -2,4 (-5,2121 to 0,4121)
Cussler et al. Internet group 26/-4,9/6,4 9/-7,7/13 1,32% 2,8 (-6,0423 to 11,6423)
Heshka et al. Commercial-program group 27/-4,8/4,8 57/-3,8/7,3 7,69% -1 (-3,621 to 1,621)
Jeffery et al. HPA group 31/-7/7,2 6/-7,8/11,6 1,13% 0,8 (-8,8216 to 10,4216)
Jeffery et al. SBT group 19/-7,5/6,3 7/0,9/6,6 2,86% -8,4 (-14,0506 to -2,7494)
Kuller et al. Lifestyle-change group 43/-7,4/6,9 16/-13,2/11,2 2,69% 5,8 (-0,0626 to 11,6626)
Obarzanet et al. Established group 76/-5,7/5,8 48/-5,5/10 6,46% -0,2 (-3,315 to 2,915)
Obarzanet et al. Established + DASH group 77/-4,7/6,6 51/-5,6/10,6 6,13% 0,9 (-2,3614 to 4,1614)
Reseland et al. Diet and exercise group 43/-6,3/5,2 2/-8,6/3,2 3,80% 2,3 (-2,3994 to 6,9994)
Rock et al. Center-based group 24/-9,4/6,2 55/-12,2/7,8 6,21% 2,8 (-0,4252 to 6,0252)
Rock et al. Telephone-based group 20/-9,5/5,9 56/-10,2/9 5,65% 0,7 (-2,7989 to 4,1989)
Rock et al. UC group 15/-5,9/4,9 36/-3,6/9 5,01% -2,3 (-6,1461 to 1,5461)
Sacks et al. LFHP group 45/-7,2/7,5 43/-8/8,7 5,84% 0,8 (-2,6005 to 4,2005)
Sacks et al. LFAP group 37/-4,6/6,9 47/-6,4/7,1 6,70% 1,8 (-1,2105 to 4,8105)
Sacks et al. HFHP group 51/-6,9/6,2 62/-5,8/7,1 8,16% -1,1 (-3,5533 to 1,3533)
Sacks et al. HFAP group 45/-7,8/7,5 41/-7,2/8,7 5,74% -0,6 (-4,0487 to 2,8487)
Svetkey et al. MD C/R-I group 40/-2,3/4,5 18/-1,3/7,2 5,44% -1 (-4,6067 to 2,6067)
Yeh et al. CBI group 4/2,5/2,5 3/-3,5/4,4 2,94% 6 (0,4509 to 11,5491)
META-ANALYSIS: 100% 0,0814 (-0,9866 to 1,1494)
-15 -10 -5 0 5 10 15
Mean Difference % weight loss

◀ **Fig. 3** **a** Meta-analysis of percentage weight change for overweight participants and class-I obese participants. **b** Meta-analysis of percentage weight change for overweight participants and class-II obese participants

association between initial weight and dropout [45]. Third, there was low to moderate heterogeneity among the interventions in the analyses, which is probably the result of the different protocols of the lifestyle interventions included. Even though random models were used to estimate the pooled effects, the interpretation of the results must be done with some caution as it is not clear which parts of the protocols cause these results and a specific component may still be more or less effective for a specific BMI class. Finally, no individual data was available for age, gender, and socioeconomic status within BMI classes, and therefore, the effects of these variables on weight change could not be examined. Nevertheless, using sensitivity analyses, we were able to show that differences in these variables within BMI classes of the interventions did not influence the results.

In conclusion, despite the suggested heterogeneity of the study participants in regard to BMI (range of 25–40 kg m^{-2}), effects of a lifestyle intervention only differ to a small extent between overweight and obese patients. This implies that these interventions are equally appropriate for all these BMI classes. Further research is needed to investigate possible differences in weight regain between these BMI classes and to investigate the effects of different components of lifestyle interventions for different BMI classes, which could lead to a more tailored and optimal preventive medicine.

Conflict of interest The authors declare no conflict of interest.

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