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Title: The effects of contemporary behavioural weight loss maintenance interventions for long term weight loss: a systematic review

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Abstract

Background: A major challenge in the treatment of obesity is the long-term maintenance of weight loss and prevention of weight regain. The Department of Health in England have recommended that health professionals should consider behaviour weight loss interventions.

Objective: To evaluate the effectiveness of behavioural weight loss interventions in maintaining long term weight loss.

Methods: Using the PRISMA statement we performed a systematic review of randomized controlled trails (RCTs). Data sources involved in the study are the Cochrane Library, MEDLINE, EMBASE, psycINFO and the Web of Science. Studies were assessed independently by two authors to provide inter-rater reliability.

Results: This review presents the findings from 13 RCT's of weight loss maintenance utilising interventions that include diet strategies, behavioural strategies, lifestyle counselling and drug therapy, group therapy and the Internet. The sample population included adult participants of 18years+ with a BMI>30kg/m^2. The results revealed that lifestyle interventions targeting diet and physical activity are effective in sustaining weight loss up to 2years with extended care. Moreover pharmacology combined with lifestyle interventions was effective.

Conclusion: There is important evidence that the use of behavioural weight loss interventions are effective in sustaining long terms weight loss, albeit limited. There was high heterogeneity among the studies; hence caution is required when interpreting the findings. Also, intention to treat principles and methods to handle missing data are not clearly reported across some studies. Blinding of participants and outcome assessors is very limited.

Keywords. Weight loss maintenance, behavioural interventions, systematic review,

lifestyle changes, internet materials,

Introduction

The global obesity epidemic is a major public health challenge which is associated with comorbidities and severe chronic medical conditions (Kopelman, 2007). In the US and Australia, the prevalence of obesity, BMI >30kg/m^2 has doubled in the past 25 years (Glory et al.,2013) According to the National Obesity Observatory (NOO), just over a quarter of adults (26 per cent of both men and women aged 16 or over) in England were classified as obese (BMI 30kg/m^2 or over) (NOO, 2013).. In spite of NICE (2006) guidelines for tackling obesity and strategies to increase public exercise and lifestyle changes (Shaw et al., 2009) these messages alluding to healthy eating and lifestyle are frequently ignored or difficult to implement for a complexity of reasons. Moreover public health policy and updated NICE guidelines recommends that primary care physicians and health professionals should target people with obesity and offer contemporary guidelines. (Stegenga et al., 2014).

There is a body of evidence that suggests that aerobic and resistance exercises are beneficial for weight loss maintenance (Donnelly et al., 2009; Jakicic et al., 2003). Swift et al.(2014) allude to the distinction between minimum levels of physical activity (PA)to maintain health (150 min/wk) and higher levels of PA to prevent weight regain (200 min/wk). Therefore, obese individuals who have lost weight require a substantial quantity of PA to maintain weight loss. Thus aerobic and resistance exercise has an important role in weight loss maintenance.

A small number of randomised trials point to the benefits of commercial weight loss programmes. A trial in the UK offering six months' free use of commercial weight loss programmes (Truby et al.,2006) yielded a weight loss of 5-6 kg compared to 0.6kg in the control group, who were requested not to control their weight. Furthermore, a

lighten up eight arm randomised controlled trial(Jolly et al.,2011)showed that commercial weight management services such as Weight Watchers, Slimming World and Rosemary Conley are more powerful, effective and cheaper than primary care services. The participants randomised to the commercial programmes lost 2.3 (1.3 to 3.4) kg more than did those allocated to the primary care programmes at the programme end (P=0.004). However, this particular study did not consider sustaining long term weight loss.

Long term weight loss is hugely important for sustained health benefits and well-being. There is evidence from systematic reviews that suggests behavioural change in relation to eating, physical activity and lifestyle can support a person in maintaining weight loss (Avenell et al., 2004; Dombrowski et al., 2010). One fairly recent systematic review of 13 randomised controlled trials investigating the impact of extended care for weight loss maintenance pointed to an average 3.2 kg difference in weight loss over 17.6 months post intervention among all participants provided with extended care compared with the control group (Middleton et al., 2012). Another contemporary review examining the effects of long term maintenance of weight loss reported that behavioural interventions that target both diet and physical activity show small but significant benefits on weight loss maintenance This particular study goes on to report that treatment with Orlistat additional to behavioural change interventions is effective in reducing weigh regain up to 36 months and beyond (Dombrowski et al., 2014). Other reviews that have investigated weight loss maintenance appear to focus on drug treatment or on specific restrictive inclusion criteria or subsets such as ‘male-only’ weight loss maintenance interventions (Yanovski et al., 2014). Although useful, there is a dearth of substantive evidence regarding maintenance of weight loss among obese adults because the greatest body of research has been concerned with initiation of weight loss. Against

this background, four components of the PICO strategy were employed to formulate the research question. First, including population: adults who underwent long-term weight loss maintenance. Second, intervention was considered involving several types of exercise, therapeutic and counselling support, diet and drug therapy. The third strategy was specifically related to control/comparison involving standard intervention or no intervention. The fourth strategy related to outcome: long-term weight loss (primary outcome) and blood lipids (secondary outcome). Blood lipids are relevant as a risk factor for cardiovascular disease and reducing lipids has an impact on relevant comorbidities associated with obesity. Hence, our PICO formulated question for this systematic review is 'How effective are behavioural interventions in maintaining long term weight loss?

Methods

This systematic review was conducted in line with the PRISMA checklist (prisma-statement.org), following a pre-specified protocol (Moher et al., 2009).

Eligibility criteria

Studies were eligible if they were randomised controlled trials (RCTs), included individuals (males and (or) females, aged 18 years +) with a body mass index ≥ 30 with participants randomised to a long term weight loss maintenance interventions with a control condition or another intervention or both, and clear intent to sustain weight loss. We excluded studies that recruited participants for bariatric surgery and specialist populations such as established eating disorders/ mental health conditions.

Types of interventions- Any behavioural/lifestyle, lifestyle combined with

pharmacological but not pharmacological singly, or alternative interventions such as written material in combination with interactive web access or counselling type interventions singly or in combinati.

Types of outcomes- The primary outcome was weight change from randomisation to post intervention end follow up time point, or final weight loss value reported in kilograms or pounds. The secondary outcome was markers of blood lipids during the maintenance treatment period.

Types of outcome assessment-Studies with a duration including follow up period of 12 months or greater were included.

Types of reports- Full text reports in English language from 2000 to December 2014. We focused on modern weight loss maintenance interventions to provide a more contemporary body of knowledge and outcomes for health practitioners.

Information sources and searches

Studies were identified by searching electronic databases from 2000-2014 using truncation and Boolean logic. The search was applied to The Cochrane Library, MEDLINE, Embase, psycINFO, CINAHL and Web of Science. Databases were searched using a comprehensive search strategy for weight loss maintenance studies in adults, aged 18 years and beyond. Search strategies used key words including overweight or obes*, weight reduction, weight main* or decreas* or control, exercise therapy, fitness (class* or program*), group therapy, obesity maintenance, lifestyle

change*, intervention, behaviour therapy, cognitive therapy, counselling, complementary therapies or web materials.

Study selection and quality assessment

Following the search, two authors (JG, MM) removed all duplicates, opinion papers, commentaries, and screened the titles and abstracts of remaining records for relevance using the inclusion and exclusion criteria. Both authors considered all decisions and any differences or disagreements were resolved by discussion. Full text articles of potentially eligible papers were retrieved for all remaining 1868 records. To ensure inter-rater reliability, results from the sift were compared and both authors (JG and MM) independently screened these articles using the prespecified eligibility criteria with both reviewers conferring on agreement and differences to reach full consensus. Figure 1 displays this selection process.

Data extraction

We extracted data concerning the type of publication, study design, sample characteristics, recruitment procedures, methods of randomisation, nature and length of the intervention, type of comparator group, outcome assessments, sources of bias, relevant confounders and drop-out rates were extracted by two reviewers (JG,MM) employing a standard data extraction form. Risk of bias was assessed based on the Cochrane Collaboration tool (Higgins and Green 2011). Two researchers (JG,MM) independently assessed risk of bias and any disagreements were resolved. Some study authors were contacted for additional information to adequately complete the data extraction processes.

Insert Figure 1 here

Data analysis and synthesis

Statistical analysis were performed using Revman 5.2 (2014). Outcome measures were quantitatively summarised, if possible, using a random effects model including an inverse variance approach. For the majority of the studies the mean changes from baseline (maintenance phase) to end point of follow up were reported. When studies reported average weight at baseline and follow up end point we calculated weight change by subtracting the final weight from the initial weight. Standard deviations for weight change were imputed using the formula specified in the Cochrane Handbook. Studies that included a comparator with two intervention groups, the mean and standard deviations of the two groups were combined and imputed according to the stipulated formula provided. To use most of the data, we pooled the studies into 2 sub sets and discrepancies were resolved by consensus with a third person. Studies were pooled/grouped according to their component intervention and delivery mode, for

example behavioural/lifestyle activity with intense v less intense delivery mode or person (face-to-face) v remote delivery. Six studies were analysed individually because they did not fit with the pooled groups and are summarised narratively.

Results

The search identified 2480 potentially appropriate records, of which 120 were selected as potentially eligible; after reviewing the full articles, 13 met the inclusion criteria (Figure 1). Table 1 summarises the characteristics and overall details of the included trials. Studies were published in 2001-2013. Trials were conducted in the USA (n=8), Canada (n=1), Findland (n=1), Sweden (n=1) and the United Kingdom (n=2). The age range of the participants was from 18 to 70 years and the average BMI before weight loss was 35.3. Most studies included a mix of obese men and women (n=8) or women only (n=3) or men only (n=1).

Of the included studies, three single trials(Appel et al., 2011; Hersey et al., 2012; Svetkey et al., 2008) evaluated community based interactive web materials versus written materials that advocated change in behaviour/lifestyle, diet, exercise and activity. Some of the interactive web programmes offered tailored feedback when participants submitted weekly assessments. Intervention arms were supported by trained health lifestyle coaches providing in person, group or telephone support, using motivational interviewing techniques applied most intensely with the interactive web arm.

Three trials (Gagnon et al.,2011; Latner et al., 2013; West et al.,2011) evaluated counselling/seminars or group therapy or motivation/skill strategies versus self-help with coaching support to increase physical activity, sustain healthy eating behaviour and

manage weight regain. A further four trials (Cooper et al., 2010; Merlin et al., 2003;Perri et al., 2001; Wadden et al., 2011) examined behavioural therapy interventions including cognitive behaviour therapy or behaviour therapy or lifestyle counselling versus less intense behavioural therapy that focused on lifestyle maintenance interventions for diet and physical activity.

Of the remaining single trials, one (Borg et al., 2002) examined resistance training and group meetings, walking and group meeting versus group meetings to maintain weight loss. The second single trial (Wadden et al. 2013) evaluated liraglutide 3.0mg daily with lifestyle counselling and exercise focused maintenance versus placebo. The third single trial (Whitham et al., 2013) examined meal replacements versus self-directed diet.

Several of the weight loss interventions lasted 24 months (n=5) and ranged from 12-52 months. Of those that reported study settings included community, home or clinic or the internet or phone or a gym context. Moreover, the intervention providers were diverse and intervention arms appeared to be facilitated by dieticians, exercise physiologists, nurses, psychologists, therapists, lifestyle coaches, nutritionists, gym instructors and peer support.

Insert Table 1 here

Sustainability of Body Weight Loss-Intervention effectiveness

Changes in body weight sustainability were pooled for two groups of studies and because heterogeneity among studies was high, the outcomes from six single trials were reported separately.

At and up to two years, three therapy/motivational skills/lifestyle studies (422 patients) including 4 comparisons (Gagnon et al., 2011; Latner et al., 2013; Wadden et al., 2011) showed a mean difference in weight change of -3.83kg (95% confidence interval -5.39 to -2.27 kg; I^2=0%: fig 2). Overall, the mean difference in weight change remained significant at and up to 2 years.

Again, at and up to two years, a further four behavioural therapy/life style studies (555 patients) including 4 comparisons could be pooled (Cooper et al., 2010;Merlin et al., 2003; Perri et al., 2001; Wadden et al ., 2011) The mean difference in weight change was -1.10 (95% confidence interval -2.50 to 0.29.36 kg; I^2=54%: fig 2). Body weight loss sustainability was not significantly different between behaviour therapy interventions and other therapies such as cognitive behaviour therapy or lifestyle counselling. The mean difference in weight change was significant. Heterogeneity among the studies was moderate.

Of the single studies, three trials evaluated interactive web/written materials to change behaviour/lifestyle to sustain healthy eating behaviour and keep the weight off (Appel et al., 2011; Hersey et al., 2012; Svetkey et al., 2008) One study (Appel et al., 2011) involving 343 patients provided a two year follow up and displayed a mean difference in weight change of -4.05 kg (95% confidence interval -5.16 to -2.94 kg; fig 2). Another single trial (Hersey et al., 2012) including 486 patients with a follow up of 18 months revealed a mean difference in weight change of -0.56kg (95% confidence interval -2.49 to 1.37kg; fig 2). A third trial (Svetkey et al.,2008) with a sample of 964 patients reported a 30 month follow up and showed a mean difference in weight change of -9.25kg (95% confidence interval -9.97 to -8.53 kg; fig 2). Changes in weight loss were significant in two of the aforementioned trials (Appel et al., 2011; Svetkey et al., 2008).

There was no evidence of robust treatment effectiveness in one trial (Hersey et al. 2012).

At two years, one single trial (Borg et al., 2002) (46 patients) examined resistance training/walking to maintain weight loss and demonstrated a mean difference in weight change of -1.30 kg (95% confidence interval -5.80 to 3.20 kg; fig 2). One study (Wadden et al., 2013) (422 patients) that used a 3.0 mg dose of Liraglutide combined with lifestyle counselling and exercise provided follow-up at 14 months, with mean difference of -6.00 kg (95% confidence interval -7.36 to -4.64 kg; fig2). A further single trial (Whitman et al., 2013) (56 patients) examined meal replacements or self-directed diet and offered a 52 week follow up, with mean difference of -0.77 (95% confidence interval -4.08 to 2.54 kg; fig 2). The treatment effect was significantly greater in the single study that used a pharmacological intervention, Liraglutide with lifestyle counselling ($Z= 25.19$, $P<0.00001$).

Plasma cholesterol

The mean changes for cholesterol concentrations were available for three studies,(Gagnon et al., 2011;Latner et al., 2013; Wadden et al., 2011)) and pooled for two studies (Gagnon et al., 2011;Latner et al., 2013) Changes in high density lipoprotein(HDL) concentration decreased and showed a significant main effect for time (Latner et al., 2013)and the ratio improved significantly in both groups (Gagnon et al., 2011)associated with intensification of treatment with statins during the study (mean difference 0.00mmol/L, 95% confidence interval -0.13 to 0.13 mmol/L; $j^2= 0\%$:fig3). Similarly, changes revealed in one single study (Wadden et al.,2013) showed a mean difference of 0.10mmol/L (95% confidence interval 0.06 to 0.14 mmol/L:fig3) but the changes from randomization to 56 weeks were of small magnitude.

Again, the mean changes for low density lipoprotein concentrations (LDL) were available for three studies, (Gagnon et al., 2011; Latner et al., 2013; Wadden et al., 2013)and pooled for two studies (Gagnon et al., 2011; Latner et al., 2013) Changes in low density lipoprotein did decrease , (Latner et al., 2013) (mean difference -0.26 mmol/L, 95 % confidence interval -2.42 to 1.90 mmol/L; I^2= 41% fig 3). Heterogeneity was moderate. Moreover, the LDL concentration changes reported in one single study (Wadden et al., 2013) were small (mean difference 0.30 mmol/L, 95% confidence interval 0.23 to 0.37 mmol/L;fig3).

Triglyceride concentration

Mean changes in triglyceride concentrations were available for three studies, (Gagnon et al., 2011; Latner et al., 2013; Wadden et al., 2013) and were pooled for two studies (Gagnon et al.,2011;Latner et al., 2013) Triglyceride levels decreased significantly; especially with intensifications of treatment with statins during the study (Gagnon et al., 2011)and at post-treatment follow up (Latner et al., 2013) and showed significant main effects for time (with a mean difference of -1.20 mmol/L, 95% confidence interval -3.95, to 1.56 mmol/L;I^2= 66%: fig3).Heterogeneity was high. In addition, the triglyceride concentrations available in one single study (Wadden et al., 2013) showed a small change (with a mean difference of -0.10 mmol/L (95% confidence interval -0.21 to 0.01 mmol/L: fig3).

Discussion

This systematic review of interventions for sustainability of weight loss demonstrates that it is possible to sustain weight loss and reduce weight regain through lifestyle/behavioural changes and pharmacological means. Lifestyle interventions targeting dietary intake and physical activity are effective in sustaining weight loss in

obese adults up to 24 months. There is some evidence that these effects can be sustained up to 3 years and beyond but the evidence is limited. Nonetheless, the strength of the evidence in this review is limited; there is moderate heterogeneity and risk of bias with regard to allocation concealment and diverse outcome assessments. All of the 13 trials reported results for the participants who completed the interventions and not the drop outs. Thus it is important to interpret the results with caution.

Liraglutide combined with a lifestyle intervention component seemed to be more effective than placebo and lifestyle intervention (Wadden et al.,2013). However, the strength of the evidence is very limited for long term sustainability because of increase in undesirable side effects could perhaps limit the acceptability at an individual service user level. Liraglutide, however, is normally prescribed as a short term treatment for obese individuals with type 2 diabetes (Astrup et al., 2009)both for weight loss and glycaemic control. Moreover the lifestyle intervention programme in the liraglutide trial included in our review is downplayed and it is unclear regarding its effects, hence it is difficult to interpret if it could be further optimised.

Furthermore for interventions that focused on physical activity alone or diet alone, using food replacements did not provide for robust effectiveness of these particular interventions. Therefore, further research is required to validate these findings. Only a few studies provide data on response of blood lipids to the behavioural interventions. Nonetheless, there is reasonable evidence to suggest a decrease in cholesterol concentration for HDL and LDL and triglyceride levels but the strength of the evidence is limited because of moderate heterogeneity.

There was no significant evidence regarding particular modes of intervention being more effective, however, face-to-face intervention or facilitator lead interventions showed an inclination to be more effective than remotely or distantly delivered modes such as by telephone, e-mail or internet. Nonetheless, the interactive web materials that provided tailored feedback displayed a tendency to be more effective in comparison to written materials. Thus the potential for using contemporary technologies or designing more innovative technologies/methods requires further exploration.

Besides the main data reported in this paper, the reasons for dropouts were reported across nine studies including diverse health problems, hospitalisations, death (metastatic cancer, 2 cases), moved to another city, personal reasons, lack of time, and not wanting to continue.

Conclusion

The major strength of this review points to the importance of maintaining contact and assisting patients with weight loss maintenance to promote favourable health effects. The current review clearly supports the use of extended care and diverse modes of delivery for long term weight loss maintenance, with significant to moderate effect found for the impact of extended care on weight regain and long-term weight loss maintenance. These findings suggest important consideration to inform the provision of care. Nonetheless, the need for further research in more diverse populations using innovative technologies is needed for developing culturally appropriate tailoring for both group and individual support.

The major limitation is the conduct of pooling studies in the presence of high

heterogeneity among the studies. Although we used a random effects model to try to mitigate the heterogeneity as a prevailing issue, and our sensitivity analysis did not alter the results.

Nonetheless, current evidence, although limited, does support that weight loss maintenance can be maintained by supportive behaviour strategies that match with individual motivations, lifestyle and personal preferences or choices.

Key points

- Current evidence suggests that extended care and diverse modes of delivery are effective for long term weight loss.
- Short term use of drugs can kick start weight loss but sustained change is subject to multiple influences and tailored support.
- Regular contact time is shown to enhance motivation which could be levered up through existing ehealth and mobile technology .

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Systematic Review Flow Diagram

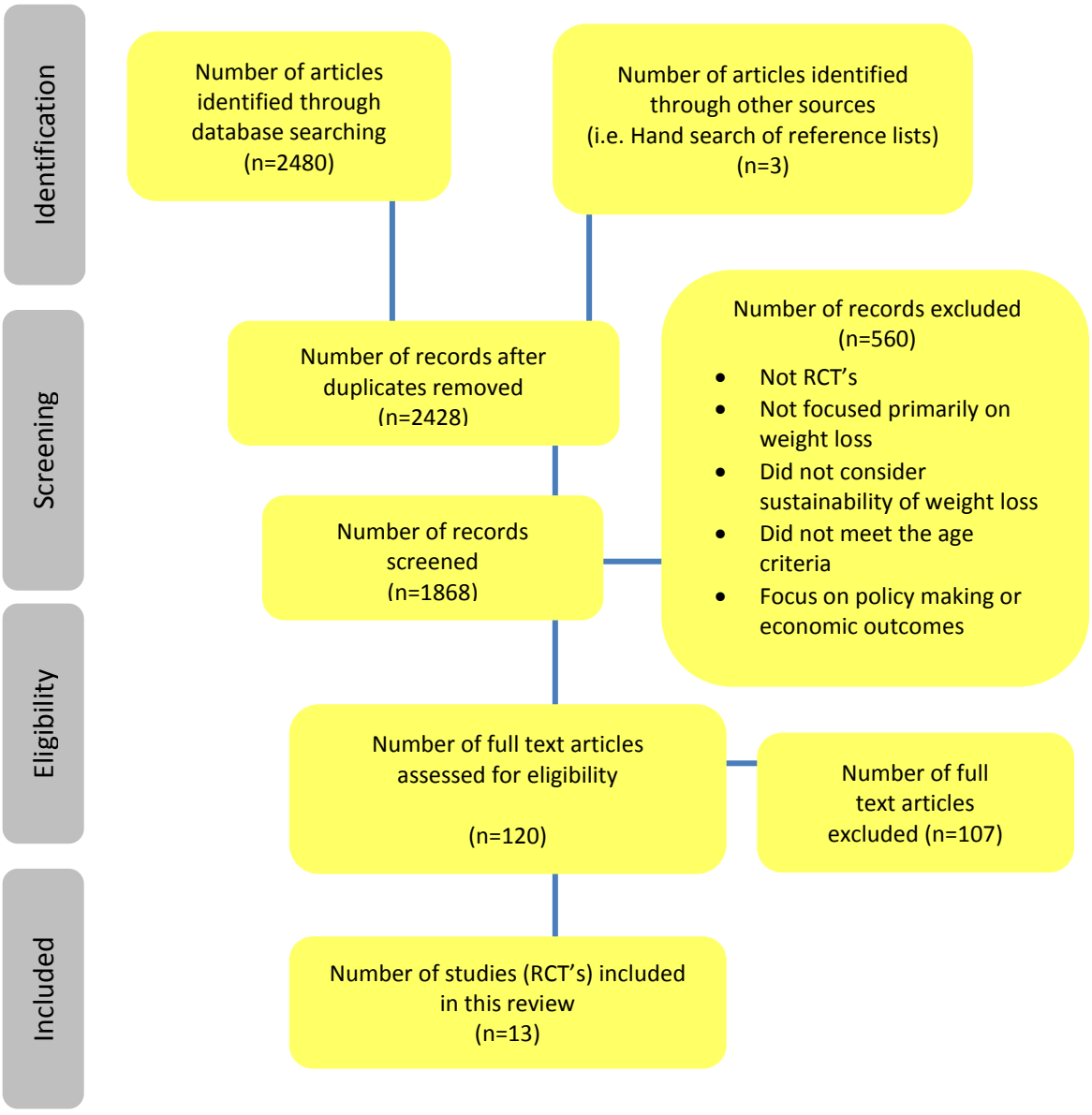

Table 1 Descriptive data of studies included in this paper, at baseline & dropout rates

Reference	Study type	Number	sex	age	Intervention	Intervention programme (maintenance)	Mean Body weight (kg)	Mean BMI (kg/m^2)	Dropout rate %	Length of treatment (weeks)	Follow-up (months)
1. Appel et al. 2011, USA[18]	RCT	347	M/F	54 (M)	BT	a) Internet delivered lifestyle intervention; b) Inpatientsupport including working with weight loss coaches focusing on weight management behaviours, motivational interviewing techniques; c) Control group received brochures and a list of websites.	103.8	36.6	16.4	156	24
2. Borg et al.2002,[19] Finland	RCT	46	M	35-50	Diet & exercise.	a) Resistance training + group meetings; b) Walking + group meetings; c) Group meetings.	106.0	32.9	24	2 months weight reduction + 6 months weight maintenance	24
3. Cooper et al.2010 [20], UK	RCT	129	F	20-60	BT.	a) New CBT group comprised 24, 50 min, one-to-one sessions; b) Modern BT (group) to help people change their eating behaviour & activity; c) Guided self -help was based on the LEARN programme to produce permanent change in 5 areas: lifestyle, exercise, attitudes, relationships & nutrition	94.04	34.69	14	44	36
4. Gagnon et al. 2011[21], Canada	RCT	41	M/F	54-58	BT/Lifestyle change	a) Counselling & seminars group received lifestyle intervention; b) Versus seminars only group who received input on diet, exercise, behaviour modification.	97.4	35	14.6	25	12
5. Hersey et al 2012,[22] USA	RCT	486	F	18-24	CB	a) Written materials including the Ehealth tools(internet component); b) Written materials including an interactive version of Ehealth that provided tailored computerized feedbacks; c) Written materials+ interactive web access & added telephonic coaching support.	100.5	33.6	10.70	78	18
6. Latner et al.2013,[23] USA	RCT	90	M/F	20-70	BT	a) All participants were provided with a maintenance manual of behavioural strategies & skills; b) Continuing care participants were trained to guidemutually supportive groups of their peers in their joint efforts to maintain weight loss.	97.64	35.80	41	26 + follow up care	18
7. Merlin et al. 2003[24], Sweden	RCT	32	M/F	25-60	BM	a) Intensive treatment, focusing on self-monitoring, education in nutrition, food habits & strategies to control eating behaviour; b) Less contact with supervisors, fewer repetitions with self-monitoring & less possibility with nutritional counselling.	97	35.1	26	104	24
8. Perri et al.2001[25],, USA	RCT	58	M/F	21-60	BT	a) Relapse prevention therapy (RPT); b) Problem solving therapy; c) No intervention control.	96.49	35.83	14	20 + follow up care	24
9. Svetkey et al.2008[26], USA	RCT	964	F	-	BT	a) Monthly personal contact; b) Unlimited access to an interactive technology intervention; c) Self-directed control.	96.7	34.1	6.3	24+ follow up care	30
10. Wadden et al. 201 1[27], USA	RCT	336	M/F	51(M)	Lifestyle Counselling	a) Usual care scheduled for quarterly primary care provider (PCP) visits to address coexisting illnesses; b) Brief lifestyle counselling scheduled for the same quarterly PCP visits as the usual care; c) Enhanced lifestyle counselling had the same PCP & counselling visits as those assigned to brief lifestyle counselling, they also chose to take sibutramine, orlistat or meal replacements.	107.7	38.5	42	104	24
11. Wadden et al. 2013[28], USA	RCT	422	M/F	45.9 (M)	Lifestyle Counselling, Liraglutide 3.0mg/	a) Liraglutide 3.0mg daily with lifestyle counselling & physical activity; b) Placebo (subcutaneous administration.	106.7	38.2	27.7	56	14
12. West et al.2011[29], USA	RCT	289	F	30+	Motivation focused or skill based.	a) The skill-based intervention focus on new skill topics including reversing small weight gains, improving body image and self-esteem, and expanding exercise options; b) The motivation- focused maintenance weight programme progressed to employ strategies derived from motivational theories/methods ; c) Control.	NR	36	14.49	24 + follow up care	18
13. Whitham et al.2013[30], UK	RCT	56	M/F	30-70	All meal provision or self-directed diet.	a) Meal provision to meal provision; b) Meal provision to self-directed diet; c) Self-directed to meal provision; d) Self-directed to self-directed.	87.0	30	34.88	24 + follow up self- care	52

NR=not reported. BMI=body mass index. BT=Behavioural Therapy. CB= Cognitive Behavioural. BM= Behavioural Modification.