

Obesity Management

Maintenance of weight loss after lifestyle interventions for overweight and obesity, a systematic review

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Summary

Lifestyle interventions can reduce body weight, but weight regain is common and may particularly occur with higher initial weight loss. If so, one may argue whether the 10% weight loss in clinical guidelines is preferable above a lower weight loss. This systematic review explores the relation between weight loss during an intervention and weight maintenance after at least 1 year of unsupervised follow-up. Twenty-two interventions (during at least 1 month) in healthy overweight Caucasians were selected and the mean percentages of weight loss and maintenance were calculated in a standardized way. In addition, within four intervention groups ($n > 80$) maintenance was calculated stratified by initial weight loss (0–5%, 5–10%, >10%). Overall, mean percentage maintenance was 54%. Weight loss during the intervention was not significantly associated with percentage maintenance ($r = -0.26$; $P = 0.13$). Percentage maintenance also not differed significantly between interventions with a weight loss of 5–10% vs. >10%. Consequently, net weight loss after follow-up differed between these categories (3.7 vs. 7.0%, respectively; $P < 0.01$). The analyses within the four interventions confirmed these findings. In conclusion, percentage maintenance does not clearly depend on initial weight loss. From this perspective, 10% or more weight loss can indeed be encouraged and favoured above lower weight loss goals.

Keywords: Initial weight loss, long-term weight loss, maintenance, weight maintenance.

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Introduction

A recent review of Wu *et al.* (1) showed that (lifestyle) interventions with a dietary component result in weight loss, but interventions with both a dietary and a physical activity component result in more weight loss. Other reviews also showed that lifestyle interventions are effective (2–4) and that weight can be reduced at reasonable costs (5). Despite the short-term effectiveness of lifestyle interventions, long-term weight loss seems to be more difficult (1). After an intervention weight regain may occur and

therefore the weight loss achieved during the intervention may not be fully maintained.

Insight into the relationship between weight loss during an intervention and subsequent maintenance of this weight loss could provide valuable information to set weight loss targets focused on optimal long-term weight loss. Current guidelines prescribe a weight loss of 5–10% for overweight or obese persons (6,7), because a weight loss of 5% has a beneficial effect on cardiovascular risk factors associated with obesity (8–10) and reduces the risk for diabetes (11). However, this guideline does not take into account possible

weight regain after an intervention. Weiss *et al.* (12) showed in a survey that a higher percentage weight loss was significantly associated with a higher percentage weight regain. Participants who lost more than 20% of their weight had 2.8 times the risk of weight regain compared with participants who lost 10–15% of their weight. Therefore, it could be hypothesized that people who lose more weight during an intervention will on average maintain less of this weight reduction. In that case, one may argue about the 10% weight loss goal (as compared with 5%) as weight cycling may have adverse health effects.

Previous reviews focused on the effect of exercise on maintenance (2,13,14) or long-term weight loss (4,15,16). However, these reviews have not focused on the relationship between short-term weight loss (the amount of weight loss during an intervention) and the maintenance of this weight loss during an unsupervised follow-up. Therefore, the aim of this systematic review was to investigate the

relationship between weight loss during a lifestyle intervention (with a dietary and physical activity component) and the maintenance of this weight loss after an unsupervised follow-up period of at least 1 year.

Methods

Search

The literature search for this study is described previously (5). Briefly, two search strategies were used to select relevant articles: (i) recent reviews about interventions aiming at weight loss and (ii) the MEDLINE database. For the present study, the search was extended to February 2009; the results of the present search are shown in Fig. 1.

Eligible studies for this review had to meet the following inclusion criteria: overweight or obese adults (mean body mass index $<40 \text{ kg m}^{-2}$); mainly Caucasian population; at

Identification

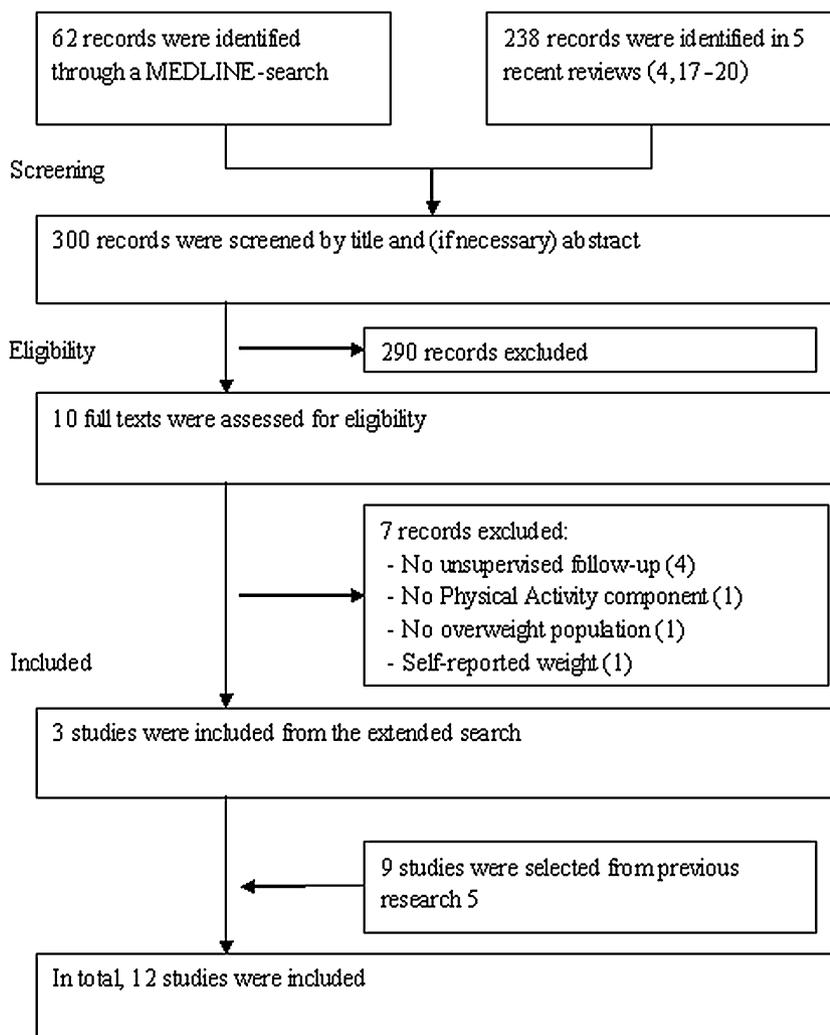


Figure 1 Flow chart of the present search.

least one intervention group with a dietary and a physical activity component (only this group was included in the analyses); an intervention duration of at least 1 month; a measured mean weight (or body mass index) reduction of at least 2% at the end of the intervention; an unsupervised follow-up after the intervention of at least 1 year; at least 20 participants randomized per intervention group; published after 1 January 1990 in English; and having the possibility to calculate the percentage weight maintenance. Exclusion criteria were: studies that included only participants with diabetes, impaired glucose tolerance or another serious disease; weight loss medication; or surgery.

Outcome measure

The primary outcome measure of this study was the percentage of weight loss immediately after the intervention that remained after an unsupervised follow-up. This percentage maintenance was calculated for every intervention group as follows:

$$\text{Percentage maintenance} = \frac{\text{Weight loss from baseline to the end of the unsupervised follow-up}}{\text{Weight loss during the intervention}} * 100$$

The percentage maintenance was corrected for differences in the duration of the unsupervised follow-up period. With the assumption that the percentage maintenance declined linearly during the unsupervised follow-up, the percentage maintenance after 1-year unsupervised follow-up was calculated. In formula, the percentage maintenance after 1 year was calculated as follows: $100\% - ((100 - \% \text{ maintenance})/\text{years of unsupervised follow-up})$. This adjusted percentage maintenance was used to calculate weight loss after 1-year unsupervised follow-up.

Because data reported in articles can reflect all participants in an intervention group, participants who completed the intervention and/or participants who completed the unsupervised follow-up, three methods were developed to manage the different data and to calculate weight losses (and thereby the percentage maintenance). For every intervention group one of the following methods (depending on the available data) was used to calculate the percentage maintenance:

- Method 1: weight losses during the intervention and from baseline to the end of the unsupervised follow-up were calculated for the completers of the follow-up.
- Method 2: weight losses during the intervention and from baseline to the end of the unsupervised follow-up were calculated for the completers of the intervention. Therefore, weight at the follow-up was calculated for the completers of the intervention using an intention-to-treat

analysis under the conservative assumption that participants who dropped out during the unsupervised follow-up regained all their weight.

- Method 3: weight losses during the intervention and from baseline to the end of the unsupervised follow-up were calculated for all participants who started the intervention. Weight at the end of the intervention was calculated under the assumption that dropouts during the intervention lost the same amount of weight as completers of the intervention (the assumption that dropouts during the intervention lost no weight was not used, because this underestimates weight loss during an intervention resulting in an overestimation of the maintenance percentage). Weight at the follow-up was calculated with an intention-to-treat analysis as described in method 2.

As the intention-to-treat analyses in methods 2 and 3 probably result in a (slightly) underestimated percentage weight maintenance, the first calculation method was the preferred method of choice; otherwise calculation method 2 was used and if data for this method were also unavailable calculation method 3 was used. Authors were contacted by email to provide the best possible data if calculation method 1 was not possible. Author response (with useful information) to email contact about information or data of the study was 67%.

In addition to the analyses between intervention groups, we also investigated weight maintenance within the intervention groups with more than 75 participants at baseline ($n = 4$). Within these intervention groups, the percentage maintenance after 1 year of unsupervised follow-up was calculated for participants with 0–5%, 5–10% and more than 10% weight loss during the intervention. To obtain the necessary data for this analysis, the authors of the four intervention groups were contacted (100% response).

Statistical analyses

The relationship between weight loss during the intervention and the percentage maintenance was investigated by a one-sided Pearson correlation. Differences in the percentage maintenance between categories of <5%, 5–10% and >10% weight loss during the intervention were tested using ANOVA. In these analyses the results were weighted by the square root of the study size (as an approximation of the inverse of the variance of the weight change, which was not always reported). A *P*-value below 0.05 was considered statistically significant. SPSS version 17.0 was used to perform the statistical analyses.

Results

Twenty-two intervention groups of 12 studies met our inclusion criteria and were selected for this review (21–42).

Nine studies were selected from the search previously described in an article (5) and three studies were selected from the extended search (see Fig. 1). Four studies from the previously described search were not included in the previous article (because of the use of meal replacements (27,28,41,42) or the lack of results at 1 year after the start of the intervention (31,32,40)), but are selected in the present study.

Despite the fact that all interventions contain a dietary and a physical activity component, the content of the interventions differed between the studies (see Appendix S1). In general, interventions contained an energy-restricted diet and participants received (behavioural) group sessions. The physical activity component existed mostly of an exercise goal or supervised exercise. The characteristics of the selected intervention groups are shown in the Appendix S1. The mean duration of these interventions was 0.8 years (range 0.2–1.5) and the unsupervised follow-up had a mean

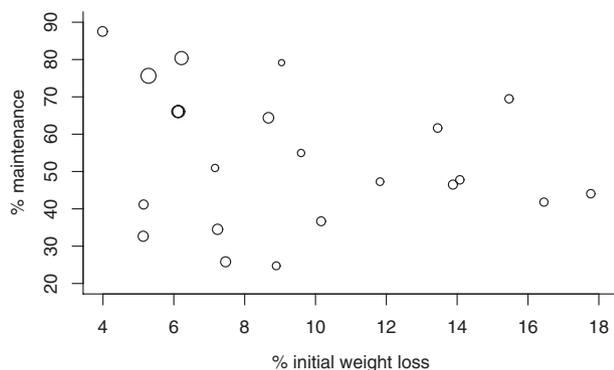


Figure 2 Scatter plot of the percentage maintenance and weight loss during the intervention.

duration of 1.1 years (range 1.0–2.0). The most distant measurement of weight was 3.3 years after the start of an intervention.

Of the 22 intervention groups the mean (SD) number of participants was 45 (27), the mean dropout during the interventions was 18% (11) and the mean dropout during the unsupervised follow-up period was 13% (11). The mean baseline weight of these intervention groups was 95 kg (6) and on average 9.5% (4.1) of baseline weight was lost during the interventions. The percentage of the weight loss during an intervention that was maintained after 1 year of unsupervised follow-up ranged from 25% to 88%. On average the percentage maintenance was 54% (18).

Figure 2 shows a scatter plot of the weight loss during an intervention and the percentage maintenance. Weight loss during the intervention and the percentage maintenance were not significantly correlated ($r = -0.26$, $P = 0.13$). In Table 1 percentage maintenance is shown for intervention groups with 5–10% and intervention groups with >10% weight loss during the intervention. Only one intervention group (88% maintenance) had less than 5% weight loss and therefore this category is not shown. Intervention groups with 5–10% weight loss during the intervention ($n = 13$) maintained on average 55% and intervention groups with more than 10% weight loss during an intervention ($n = 8$) maintained on average 49% ($P = 0.39$). The weight loss after 1 year of unsupervised follow-up differed significantly between these categories, 3.7% and 7.0%, respectively ($P < 0.01$).

In Table 2 weight maintenance is shown within the four intervention groups. In one intervention group participants with a relatively low weight loss maintained more weight loss (they even continued losing weight during the unsu-

	5–10% weight loss during intervention ($n = 13$)	>10% weight loss during intervention ($n = 8$)
Mean (SD) % weight loss during intervention	6.8 (1.5)	14.1 (2.5)
Range % weight loss during intervention	5.1–9.6	10.2–17.8
Mean (SD) % maintenance	55 (20)	49 (11)
Range % maintenance	25–80	37–69
Mean (SD) % weight loss after 1-year unsupervised follow-up	3.7 (1.5)	7.0 (2.1)

Table 1 Percentage maintenance and percentage weight loss after unsupervised follow-up for interventions with 5–10% and >10% weight loss during the intervention

Table 2 Percentage maintenance within four intervention groups stratified by weight loss during the intervention

	0–5% weight loss during intervention	5–10% weight loss during intervention	>10% weight loss during intervention
Burke <i>et al.</i> (21–23)	74% ($n = 19$)	78% ($n = 20$)	84% ($n = 14$)
Cussler <i>et al.</i> (25) and Teixeira <i>et al.</i> (26)	63% ($n = 21$)	67% ($n = 21$)	99% ($n = 12$)
Riebe <i>et al.</i> (35,36) and Blissmer <i>et al.</i> (37)	140% ($n = 13$)	55% ($n = 23$)	63% ($n = 9$)
Riebe <i>et al.</i> (35,36) and Blissmer <i>et al.</i> (37)	59% ($n = 20$)	75% ($n = 15$)	71% ($n = 12$)

pervised follow-up) than participants with a relatively high weight loss during the intervention. Conversely, in the other three intervention groups participants with more than 10% weight loss during the intervention had a comparable or higher percentage maintenance than participants with a lower initial weight loss.

Discussion

This is the first systematic review investigating the association between weight loss achieved during an intervention and the percentage of this weight loss that was maintained after an unsupervised follow-up period. The results show that the correlation between weight loss during the intervention and the percentage maintenance was not significant. The percentage maintenance between intervention groups with 5–10% and >10% weight loss during the intervention showed also no significant difference, but a greater net weight loss was observed for intervention groups with >10% weight loss. Additional analyses within intervention groups, stratified by the amount of weight loss, confirmed the findings on the percentage maintenance for three out of four intervention groups.

The results also show that an intervention group on average lost 9.5% of their baseline weight during the intervention and that 1 year after the intervention on average 54% of this weight loss was maintained. This percentage maintenance is similar to previous reviews (2,15), which showed 50% maintenance at 1 year after the end of the intervention and 44% maintenance at 2-year follow-up, respectively.

Moreover, our results show that there was considerable variation in the percentage weight maintenance between the intervention groups (see Fig. 2). A variety of factors can influence weight maintenance (43), and the content of the interventions may explain a large part of the variation in percentage maintenance. Therefore, 'best practices' with a focus on prevention of weight regain have to be developed. On this topic no conclusions could be drawn from our study, because of the small number of intervention groups and the poor description of the intervention content in different articles. Wing and Hill (44) identified three behaviours of patients who successfully maintained their weight loss: a low-fat high-carbohydrate diet, regular self-monitoring of weight and engagement in high levels of physical activity (2500–3000 kcal week⁻¹ or about 1 h d⁻¹). Elfhag and Rössner (43) identified a number of predictors of long-term weight management (e.g. regular meal rhythm including breakfast, high self-efficacy, social support and self-monitoring of behaviour), many of which could be promoted during treatment with potential for enhancing weight loss maintenance. Other potential targets include developing a flexible restrained approach to diet and lower emotional eating (45), increasing exercise intrinsic motiva-

tion (46) and autonomous self-regulation for exercise and weight control (47,48), and helping participants distinguish between weight loss and weight maintenance skills and behavioural targets (49). Examples of factors that may lead to weight regain are a history of weight cycling, poor coping strategies, dichotomous thinking, more passive reactions to problems and an external motivation to lose weight (e.g. pressure from others) (43). Identifying intervention-related predictors and mediators of long-term weight maintenance in behavioural intervention studies with adequate control groups remains a research priority.

Our data also show that a greater weight loss during the intervention results in greater net weight loss after the unsupervised follow-up. This result is in accordance with the review of Astrup and Rössner (50), which concluded that higher initial weight loss was positively related with a better outcome at 1–5 years thereafter. However, when discussing outcomes of weight control programmes, it is also important to consider additional outcomes besides weight change as criteria for success. First, participants with low percentage of weight maintenance may continue their trend of greater weight regain, which would ultimately result in a lower weight loss in the longer term. Analyses examining the pattern of weight regain after interventions over longer periods of follow-up are needed to provide sufficient insight into this relationship. Second, participants who have a low percentage maintenance fluctuate in their body weight to a higher extent, compared with a high maintenance group, which may have detrimental consequences to health. In a longitudinal study with a follow-up of 7 years, Vergnaud *et al.* (51) concluded that weight fluctuations (adjusted for relative weight change) are a risk factor for the metabolic syndrome. Therefore, it may be more beneficial for the participants' health to achieve and maintain a lower weight loss instead of losing more weight and regain a substantial part of it (even when total weight loss is more). This needs to be further investigated. Finally, it is suggested that regaining more weight and weight cycling may potentially negatively impact psychological factors, which may exacerbate further weight regain (52,53). Further study is needed into the psychological sequels of weight regain following an intervention and its ultimate impact of future weight-related behaviours via factors, such as reduced self-efficacy.

A limitation of (systematic) reviews on weight maintenance is the many different data (e.g. data of participants who started the intervention, data of participants who completed the intervention and/or data of completers of the follow-up) that are presented in weight loss articles. This results in a lack of knowledge as to how weight loss was calculated in the reviews and the likelihood that data of the entire intervention group and of the completers of the follow-up may have been merged to calculate weight loss. Contrary to other reviews, we used three clear methods to

manage the different data. This ensures better quality of data for subsequent analyses because the method with the least assumptions was chosen.

Besides the explicit methods, a strength of our review is the fact that we were able to perform analyses between and within intervention groups. A limitation in our study is that we assumed in the data calculation that the percentage maintenance diminishes linearly to correct for the duration of the unsupervised follow-up. Additionally, only the weight losses during intervention and weight regain during unsupervised follow-up were known: data on the maximal weight loss (that may have occurred at a point during an intervention or after an intervention had ended) were not available. Therefore, maintenance had to be calculated relative to the weight loss at the end of the intervention. However, after correcting the relationship between weight loss during an intervention and percentage maintenance during an unsupervised follow-up for the differences in the duration of an intervention also no significant relation was found. Moreover, the percentage maintenance is (slightly) underestimated in some cases (calculation methods 2 and 3). However, in most of the cases method 1 was used (see Appendix S1) and when analysing methods 2 and 3 without the intention-to-treat method or method 3 under the assumption that dropouts during the intervention lost no weight (and in this way probably overestimating the percentage maintenance in calculation methods 2 and 3) a similar pattern was observed. Finally, the results of this study can only be generalized to a healthy adult overweight population, and results may vary for other populations.

In conclusion, no relation between the percentage weight maintenance after 1 year of unsupervised follow-up and weight loss during an intervention was found. However, a greater weight loss during the intervention did result in greater net weight loss after the unsupervised follow-up. From this perspective, 10% or more weight loss should be encouraged and favoured above a lower weight loss. More research is needed to further elucidate the association between weight loss and maintenance on an individual level, to determine optimal weight loss targets and to establish best practices for an optimal maintenance of weight loss.

Conflict of Interest Statement

We declare that we have no conflict of interest.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Appendix S1. Overview of the included intervention groups.

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