

Obesity Treatment/Weight Management

Determinants of weight loss maintenance: a systematic review

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Received 22 June 2018; accepted 21 August 2018

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Summary

Background: Discerning the determinants of weight loss maintenance is important in the planning of future interventions and policies regarding overweight and obesity. We have therefore systematically synthesized recent literature on determinants of weight loss maintenance for individuals with overweight and obesity.

Methods: With the use of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement, prospective studies were identified from searches in PubMed and PsycINFO from 2006 to 2016. We included articles investigating adults with overweight and obesity undergoing weight loss without surgery or medication. Included articles were scored on their methodological quality, and a best-evidence synthesis was applied to summarize the results.

Results: Our search resulted in 8,222 articles of which 67 articles were selected. In total, 124 determinants were identified of which 5 were demographic, 59 were behavioural, 51 were psychological/cognitive and 9 were social and physical environmental determinants. We found consistent evidence that demographic determinants were not predictive of weight loss maintenance. Behavioural and cognitive determinants that promote a reduction in energy intake, an increase in energy expenditure and monitoring of this balance are predictive determinants.

Conclusion: This review identifies key determinants in weight loss maintenance. However, more research regarding cognitive and environmental determinants of weight loss maintenance is needed to advance our knowledge on determinants of weight loss maintenance.

Keywords: Obesity, overweight, predictors, weight loss maintenance, weight management, weight regain.

Introduction

In an effort to prevent further increase in overweight and obesity, many studies have investigated ideal weight loss and weight loss strategies. A 5% weight loss has shown to improve health outcomes and is currently a standard goal in weight loss interventions (1,2). However, diet, exercise, behaviour and pharmacologic weight loss strategies have indicated that maximal weight loss is achieved at 6 months with most individuals regaining weight thereafter (3). Wing and Phelan notably reported that roughly 20% of

individuals who are overweight are successful in long-term weight loss (4). Moreover, a systematic review by Dombrowski *et al.* in 2014 promisingly demonstrated that weight loss maintenance interventions using strategies of behaviour/lifestyle modification were moderately effective at maintaining weight loss up to 24 months (5). These studies illustrate that long-term weight loss can be achieved and the importance of interventions to increase the rate of success.

In order to improve weight loss maintenance strategies, successes and failures can be studied. Comparing

individuals who are able to maintain their weight loss with those who regain weight in studies such as the National Weight Control Registry has identified several characteristics associated with successful weight loss maintenance. A systematic review conducted by Elfhag and Rössner in 2005 identified and summarized factors in successful weight loss maintenance and characterized successful individuals as those who had substantial weight loss during initial treatment, those who reach a self-determined weight loss goal, those who lead an active lifestyle and those who engage in leisure time activities (6). They further define those successful in weight loss maintenance as those who continue to monitor their weight and eating behaviour. Further, these individuals ate healthy and low-fat diets, ate at regular intervals and did not skip breakfast. Individuals who were successful in weight loss maintenance were also able to correct weight regain quickly, were self-sufficient and autonomous and suffered less from psychological and emotional instability, binge eating and weight cycling. Lastly, Elfhag and Rössner report that individuals successful in weight loss maintenance used support from a social context (6).

Since 2005, many studies that have measured determinants of weight loss maintenance have been published. Obesity remains a multifactorial process involving not only behaviour but also psychology and the environment. Investigating weight loss maintenance, therefore, requires a synthesis of all determinants influencing an individual

(7). Synthesizing the newest insights with an updated search of current literature will help to determine the level of evidence for known determinants and will identify new determinants in weight loss maintenance. Additionally, previous reviews have yet to systematically evaluate the quality of evidence for individual determinants. It is therefore our aim to systematically review the current evidence on prospectively assessed demographic, behavioural, psychological/cognitive and environmental (social and physical) determinants of weight loss maintenance in adults who recently lost weight, while taking the methodological quality of the studies into account.

Methods

This review adheres to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. The review protocol is registered in the PROSPERO International Prospective Register of Systematic Reviews (registration number CRD42017058033) (8).

Search strategy

A systematic literature search of studies published between January 2006 and October 2016 in peer-reviewed journals was conducted in the medical database PubMed and the psychological database PsycINFO with the eligibility criteria presented in Table 1. The full search strategy was

Table 1 Eligibility criteria

	Inclusion	Exclusion
Population	Studies with a mean age of 18 to 65. BMI before weight loss $> 25 \text{ kg m}^{-2}$. Studies using WHO definition of overweight and obesity. Weight loss of 5% before initiation of maintenance phase.	Participants with acute or chronic disease unable to undergo a weight loss trial. Participants who are using medication to lose weight. Participants who are pregnant or lactating.
Intervention	Experimental study where long-term weight loss is followed by ≥ 1 -year post-intervention. Experimental study where weight loss maintenance is conducted for ≥ 1 year from baseline. Observational study where participants have been followed up ≥ 1 year.	Cross-sectional study. Qualitative study.
Outcome	Determinant analysed for effect on weight. Long-term weight loss: Weight change (kg), percent weight change (%), BMI change (kg m^{-2}) from end of study to follow-up. Weight loss maintenance study: Weight change (kg), percent weight change (%), BMI change (kg m^{-2}) from baseline to follow-up. Observational study: Maintenance vs. regain, where maintenance is defined as 5% weight loss for > 1 year. Demographic, behavioural, psychological/cognitive, environmental (social and physical) determinants.	
Study	Language: English. Year: Publication year 2006–2016. Publication type: peer-reviewed journals.	

BMI, body mass index; WHO, World Health Organization.

created by JK, RV and MS. The full search strategy is published elsewhere (8) and includes the following search terms: Obesity and overweight AND Weight loss AND Weight maintenance AND observational studies, randomized controlled trials, systematic reviews AND Determinant AND Physical Activity and Eating Behaviour NOT (<18 years old OR Animal Studies OR Pharmacological Studies OR Bariatric Surgery OR Pregnancy, lactation OR Publication types that are not journal articles OR Cancer OR Mental Disorders OR Diabetes mellitus type 1).

Study inclusion criteria

Study design

We included longitudinal studies, both experimental and observational. Experimental studies included randomized controlled and non-controlled trials and were long-term weight loss interventions or weight loss maintenance interventions. Long-term weight loss interventions consisted of an initial weight loss programme with a follow-up for a minimum of a year after weight loss. Weight loss maintenance interventions included participants who had already lost weight and were observed for a minimum of a year. Observational studies included prospective cohort studies and follow-up studies on randomized and non-randomized controlled trials.

Participation

We included studies with participants between the ages of 18 and 65. Studies where participants had overweight or obesity, or had overweight and obesity prior to a weight loss maintenance phase, were included. Overweight and obesity are defined by the World Health Organization classification body mass index (BMI) $25\text{--}29.9\text{ kg m}^{-2}$ and $\text{BMI} > 30\text{ kg m}^{-2}$, respectively. We selected the age range, 18–65, as evidence suggests that the current World Health Organization cut-offs for overweight and obesity are not appropriate for those above the age of 65 (9).

As our population of interest are those who have overweight and obesity, we chose to exclude studies that had a sole focus on acute or chronic diseases. However, if studies had a focus on participants with overweight and obesity, and these individuals had acute or chronic diseases without contraindication to active weight loss or participation in weight loss trials, these were included. Therefore, studies including participants with type 2 diabetes, hypertension and hypercholesterolaemia were included. Furthermore, studies that included pregnant or lactating participants or individuals who had undergone bariatric or pharmacological weight loss were excluded.

We further specified our inclusion criteria for studies that define weight loss maintenance as weight loss of at least 5% of initial body weight and remaining below 5% for the minimum duration of a year. We chose 5% as a cut-off as

current guidelines on weight loss practices indicate that 5% to 10% weight loss leads to health benefits (10,11). Although a greater reduction of $\geq 10\%$ may be preferred for maximal health benefits, studies have shown that a minimum of 5% has positive effects on blood glucose level, hypertension, cholesterol and mental health (10–12).

This review was further limited to articles published within the last decade (2006–2016). We are interested in the newest insights in the determinants of weight loss maintenance and build upon a previous narrative review by Elfhag and Rössner entitled ‘Who succeeds in maintaining weight loss?’ published in 2005 (6).

Outcomes

The primary outcome is the determinant predictive of weight loss maintenance. The determinant was included if it was analysed between individuals who were able to maintain weight loss or suffered regain, or if the determinant was analysed for change in weight (kg) from baseline, percent weight change or BMI change (Table 1). Determinants measured were required to have been specifically analysed as determinant of weight loss maintenance. Studies with demographic, behavioural, psychological/cognitive and environmental (social and physical) determinants as outcomes were included. We chose to include these determinants as these may help detect target groups and inform intervention content.

Study selection

One reviewer (RV) screened all titles ($n = 8,229$), and two reviewers (RV and MS) independently screened abstracts ($n = 3,858$) to assess inclusion. Two reviewers (RV and MS) conducted the full-text screening independently ($n = 380$). Disagreements during abstract screening and full-text screening were resolved through consensus discussion. When disagreements could not be resolved, the third and fourth reviewers (IS and WK) were called on to make a final decision.

Data extraction

Study characteristics including authors, year of publication, country of origin, study design and duration, analytic sample, mean age, mean BMI and weight measure were collected by RV. Determinants were collected by two reviewers (RV and MS). As study designs vary greatly, we categorized the studies as cohort studies, follow-up studies on randomized controlled trials or non-controlled trials. When determinants were reported with univariate and multivariate analyses, the result under multivariate analysis was taken.

Quality assessment

Quality assessment was conducted using a modified quality assessment tool formerly used by Uijtdewilligen *et al.* (13). A maximum of one point could be awarded per category (Table 2), and a total score of six points could be awarded per article. The categories, as previously described by Uijtdewilligen *et al.*, in which studies could score points, were as follows (13):

- The representativeness of the exposed cohort. A point was given if the participation rate at baseline was at least 80% or if the non-response was not selective.
- Non-selective non-response during follow-up measurements. A point is given if the response rate at follow-up was greater than or equal to 80% or if the non-selective dropout on key characteristics (age, gender, determinants or weight) is reported.
- Determinants were measured with a valid and reliable tool. If the determinant measure showed test–retest

correlations of ≥ 0.80 or $\kappa/\text{ICC} \geq 0.70$, one point is given (13). If the article investigates multiple determinants, this criterion is scored on a scale of 0–1. For example, if a study assessed four determinants, of which one was measured with a reliable tool, a score of 0.25 is given.

- Weight was measured with a valid and reliable tool. A point is given only if weight was assessed with an objective measurement instrument, or questionnaire with test–retest correlations of ≥ 0.80 or $\kappa/\text{ICC} \geq 0.70$.
- Sample size ≥ 10 times the number of independent variables.
- Appropriate statistical model adjusted for relevant confounders. In experimental studies, the findings of a determinant analysis were included (i.e. *b*-path of mediation analysis).

This was converted to a percentage by calculating the mean and multiplying 100. A score $\geq 75\%$ was considered high quality and $<75\%$ low quality.

Table 2 Quality assessment tool (13)

Representativeness of the exposed cohort	1 point is awarded if the participation rate is $\geq 80\%$. 1 point is awarded if the participation rate is $<80\%$ and the non-response was not selective. 0 points are awarded if the participation rate is $<80\%$ and the non-response is selective or not described.
Non-selective non-response	1 point is awarded if attrition rate $\geq 80\%$. 1 point is awarded if attrition rate $< 80\%$ and dropout was not selective on key study characteristics (age, gender, determinant or weight). 0 points are awarded if attrition rate $< 80\%$ and dropout was selective on key study characteristics or not described.
Determinants are measured with valid and reliable tools	Each determinant measured in the outcome is assessed and scored. Each determinant can score either 1 (valid and reliable) or 0 (not valid nor reliable). The average of all determinants is taken as the total score.
Weight is measured with a valid and reliable tool	1 point is awarded if weight is measured with a valid and reliable tool. 0 points are awarded if weight is not measured with a valid and reliable tool.
Sample size	1 point is awarded if <i>n</i> is 10 times the number of measured determinants. 0 points are awarded if <i>n</i> is less than 10 times the number of measured determinants.
Appropriate statistical model	1 point is awarded if appropriate statistical analysis is conducted. 0 points are awarded if the statistical analysis is not appropriate or not clearly reported.

Data synthesis

Categorization of determinants

The determinants and their predictive nature were extracted. The quality of the determinant was determined by the quality assessment of the study in which it was measured. These determinants were then first categorized into four main categories:

- demographic, personal determinants;
- behavioural determinants;
- cognitive/psychological determinants; and
- social and physical environmental determinants.

After determinants and their quality were extracted, each determinant was placed under conceptual categories (14). Figure 1 illustrates how the determinants were placed into these conceptual categories, and finally under the four main determinant groups. Determinants were first listed as shown in Fig. 1. In this figure, we give the following examples of determinants: fruit and vegetable consumption increase, fish consumption increase, portion control, healthy eating increase, protein intake increase, fat intake (baseline) and binge eating. These determinants could be categorized under similar concepts. In Fig. 1, the conceptual categories were created as follows: dietary intake product level, eating behaviour, dietary intake nutrient level and problematic eating. These concepts were then categorized under a general concept of dietary intake, which falls under the main determinant category, behavioural determinants. The placement of the determinants under concept categories was conducted by RV and MS. Reviewers WK and IS were consulted when there were disagreements in the creation of concepts or placement of determinants within these concepts.

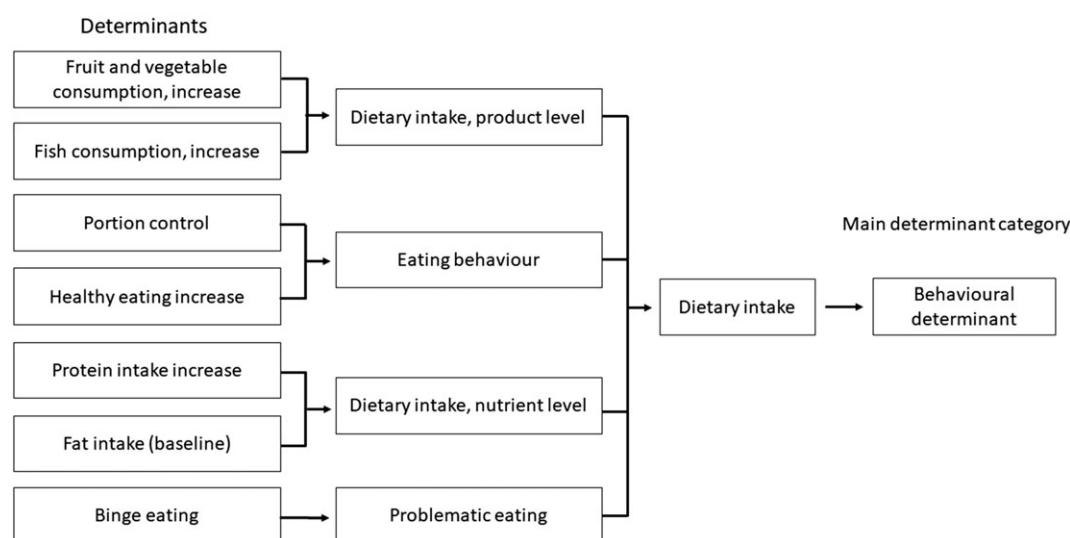


Figure 1 Categorization of determinants

Best-evidence synthesis

In order to determine the level of the evidence for each determinant, we combined the quality of the studies the determinant was measured in with the consistency of the direction of the association of each determinant. This was performed using similar methods as Uijtendwilligen *et al.* (13).

Determinants of weight loss were categorized as significantly positively predictive, significantly negatively predictive or not significant in either direction of weight loss maintenance. Dividing the number of times a determinant is reported in a certain direction by the total number of times the determinant is measured multiplied by a hundred gave a percentage of consistency. If the determinant was reported more than 75%, we considered this a consistent finding in a certain direction. As previously used in Uijtendwilligen *et al.*, the quality of evidence was identified as follows (13):

- Strong evidence: consistent findings in multiple (≥ 2) high-quality studies.
- Moderate evidence: consistent findings in one high-quality study and one or more low-quality studies, or in multiple (≥ 2) low-quality studies.
- Insufficient evidence: only one study available or inconsistent findings in multiple (≥ 2) studies.

A determinant that was reported in a certain direction greater than 75% with two or more of these studies being high quality would result in the conclusion that there is strong evidence that the determinant is positively, negatively or not predictive of weight loss maintenance.

Results

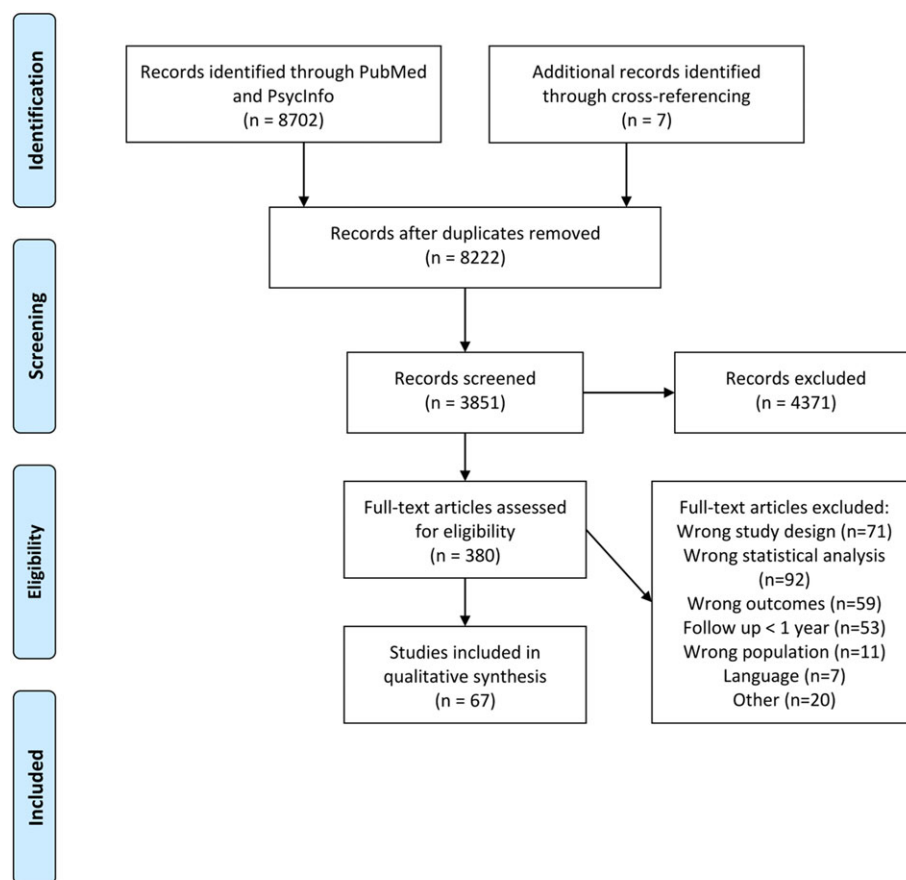
As shown in Fig. 2, this search yielded 8,222 articles. Title screening led to the selection of 3,851 articles. Articles

excluded at this stage were animal studies or paediatric studies. Further screening of the abstracts led to the selection of 373 articles for full-text screening. Through cross referencing, seven more articles were included in the full-text screening. Full-text manuscripts were retrieved for 380 articles and screened on the basis of the eligibility criteria found in Table 1. A total of 49 studies, reported in 67 articles, fulfilled all inclusion criteria and are analysed in this review.

Study characteristics are found in Table 3. Thirty of the 49 studies were conducted in the USA (15–60). Studies were further conducted in Germany (4) (61–64), Finland (4) (65–68), Japan (3) (69–71), Australia (2) (72,73), Portugal (1) (74,75), Switzerland (76), Denmark (77), Israel (78), France (79), Canada (80) and the Netherlands (81). Twenty-nine studies were follow-up studies on randomized controlled trials, 13 were follow-up studies on non-controlled trials and 7 were observational cohort studies. In total 31,741 participants were included, and the average duration of studies was 30 months, with a range from 12 months (45) to 10 years (32). There was a great heterogeneity in the included studies with ages ranging from an average of 28.9 (77) to an average age of 61.2 (80) and baseline BMIs ranging from 27.3 (77) to 42 (71). The average age of participants was 47.2 years with a baseline BMI of 35.5 kg m^{-2} , and 72% was female.

Quality

Table 4 shows the percentage of articles fulfilling each quality criterion assessed. On average, the quality of the articles was low with 42 (63%) of the 67 articles scoring low on the quality assessment and 25 articles (37%) scoring high. A large percent of the articles used valid and reliable tools



Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009)

Figure 2 Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram [Colour figure can be viewed at wileyonlinelibrary.com]

for measuring weight and included an appropriate sample size, where most articles lost points were in the representativeness of the exposed cohort, mainly due to unclear reporting and baseline participation below 80% without reporting the non-selective non-response. While assessing the validity and reliability of the determinants, we found that many articles reported the validity and reliability of their determinant tools. Lastly, the statistical models used for the determinants of weight loss maintenance were often not adjusted for relevant confounders or were associative and not longitudinal analyses.

In total, 124 determinants were identified, and 28 conceptual categories were created. The measured determinants, their predictive nature on weight loss maintenance and level of evidence can be found in Tables 5–8. The results are summarized per main determinant category: demographic, behavioural, cognitive/psychological, and social and physical determinants.

Demographic determinants

The five demographic determinants of, age, gender, ethnicity, socioeconomic status and marital status were identified,

and the quality and strength of evidence were synthesized for the predictive effect on weight loss maintenance. Consistent evidence was found that age, gender and socioeconomic status were not significantly predictive of weight loss maintenance (Table 5). Insufficient evidence was found to make a conclusion for marital status and ethnicity.

Behavioural determinants

Table 6 shows the 59 behavioural determinants identified in the articles included in this review. These behavioural determinants were grouped into four concepts – weight-related determinants, monitoring determinants, determinants related to energy expenditure and determinants related to energy/nutritional intake – and a miscellaneous group including determinants such as smoking or alcohol intake.

Of the weight-related determinants, weight history had strong evidence of being non-significant in predicting weight loss maintenance. Other determinants showed insufficient evidence.

Self-monitoring weight and self-monitoring eating had strong evidence to suggest they were predictive of weight

Table 3 Study characteristics of the 67 articles included in this review

	Analytic sample	Weight measure	Study duration including follow-up	Determinants	Outcome measures	Quality
Look Action for Health in Diabetes (AHEAD) Look AHEAD Research Group, 2014 (15)	Country: USA Population: 825 overweight adults aged 45–76 with type 2 diabetes participating in the Look AHEAD intervention who lost $\geq 10\%$ of weight at year 1. Study design: follow-up on RCT Mean age: 58.7 ± 6.8 Mean BMI or weight: $36.0 \pm 5.9 \text{ kg m}^{-2}$ % Female: 59.3	Weight change (kg)	8 years	Individuals compared at year 8 who maintained the $\geq 10\%$ loss versus gained above baseline weight revealed that those who are successful at maintaining weight loss (at year 8) had a higher activity-related energy expenditure (1471.9 ± 121.1 vs. $799.9 \pm 100.9 \text{ kcal week}^{-1}$, $p < 0.001$) and a greater number of weeks (in the prior year) reducing their calorie and fat intake (both p values < 0.001). Individuals who were able to maintain weight loss were also more likely than those who suffer full regain to weigh themselves daily or more often (47.8% vs. 28.4%), as well as weekly or more (82.4% vs. 69.8%) (both $p < 0.001$). The odds of achieving a $\geq 10\%$ weight loss at year 8 were 2.3 (95% CI: 1.83, 2.97) times greater for participants who at year 1 lost $\geq 10\%$, than for those who lost 5 to $< 10\%$, and 3.9 (95% CI: 2.99, 5.15) times greater than for those who lost $< 5\%$ at year 1. Both individuals who had larger month-to-month weight losses (vs. smallest monthly losses) in year 1 and whose weight loss was more sustained (vs. early but not sustained) during the first year had better maintenance of weight loss over 4 years, independent of characteristics traditionally linked to weight loss success ($p < 0.001$). Greater weight loss at months 1 and 2 was associated with greater weight loss at any given year over the 8-year period (p 's < 0.001). Participants achieving the	Energy expenditure: Paffenbarger Activity Questionnaire. Calorie and fat intake reduction: questionnaire developed by authors Self-weighing: questionnaire developed by authors Initial weight loss: digital scale (model BWB-800; Tanitas, Willowbrook, IL)	High
Neiberg RH <i>et al.</i> , 2012 (16)	Country: USA Population: 2,438 overweight adults aged 45–76 with type 2 diabetes participating in the Look AHEAD study. Study design: follow-up on RCT Mean age: — Mean BMI or weight: — % Female: 59.5	Weight change (kg)	4 years		Gradual and sustained weight loss: digital scale (model BWB-800; Tanitas, Willowbrook, IL)	High
Unick JL <i>et al.</i> , 2015 (17)	Country: USA Population: 2,290 overweight adults aged 45–76 with type 2 diabetes	Weight change (%)	8 years		Initial weight loss: digital scale (model BWB-800; Tanitas, Willowbrook, IL)	High

(Continues)

Table 3 (Continued)

	Analytic sample	Weight measure	Study duration including follow-up	Determinants	Outcome measures	Quality
Wadden TA <i>et al.</i> , 2011 (18)	participating in the Look AHEAD study Study design: follow-up on RCT Mean age: 58.69 ± 6.82 Mean BMI or weight: 35.65 ± 5.93 % Female: 59.2	Weight maintenance	4 years	greatest weight loss at month 1 (>4%) and month 2 (>6%) had the highest odds (OR = 1.99; 95% CI: 1.54, 2.55; and OR = 2.78; 95% CI: 2.15, 3.57, respectively) of achieving ≥5% weight loss at years 4 and 8.	Physical activity: Paffenbarger Activity Questionnaire Calorie intake reduction: questionnaire developed by author	High
	Country: USA Population: 887 overweight adults aged 45–76 with type 2 diabetes participating in the Look AHEAD intervention. Study design: follow-up on RCT Mean age: 58.6 ± 6.8 Mean BMI or weight: 35.3–36.3 kg m ⁻² % Female: 59.3			Participants who maintained a 10% loss from the end of year 1 to the end of year 4, compared with those who did not, reported more favourable physical activity ($p < 0.005$) and reported eating fewer calories ($p < 0.001$) at year 4.		
PESO Study Santos I <i>et al.</i> , 2015 (74)	Country: Portugal Population: 154 overweight women participating in a weight loss and management trial PESO Study design: follow-up on RCT Mean age: 37.6 ± 7.0 Mean BMI or weight: 31.6 ± 4.1 kg m ⁻² % Female: 100	Weight maintenance of weight change (%)	3 years	Correlation analysis: participants with high exercise intrinsic motivation, high intrinsic exercise goals, high exercise self-efficacy, low perceived barriers, low self-ideal body size discrepancy, high physical self-worth, low impact of weight on quality of life and high, moderate to vigorous physical activity were more likely to have lost weight at 3 years. No association with weight change at 3 years was found for awareness of self, perceived choice, exercise controlled motivation, exercise autonomous motivation, extrinsic exercise goals, body shape concerns, self-esteem, body attractiveness, exercise social support, depressive symptoms, physical health-related quality of life, mental health-related quality of life, flexible restraint, rigid restrained, disinhibition, hunger, energy intake, fat intake, fibre intake.	General and exercise motivation: Self-Determination Scale, Exercise Self-Regulation Questionnaire, Intrinsic Motivation Inventory, the Exercise Motivations Inventory, self-efficacy for exercise barriers scale and exercise perceived barriers scale. Psychological well-being and quality of life: Figure Rating Scale, Body Shape Questionnaire, Rosenberg Self-Concept/Self-Esteem Scale, Physical Self-Perception Profile Questionnaire, Social Support for Exercise Survey, Beck Depression Inventory, Short Form Health Survey and Weight on Quality of Life-Lite.	Low

(Continues)

Table 3 (Continued)

	Analytic sample	Weight measure	Study duration including follow-up	Determinants	Outcome measures	Quality
Silva MN <i>et al.</i> , 2011 (75)	Country: Portugal Population: 156 overweight women participating in a weight loss and management trial PESO Study design: follow-up on RCT Mean age: 37.6 ± 7.0 Mean BMI or weight: 31.6 ± 4.1 kg m ⁻² % Female: 100	Weight change (%)	3 years	Weight change at 3 years was significantly associated with perceived need support at year 1 ($b = -0.04$; SE = 0.01), autonomous self-regulation at year 1 ($b = 0.08$; SE = 0.03) and at year 2 ($b = -0.11$; SE = 0.04) and moderate to vigorous physical activity at year 2 ($b = -0.32$). No association was found with external self-regulation or introjected self-regulation.	Eating behaviour and eating habits: the Three-Factor Eating Questionnaire and semi-quantitative Food-Frequency Questionnaire. Physical activity: 7-Day Physical Activity Recall Scale and lifestyle physical activity index. Body weight: electronic scale (SECA, Hamburg, Germany). Perceived need support: Health Care Climate Questionnaire. Behavioural regulations of exercise: 7-Day Physical Activity Recall Scale Body weight: electronic scale (SECA, Hamburg, Germany).	Low
Treatment of Obesity in Underserved Rural Settings (TOURS) study						
Laitner MH <i>et al.</i> , 2016 (19)	Country: USA Population: 152 obese women living in medically underserved rural counties participating in the TOURS trial Study design: follow-up on RCT Mean age: 59.9 ± 6.2 Mean BMI or weight: 37 ± 5.1 % Female: 100	Weight maintenance	18 months	Participants who were in the weight loss maintenance cluster significantly completed more dietary self-monitoring records than did participants who were in the 'weight loss and regain' cluster ($p < 0.001$) or 'low weight loss success' cluster ($p < 0.001$).	Dietary self-monitoring: standardized self-monitoring logs. Height and weight: calibrated and certified beam scale.	Low
Nackers LM <i>et al.</i> , 2010 (20)	Country: USA Population: 298 obese women living in medically underserved rural counties participating in the TOURS trial Study design: follow-up on RCT Mean age: 59.3 ± 6.2 Mean BMI or weight: 36.8 ± 5.0 kg m ⁻²	Weight change (kg)	18 months	No significant differences were found in weight maintenance between 6 and 18 months between participants who lost weight at a fast, moderate or slow rate within the first months of behavioural treatment.	Height and weight: certified balance beam and scale.	Low

(Continues)

Table 3 (Continued)

	Analytic sample	Weight measure	Study duration including follow-up	Determinants	Outcome measures	Quality
Perri MG <i>et al.</i> , 2008 (21)	% Female: 100 Country: USA Population: 298 obese women living in medically underserved rural counties participating in the TOURS trial Study design: follow-up on RCT Mean age: 59.4 ± 6.1 Mean BMI or weight: 36.8 ± 4.9	Weight change (kg)	18 months	A significant relationship between adherence to weight management strategies and weight changes during months 6 to 18 was observed, with poorer adherence resulting in greater weight gain.	Adherence to weight management strategies: Number of self-monitoring records completed. Height and weight: certified balance beam and scale.	High
Peterson ND <i>et al.</i> , 2014 (22)	% Female: 100 Country: USA Population: 220 women living in medically underserved rural counties who took part in the TOURS trial Study design: follow-up on RCT Mean age: 59.3 ± 6.1 Mean BMI or weight: 36.8 ± 4.9	Weight change (%)	18 months	High-frequency and high-consistency self-monitoring of diet produced beneficial effect on weight change. Meeting daily caloric intake goals was associated with weight change.	Dietary self-monitoring records: Self-monitoring forms. Height and weight: certified balance beam and scale.	High
Weight Loss Maintenance trial (WLMT) Brantley PJ <i>et al.</i> , 2014 (23)	% Female: 100 Country: USA Population: 1,025 overweight/obese adults who were taking medication for either hypertension or hyperlipidaemia and participated in the Weight Loss Maintenance trial Study design: follow-up on RCT Mean age: 55.6 ± 8.7 Mean BMI or weight: — % Female: 63	Weight change (kg)	12 and 30 months	At 12 months, higher SF-36 mental health composite score ($b = -0.05$; $SE = 0.02$) were associated with less weight regain, family discouragement on healthy eating was related to more weight regain ($b = 0.25$; $SE = 0.11$), friends' discouragement on healthy eating was associated with less weight regain ($b = -0.24$; $SE = 0.11$) and higher exercise encouragement was related to more weight regain (only Black participants). At 30 months, friends' encouragement for healthy eating was associated with more weight regain, higher SF-36 mental health composite scores were related to less weight regain ($b = -0.15$; $SE = 0.05$), lower perceived physical functioning was related to more weight regain for non-Black and higher vitality	Social Support and Exercise Survey, Social Support and Eating Habits Survey and SF-36. Height and weight: calibrated height and weight scale.	High

(Continues)

Table 3 (Continued)

	Analytic sample	Weight measure	Study duration including follow-up	Determinants	Outcome measures	Quality
Champagne CM <i>et al.</i> , 2011 (24)	Country: USA Population: 1,032 overweight/obese adults who were taking medication for either hypertension or hyperlipidaemia and participated in the Weight Loss Maintenance trial Study design: follow-up on RCT Mean age: 55.6 Mean BMI or weight: $34.0 \pm 5.0 \text{ kg m}^{-2}$ % Female: 63	Weight change (kg)	3 years	scores were associated with less weight regain among Blacks. Participants who substituted protein for fat ($b = -0.07$; 95% CI: -0.10 , -0.05), substituted fat for carbohydrates ($b = -0.03$; 95% CI: -0.04 , -0.02), substituted protein for carbohydrates ($b = -0.05$; 95% CI: -0.07 , -0.02), increased fruit and vegetable intake ($b = -0.04$; 95% CI: -0.07 , -0.01) or increased dairy intake ($b = -0.17$; 95% CI: -0.26 , -0.08) lost more weight at follow-up. Dietary fibre intake was not associated with weight change (25).	Height and weight: calibrated height and weight scale. Dietary intake: block food frequency questionnaire.	High
Coughlin JW <i>et al.</i> , 2013 (25)	Country: USA Population: 880 overweight/obese adults who were taking medication for either hypertension or hyperlipidaemia and participated in the Weight Loss Maintenance trial Study design: follow-up on RCT Mean age: 55.9 ± 8.7 Mean BMI or weight: 30.9 ± 4.7 % Female: 62	Weight change (kg)	30 months	Increased physical activity ($b = -1.25$; SE = 0.51), increased intake of fruit and vegetables ($b = -2.39$; SE = 0.63), more frequent weighing ($p < 0.0001$), decreases in number of times eating fast food ($p < 0.05$), decreases in portion sizes ($p < 0.01$), decreases in amount of desserts ($p < 0.0001$) and decreased consumption of sugared beverages ($p < 0.10$), as well as increase in intake of water or diet beverages ($p < 0.10$) predicted less weight regain at follow-up.	Height and weight: calibrated digital scale. Weight management strategies questionnaire. Physical activity: RT3 accelerometers. Dietary intake: Block food frequency questionnaire.	High
Svetkey LP <i>et al.</i> , 2012 (26)	Country: USA Population: 1,032 overweight/obese adults who were taking medication for either hypertension or hyperlipidaemia and participated in the Weight Loss Maintenance trial Study design: follow-up on RCT Mean age: 53–58 Mean BMI or weight: $33.4\text{--}35.3 \text{ kg m}^{-2}$ % Female: 63	Weight change (%)	3 years	Older age, male sex, less social support for diet and physical activity at entry of study, higher healthy eating at entry and increase in healthy eating and increase in moderate to vigorous physical activity were associated with more weight loss from end of phase 1 to end of study. Educational level, income, smoking status, quality of life, perceived stress, depression, weight loss history, perceived discrepancy between current weight and desired weight were not associated with weight loss.	Height and weight: calibrated scale dietary intake: Block food frequency questionnaire. Physical activity: RT3 accelerometers. Questionnaire of demographic characteristics. Health-related quality of life: SF-36. Patient Health Questionnaire depression scale PHQ-8. Perceived Stress Scale.	High

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Table 3 (Continued)

	Analytic sample	Weight measure	Study duration including follow-up	Determinants	Outcome measures	Quality
Weight-to-Be Study (WTB) Linde JA <i>et al.</i> , 2006 (27)	Country: USA Population: 1,801 adults with a self-reported BMI of >27.0 participating in the Weight-to-Be Study Study design: follow-up on RCT Mean age: 50.7 ± 12.4 Mean BMI or weight: 34.2 kg m^{-2} % Female: 28.2	Weight change (kg)	2 years	Decreased fat intake (men: $b = 0.04$; SE = 0.01; $p < 0.01$; women: $b = 0.03$; SE = 0.01; $p < 0.01$), and increased fruit/vegetable/fibre intake over the course of the study were associated with reductions in BMI at 24 months (men: $b = -0.02$; SE = 0.01; $p < 0.01$; women: $b = -0.02$; SE = 0.00 $p < 0.01$). Among individual food items, for men, increased hamburger, beef, hot dog, salad dressing, margarine, cheese, French fry, chip ice cream, pastry and total fat intake was associated with increased BMI; and increased fruit, green salad, vegetable, high-fibre cereal, dark bread and total fibre intake was associated with decreases in BMI. For women, increased hamburger, beef, hot dog, salad dressing, margarine, bacon, cheese, French fry, ice cream, pastry and total fat intake over the course of the study was associated with increases in BMI; and increased fruit, green salad, vegetable, high-fibre cereal and total fibre intake was associated with decreases in BMI.	Height and weight: calibrated electronic scale and a wall-mounted ruler. Dietary intake: block screening questionnaire for fat and block screening questionnaire for fruit/vegetable/fibre intake.	Low
Linde JA <i>et al.</i> , 2006 (28)	Country: USA Population: 1,801 adults with a self-reported BMI of >27.0 participating in the Weight-to-Be Study Study design: follow-up on RCT Mean age: 50.7 ± 12.4 Mean BMI or weight: 34.2 kg m^{-2} % Female: 28.2	Weight change (kg)	2 years	Reducing calories ($p < 0.0001$), increasing fruits and vegetables ($p < 0.01$), decreasing fat intake ($p < 0.001$), cutting sweets/junk food ($p < 0.0001$) and reducing amount of food ($p < 0.0001$) were associated with associated with weight loss at 24 months. Increasing exercise was not associated with 24-month weight change, although the duration of increasing exercise was associated with weight change ($b = -0.10$; SE = 0.01; $p < 0.0001$). Increased use of these weight loss	Height and weight: calibrated electronic scale and a wall-mounted ruler. Weight loss strategies (reducing calories, increasing fruit and vegetables, increasing exercise etc.).	High

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Table 3 (Continued)

	Analytic sample	Weight measure	Study duration including follow-up	Determinants	Outcome measures	Quality
National Weight Control Registry (NWCRC) Butryn ML <i>et al.</i> , 2007 (29)	Country: USA Population: 3,003 adults who enrolled in the NWCRC and have maintained a weight loss of at least 30 lb for at least a year Study design: cohort study Mean age: 48.0 ± 12.6 Mean BMI or weight: 37.1 ± 8.8 kg m ⁻² % Female: 75.1	Weight loss maintainers	1-year follow-up	strategies was significantly associated with greater 24 months weight loss. Weight regain at 1-year follow-up was significantly greater for participants whose self-weighting frequency decrease between baseline and 1 year than for those whose frequency increased or remained the same.	Height and weight: self-report. Self-weighting frequency.	High
Lillis J <i>et al.</i> , 2016 (30)	Country: USA Population: 5,320 who enrolled in the NWCRC and have maintained a weight loss of at least 30 lb for at least a year without bariatric surgery and who have reached 5-year follow-up Study design: cohort study Mean age: 47 ± 12.2 Mean BMI or weight: 25.07 ± 4.5 % Female: 75	Weight change (%)	5-year follow-up	Percent weight loss across the 5-year follow-up period was lower in the presence of higher baseline scores on both internal disinhibition (ID) and external disinhibition (ED), but only baseline ID was significantly related to more rapid deterioration in percent weight loss. Baseline ED was not significantly associated with the rate of change in percent weight loss over 5 years. Higher scores on ID were significantly associated with lower percent weight loss at the following year's assessment. Scores on ED were not predictive of weight change.	Height and weight: self-report. Disinhibition: Three-Factor Eating Questionnaire.	Low
Raynor HA <i>et al.</i> , 2006 (31)	Country: USA Population: 1,884 Study design: cohort study Mean age: 47.9 ± 12.7 Mean BMI or weight: 36.4 ± 8.9 % Female: 77	Weight change (kg)	1-year follow-up	Baseline TV viewing ($\beta = 0.081$; $p < 0.05$), increases in TV viewing over 1 year ($\beta = 0.123$; $p < 0.001$), decrease in physical activity over 1 year ($\beta = -0.074$; $p < 0.05$) and increase in % calories from sweets ($\beta = 0.088$; $p < 0.005$) were significant predictors of 1-year weight regain. Baseline physical activity and baseline % calories from sweets were not associated with weight change. Participants with larger initial weight losses and longer duration of maintenance of weight upon enrolment were associated with better weight loss maintenance. Being	Height and weight: self-report. TV viewing: questionnaire by author. Physical activity: Physical Activity Questionnaire. Dietary intake: Block food frequency questionnaire.	Low
Thomas JG <i>et al.</i> , 2014 (32)	Country: USA Population: 2,886 participants who lost ≥30 lb and maintained that for ≥1 year	Weight change (kg and %)	10 years		Demographics and weight history: questionnaire by author.	Low

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Table 3 (Continued)

	Analytic sample	Weight measure	Study duration including follow-up	Determinants	Outcome measures	Quality
	Study design: cohort Mean age: 47.8 ± 12.4 Mean BMI or weight: 24.8 ± 4.5 % Female: 77.5			female and having less than a college degree were associated with short-term weight loss maintenance but not with long-term weight loss maintenance. Ethnic and racial background was not associated with weight change. Baseline levels of dietary intake, percent of calories from fat, restraint, disinhibition, self-weighting frequency and leisure time caloric expenditure were not associated with 10-year weight change. However, decreases in leisure time caloric expenditure, restraint, and self-weighting frequency and increases in % of intake from fat and disinhibition from baseline to 1 year were independently associated with increased weight regain across 10 years.	Height and weight: self-report. Weight-related behaviours: established questionnaires. Physical activity: Physical Activity Questionnaire. Dietary intake: block food frequency questionnaire. Dietary restraint: Three-Factor Eating Questionnaire. Self-weighting: questionnaire by author.	
PREMIER Trial Bartfield JK <i>et al.</i> , 2011 (33)	Country: USA Population: 507 overweight/obese adults with either pre-hypertension or stage 1 hypertension not on anti-hypertensive medication Study design: follow-up on RCT Mean age: 49.8 ± 8.7 Mean BMI or weight: $33.7 \pm 5.6 \text{ kg m}^{-2}$ % Female: 60.9	Measured weight loss maintenance	18 months	Participants who maintained their lost weight kept (=less decline) a higher number of food records and recorded days of physical activity at 18 compared with 6 months than did people who relapsed in lost weight.	Food and physical activity records: Food & Fitness Diary. Weight and height: calibrated scale and a wall-mounted stadiometer.	Low
Chen L <i>et al.</i> , 2009 (34)	Country: USA Population: 810 adults with pre-hypertension or stage 1 hypertension Study design: follow-up on RCT Mean age: 50.0 ± 8.9 Mean BMI or weight: $33.1 \pm 5.8 \text{ kg m}^{-2}$ % Female: 62	Weight change (kg)	18 months	Reduction in liquid calorie intake ($b = 0.24$; 95% CI: 0.06, 0.41), reduction in solid calorie intake ($b = 0.09$; 95% CI: 0.005, 0.16), reduction in sugar-sweetened beverage consumption ($b = 0.65$; 95% CI: 0.22, 1.09) were associated with long-term weight loss. Changes in diet drinks, milk, juice, coffee and tea with sugar, coffee and tea without sugar and alcoholic beverages were not associated with weight change.	Dietary intake: 24-h dietary recall. Weight and height: calibrated scale and a wall-mounted stadiometer.	High

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Table 3 (Continued)

	Analytic sample	Weight measure	Study duration including follow-up	Determinants	Outcome measures	Quality
Wingo BC <i>et al.</i> , 2013 (35)	Country: USA Population: 537 adults with pre-hypertension/stage 1 hypertension not receiving medication, participating in the intervention arm of the PREMIER trial Study design: follow-up on RCT Mean age: 50 ± 8.9 Mean BMI or weight: 33.2 ± 5.9 % Female: 6	Weight change (kg)	18 months	At 18 months, the group with the greatest decrease in dietary self-efficacy lost 6.0 ± 1.6 lb less than did the group with no significant changes in dietary self-efficacy and 6.0 ± 1.5 lb less than the group with the greatest increase in dietary self-efficacy ($p < 0.001$). The group with the greatest increase in exercise self-efficacy lost 7.7 ± 1.5 lb more than did the group with the greatest decrease in exercise self-efficacy score ($p < 0.001$). Changes in minutes of physical activity were not significantly associated with changes in weight. Change in cardiorespiratory fitness was significantly associated with change in weight ($\beta = -0.31$; $p < 0.001$)	Self-efficacy: eating habits confidence questionnaire and exercise confidence questionnaire. Physical activity: 7-day physical recall. Weight and height: calibrated scale and a wall-mounted stadiometer.	Low
Healthy Weight for Life (HW4L) Cussler EC <i>et al.</i> , 2008 (36)	Country: USA Population: 161 peri-menopausal women participating in the Healthy Weight for Life programme Study design: follow-up on RCT Mean age: 48.0 ± 4.4 Mean BMI or weight: 31.1 ± 3.8 % Female: 100	Weight change (%)	16 months	Internet diet-log entries were correlated with follow-up weight change ($r = -0.29$; $p < 0.05$). Follow-up weight change was not correlated with change in dietary intake.	Internet log entries. Dietary intake: diet record entries. Weight and height: electronic scale (SECA model 770, Hamburg, Germany).	Low
Teixeira PJ <i>et al.</i> , 2006 (37)	Country: USA Population: 136 overweight and obese middle-aged women who lost weight in a 4-month behavioural weight loss intervention participating in a 12-month Weight Loss Maintenance trial Study design: follow-up on RCT Mean age: 48.1 ± 4.4 Mean BMI or weight: 30.6 ± 5.6 kg m ⁻² % Female: 100	Weight change (kg)	16 months	Weight loss during initial 4 months, high (intrinsic) exercise motivation, less exercise perceived barriers, higher exercise self-efficacy and higher physical self-worth were associated with more weight loss during the maintenance period. Eating restraint, disinhibition, binge eating and body image were not associated with weight change.	Weight and height: electronic scale (SECA model 770, Hamburg, Germany). Eating related variables: Three-Factor Eating Questionnaire and the Binge Eating Scale. Exercise related variables: self-efficacy for exercise behaviour scale, exercise perceived barriers scale and	High

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Table 3 (Continued)

	Analytic sample	Weight measure	Study duration including follow-up	Determinants	Outcome measures	Quality
Buscemi J <i>et al.</i> , 2014 (38)	Country: USA Population: 202 overweight/obese adults Study design: follow-up on RCT Mean age: 51.3 Mean BMI or weight: 34.9 kg m ⁻² % Female: 58	Weight change	Buscemi and Raynor 6 to 18 months	Gender, race, baseline reinforcement ratio, change in reinforcement ratio and baseline BMI were not associated with BMI change from 6 to 18 months.	Intrinsic Motivation Inventory. Body image variables: Body Shape Questionnaire and Physical Self-Perception Profile Questionnaire. Demographics: questionnaire by authors. Weight and height: calibrated digital scale and stadiometer. Reinforcement: activity level-questionnaire eating version. Dietary intake: 24-h dietary recall.	Low
Raynor HA <i>et al.</i> , 2012 (39)	Country: USA Population: 202 overweight adults participating in a behavioural weight loss programme Study design: follow-up on RCT Mean age: 51.3 ± 9.5 Mean BMI or weight: 34.9 ± 4.3 kg m ⁻² % Female: —	Weight change (%)	18 months	No significant association was found between energy intake and weight loss at 18 months.	Dietary intake: 24-h dietary recall. Weight and height: calibrated digital scale and stadiometer.	Low
Annesi JJ <i>et al.</i> , 2016 (40)	Country: USA Population: 51 obese adult women who were physically inactive participating in a weight loss trial who were classified as emotional eaters Study design: follow-up on RCT Mean age: 49.3 Mean BMI or weight: 35.5 % Female: 100	Weight change (kg)	2 years	Increase in weight from baseline to 24 months was significantly predicted by 24-month decrease in fruit and vegetable ($\beta = -0.31$; SE = 0.49; $p = 0.01$), increase in sweets ($\beta = 0.37$; SE = 0.62; $p = 0.003$) and decrease in physical activity ($\beta = -0.24$; SE = 0.08; $p = 0.04$)	Dietary intake: self-report survey. Physical activity: Godin-Shephard Leisure Time Physical Activity Questionnaire. Weight and height: calibrated digital scale and stadiometer.	Low
Annesi JJ <i>et al.</i> , 2016 (41)	Country: USA Population: 110 obese women Study design: follow-up on RCT Mean age: 48.2 ± 7.8 Mean BMI or weight: 35.3 ± 3.2 kg m ⁻² % Female: 100	Measured weight change during weight loss maintenance phase (kg)	2 years	Changes in physical activity (-0.45 ; SE = 0.11) and changes in fruit and vegetable consumption (-0.25 ; SE = 0.87) significantly predicted weight change during the weight loss maintenance phase (6 and 24 months). Changes in self-regulation ($b = -5.91$;	Physical activity: Godin-Shephard Leisure Time Physical Activity Questionnaire. Dietary intake: self-report survey. Self-regulation: validated scale.	High

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Table 3 (Continued)

	Analytic sample	Weight measure	Study duration including follow-up	Determinants	Outcome measures	Quality
Barone Gibbs B <i>et al.</i> , 2012 (42), WOMAN study	Country: USA Population: 419 Overweight and obese post-menopausal women Study design: follow-up RCT Mean age: 57.0 ± 2.9 Mean BMI or weight: 30.8 ± 3.8 % Female: 100	Measured long-term weight loss (kg)	4 years	SE = 1.52) predicted weight change during the weight maintenance phase. Changes in self-efficacy and mood were not predictors. Decreased desserts ($b = 1.2$; $p < 0.01$), decreased sugar-sweetened beverages ($b = 1.25$; $p < 0.05$), decreased meats/cheeses ($b = 0.82$; $p < 0.05$) and increased fruit and vegetable ($b = -1.48$; $p < 0.001$) consumption were associated with weight loss from baseline to 48 months. No association was found for changes in eating at restaurants, changes in fried foods and changes in fish consumption. Initial weight loss (OR = 0.85; 95% CI: 0.78, 0.93); exercise 30–60 min d ⁻¹ (OR = 5.09; 95% CI: 1.69, 15.36) and perceived difficulty of managing weight as easy compared with impossible (OR = 24.08; 95% CI: 2.24, 259.4) were more likely to successfully maintain lost weight. Fruit and vegetable consumption, using pre-packaged meals, planning ahead for meals, portion control, counting carbs, counting fats, keeping dietary food logs, keeping exercise logs, making specific plans for exercise, using a pedometer, self-monitoring weight, reading diet books and participating in commercial weight loss programmes were not associated with successful weight loss maintenance.	Self-efficacy: Exercise Self-Efficacy Scale. Overall negative mood: Profile of Mood States Short Form. Self-efficacy for controlled eating: weight efficacy lifestyle scale. Weight and height: calibrated digital scale and stadiometer. Height and weight: not reported. Eating behaviour: Connor Diet Habit Survey. Leisure time physical activity: modifiable activity questionnaire.	High
Beftor CA <i>et al.</i> , 2008 (43)	Country: USA Population: 179 Study design: follow-up on RCT Mean age: 48.7 ± 9.0 Mean BMI or weight: $37.6 \pm 6.5 \text{ kg m}^{-2}$ % Female: 65.9	Weight maintenance	6–21 months		Height and weight: self-report. Frequency of weight control behaviour and barriers: questionnaire by author.	High
	Country: USA	Weight change (kg)	13 months			Low

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Table 3 (Continued)

	Analytic sample	Weight measure	Study duration including follow-up	Determinants	Outcome measures	Quality
Brock DW <i>et al.</i> , 2010 (44)	Population: 113 formerly overweight pre-menopausal women who had previously completed a weight loss programme to achieve a normal body weight Study design: follow-up on NCT Mean age: 34.6 ± 6.2 Mean BMI or weight: $28.2 \pm 1.3 \text{ kg m}^{-2}$ % Female: 100	Weight change	5 years	More days to weight loss goal ($b = 0.026$; $p < 0.001$) and perceived exertion during exercise ($b = 0.44$; $p = 0.015$) were associated with weight regain. No association was found for age and pre-weight loss BMI.	Physical activity: 7-Day Physical Activity Recall Scale. Perceived effort: measured during submaximal aerobic exercise.	
Buclin-Thiébaud S <i>et al.</i> , 2010 (76)	Country: Switzerland Population: 39 obese patients Study design: follow-up on NCT Mean age: 57 Mean BMI or weight: $35-42 \pm \text{kg m}^{-2}$ % Female: 70	Weight change	5 years	Dietary habits (daily caloric intake, fat, carbohydrates and alcohol consumption) ($p < 0.01$), physical activity ($p = 0.006$), weight management and psychosocial difficulties ($p = 0.0007$), motivation, difficulties in dietary adherence and modification of the attitude of the entourage ($p < 0.001$) had a significant relationship to body weight after the 5 years' follow-up. No information on other included variables was provided.	Dietary intake, eating behaviour, dietary structure, and weight management strategies: questionnaire by author, diaries, dietician interviews. Physical activity: validated questionnaire. Psychosocial difficulties: Holmes's scale.	Low
Chandler-Laney PC <i>et al.</i> , 2009 (45)	Country: USA Population: 120 moderately overweight pre-menopausal women and of European American or African-American ancestry Study design: cohort Mean age: EA, 34.47 ± 0.84 ; AA, 35.03 ± 0.79 Mean BMI or weight: EA, 28.2 ± 0.17 ; AA, 28.19 ± 0.15 % Female: 100	Weight change (% fat)	12 months	For European Americans, women who perceived others' body size as overweight gained more % body fat 1 year after weight loss than did those who perceived others as less overweight. This association was not apparent in African-American women. Cognitive restraint, age and perceived body size were not associated with percent body fat change.	Demographic and race: self-report. Body perception: Stunkard body rating scale. Restraint: Three-Factor Eating Questionnaire.	Low
Clifton PM <i>et al.</i> , 2008 (72)	Country: Australia Population: 79 healthy women Study design: follow-up on RCT Mean age: 49 ± 9 Mean BMI or weight: 32.8 ± 3.5 % Female: 100	Weight change (%)	1 year	Protein in grams ($r = 0.39$; $p = 0.001$), the percentage of energy as protein ($r = 0.36$; $p = 0.002$) and the percentage of energy as carbohydrate ($r = -0.24$; $p = 0.04$) were associated with weight change.	Dietary intake: 3-d weighed food record. Weight and height: digital scale (model AMZ 14; mercury digital scales, Tokyo, Japan) and	Low

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Table 3 (Continued)

	Analytic sample	Weight measure	Study duration including follow-up	Determinants	Outcome measures	Quality
Cox TL <i>et al.</i> , 2007 (46)	Country: USA Population: 89 former participants of weight loss programme Study design: follow-up on NCT Mean age: 52.5 ± 13.3 Mean BMI or weight: 91.9 ± 30.6 % Female: 80.9	Weight maintenance	>1 year (mean: 764.1 d; SD: 409.5)	Compared with individuals who suffered regain, those who were able to maintain weight loss were older ($p = 0.01$), consumed less total energy ($p = 0.01$) and had a significant lower energy density patterns ($p < 0.01$). No differences in level of physical activity were found.	stadiometer (Seca, Hamburg, Germany). Physical activity: Centers for Disease Control and Prevention Behavioural Risk Factor Surveillance System Survey questionnaire. Dietary intake: 4-d food record. Weight and height: Tanita digital scale (model no. BWB500A; Tanita Corp., Arlington Heights, IL) and a wall-mounted stadiometer.	Low
Del Corral P <i>et al.</i> , 2011 (47)	Country: USA Population: 116 healthy pre-menopausal women who recently lost weight to bring their BMI < 25 on a low-calorie diet Study design: follow-up on NCT Mean age: $33.4-35.0$ Mean BMI or weight: $64.5-66.8$ kg % Female: —	Weight change (%)	2 years	Percent weight regained ($30.9 \pm 6.7\%$ vs. $66.7 \pm 9.4\%$; $p < 0.05$) was significantly lower in participants with high dietary adherence to a low-calorie diet than in participants with low adherence.	Adherence to diet and dietary intake: calculated by authors. Weight and height: dual-energy X-ray absorptiometry (GE-Lunar-Prodigy, Madison, WI).	Low
Due A <i>et al.</i> , 2015 (77)	Country: Denmark Population: 20 participants who achieved 8% weight loss in previous trial randomized to a monounsaturated fatty acid intervention Study design: follow-up on RCT Mean age: $28.9 (26.6-31.1)$ Mean BMI or weight: $27.3 (26.4-28.6)$ % Female: 65	Weight change (kg)	18 months	A negative correlation was seen in body-weight regain and self-reported adherence to intake of monounsaturated fat ($r = -0.703$; $p < 0.001$), low intake of sugar ($r = -0.479$; $p < 0.033$) and high intake of legumes ($r = -0.479$; $p < 0.033$). Intake of whole grains, dairy products, red meat, fish and poultry was not associated with body-weight regain.	Weight and height: calibrated scale. Dietary intake and compliance: questionnaire by author.	Low
Flood A <i>et al.</i> , 2009 (48), LIFE study	Country: USA Population: 155 obese adults (BMI between 30 and 39 kg m^{-2}) without chronic illness Study design: follow-up on RCT Mean age: $49.4-50.6$ Mean BMI or weight: $33.8-35.4 \text{ kg m}^{-2}$	BMI change (kg m^{-2})	18 months	Changes in energy density were not associated with changes in BMI between 12 and 18 months ($b = -0.31$; $p = 0.15$)	Weight and height: calibrated scale and wall-mounted stadiometer. Dietary assessment: block food frequency questionnaire.	High

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Table 3 (Continued)

	Analytic sample	Weight measure	Study duration including follow-up	Determinants	Outcome measures	Quality
Giel KE <i>et al.</i> , 2008 (61)	% Female: 37.5–59.0 Country: Germany Population: 79 overweight and obese patients in ambulatory weight loss programme Study design: follow-up on NCT Mean age: 45.5 ± 12.2 Mean BMI or weight: 36.7 ± 5.6 kg m ⁻² % Female: 80	Weight change (kg)	2 years	Age, gender, amount of initial weight loss and BMI at baseline were not correlated with weight loss maintenance.	Weight and height: self-report.	Low
Greenberg I <i>et al.</i> , 2009 (78), DIRECT trial	Country: Israel Population: 322 moderately obese participants of DIRECT trial Study design: follow-up on RCT Mean age: 52.0 ± 7.0 Mean BMI or weight: 31.0 ± 3.6 kg m ⁻² % Female: —	Weight change (%)	2 years	Individuals who lost 5% or more of their initial weight were characterized by a higher initial BMI (31.3 ± 3.8) and a greater weight loss in the first 6 months of the intervention (9.3 ± 6.0 kg). Age, sex, smoking status, physical activity level, educational level, intake of energy (kcal), protein, fat, carbohydrate, cholesterol and dietary fibres at baseline were not associated with weight change. Compared with those who gained weight (gained 5% or more of their body weight at follow-up), those who maintained weight loss had significantly lower energy density intake at follow-up (adjusted for age, gender, body-weight post-intervention and length of follow-up time). No significant associations were found for total calorie intake, percent of calories from carbohydrates, protein, fat, or saturated fat, dietary fibre intake and food weight at follow-up. Those who gained weight had larger portions of food items from several groups including meat/dairy, fats/nuts, fruits and beverages. No associations were found for vegetables and grains.	Dietary intake: food frequency questionnaire. Physical activity: validated questionnaire. Weight and height: scale and stadiometer.	Low
Greene LF <i>et al.</i> , 2006 (49), EatRight study	Country: USA Population: 74 former participants of the physician directed EatRight Weight Management programme through qualitative dietary changes Study design: follow-up on NCT Mean age: 51.5 ± 12.9 Mean BMI or weight: 94.1 ± 25 kg % Female: —	Weight maintainers	2 years	Energy density intake at follow-up (adjusted for age, gender, body-weight post-intervention and length of follow-up time). No significant associations were found for total calorie intake, percent of calories from carbohydrates, protein, fat, or saturated fat, dietary fibre intake and food weight at follow-up. Those who gained weight had larger portions of food items from several groups including meat/dairy, fats/nuts, fruits and beverages. No associations were found for vegetables and grains.	Weight and height: Tanita digital scale (Model BWB500A; Tanita, Tokyo, Japan) and a wall-mounted stadiometer. Dietary intake: 4-d food recall.	Low
Hübner C <i>et al.</i> , 2016 (62), German	Country: Germany Population: 381 adults whose lifetime maximum weight was in the range of overweight and	BMI change (kg m ⁻²)	5.61 ± 5.78 years	Greater effect of retrospective weight-related teasing during childhood and adolescence predicted less successful adult weight loss maintenance over	Weight-related teasing: Perception of Teasing Scale.	Low

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Table 3 (Continued)

	Analytic sample	Weight measure	Study duration including follow-up	Determinants	Outcome measures	Quality
Weight Control Registry	who intentionally lost at least 10% of weight that was maintained for at least 1 year Study design: cohort study Mean age: 40.6 ± 12.45 Mean BMI or weight: 33.02 ± 6.09 kg m ⁻² % Female: —			2 years ($\beta = 0.12$; $p < 0.05$). Greater emotional eating predicted a greater increase or a lower decrease in BMI between baseline and follow-up ($\beta = 0.14$; $p < 0.05$). Restrained and external eating were not associated with change in BMI.	Dutch Eating Behaviour Questionnaire. Weight and height: self-report.	
Keränen AM <i>et al.</i> , 2009 (65)	Country: Finland Population: 49 obese adults participating in weight loss counselling intervention Study design: follow-up on RCT Mean age: 49 ± 9 Mean BMI or weight: 35 ± 5 % Female: 72	Weight maintainers	18 months	Success in weight loss maintenance was associated with high scores of cognitive restraint ($p < 0.01$) and low scores of uncontrolled eating, emotional eating ($p < 0.05$) and binge eating symptoms at followup ($p < 0.001$).	Eating behaviour: Three-Factor Eating Questionnaire. Binge eating: Binge Eating Scale. Weight and height: calibrated scale.	Low
Lenoir L <i>et al.</i> , 2015 (79)	Country: France Population: 14,280 overweight/obese patients managed for weight loss by a primary care physician practicing behavioural nutrition Study design: retrospective cohort study Mean age: 44.97 ± 11.71 Mean BMI or weight: 31.15 ± 4.99 % Female: 84.6	Weight maintainers	≥12 months after weight loss (mean 35.4 ± 19.3)	Initial weight and baseline BMI of patients were significantly higher in the successful maintenance (SM) group than in the unsuccessful maintenance (UM) group ($p < 0.001$). The achievement of the 10% initial weight loss required a shorter period in the SM group than in the UM group.	Weight, height and body composition: digital scale and bioelectric impedance (Tanita TBF 300, Tanita BC 1000.1 or Tanita BC 420).	High
Lindstrom J <i>et al.</i> , 2006 (66), Finnish Diabetes Prevention Study	Country: Finland Population: 522 overweight, middle-aged adults with impaired glucose tolerance participating in the Finnish Diabetes Prevention Study Study design: follow-up on NCT Mean age: 55.0 ± 7.0 Mean BMI or weight: 31.0 ± 4.0 kg m ⁻² % Female: 33.2	Weight change (kg)	3 years	Individuals with a diet low in fat, low in saturated fat, high in fibre (OR = 2.67; 95% CI: 1.26, 5.65) and/or low in energy density lost more weight and had a higher odd of achieving >5% weight reduction at year 3 than those consuming a diet high in fat (OR = 0.45; 95% CI: 0.23, 0.88), high in saturated fat (OR = 0.36 95% CI: 0.18, 0.74), low in fibre and low in energy density (OR = 0.19; 95% CI: 0.08, 0.41).	Dietary intake: 3-d food record.	Low
Mason AE <i>et al.</i> , 2016 (50), SHINE trial	Country: USA	Weight change (kg)	18 months	Neither reward-based eating ($\beta = 0.06$; $p = 0.350$) or psychological	Reward-based eating: reward-based eating scale.	High

(Continues)

Table 3 (Continued)

	Analytic sample	Weight measure	Study duration including follow-up	Determinants	Outcome measures	Quality
Nakade M <i>et al.</i> , 2012 (69), SCOP study	Population: 194 adults with obesity participating in the SHINE trial Study design: follow-up on RCT Mean age: 47.0 ± 12.7 Mean BMI or weight: $35.5 \pm 3.6 \text{ kg m}^{-2}$ % Female: 82			stress ($\beta = 0.03$; $p = 0.556$) were associated with weight loss at 18 months.	Psychological stress: Perceived Stress Scale. Weight: calibrated digital scale (Wheelchair Scale 6002, Scale-Tronix, Carol Stream, IL).	
	Country: Japan Population: 116 participants who participated in a 1-year weight loss programme Study design: follow-up on NCT Mean age: USWM, 54.9 ± 6.0 ; SWM, 54.8 ± 6.8 Mean BMI or weight: USWM, 30.3 ± 3.1 ; SWM, 31.6 ± 4.8 % Female: USWM, 77; SWM, 79	Weight change (kg and %)	1 year	No significant differences in the proportion of men, baseline age, height, weight and BMI between successful and unsuccessful weight maintenance. Significantly more participants successful in weight maintenance answered yes to the questions about self-efficacy for practicing dietary objectives, measuring weight, and assessing practice and keeping records than did the participants unsuccessful in weight loss maintenance both without adjustment and after adjusting for age, sex and baseline weight. The frequency of weighing was higher in those successful in weight loss maintenance after adjusting for age, sex and baseline weight. Successful participants felt significantly less stress about measuring weight. They also felt less stress regarding assessing their practice and keeping records every day, but significance was not seen after adjusting for age, sex and the values at the end of the programme. Walking steps were significantly greater for the participants successful in weight loss maintenance after adjusting for age, sex and baseline values.	Weight: bioelectric impedance analysis (TB-220, Tanita Co., Japan). Weight management strategies, self-efficacy and stress: questionnaire by author. Daily steps: uniaxial accelerometer (Suzuken Co., Japan).	High
	Country: Japan	Weight change (kg)	30 months	Participants in the highest quartile of percent weight lost significantly		Low

(Continues)

Table 3 (Continued)

	Analytic sample	Weight measure	Study duration including follow-up	Determinants	Outcome measures	Quality
Nakata Y <i>et al.</i> , 2014 (70)	Population: 188 overweight adults aged 40–65 participating in weight loss intervention Study design: follow-up on RCT Mean age: 50.7–51.7 Mean BMI or weight: 29.0–29.2 kg m ⁻² % Female: 66–81			increased their step counts by 2,607, which was higher than observed in other groups ($p < 0.05$) and increased their moderate to vigorous physical activity by 21 min d ⁻¹ , which was higher than in the lowest quartile ($p < 0.054$). No significant differences were observed in energy intake (kcal d ⁻¹), age or gender between the weight loss groups. Compared with participants who reported weighing themselves infrequently (never to less than once monthly), those who weighed themselves more frequently were more likely to be successful in weight loss maintenance ($p < 0.001$). Participants who reported they ate takeaway foods less than once weekly, particularly those who never consumed takeaway foods, were more likely to be successful (OR = 4.56; 95% CI: 1.72, 12.08). Participants who did not skip meals (OR = 2.18; 95% CI: 1.39, 3.41) or do not keep snack foods in the house (OR = 1.97; 95% CI: 1.28, 3.02), as well as those with higher dietary restraint scores (OR = 1.18; 95% CI: 1.06, 1.31) were also significantly more likely to be successful. The higher a participant's emotional eating score, the less likely the participant was to be successful (OR = 0.84; 95% CI: 77, 91). Self-monitoring of exercise, fruit and vegetable intake, fry food intake, use butter in cooking, drink tea or coffee with milk, use low-fat products, drink water, breakfast consumption frequency, soft drink consumption, alcohol intake, physical activity level and time spent sitting were unrelated in the multiple logistic model.	Weight and height: calibrated digital scale (WB-150; Tanita) and a wall-mounted stadiometer. Energy intake: 3-d food record. Physical activity: Active Style Pro three-axis accelerometer (HJA-350IT; Omron Healthcare, Kyoto, Japan).	
Neve M <i>et al.</i> , 2012 (73)	Country: Australia Population: 614 overweight adults subscribed for a commercial web-based weight loss programme Study design: follow-up on NCT Mean age: — Mean BMI or weight: — % Female: 88	Weight change (kg)	15 months		Weight and height: self-report. Dietary questions: validated questionnaire. Dietary restraint, emotional eating and uncontrolled eating: Three-Factor Eating Questionnaire. Physical activity: International Physical Activity Questionnaire short format.	Low

(Continues)

Table 3 (Continued)

	Analytic sample	Weight measure	Study duration including follow-up	Determinants	Outcome measures	Quality
Niemeier HM <i>et al.</i> , 2007 (51) TRIM trial and NWCR	Country: USA Population: 202 overweight participants in the TRIM behavioural weight loss trial and 3,345 weight loss maintainers registered in the NWCR Study design: cohort/follow-up study Mean age: TRIM, 40.7 ± 6.6; NWCR, 47.2 ± 12.5 Mean BMI or weight: TRIM, 31.3 ± 3.0; NWCR, 25.2 ± 4.9 % Female: TRIM, 63.6%; NWCR, 76.1%	Weight change (kg)	TRIM: 18 months NWCR: 12 months	In TRIM, internal disinhibition marginally significantly predicted weight loss at 18 months ($b = 0.62$; $SE = 0.33$; $p = 0.06$) with higher levels of internal disinhibition at baseline predicting less weight loss. External disinhibition did not predict weight loss. In NWCR, internal disinhibition significantly predicted 1-year weight change ($b = 0.26$; $SE = 0.08$; $p = 0.01$) while external disinhibition did not. Higher levels of internal disinhibition on entry into the registry predicted more weight regain in the first year of membership.	Disinhibition: disinhibition scale, Three-Factor Eating Questionnaire. Weight and height: TRIM, calibrated scale and stadiometer. NWCR, self-report.	High
Nurkkala M <i>et al.</i> , 2015 (67)	Country: Finland Population: 120 obese adults participating in a behavioural weight loss trial Study design: follow-up on RCT Mean age: 45.0 ± 11.0 Mean BMI or weight: 35.6 (33.2–30.1) % Female: 94	Weight maintenance	3 years	Participants successful in weight loss maintenance (weight loss maintenance ≥ 5%) had a higher increase in cognitive restraint ($p = 0.015$) and had less uncontrolled eating from 9 to 36 months ($p < 0.05$) and less emotional eating from 24 to 36 months ($p < 0.05$).	Weight and height: calibrated digital scale (SOEHNLE S20, Soehnle waagen, Germany), and a right-angle ruler and a tape measure. Eating behaviour: Three-Factor Eating Questionnaire.	Low
Ochner CN and Lowe MR, 2007 (52)	Country: USA Population: 103 overweight or obese women participating in a dietary weight loss trial Study design: follow-up on RCT Mean age: 43.87 ± 10.49 Mean BMI or weight: 31.85 ± 2.61 % Female: 100	Weight change (kg)	33 months	Increases dietary calcium intake at between 6 and 18-months follow-up inversely predicted weight regain ($\beta = -0.380$; $p < 0.05$), whereas increased energy intake positively predicted weight regain ($\beta = .511$; $p < 0.01$).	Weight and height: digital scale (Tanita BWB-800P) and standardized stadiometer. Dietary intake: 110-item block and 5-d food records.	High
Pekkarinen T <i>et al.</i> , 2015 (68)	Country: Finland Population: 201 obese patients participating in a Weight Loss Maintenance trial Study design: follow-up on RCT Mean age: 47 Mean BMI or weight: 40	Weight change (%)	69 weeks (post-maintenance programme) and 121 weeks (1-year post-maintenance programme)	Partial correlation, which controlled for treatment, baseline weight and therapist, showed that weight loss percent at week 17 correlated with weight loss percent at week 69 ($r = 0.63$, $p < 0.0001$) and at week 121 ($r = 0.46$, $p < 0.0001$). There was	Weight: digital scale (Soehnle model 7307, Soehnle-Waagen GmbH & Co., Murrhardt, Germany). Demographic and other anthropometric data: self-report.	High

(Continues)

Table 3 (Continued)

	Analytic sample	Weight measure	Study duration including follow-up	Determinants	Outcome measures	Quality
	% Female: 71			no interaction with treatment and sex, age of the onset on obesity (child/adult), previously lost weight > 10 kg (no, once, twice or more), basic education and employed (yes/no) on weight loss at week 69 or 121.		
Phelan S <i>et al.</i> , 2010 (53), CARDIA study	Country: USA Population: 536 overweight/obese African-American and White young adults who had ≥5% weight loss. Study design: cohort study Mean age: 40.1 ± 3.7 Mean BMI or weight: 34.0–35.4 kg m ⁻² % Female: 47	Weight maintainers	5 years	Higher odds of successful weight loss maintenance were related to African-American race (OR = 1.7; <i>p</i> = 0.03), smoking (OR = 3.4; <i>p</i> ≤ 0.001); increases in moderate physical activity (OR = 1.4; <i>p</i> < 0.001); increases in emotional support (OR = 1.6; <i>p</i> = 0.001) and less sugar-sweetened soft drink consumption at follow-up (OR = 0.08; <i>p</i> < 0.01). Gender, marital status, initial weight loss and dieting history were not associated with weight change.	Weight and height: calibrated equipment. Leisure time activity: CARDIA Physical Activity Questionnaire. Dietary intake: diet history intake and fast food habits questionnaire. Psychosocial measures: social support.	Low
Postrach E <i>et al.</i> , 2013 (63), KiloCoach	Country: Germany Population: 479 overweight users of the commercial weight loss KiloCoach platform Study design: cohort study Mean age: 44.2 ± 11.8 Mean BMI or weight: 31.3 ± 3.1 kg m ⁻² % Female: 61.3	Weight maintainers	~18 months	A significant positive correlation between early weight loss in weeks 1–2 and weight maintenance up to 2 years (<i>r</i> = 0.278; <i>p</i> < 0.01). No gender differences were found.	Weight and height: self-report.	Low
Senechal M <i>et al.</i> , 2011 (80)	Country: Canada Population: 19 obese women who participated in a 15-week weight loss programme Study design: follow-up on NCT Mean age: 61.2 ± 6.0 Mean BMI or weight: 31.8 ± 4.0 kg m ⁻² % Female: 100	Weight change (kg)	15.5 months	Body-weight gain since menopause (<i>r</i> = 0.65; <i>p</i> < 0.01), baseline body weight (<i>r</i> = 0.48; <i>p</i> < 0.01) and BMI (<i>r</i> = 0.58; <i>p</i> < 0.01) were associated with body-weight regain. Age was not associated with regain.	Weight and height: calibrated balance (Seca 707; Seca, Hamburg, Germany) and a standard stadiometer (Takei Scientific Instruments Co. Ltd, Tokyo, Japan). Weight gain since menopause: self-report.	Low
Szabo-Reed AN <i>et al.</i> , 2016 (57)	Country: USA Population: 359 overweight/obese adults participating in a	Weight change (%)	18 months	During maintenance, participants at 18 months with ~14% weight loss performed more physical activity (<i>p</i> < 0.001), had higher self-efficacy	Weight and height: digital scale (Befour Inc Model #PS6600, Saukville, WI) and stadiometer (model PE-WM-60-84,	Low

(Continues)

Table 3 (Continued)

	Analytic sample	Weight measure	Study duration including follow-up	Determinants	Outcome measures	Quality
	behavioural weight loss programme Study design: follow-up on NCT Mean age: 44.4 ± 0.5 Mean BMI or weight: $34.7 \pm 0.3 \text{ kg m}^{-2}$ % Female: 66.6			for weight management ($p < 0.0001$) and had higher self-efficacy for exercise barriers ($p < 0.0001$) than did participants who had $< 1\%$ weight loss at 18 months. Participants with greater weight loss had higher fruit and vegetable consumption ($p < 0.0001$). No differences were found between weight loss groups in entrées and shakes consumption, gender, ethnicity, income level and weight at baseline.	Perspective Enterprises, Portage, MI). Barriers to exercise: 5-item questionnaire by Marcus and Owen 1992. Weight management and self-efficacy: Weight Efficacy Lifestyle Questionnaire. Estimated income: self-report and zip code.	
Tate DF <i>et al.</i> , 2007 (58)	Country: USA Population: 202 overweight adults participating in a behavioural weight loss programme Study design: follow-up on RCT Mean age: 42.4 ± 6.4 Mean BMI or weight: $31.7 \pm 2.6 \text{ kg m}^{-2}$ % Female: 58	Weight change (kg)	30 months	Participants sustaining higher exercise levels for 30 months had significantly ($p < 0.001$) greater 30-month weight loss than had those exercising less. Weight loss from baseline to 30 months was greater in men than in women.	Weight and height: calibrated digital scale (Detecto, Webb City, MS) and wall-mounted stadiometer (Perspective, Portage, MI). Physical activity: Paffenbarger activity questionnaire.	High
Vogels N and Westertrop-Plantenga MS, 2007 (81)	Country: The Netherlands Population: 133 overweight and obese participants following a very-low-calorie diet Study design: follow-up on NCT Mean age: 49.6 ± 9.7 Mean BMI or weight: $30.9 \pm 3.8 \text{ kg m}^{-2}$ % Female: —	Weight maintainers	25.5 months	After 2 years, participants successful in long-term weight loss maintenance ($< 10\%$ body-weight regain) had higher baseline BMI and significantly increased their dietary restraint over 2 years than had those who suffered regain ($> 10\%$ body-weight regain). No associations were found with level physical activity, disinhibition and hunger.	Weight and height: digital balance (model 707; Seca, Hamburg, Germany) and a stadiometer (model 220; Seca). Attitudes towards eating: Three-Factor Eating Questionnaire. Physical activity: validated Baecke questionnaire.	Low
Volger S <i>et al.</i> , 2013 (59), POWER UP study	Country: USA Population: 390 obese adults aged ≥ 21 years living in the Philadelphia region participating in the weight loss intervention POWER-UP Study design: follow-up on RCT Mean age: 51.5 ± 11.5 Mean BMI or weight: 38.5 ± 4.7 % Female: —		2 years	There were no associations between 24-month weight loss and any of the baseline measures of diet, physical activity, eating behaviour, gender and age. Change in hunger (partial R^2 ; $p = 0.038$) and race ($p < 0.0001$) were significantly associated with 24-month weight loss. Changes in restraint and disinhibition at 6 months did not increase the explained variance in 24-month weight loss. The odds of	Weight and height: digital scale (Tanita BWB 800, Tanita Corp, Tokyo, Japan) and stadiometer (Seca Stadiometer 202, Seca, Hamburg, Germany). Eating behaviour: eating inventory). Dietary assessment: fruit and vegetable screener	Low

(Continues)

Table 3 (Continued)

	Analytic sample	Weight measure	Study duration including follow-up	Determinants	Outcome measures	Quality
Wang J <i>et al.</i> , 2015 (60)	Country: USA Population: 210 overweight (BMI 27–43) adults (aged 21–59) without major medical conditions participating in behavioural weight loss interventions Study design: follow-up on RCT Mean age: 46.8 ± 9.0 Mean BMI or weight: 34 ± 4.5 % Female: 84.8	Weight change (kg)	2 years	losing 5% or more weight at 24 months were 4.7 times greater (95% CI: 2.83, 7.77) for participants who lost ≥5% of their weight at month 6 than for those who did not achieve a 5% weight loss at this time. The barriers to healthy eating ($\beta = 0.11$; $p < 0.001$) as well as the scores on the emotions subscale ($\beta = 0.19$; $p < 0.001$), the daily mechanics subscale ($\beta = 0.19$; $p < 0.001$) and the social support subscale ($\beta = 0.16$; $p = 0.01$) were significantly associated with weight over the 24 months.	and percentage from fat screener. Physical activity: Paffenbarger activity questionnaire. Weight: digital scale (TBF-300A, Tanita Corp., Arlington Heights, IL). Barriers to healthy eating: Barriers to Healthy Eating Scale.	Low
Wang X <i>et al.</i> , 2008 (54)	Country: USA Population: 34 overweight/obese post-menopausal women participating in a weight loss intervention Study design: follow-up on RCT Mean age: 58.6 ± 5.2 Mean BMI or weight: 90.1 ± 10.2 kg % Female: 100	Weight change (kg)	16.5 months	The amount of weight regained 12 months post-intervention was inversely associated with decreases in physical activity energy expenditure during the initial weight loss period ($r = -0.404$; $p < 0.05$).	Weight and height: measured Physical activity energy expenditure: RT3 (StayHealthy, Inc., Monrovia, CA).	Low
West DS <i>et al.</i> , 2011 (55)	Country: USA Population: 226 overweight women with urinary incontinence who participated in a behavioural weight loss intervention and randomized to a Weight Loss Maintenance trial Study design: follow-up on RCT Mean age: 53.0 ± 10 Mean BMI or weight: 36 ± 6 kg m ⁻² % Female: 100	Weight change (kg)	18 months	Within the skill-based programme, successful weight maintenance self-concept ($b = 0.56$; $p < 0.01$) predicted weight change during maintenance phase. In the motivation-focused programme, focus on progress ($b = 2$; $p < 0.001$) and self-concept as an exerciser ($b = 0.28$; $p = 0.02$) predicted weight change during maintenance phase. Autonomous self-regulation, controlled self-regulation and reinforcing activities were not associated with weight change. Impulse control (measured with activity in the dorsolateral prefrontal cortex) at	Weight and height: digital scale (Tanita BWB 800) and a wall-mounted stadiometer. Motivational self-measures: Treatment Self-Regulation Questionnaire. Measures of self-identity: adapted Exercise Identity Scale.	High
Weygandt M <i>et al.</i> , 2015 (64)	Country: Germany	Weight change (BMI)	12 months			Low

(Continues)

Table 3 (Continued)

	Analytic sample	Weight measure	Study duration including follow-up	Determinants	Outcome measures	Quality
	Population: 23 subjects who achieved reduction in their body weight by 8% during an earlier 12-week diet Study design: follow-up on RCT Mean age: — Mean BMI or weight: — % Female: —			baseline was coupled to the degree of success in weight maintenance ($p < 0.05$). No association was found between changes in impulse control and success in weight maintenance. Higher behavioural impulsivity at baseline was associated with poorer weight maintenance ($r = -0.36$; $p = 0.047$). Changes in impulsivity were not associated with changes in weight loss maintenance. Increases in daily self-weighting were associated with a decreased risk of regaining 2.3 kg or more.	Impulse control: fMRI activity in the dorsolateral prefrontal cortex.	
Wing RR <i>et al.</i> , 2006 (56)	Country: USA Population: 314 participants who lost 10% of their body weight in the previous 2 years Study design: follow-up on RCT Mean age: $C = 52.0 \pm 10.8$; $I1 = 50.9 \pm 9.3$; $I2 = 51.0 \pm 10.3$ Mean BMI or weight: $C = 29.1 \pm 5.0$; $I1 = 28.1 \pm 4.6$; $I2 = 28.7 \pm 4.7$ % Female: 81	Weight change (kg)	18 months		Weight and height: calibrated scale and a stadiometer. Self-weighting: frequency of self-weighting self-report.	Low
Yamada T <i>et al.</i> , 2015 (71)	Country: Japan Population: 120 consecutive hospital patients with severe obesity participating in an in-patient programme targeting 5% weight loss. Study design: follow-up on NCT Mean age: 48.0 ± 14 Mean BMI or weight: 42.0 ± 9.0 % Female: 57	Weight maintenance	2 years	Greater than 5% weight loss was associated with lower risk of regaining weight compared with $\leq 5\%$ weight loss (HR = 0.37; 95% CI: 0.15, 0.89). Rapid weight loss ($>3\%$ within 7 d after admission) did not significantly increase the risk of subsequently regaining weight than in patients who showed slower weight loss ($\leq 3\%$ within 7 d: HR = 1.26; 95% CI: 0.64, 2.48)	Weight and height: AD 6107NW scales (A and D Co. Ltd, Tokyo, Japan).	Low

BMI, body mass index; CI, confidence interval; HR, hazard ratio; NCT, non-controlled trial; OR, odds ratio; RCT, randomized controlled trial; SE, standard error.

Table 4 Percentage of articles fulfilling each quality assessment criterion

Criteria assessing quality of studies	Percent of articles fulfilling the criteria
Representativeness of the exposed cohort	25.4
Non-selective non-response	47.0
Determinants were measured with a valid and reliable tool	64.1
Weight was measured with a valid and reliable tool	89.6
Sample size ≥ 10 times number of independent variables	91.0
Appropriate statistical model adjusted for relevant confounders	56.7

loss maintenance. Self-monitoring of exercise, on the other hand, had moderate evidence of predicting weight loss maintenance.

Strong evidence was found for physical activity increase being positively predictive of weight loss maintenance, whereas moderate evidence was found for physical activity level at baseline being non-significant in predicting weight loss maintenance.

Eating behaviours such as portion control, cutting unhealthy foods and reducing energy intake were found to be positively predictive of weight loss maintenance supported by strong evidence. Furthermore, eating out and use of meal replacements were supported by strong evidence to be non-significant in predicting weight loss maintenance.

At the product level, an increase in fruit and vegetable consumption and a reduction in sugar-sweetened beverages were positively predictive of weight loss maintenance. The evidence supporting these results were strong. Moderate evidence was found for fish consumption increase and whole grain consumption as non-significant in predicting weight loss maintenance. At the nutrient level, fat intake decrease was found to be positively predictive of weight loss maintenance.

Problematic eating was found to be negatively predictive of weight loss maintenance with moderate evidence. Other behaviours such as smoking and alcohol consumption had insufficient evidence to draw conclusions.

Psychological/cognitive determinants

Fifty-one psychological or cognitive determinants were found. These determinants were sorted in the concepts: stress, mood/depression, quality of life, motivation, self-efficacy and perceived barriers, body image, self-concept, disinhibition/impulse control and reinforcement (Table 7).

Strong evidence found that psychological stress was non-significant in predicting weight loss maintenance. Differently, self-efficacy for exercise and self-efficacy for weight management were strongly supported to be positively predictive of weight loss maintenance. Moderate evidence was found for self-efficacy of diet being predictive of weight loss maintenance. Having high physical self-worth was found to be positively predictive of weight loss maintenance with moderate evidence. Disinhibition or low impulse control was found to not be predictive of weight loss maintenance with moderate evidence, whereas strong evidence supported having high internal disinhibition as negatively predictive of weight loss maintenance. A change in reinforcement was moderately supported to be not predictive of weight loss maintenance. None of the determinants measured in the concept groups of depression and mood, quality of life, motivation and self-concept had sufficient evidence to draw conclusions.

Social and physical environmental determinants

Table 8 shows the ten social and physical environmental determinants identified in the articles included in this review. The three concepts were social support, weight-related teasing and availability of unhealthy foods. None of the determinants in this main determinant group had sufficient evidence to draw conclusions for weight loss maintenance. However, family discouragement of healthy eating and exercise encouragement were measured in a high-quality paper and were reported to be negatively predictive of weight loss maintenance. Additionally, the use of a commercial weight loss programme was not found to be significantly

Table 5 Demographic determinants, percentage of directional consistency and level of evidence

Conceptual category of determinant	Determinant	% Positively predictive of weight loss maintenance	% Not significantly predictive of weight loss maintenance	% Negatively predictive of weight loss maintenance	Level of evidence	Number of studies
Age (older)		18.2	81.8	0	Strong	$n = 11$
Gender (female)		0	78.5	21.4	Strong	$n = 154$
Ethnicity/race		28.6	71.4	0	Strong	$n = 5$
Socioeconomic status (high)	Education level, income, occupational status	0	100	0	Strong	$n = 5$
Marital status (married/living together)		0	100	0	Insufficient	$n = 1$

Table 6 Behavioural determinants, percentage of directional consistency and level of evidence

Conceptual category of determinant	Determinant	% Positively predictive of weight loss maintenance	% Not significantly predictive of weight loss maintenance	% Negatively predictive of weight loss maintenance	Level of evidence	Number of studies
Weight-related determinants						
Weight	Pre-weight loss BMI/weight/fat mass at baseline.	33.3	55.6	11.1	Insufficient	n = 9
Weight loss patterns	Initial weight loss (kg)	71.4	28.6	0	Insufficient	n = 14
	Duration to weight loss goal, and gradual and sustained weight loss vs. early but not sustained	40	40	20	Insufficient	n = 5
	Duration of weight loss maintenance	100	0	0	Insufficient	n = 1
	Weight history (weight cycling and history of weight loss)	0	100	0	Strong	n = 3
	Weight gain since menopause	0	0	100	Insufficient	n = 1
Monitoring determinants						
Monitoring weight	Weekly data reports completed, being frequently weighed in trial, frequent self-weighing/monitoring body weight	80	20	0	Strong	n = 10
	Weight management	100	0	0	Insufficient	n = 1
Self-monitoring exercise	Self-monitoring exercise, use of a pedometer	75	25	0	Moderate	n = 4
Self-monitoring diet	Counting carbohydrates and counting fats	0	100	0	Insufficient	n = 1
Self-monitoring eating		75	25	0	Strong	n = 4
Physical activity determinants						
Energy expenditure	Physical activity level at baseline ^{†††}	0	100	0	Moderate	n = 3
	Increase in physical activity level, energy expenditure, leisure time activity at follow-up ^{††}	76.2	23.8	0	Strong	n = 21
	Change in cardiovascular fitness from baseline to follow-up [†]	100	0	0	Insufficient	n = 1
	Baseline TV viewing ^{††}	0	0	100	Insufficient	n = 1
	Increase in TV viewing ^{††}	0	0	100	Insufficient	n = 1
	Time sitting	0	100	0	Insufficient	n = 1
Dietary intake						
Eating behaviour	Restrained eating; cognitive restraint eating at baseline ^{†††}	44.4	55.6	0	Insufficient	n = 9
	Increase in restrained eating ^{†††}	50	50	0	Insufficient	n = 2
	Flexible restraint post-weight loss	0	0	100	Insufficient	n = 1
	Meal replacement usage during weight loss and maintenance (as weight management technique)	20	80	0	Strong	n = 4
	Portion control and reducing the amount of food during weight loss and maintenance	75	25	0	Strong	n = 4
	Following a diet (book) or adherence to a diet during weight loss and maintenance.	66.7	33.3	0	Insufficient	n = 3
	Healthy eating at baseline ^{††}	100	0	0	Insufficient	n = 1

(Continues)

Table 6 (Continued)

Conceptual category of determinant	Determinant	% Positively predictive of weight loss maintenance	% Not significantly predictive of weight loss maintenance	% Negatively predictive of weight loss maintenance	Level of evidence	Number of studies
Dietary intake, product level	Increase in healthy eating ^{##}	100	0	0	Insufficient	n = 1
	Cut unhealthy food (cut sweet/junk food, decreased fried food consumption, decrease fast food consumption, decrease dessert consumption) during weight loss and maintenance	87.5	12.5	0	Strong	n = 7
	Low fat product use during weight loss maintenance	0	100	0	Insufficient	n = 1
	Not skipping meals and eating breakfast during weight loss maintenance	50	50	0	Insufficient	n = 2
	Energy intake, baseline energy/calorie intake, energy intake level, energy density	33.3	66.7	0	Insufficient	n = 6
	Decrease or reduction in energy intake, energy density, calories (liquid or solid) ^{##}	80	20	0	Strong	n = 10
	Eating out or eating at restaurants during weight loss maintenance	0	100	0	Strong	n = 2
	Eating packaged meals during maintenance	0	100	0	Insufficient	n = 1
	Change in meat and cheese consumption, decrease ^{##}	50	50	0	Insufficient	n = 2
	Change in fish consumption, increase ^{##}	0	100	0	Moderate	n = 2
	Change in whole grain consumption, increase ^{##}	0	100	0	Moderate	n = 2
	Fruit and vegetable intake at baseline ^{†††}	40	60	0	Insufficient	n = 5
	Change in fruit and vegetable consumption, increase ^{##}	83.3	16.7	0	Strong	n = 6
	Eating takeaway, fast food and sweets at baseline ^{†††}	0	50	50	Insufficient	n = 2
	Eating fried food and using unhealthy cooking practices (i.e. cooking with butter) during maintenance	0	100	0	Insufficient	n = 1
	Sugar-sweetened beverages intake during maintenance	0	100	0	Insufficient	n = 1
Dietary intake, nutrient level	Change in consumption of sugar-sweetened beverages, coffee and tea with sugar, and juice, decrease ^{##}	80	20	0	Strong	n = 5
	Change in consumption of coffee and tea without sugar, without milk and diet drinks, increase ^{##}	33.3	66.7	0	Insufficient	n = 3
	Diet drinks intake and water during maintenance	0	100	0	Insufficient	n = 1
	Change in dietary calcium intake, dairy intake and milk intake, increase ^{##}	50	50	0	Insufficient	n = 4

(Continues)

Table 6 (Continued)

Conceptual category of determinant	Determinant	% Positively predictive of weight loss maintenance	% Not significantly predictive of weight loss maintenance	% Negatively predictive of weight loss maintenance	Level of evidence	Number of studies
Problematic eating	Protein intake	0	100	0	Moderate	n = 2
	Increase in protein intake, substituting protein for fat, substituting protein for carbohydrates during weight loss maintenance	100	0	0	Moderate	n = 2
	(Dietary) fibre intake at baseline ^{†††}	40	60	0	Insufficient	n = 5
	Change in (dietary) fibre intake, increase ^{††}	0	100	0	Insufficient	n = 1
	Carbohydrate intake during weight loss and maintenance	40	40	20	Insufficient	n = 5
	Change in carbohydrates, substitute fat for carbs, decrease ^{††}	100	0	0	Insufficient	n = 1
	Fat intake at baseline ^{†††}	37.5	50	12.5	Insufficient	n = 8
	Change in fat intake, decrease ^{††}	75	25	0	Strong	n = 4
	Cholesterol intake at baseline [†]	0	100	0	Insufficient	n = 1
	Binge eating, uncontrolled eating, emotional eating during weight loss and maintenance	0	20	80	Moderate	n = 5
Other behaviours	External eating during weight loss maintenance	0	100	0	Insufficient	n = 1
	Reward-based eating during weight loss and maintenance	0	100	0	Insufficient	n = 1
	Smoking	33.3	66.7	0	Insufficient	n = 3
	Alcohol intake at baseline ^{†††}	33.3	66.7	0	Insufficient	n = 3
	Change in alcohol consumption, increase [†]	0	100	0	Insufficient	n = 1

[†]Baseline measurement at the beginning of a weight loss intervention.

^{††}Baseline measurement at the beginning of a weight maintenance cohort.

^{†††}Baseline measurements at the beginning of a long-term weight loss intervention or at baseline entry in a weight maintenance intervention/cohort.

[#]Increase in measurement from baseline of a weight loss intervention to the end of the follow-up period.

^{##}Increase in measurement from baseline of a weight maintenance intervention/cohort to the end of the follow-up period.

^{###}Increase in measurement from baseline of a weight loss intervention or weight maintenance intervention/cohort to the end of the follow-up period.

Table 7 Psychological/cognitive determinants, percentage of directional consistency and level of evidence

Conceptual category of determinant	Determinant	% Positively predictive of weight loss maintenance	% Not significantly predictive of weight loss maintenance	% Negatively predictive of weight loss maintenance	Level of evidence	Number of studies
Stress	Psychological stress during weight loss and maintenance	0	100	0	Strong	<i>n</i> = 2
	Stress about self-weighting (low)	100	0	0	Insufficient	<i>n</i> = 1
	Stress about self-monitoring	0	100	0	Insufficient	<i>n</i> = 1
	Depressive symptoms, negative mood	0	66.7	33.3	Insufficient	<i>n</i> = 3
Depression, mood and psychiatric diagnoses	Change in negative mood, increase [†]	0	100	0	Insufficient	<i>n</i> = 1
	Psychosocial difficulties	0	0	100	Insufficient	<i>n</i> = 1
	Emotions	100	0	0	Insufficient	<i>n</i> = 1
	Quality of life – physical	0	100	0	Insufficient	<i>n</i> = 1
Quality of life	Quality of life – mental	50	50	0	Insufficient	<i>n</i> = 2
	Quality of life	0	100	0	Insufficient	<i>n</i> = 1
	Impact of weight loss on quality of life, low	100	0	0	Insufficient	<i>n</i> = 1
	Exercise autonomous motivation (high) and intrinsic motivation (high) during weight loss and maintenance	66.7	33.3	0	Insufficient	<i>n</i> = 3
Motivation	Exercise controlled motivation during weight loss and maintenance	0	100	0	Insufficient	<i>n</i> = 1
	Motivation during weight loss and maintenance	100	0	0	Insufficient	<i>n</i> = 1
	Change in self-efficacy, increase [†]	0	100	0	Insufficient	<i>n</i> = 1
	Self-efficacy for exercise and exercise barriers (high) during weight loss and maintenance	80	20	0	Strong	<i>n</i> = 5
Self-efficacy/barriers	Change in self-efficacy for exercise, increase [†]	100	0	0	Insufficient	<i>n</i> = 1
	Self-efficacy for diet during weight loss maintenance	100	0	0	Moderate	<i>n</i> = 2
	Change in self-efficacy for diet, increase [†]	100	0	0	Insufficient	<i>n</i> = 1
	Self-efficacy for weight management and perceived difficulty weight management during weight loss maintenance	100	0	0	Strong	<i>n</i> = 3
Body image	Barriers to Healthy Eating, daily mechanics	100	0	0	Insufficient	<i>n</i> = 1
	Perceived choice	0	100	0	Insufficient	<i>n</i> = 1
	Perceived low physical functioning	0	0	100	Insufficient	<i>n</i> = 1
	Perceived exertion during exercise	0	0	100	Insufficient	<i>n</i> = 1
	Self-ideal body size discrepancy (high = negative body image)	0	0	100	Insufficient	<i>n</i> = 1
	Self-awareness	0	100	0	Insufficient	<i>n</i> = 1
	Body shape concerns	0	100	0	Insufficient	<i>n</i> = 2
	Body satisfaction, body attractiveness and body image	0	100	0	Insufficient	<i>n</i> = 2
	Physical self-worth (high)	100	0	0	Moderate	<i>n</i> = 2
	Perceived self-body size	0	100	0	Insufficient	<i>n</i> = 1

(Continues)

Table 7 (Continued)

Conceptual category of determinant	Determinant	% Positively predictive of weight loss maintenance	% Not significantly predictive of weight loss maintenance	% Negatively predictive of weight loss maintenance	Level of evidence	Number of studies
Self-concept	Perceived discrepancy between current weight and desired weight	0	100	0	Insufficient	n = 1
	Perceiving others as overweight	0	0	100	Insufficient	n = 1
	Self-concept as successful weight maintainer	100	0	0	Insufficient	n = 1
	Self-concept as exerciser	100	0	0	Insufficient	n = 1
Self-regulation	Self-esteem	0	100	0	Insufficient	n = 1
	Change in autonomous self-regulation, increase [†]	66.7	33.3	0	Insufficient	n = 3
	Controlled self-regulation during weight loss maintenance	0	100	0	Insufficient	n = 1
	External self-regulation and introjected self-regulation	0	100	0	Moderate	n = 2
Disinhibition/impulse control	Focus on progress to sustain engagement in weight control behaviours	100	0	0	Insufficient	n = 1
	Intrinsic exercise goals (high)	100	0	0	Insufficient	n = 1
	Extrinsic exercise goals	0	100	0	Insufficient	n = 1
	Planning exercise	100	0	0	Insufficient	n = 1
	Planning meals and snacks	0	100	0	Insufficient	n = 1
	Disinhibition, low impulse control and impulsivity	0	80	20	Moderate	n = 5
	Change in disinhibition, impulse control change ^{††}	33.3	66.7	0	Insufficient	n = 3
	Change in internal disinhibition, increase ^{††}	0	0	100	Insufficient	n = 1
	Internal disinhibition (high)	0	0	100	Strong	n = 2
	Change in external disinhibition, decrease ^{††}	0	100	0	Insufficient	n = 1
Reinforcement	External disinhibition	0	50	50	Insufficient	n = 2
	Baseline reinforcement ratio	0	100	0	Insufficient	n = 1
	Change in reinforcement ratio/reinforcement	0	100	0	Moderate	n = 2

[†]Baseline measurement at the beginning of a weight loss intervention.^{††}Baseline measurement at the beginning of a weight maintenance cohort.^{†††}Baseline measurements at the beginning of a long-term weight loss intervention or at baseline entry in a weight maintenance intervention/cohort.[‡]Increase in measurement from baseline of a weight loss intervention to the end of the follow-up period.^{‡‡}Increase in measurement from baseline of a weight maintenance intervention/cohort to the end of the follow-up period.^{‡‡‡}Increase in measurement from baseline of a weight loss intervention or weight maintenance intervention/cohort to the end of the follow-up period.

Table 8 Social and physical environmental determinants, percentage of directional consistency and level of evidence

Conceptual category of determinant	Determinant	% Positively predictive of weight loss maintenance	% Not significantly predictive of weight loss maintenance	% Negatively predictive of weight loss maintenance	Level of evidence	Number of studies
Social environmental determinants	Social support					
	Change in emotional support, increase [†]	100	0	0	Insufficient	n = 1
	Social support for behaviour, social support exercise, and social support exercise and diet during weight loss and maintenance	33.3	33.3	33.3	Insufficient	n = 3
	Family discouragement of healthy eating during weight loss and maintenance	0	0	100	Insufficient	n = 1
	Friends' discouragement of healthy eating during weight loss and maintenance	100	0	0	Insufficient	n = 1
	Exercise encouragement during weight loss and maintenance	0	0	100	Insufficient	n = 1
Physical environmental determinants	Weight-related teasing					
	Perceived need of support	100	0	0	Insufficient	n = 1
	Modification of the attitude of the entourage	100	0	0	Insufficient	n = 1
	History of weight-related teasing	0	0	100	Insufficient	n = 1
	Availability of unhealthy food					
	Keep snack food in house	0	0	100	Insufficient	n = 1

[†]Baseline measurement at the beginning of a weight loss intervention.^{††}Baseline measurement at the beginning of a weight maintenance cohort.^{†††}Baseline measurements at the beginning of a long-term weight loss intervention or at baseline entry in a weight maintenance intervention/cohort.[#]Increase in measurement from baseline of a weight loss intervention to the end of the follow-up period.^{##}Increase in measurement from baseline of a weight maintenance intervention/cohort to the end of the follow-up period.^{###}Increase in measurement from baseline of a weight loss intervention or weight maintenance intervention/cohort to the end of the follow-up period.

predictive of weight loss maintenance in one high-quality study.

Discussion

With the findings from this review, the model in Fig. 3 was created, illustrating the influence of the determinants on energy balance. The determinants included in this figure were those with moderate or strong levels of evidence and represent their influence on weight loss maintenance. Arrows indicate the direct and indirect influences of the determinants on weight loss maintenance.

This review identified several energy intake-reducing behaviours and energy expenditure-increasing behaviours previously identified in the Elfhag and Rössner review (6). These determinants were the most studied and reported in this review. However self-evident, these determinants remain key elements in weight loss maintenance.

In Fig. 3, we emphasize the indirect influence that determinants can have on weight loss maintenance. Specifically, self-monitoring determinants were found to be positively predictive in weight loss maintenance. Previously, Michie *et al.* (82) and Samdal *et al.* (83) reported self-monitoring as one of the five main techniques of self-regulation, and an effective tool in engaging healthy eating and physical activity. Monitoring determinants are important as they influence behaviours regarding energy intake and expenditure.

In addition to self-monitoring determinants, several cognitive/psychological determinants also indirectly influence weight loss maintenance, i.e. high self-efficacy for

exercise and self-efficacy for weight management. A review by Teixeira and colleagues found similar trends in social/cognitive determinants considered to be important for weight loss maintenance (84). Unfortunately, research on the psychological determinants of weight loss maintenance remains limited. Considering the critical influence of self-efficacy on self-regulation techniques through its effects on goal setting, preparation for action (85,86) and consequently behaviour, it may be meaningful to conduct further research in self-efficacy in promoting weight loss maintenance. Specifically, a systematic review and meta-analyses on changing physical activity self-efficacy and behaviour by Olander *et al.* found four behaviour change techniques that enabled a positive change in self-efficacy. These techniques are action planning, time management, prompting of self-monitoring behaviour outcomes and planning of social support change (87). Similarly, a meta-analysis by Prestwich *et al.* reports on the increase of self-efficacy in dietary interventions that stress management and several behaviour change techniques including self-monitoring, providing feedback and prompting review of behavioural goals (88). We hypothesize that interventions that increase self-efficacy will enable longer maintenance of weight loss.

When reviewing the existing literature, it is equally important to establish the determinants that do not influence weight loss maintenance. Interestingly, no demographic determinants had a predictive effect on weight loss maintenance or, rather, lacked evidence to be conclusive (Fig. 3). Fascinatingly, consistent evidence shows that age, gender and socioeconomic status are not significant in

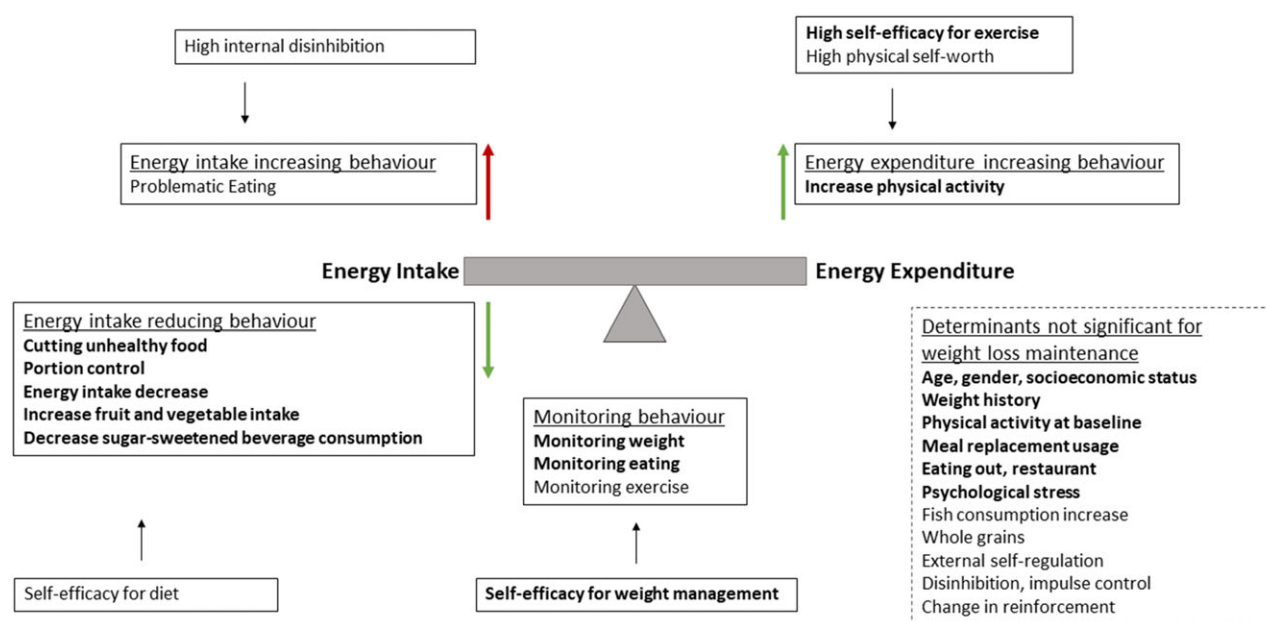


Figure 3 Determinants of weight loss maintenance. Determinants in bold have a strong level evidence; those not bolded have moderate level of evidence. The green arrows indicate positive factors for weight loss maintenance. The red arrow indicates negative determinants in weight loss maintenance. Determinants that are not significant for weight loss maintenance are represented in the dotted box [Colour figure can be viewed at wileyonlinelibrary.com]

predicting weight loss maintenance. This may indicate that target groups are better selected using non-demographic-related factors.

In addition to demographic determinants, baseline measures seem to be insignificant or inconclusive in predicting weight loss maintenance. Measures such as baseline physical activity, energy/calorie intake, protein, fat, carbohydrate and dietary intake do not predict weight loss maintenance (Fig. 3). The results of this systematic review propose that individuals can achieve weight loss maintenance despite their baseline dietary intake and baseline physical activity level. The most important determinants appear to be those that involve change in behaviour.

A few articles in this review examined determinants of weight loss maintenance at the nutrient level. With the exception of fat intake decrease, intake of nutrients such as calcium, protein, fibre and carbohydrates failed to show conclusive evidence for achieving weight loss maintenance. It has been previously suggested by Sacks *et al.* (89) and Katan (90) that macronutrient composition plays a lesser role in weight loss than previously believed. Despite our findings being inconclusive, we hypothesize that determinants at the nutrient level are less important in weight loss maintenance than are other eating behaviours such as overall energy reduction.

Recommendations

On the basis of this systematic review, we recommend that future weight loss maintenance programmes focus on changing behaviour to reduce energy intake through cutting unhealthy foods, decreasing sugar-sweetened beverage consumption and fat intake, portion control, increasing fruit and vegetable intake, and adhering to a diet. Additionally, energy expenditure should be promoted through increasing physical activity. Greater focus on behaviour change techniques such as self-monitoring should be regarded as central to future interventions. Furthermore, it is the hypothesis of the reviewers that behaviour change can be predominantly stimulated by helping individuals to develop self-efficacy for diet, exercise and weight management.

We suggest future research focus on two determinant groups with limited evidence. Firstly, despite cognitive and psychological determinants being reported more frequently in the last decade, there remains a limited amount of evidence for several determinants. One issue we encountered was that studies often use varying theoretical models and different questionnaires, leading to many new determinants being reported but with little replication (Table 3). We hypothesize that cognitive/psychological determinants influence weight loss maintenance through their effect on behaviour. Therefore, we suggest further research to identify psychological and cognitive determinants on weight loss maintenance.

Secondly, environmental determinants were the least measured group of determinants with insufficient evidence to draw any conclusions. Elfhag and Rössner previously suggest that the environment influences opportunities and barriers for engaging in healthy eating and regular physical activity, and thereby weight loss maintenance (6). The most frequently reported environmental determinants were those pertaining to the social environment. Moreover, Elfhag and Rössner (6) and Wing and Hill (91) have mentioned the use of social support by individuals with successful weight loss maintenance in their respective publications. Yet in contrast, Brantley *et al.* report that friends' encouragement of healthy eating is negatively predictive of weight loss maintenance (23). Evidently, more research needs to be conducted to draw any conclusions. In addition, physical and macro-environmental determinants for weight loss maintenance were scarcely reported. A singular study by Neve *et al.* reported not keeping unhealthy food in the house as positively predictive for weight loss maintenance (73). Previously, studies have shown the impact of physical environment on obesity (92). Our hypothesis is that an obesogenic environment would create barriers for weight loss maintenance and may be an intriguing area to investigate. Lastly, the macro-environment and factors such as gross domestic product per capita (93) and pricing policies (94,95) have been reported to be associated with weight and weight control behaviours but were not identified in this review on weight loss maintenance.

Limitations

This is the first systematic review summarizing evidence of the determinants of weight loss maintenance while taking methodological quality of studies into account. Moreover, it is the first systematic review to determine the level of evidence for determinants of weight loss maintenance.

Through our inclusion/exclusion criteria and quality assessment, we have aimed to draw conclusions with the best level of evidence. Consequently, our strict criteria may account for the differences to previous reviews. Elfhag and Rössner report achieving greater initial weight loss as a characteristic of an individual successful in weight loss maintenance (6). In our review, we found insufficient evidence to draw the same conclusions. We found initial weight loss to be predictive of weight loss maintenance in 71.4% of the included studies. As our criteria require $\geq 75\%$ to draw conclusions, the level of evidence for this determinant is insufficient. These cut-offs remain arbitrary and can explain the differences we find to previous literature. Furthermore, as with any systematic review, the inclusion and exclusion are based on the reviewers and are subject to the researchers' interpretation. We attempt to reduce this subjectivity by having two independent

reviewers to include and exclude studies and the third and fourth reviewers to be included if necessary.

We further limited studies to those published in English and those published after 2006. This cut-off may have led to certain determinants being underreported in this review. Meal rhythm, meal frequency and breakfast consumption, locus of control, personality and attitude are a few determinants discussed in other reviews that either were not reported in the studies we included or were reported less frequently than was previous literature (6,91).

A further limitation is the great heterogeneity in the studies included in this review. This remains an issue when comparing behavioural determinants as study designs vary greatly. Previous studies attempting to compare behavioural studies have faced similar issues (82). Furthermore, there was a general lack of detail in regard to methodology of interventions. Many included studies have scored low on areas regarding participant selection and validity/reliability of determinant measurement, largely owing to a lack of reporting. Additionally, a range of terminology and methods are used when measuring determinants of weight loss maintenance, making comparability difficult. However, reviews are necessary in order to develop hypotheses for more effective and innovative interventions.

Furthermore, the validity of memory-based measurements of nutrition has increasingly been questioned in the nutrition field. This may have consequences for studies that may have scored highly in the quality assessment.

Another crucial limitation in this review is the comparison of long-term weight loss studies to studies differentiating those who are successful in maintenance to those who regain. In long-term weight loss, the initiation of weight loss is included, whereas studying the maintenance phase or comparing weight maintenance and regain purely observes the maintenance phase. The determinants in these two phases may therefore differ. Such an example is the determinant initial weight loss. In long-term weight loss trials, the initial weight loss phase is observed in which it may give the appearance that an individual is successful in weight loss maintenance owing to a greater initial weight loss; however, this says little about the actual maintenance of weight loss itself. In essence, the maintenance phase is observing whether an individual can maintain their new weight. This information is lost when observing long-term weight loss. In the study by Nackers *et al.*, they found that initial weight loss was predictive of long-term weight loss maintenance, although this was not the case for weight regain (20). Such differences in outcome illustrate the importance of separating the weight loss phase from the maintenance phase in long-term weight loss maintenance. This may further explain the inconclusive evidence found for some determinants such as initial weight loss. Future studies in determinants of weight loss maintenance need to make clear distinctions between the weight loss phase and maintenance phase.

Conclusion

The overweight and obesity epidemic remains a growing public health issue. With this systematic review, we conclude with a high level of evidence that weight loss maintenance is not entirely reliant on the individual's demographic background but on the behavioural determinants engaging in energy balance and determinants promoting it. The current literature in regard to psychological/cognitive, social, physical and macro-environmental determinants remain scarce or ambiguous at best. Future solutions in weight loss maintenance likely require a greater focus on self-efficacy to engage in behaviour change and to maintain it.

Conflict of interest statement

We declare to have no conflict of interest.

Acknowledgement

The contribution of MS is supported by the Innovational Research Incentives Scheme Veni from Nederlandse Organisatie voor Wetenschappelijk Onderzoek (Netherlands Organization for Scientific Research – Division for the Social Sciences) project number 451-16-018.

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