Effectiveness of male-only weight loss and weight loss maintenance interventions: a systematic review with meta-analysis

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Summary

The objectives of this systematic review were to investigate the effectiveness of male-only weight loss and weight loss maintenance interventions and to identify intervention characteristics associated with effectiveness. In May 2011, a systematic literature search with no date restrictions was conducted across eight databases. Twenty-four articles describing 23 studies met the eligibility criteria. All studies included a weight loss intervention and four studies included an additional weight loss maintenance intervention. Study quality was mostly poor for weight loss studies (median = 3/10, range = 1-9) and weight loss maintenance studies (median = 3.5/10, range = 1-6). Twenty-three of 31 individual weight loss interventions (74%) from the eligible studies were considered effective. Meta-analysis revealed a significant difference in weight change favoring weight loss interventions over no-intervention controls at the last reported assessment (weighted mean difference -5.66kg [-6.35,-4.97] Z=16.04 [P<0.00001]). Characteristics common to effectiveness were: younger sample (mean age ≤ 42.8 years), increased frequency of contact (> 2.7 contacts/month), group face-to-face contact and inclusion of a prescribed energy restriction. Preliminary evidence suggests men-only weight loss programs may effectively engage and assist men with weight loss. However, more high quality studies are urgently needed to improve the evidence base, particularly for maintenance studies.

Keywords: weight loss, weight loss maintenance, men, systematic review

Introduction

Men who are overweight or obese are widely recognized as a hard to engage, yet high-risk group for obesity-related chronic disease (1, 2). Despite estimated global prevalence rates of obesity almost doubling for both men (4.8% to 9.8%) and women (7.9% to 13.8%) over the past 30 years (3), males remain less likely to perceive themselves as overweight (4), attempt weight loss or participate in weight loss programs (2, 5, 6). Men are also more likely than pre-menopausal women to store excess fat abdominally (4), which independently increases the risk of many obesity-related diseases including type 2 diabetes, cardiovascular disease, dyslipidemia, hypertension, the metabolic syndrome (7) and some cancers (8). To compound these problems, many people who lose weight are poor at sustaining weight loss long-term (9) and most men will return to their baseline weight within five years post treatment (10). This demonstrates a clear and urgent need to identify evidence-based approaches and program components that can effectively engage men in initial weight loss and successful long-term weight loss maintenance.

Providing evidence-based strategies to weight loss for males is difficult as men are consistently underrepresented in weight loss research. For example, in a systematic review of 80 weight loss trials of at least 12 months duration (published between 1997 and 2004), the average proportion of male participants per study was only 27% (11). Further, only three of the 80 studies (4%) had male-only groups compared to 19 (24%) that were female-only. Another recent systematic review of web-based weight loss interventions identified that at least 77% of 5700 included participants were female (12). A possible explanation for this difference is that men want weight loss programs with participants they can relate to (2, 13) and may feel uncomfortable signing up to programs where the majority of participants are women (2, 14). Regardless of the reasons, it is clear that treatments available to men are currently informed by weight management studies that have been largely conducted in

females (5, 15, 16). Studies that are male only and/or include programs tailored specifically for men are needed to determine which treatment approaches and strategies are linked to successful weight loss and long-term weight loss maintenance in men.

The aim of this systematic review was to synthesize the current evidence of the effectiveness of weight loss and weight loss maintenance interventions that recruited men only, in order to encourage and inform future research into weight management treatments for men. A secondary aim of this review was to identify the characteristics of male-only interventions that were associated with successful outcomes.

Methods

The conduct and reporting of this review adhered to the guidelines outlined in the *Preferred Reporting Items for Systematic Reviews and Meta-analysis* (PRISMA) Statement (17).

Eligibility criteria

Types of participants: Males aged 18-65 years who were overweight or obese by recognized criteria at baseline (e.g. World Health Organization BMI cut offs or ≥ 120% of ideal weight for height). *Types of intervention*: Weight loss or weight loss maintenance interventions with clear intent to change behavior or lifestyle. *Types of primary outcome measures*: Weight change or weight at baseline and a minimum of one post-intervention time point, reported in kilograms or pounds. *Types of studies*: Experimental trials investigating the impact of weight loss or weight loss maintenance treatments.

Studies were excluded if they met any of the following criteria: (i) participants were targeted groups with diagnosed complications linked to obesity (e.g. type II diabetes) or were from special populations (e.g. people with severe mental illness, people with eating

disorders); (ii) the intervention involved bariatric surgery, anti-obesity medication, or a supervised exercise or dietary regime employed primarily to investigate the effect of weight loss on other outcomes; or (iv) the study was published in a language other than English.

Information sources and search

Studies were identified by searching electronic databases and scanning reference lists of included articles. The search was applied to CINAHL, EMBASE, MEDLINE, PsycINFO, and PubMed and was adapted for SportDiscus, SCOPUS and Web of Science. No publication date restrictions were imposed in any database and the last search was completed in May 2011. Search terms were divided into three groups: (i) population (e.g. overweight OR obes*); (ii) study design (e.g. intervention OR random*) and (iii) intervention type (e.g. weight loss OR obesity treat*). The Boolean phrase 'AND' was used between groups and the phrase 'OR' was used within groups. Articles with the terms 'women' or 'female*' in the subject heading were excluded. Limits used were English language, male, journal article or review, human and adult (18-65 years of age). See Table S1 for the complete search syntax used for all databases.

Study selection

Following the search, the lead author (MDY) removed all duplicates and screened the titles and abstracts of remaining records for relevance in a non-blinded, standardized manner. A second author (PJM) checked all decisions and any disagreements were resolved by discussion. Full text articles were retrieved for all remaining records. Both authors (MDY and PJM) independently screened these articles for inclusion and exclusion with both reviewers conferring on differences to reach full consensus on all articles. Reference lists of included

studies were searched for additional eligible studies although none were identified. Figure 1 displays this selection process in more detail.

Data collection process

One reviewer (MDY) extracted data relating to methodology (e.g. design, sample size, treatment length), participant characteristics (e.g. mean age, mean BMI), intervention description (e.g. focus, mode of delivery, treatment intensity and frequency) and the intervention effect on weight. (i.e. mean weight or mean weight change, standard deviations and the number of participants included in the analysis). In a small number of cases the required statistics were not reported. If available, and if possible, other statistics (e.g. 95% confidence intervals) were converted to the required form according to the calculations outlined in the *Cochrane Handbook for Systematic Reviews of Interventions* (18).

Risk of bias in individual studies

Risk of bias was independently assessed by two reviewers (MDY and PJM) using a tool adapted from the Consolidated Standards of Reporting Trials (CONSORT) statement (19) and previously used quality criteria for methodology and reporting (20) (Table S2). Each item was scored as 'present' (✓), 'absent' (×) or 'unclear or inadequately described' (?). Disagreements were resolved by discussion. Following this, inter-rater reliability was calculated on a dichotomous scale (✓ vs. × or ?) using percentage agreement and Cohen's κ. Depending on the study design, some items were not applicable. These were scored as such (n/a) prior to assessment. Unweighted sum totals were calculated for each study using a pre-defined scoring system (✓ = 1 | × = 0 | ? = 0 | n/a = 0). Each study was then assigned a risk of bias category based on the following cut-offs: high risk (0-3), medium risk (4-7) or low risk (8-10).

Synthesis of results

The first aim was to investigate the effectiveness of male-only weight loss and weight loss maintenance interventions. To address this, data were first collated and described in a narrative summary with emphasis given to results from RCTs. In addition, results from weight loss interventions in RCTs with true controls (n = 7) were pooled in a meta-analysis using RevMan Analyses 5.1.2 (21). When a study compared multiple treatment groups to a single control (n = 2), the sample size of the shared control was split to avoid double counting (18). All results were continuous and reported on the same scale (kg) so the aggregate result was calculated as the weighted mean difference (WMD) between interventions and controls. Meta-analysis was not possible for weight loss maintenance treatments due to the small number of RCTs (n = 2).

The second aim was to determine which characteristics in male-only studies were commonly associated with effectiveness. Interventions were considered effective if participants achieved a mean weight loss of at least 5% by the final assessment, prior to any additional weight loss maintenance intervention. This represents clinically important weight loss and is linked to a reduction in weight-related morbidity (22, 23). Interventions were dichotomized a number of times according to whether or not they featured a particular characteristic (e.g. a prescribed energy restriction) and proportions of effective interventions in each group were compared. A particular characteristic was regarded as more (or less) related to effectiveness if the difference in proportions was at least 20%. Recently, Fjeldsoe and colleagues (24) used this approach in a systematic review of physical activity and dietary interventions. However, this analysis used a more conservative cutoff, as some interventions being compared were from the same study and may have shared some additional factors in common. Continuous characteristics (e.g. mean age of participants) were investigated by

dichotomizing interventions that were greater than or less than or equal to the median of all interventions.

Results

Study selection

The search provided a total of 3872 unique citations. From this, a total of 24 articles describing 23 studies were identified for inclusion. Figure 1 presents a flow diagram detailing the selection process.

Study characteristics

Table 1 displays selected characteristics of all eligible studies, representing 1869 participants. All studies tested a male-only weight loss intervention (25-48). Participants in four studies also received a maintenance of lost weight intervention (29, 40, 44, 48). For this review, all weight loss interventions are reported together, but the four maintenance interventions are reported separately. Each maintenance intervention received an individual risk of bias assessment, unrelated to the preceding weight loss intervention.

Five weight loss studies were published between 2010-2011 (31-33, 37, 38), nine between 2000-2009 (27, 29, 30, 34, 40-42, 45-47), eight between 1990-1999 (25, 26, 28, 36, 39, 43, 44, 48), and one in 1985 (35). The majority of studies were conducted in Australia (30, 32-34, 36, 43), the United States of America (25-28, 35, 44) and Japan (37, 38, 45-47). Remaining studies were tested in the United Kingdom (29, 42), Canada (41), Finland (40), Sweden (39) and the Netherlands (48).

Weight loss interventions were investigated using the following designs: randomized controlled trial (RCT, n = 12) (25-30, 32-37), pseudo-RCT (n = 1) (38) and pre-test/post-test (n = 10) (39-48). The active intervention periods ranged from 3 weeks to 24 months. Eleven

interventions ranged from 3-4 months (25, 28-30, 32-34, 38, 42, 45, 48), five ranged from three weeks to 2 months (27, 35, 37, 40, 43, 44), five ranged from 11.5-12 months (26, 36, 41, 46, 47) and one was 24 months (39). Participant follow-up, defined as the length of time after post-test assessment, was included in four weight loss studies (30, 33, 37, 43) and ranged from 3 months (33) to 21 months (43) (median length of follow-up: 7.5 months).

Table 1 also displays the characteristics of the weight loss maintenance interventions, which followed four previously described weight loss interventions (29, 40, 44, 48). Two interventions used a pre-test/post-test design and two were RCTs where participants were randomized to either weight loss maintenance or to no intervention groups after the conclusion of a weight loss phase (40, 48).

Risk of bias within studies

Table 2 displays the risk of bias assessments for all studies. Inter-rater reliability metrics for the quality assessments indicated substantial agreement for all 266 items (percentage agreement 98%, $\kappa = 0.96$). Quality scores varied, but were mostly poor for both weight loss studies (median score = 3, range = 1 - 9) and weight loss maintenance studies (median score = 3.5, range = 1 – 6). Three weight loss studies met the criteria to be considered at low risk of bias (30, 32, 33) and these were all from the same research group. No maintenance studies met the criteria.

For weight loss trials, only seven studies (30%) used intention-to-treat analysis (27, 29, 30, 32, 33, 37), five studies (22%) accounted for confounders in the analyses (30, 32-34, 38) and five studies (22%) provided a power calculation and were adequately powered (27, 29, 32, 33, 42). Fourteen studies (61%) met the criteria for adequate retention rates (dropout $\leq 20\%$ for ≤ 6 month follow-up and $\leq 30\%$ for > 6 month follow-up) (26, 27, 30, 32-34, 36-38, 40, 43, 45, 47, 48) and 14 studies (61%) assessed weight status at least 6 months after

baseline assessments (26, 29, 30, 33, 36, 37, 39-41, 43, 44, 46-48). Twenty-one studies (91%) reported measuring weight objectively (25-30, 32-42, 45-48). However, only one study (4%) reported assessor blinding at all time points (30) and only three RCTs (25%) described the randomization procedure in sufficient detail (30, 32, 33).

Two weight loss maintenance studies had quality assessments indicating a high risk of bias (29, 44) and two were at moderate risk of bias (40, 48). None of the maintenance interventions reported assessor blinding or used intention-to-treat analysis, and neither of the RCTs described the randomization process sufficiently. Three studies included sufficient follow-up (40, 44, 48), but only two reported adequate retention rates (40, 48). As mentioned above, these scores relate specifically to the maintenance interventions in studies that also included a weight loss intervention.

Effectiveness of male only interventions aiming to achieve weight loss

Summary of evidence from RCTs

Table 3 shows the weight loss results for all male-only weight loss studies. Results from the 12 RCTs will be discussed in detail, as these are considered the gold standard for experimental research (19). The first RCT with a low risk of bias (30) investigated the effectiveness of a weight loss program with internet support and dietary feedback to a minimal intervention, resources-only control. Both study arms received one group information session. No difference was observed between the groups at 3-month follow-up (-5.3 [5.7] vs. -3.5 [5.9], $P = 0.23$) or 9-month follow-up (-5.3 [6.4] vs. -3.1 [6.7], $P = 0.41$). However, at both 3- and 9-month follow-up, both groups weighed significantly less than at baseline ($P < 0.001$).

In the second low-risk of bias RCT (32), male shift workers were provided with a weight loss information session, a resources package, and access to a diet and exercise self-

monitoring website. E-feedback on diet and exercise was provided on seven occasions. At post-test, the intervention group demonstrated significantly greater mean weight loss compared to the control group (3.5 month: -4.0 [4.4] vs. 0.3 [3.0], $P < 0.001$).

The third RCT with a low-risk of bias (33) investigated a weight loss program targeting fathers of children aged 5-12 years. The intervention involved five information sessions and three active sessions where fathers participated in various physical activities with their children. At post-test, the intervention group showed a significantly greater mean weight loss compared to the control group (3-month: -6.7 [3.9] vs. -0.4 [3.7], $P < 0.001$) and this difference was greater at 3-month follow-up (-7.6 [4.0] vs. 0.0 [3.7], $P < 0.001$).

Seven of the remaining nine RCTs included at least one intervention with a prescribed energy restriction. Three studies compared these dietary interventions to a no intervention or wait-list control group and reported similar results. In the first RCT (26), participants receiving a reduced energy diet lost significantly more weight on average than those in a no intervention control group (12 month: -6.68 [3.94] vs. 0.38 [3.66], $P < 0.001$). Another RCT (29) observed no significant difference at 3-month post-test between a reduced energy diet group and a low energy diet group (-4.6 [3.4] vs. -5.6 [3.7], $P = 0.22$), with both demonstrating significantly greater weight loss than a wait-list control. A third RCT compared the effects of a stepped intervention with three components (reduced energy diet alone vs. reduced energy diet plus aerobic exercise vs. reduced energy diet plus aerobic exercise plus resistance training) to a no intervention control (28). After 3 months, a significantly greater weight loss was observed for all interventions compared to the control ($P < 0.05$) with no significant difference observed between interventions.

Two RCTs investigated the effectiveness of weight loss programs against usual care control groups. One identified a significant weight loss effect in both a reduced energy diet intervention and a physical activity intervention against the control ($P < 0.05$), with

participants in the reduced energy diet condition losing significantly more weight on average than those in the physical activity condition (36). The second was conducted onboard a Navy vessel and investigated the additional effect of a reduced energy diet and lifestyle modification program to the Navy's standard fitness program (25). At post-test, average weight loss in the intervention group was significantly greater than in the control (4 month: -8.6 [5.0] vs. -5.0 [4.1], $P < 0.05$).

Three RCTs investigated dietary approaches to weight loss without using a control group (27, 34, 35). Although all groups demonstrated a significant time effect for weight loss, no studies identified a significant difference between groups at post-test. One of these investigated the effectiveness of a low energy diet with partial meal replacements to a low energy diet without meal replacements (27). The second RCT compared a low fat dietary condition to a dietary condition where participants had set daily fruit and vegetable targets (34). The third RCT originally randomized participants to eight study arms (one of two low energy diets or one of two very low energy diets, with or without physical activity). However, in reporting results the study arms were collapsed into two groups and no difference was observed between diet and exercise groups vs. diet without exercise for weight loss.

Meta-analysis of male-only weight loss interventions vs. true control groups

Results from RCTs with true control groups were pooled in a meta-analysis to establish the overall effect of male-only weight loss interventions compared to no-intervention controls (Figure 2). Three interventions from a study at high risk of bias were excluded . Included interventions were sufficiently homogenous ($\chi^2 = 9.89$, d.f. = 6 [$P = 0.13$], $I^2 = 39\%$), so the fixed effects model was used. This revealed a significant difference in weight change favoring interventions over controls at the last reported assessment prior to any additional maintenance intervention (WMD -5.66 [-6.35, -4.97] $Z = 16.04$ [$P <$

0.00001]). A funnel plot to assess publication bias was not generated as fewer than 10 interventions were included in the meta-analysis(18).

Summary of evidence from other weight loss trials

Table 3 also displays results from the 11 male-only weight loss trials that did not use an RCT design. Results from these studies must be considered with caution, as the overall quality of these studies was low (median = 2, range = 1 – 4). Most studies investigated lifestyle interventions (38, 39, 43, 44, 47) or dietary interventions (40, 42, 45). Despite varying considerably in the approach, duration and intensity of contact, almost all intervention groups recorded a significantly reduced mean weight at post-test compared to baseline.

Effectiveness of male-only interventions aiming to achieve weight loss maintenance

Table 3 summarizes the results from specific weight loss maintenance interventions. The small number of heterogeneous studies, including only two RCTs, limits investigation into the effectiveness of maintenance interventions. The first RCT investigated the impact of a walking or resistance training exercise program on weight maintenance versus a control group (40). After the 6-month intervention, weight regain was significant but comparable across all groups and this was also evident at 23-month follow-up. The second RCT also investigated the impact of an exercise program for weight maintenance (48), however, participants in the maintenance intervention demonstrated significant and comparable weight regain to those in the control group after the 12-months.

Components of male only weight loss interventions that are commonly associated with effectiveness

Thirty-one individual interventions were identified from the 23 weight loss studies identified in this review. The mean weight loss for these interventions ranged from 3% (36) to 13.5% (40) (median loss: 6.25%). One intervention group gained weight during the study (+0.4%) (47). Twenty-three interventions (74%) were considered effective based on a mean weight loss ≥ 5% at the final weight loss phase assessment. Using the approach from a recent systematic review (24), a number of characteristics that were commonly associated with effectiveness were identified (Table 4).

Eighty-seven percent of interventions with a mean age less than or equal to the median for all interventions (42.8 years) were effective compared to 60% of interventions with a mean age greater than the median. Frequency of contact was strongly related to effectiveness whereas intervention length and the total number of contacts were not. Ninety-three percent of interventions with greater than the median (2.7 contacts per month) were effective compared to 56% of interventions with less contact per month.

Including a prescribed energy restriction in the weight loss intervention was strongly related to effectiveness. Eighty-nine percent of interventions with a prescribed energy restriction achieved ≥ 5% weight loss compared to 46% that did not. When considering the dietary approach, all interventions that prescribed a very low energy diet were effective, eight of nine low energy diet interventions and four of five reduced energy diet interventions were also considered effective. Studies that used a group face-to-face mode of delivery were more often effective (85%) than those that did not (55%). The proportion of effective interventions did not differ substantially between those that did or did not include individual face-to-face contact, a set physical activity program or written health resources.

Several other characteristics of interest could not be investigated as they were not observed in sufficient interventions to allow for meaningful comparisons. For example, only three interventions used email contact as a mode of delivery (30, 32, 37), five studies used

interventions that were tailored for men (30, 32, 33, 39, 43) and three interventions were based on a theoretical framework (30, 32, 33).

Discussion

This is the first systematic review of overweight and obesity treatment studies that recruited men only. The aims of this review were: (i) to investigate the effectiveness of male-only weight loss and weight loss maintenance interventions and (ii) to identify which intervention characteristics were commonly associated with effectiveness. Twenty-three eligible weight loss studies were identified, four of which also included a subsequent weight loss maintenance intervention. Twelve weight loss interventions (52%) and two maintenance interventions used an RCT study design. Despite this, the overall risk of bias across studies was high. Using van Sluijs *et al.*'s flow chart for levels of evidence (20), this review demonstrates the evidence base for the effectiveness of male-only weight management programs is 'limited' (three small, high quality RCTs demonstrating consistent, positive results).

Trialing men-only weight management interventions is clearly a new and developing area of research. Although the earliest trial identified in this review was conducted in 1985 (35), more than 60% were conducted since 2000. These studies included interventions that varied greatly in treatment approach, duration, mode of delivery and intensity of contact. Despite these differences, a common limitation is the absence of participant follow-up beyond immediate post-test assessment. This was true for most weight loss interventions (25-28, 32, 34-36, 38, 39, 41, 42, 45-47) and weight loss maintenance interventions (29, 44, 48).

Effectiveness was assessed using a number of approaches. Meta-analysis revealed a favorable weight loss effect for participants in male-only weight loss interventions when compared to non-intervention control groups. The weighted mean difference between groups

of -5.66 kg [-6.35, -4.97] is comparable to that of another meta-analysis investigating dietary and behavior change weight loss approaches for both men and women (15). The intervention groups from the three RCTs with a low-risk of bias demonstrated a significant time effect for weight loss, with two of these three considered effective based on reporting a mean weight loss ≥ 5% by the final assessment (which ranged from 3.5 months to 12 months post-baseline) (30, 33). These three studies all investigated lifestyle modification programs and were conducted by the same research group (30, 32, 33).

When considering the totality of the evidence, 19 of the 23 weight loss studies included in this review (83%) included at least one group that was deemed effective. Although this appears promising, these results are undermined by the generally low study methodological quality of studies, indicating an increased risk of bias, and should be interpreted with caution. Sixteen studies did not use intention-to-treat analysis (70%) and nine studies (39%) did not achieve adequate retention rates of ≤ 20% dropout for ≤ 6-month follow-up (and ≤ 30% dropout for > 6-month follow-up). These factors are likely to bias the results by inflating both the success rate of participants and the magnitude of weight loss, as participants who drop out of weight loss studies may do so due to lack of success or unwillingness to follow the prescribed intervention (49). Despite this, the average participant dropout rate for studies in this review (22%) was lower than that reported in another review of behavioral weight loss studies (32%) (50). The high proportion of effective studies identified in this review may also be related to publication bias, as studies with positive results may be more likely to be submitted or accepted for publication (51).

Insights into the effectiveness of male-only weight loss maintenance studies were limited by the lack of available research. Preliminary data from the two RCTs (40, 48) suggest that exercise alone may not be sufficient to achieve weight loss maintenance in men. However, it was unclear whether these studies were adequately powered to detect differences

in weight regain between intervention and control groups and both studies reported difficulties with participant compliance. Poor adherence to physical activity protocols has been proposed previously as a key confounder of weight loss maintenance treatment effects (52). Evidence from future high quality and rigorously designed weight loss maintenance trials is needed to determine which intervention approaches and components can help men achieve long-term weight loss success.

This review identified several characteristics of interventions that may be linked to effectiveness in male-specific weight loss studies. These were: a prescribed energy restriction, inclusion of group face-to-face contact, higher frequency of contact (> 2.7 contacts/month) and a younger sample (mean age ≤ 42.8 years). It is important to note that not all interventions were designed to experimentally investigate these characteristics and some interventions with a particular characteristic may have other shared factors in common, particularly interventions from the same study or research group. To adjust for this, a conservative cut off was used, than that of a previous study (24), to identify characteristics linked to effectiveness.

For this review, a weight loss intervention was defined as effective if the group demonstrated a mean weight loss of at least 5% by final assessment prior to a maintenance intervention. However, it is reasonable to assume that tracking participants over a long period of time would provide a more realistic indication of an intervention's effectiveness. Further, it is possible that different treatment approaches (e.g. diet-only, exercise-only, combined lifestyle modification programs) and different treatment intensities may be more or less conducive to maintenance of lost weight. This could not be explored in the current review due to the heterogeneity of interventions. It is critical that future interventions include long-term follow-up in order to establish the long-term and more realistic effectiveness of the various approaches to weight loss in men.

Considering that men may be more likely to engage in male-only weight loss programs (2, 13), it would be of interest to compare the recruitment and overall success of men in male-only programs to men in mixed-sex programs. However, this was beyond the scope of this review. Of interest, only five included studies tested 'gender-sensitive' weight loss interventions (i.e. tailored for men) (30, 32, 33, 39, 43), whereas the majority trialed a standard, gender-neutral weight loss program. A similar proportion of 'gender sensitive' programs was identified in a recent systematic review of health promotion interventions targeting men (53). Further evidence is needed to determine whether providing gender specific approaches to weight loss for males is more or less effective than a standardized approach.

Strengths and limitations

This review had several strengths: a comprehensive search strategy across multiple databases with no date restrictions, high agreement levels for quality assessments, and detailed data extraction to allow for comparisons between studies. The conduct and reporting of this review also aligned with the PRISMA statement for transparent reporting of systematic reviews and meta-analyses (54).

This review also had some limitations that should be acknowledged. Firstly, studies were required to be published in English and in a prominent database. In addition, this review reported on a relatively small and heterogeneous sample of studies. Due to this, any synthesis of results must be interpreted with caution. Finally, this review reported on weight outcomes and did not present results relating to other obesity-related health outcomes such as waist circumference, blood pressure or body composition.

Conclusions

Implications for practice

Currently, the evidence base for male-only weight management programs is limited in both quantity and quality. However, the existing evidence suggests that men-only weight loss programs may be an effective way to engage and assist men with weight loss. Preliminary evidence suggests that weight loss interventions with men only are more likely to be successful if they include any prescribed energy restriction within the dietary intervention, group face-to-face contact and close to three contacts per month.

Implications for research

To improve the current evidence base for male-only weight loss and weight loss maintenance approaches, future studies should use a randomized controlled design and adhere to the guidelines outlined in the CONSORT statement. Further, all research should include follow-up assessments over a substantial period of time after the intervention has finished (a minimum of one year but ideally for a number of years). Although this places additional burdens on participants, researchers and resources, this evidence is essential. More evidence is needed to determine which components of weight loss maintenance programs are linked to successful, long term weight loss outcomes in men. A standard timeframe is required to guide when a weight loss intervention ceases and the maintenance intervention begins. Preferably, this maintenance intervention should extend for a number of years. Finally, future research should investigate whether there is a difference in recruitment, retention and success rates of male participants in 'gender sensitive' programs compared to those that provide a standard weight loss program to a male-only or mixed-sex population.

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Table 1 Intervention characteristics of male-only weight loss and weight loss maintenance interventions

Study	Length (months)	Mode	Treatment Intensity (contacts)					Freq*	Description
			Total	M	PA	E	Ph		
Weight Loss*: *Randomized Controlled Trials									
Dennis *et al.* (1999) (25)	4	(a) F2F (Group) + resources	80	*16*	*64*	-	-	20	(a) **Diet**: RED (500 kcal daily deficit; 50-55% carbohydrate, <20% protein, <30% fat) + **Cognitive-behavioral (CB):** Dietary advice, non-descript behavior modification & cognitive control techniques, weight & diet self-monitoring + **Physical Activity (PA)**: Aerobic exercise sessions. (b) *Usual care control*: **PA**: as in (a) [usual navy training routine]
		(b) F2F (group)	64	-	*64*	-	-	16	
Frey-Hewitt *et al.* (1990)† (26)	11.5	(a) F2F (group) + F2F (ind)	20	*20*	-	-	-	1.7	(a) **Diet:** RED (300-500 kcal daily deficit; macronutrient composition maintained) + **CB:** Dietary advice, goal setting, weight & dietary self-monitoring. (b) *No intervention control*.
		(b) n/a (control)	-	-	-	-	-	-	
Hannum *et al.* (2006) (27)	2	(a) F2F (group)	8	*8*	-	-	-	4	(a) **Diet:** LED (approx. 1700 kcal/day; 55% carbohydrate, 25% protein, fat 20%) based on the *Food Group Pyramid* + **CB:** Straightforward instruction & information. Weight self-monitoring. (b) **Diet:** as in (a), however pre-packaged meals provided for lunch & dinner + **CB:** As in (a).
		(b) F2F (group)	8	*8*	-	-	-	4	
Kraemer *et al.* (1999) (28)	3	(a) F2F (group)	12	*12*	-	-	-	4	(a) **Diet:** LED (1600 kcal/day) with partial meal replacements + **CB:** dietary advice, non-descript behavior modification, weight & dietary self-monitoring with feedback. (b) **Diet:** LED (1400 kcal/day) with partial meal replacements **+ CB:** As in (a) + **PA**: Aerobic exercise sessions. (c) **Diet:** as in (b) **+ CB:** As in (a) + **PA**: As in (b) + strength training. (d) *No intervention control*.
		(b) F2F (group)	48	*12*	*36*	-	-	16	
		(c) F2F (group)	48	*12*	*36*	-	-	16	
		(d) n/a (control)	-	-	-	-	-	-	

Leslie *et al.* (2002)‡ (29)	3	(a) F2F (ind) (b) F2F (ind) (c) n/a (control)	6 6 -	*6* *6* -	- - -	- - -	- - -	2 2 -	(a) **Diet:** RED (600 kcal daily deficit; >50% carbohydrate, <35% fat, <20% protein) + **CB**: Dietary education. (b) **Diet:** LED (1500 kcal/day; >50% carbohydrate, <35% fat, <20% protein) + **CB**: As in (a) (c) *Wait-list control*.
Morgan *et al.* (2009) (30, 31)	3	(a) F2F (group) + online + resources (b) F2F (group) + resources	8 1	*1* *1*	- -	*7* -	- -	2.7 0.3	(a) **CB:** Instruction on modification of dietary & PA habits tailored for men, website to self-monitor weight, diet & PA, individualized diet feedback (emailed). (b) *Minimal intervention control*: **CB**: as in (a), without website or dietary feedback.
Morgan *et al.* (2011a) (32)	3.5	(a) F2F (group) + online + resources (b) n/a (control)	8 -	*1* -	- -	*7* -	- -	2.3 -	(a) **CB:** Education on energy balance tailored for shift-workers, weight loss tips for men, self monitoring, goal setting & social support & group based monetary incentives. (b) *Wait list control*.
Morgan *et al.* (2011b) (33)	3	(a) F2F (group) + online + resources (b) n/a (control)	8 -	*5* -	*3* -	- -	- -	2.7 -	(a) **CB:** Education on reducing health risks via behavior change & importance of role modeling healthy behavior to kids + **PA**: '*Father & child/ren*' activity sessions. (b) *Wait list control*.
Nowson *et al.* (2005) (34)	3	(a) F2F (ind) + telephone + resources (b) F2F (ind) + telephone + resources	6 6	*4* *4*	- -	- -	*2* *2*	2 2	(a) **Diet:** Non-prescriptive, modified DASH diet with targets for fruit, vegetable & dairy + **CB:** PA & diet goal setting, written material given with tips to encourage compliance + **PA**: Self-driven PA required for all/most days (30-min moderate intensity). (b) **Diet:** Non-prescriptive, low fat diet with general guidelines on increasing fruit and vegetables & reducing fat + **CB & PA**: as in (a)
Pavlou *et al.* (1985) (35)	2	(a) F2F (group) (b) F2F (group)	8 32	*8* *8*	- *24*	- -	- -	4 16	(a) **Diet**: One of the following dietary conditions (all conditions collapsed in analysis): LED (1000 kcal/day), VLED (800 kcal/day) or VLED (420 kcal/day) + **PA**: Combination of endurance interval training (walk, jog, run) & resistance training + **CB**: Diet & PA self monitoring, nondescript behavior modification, general nutrition education. (b) **Diet & CB**: as in (a).

Pritchard *et al.* (1997) (36)	12	(a) F2F (ind) + resources	12	*12*	-	-	-	1	(a) **Diet:** RED (500 kcal deficit¶; 22-25% fat) + **CB:** Compliance review, barriers discussed.
		(b) F2F (ind) + resources	12	*12*	-	-	-	1	(b) **PA**: Self-selected aerobic exercise regime (65-75% max heart rate encouraged) + **CB:** As in (a).
		(c) F2F (ind)	12	*12*	-	-	-	1	(c) *Usual care control*: Assistance to maintain pre-study dietary & PA habits
Tanaka *et al.* (2010) (37)	1	(a) Online + resources	2	-	-	*2*	-	2	(a) **CB:** Weight & behavior self-monitoring, computerized feedback with advice on changing behaviors.
		(b) Resources	0	-	-	-	-	0	(b) *Minimal intervention control*: **CB:** Weight control booklet only.
Weight loss*: *Pseudo-randomized Controlled Trials									
Matsuo *et al.* (2010) (38)	3.5	(a) F2F (group) + F2F (ind)	16	*14*	*2*	-	-	4.6	(a) **Diet:** LED (1680 kcal/daily) based on the *Four-Food-Group* method + **PA**: Basic instruction, walking & light resistance training + **CB**: Diet & weight self monitoring, dietary feedback.
		(b) Indirect	0	-	-	-	-	0	(b) No direct intervention, but the men's partners received the intervention described in (a).
		(c) F2F (group)	1	*1*	-	-	-	0.3	(c) *Minimal intervention control*: Basic information on improving metabolic syndrome status.
Weight loss:* *Pre-test/post-test Trials									
Andersson *et al.* (1997) (39)	24	(a) F2F (group)	104	*104*	-	-	-	4.3	(a) **Diet**: LED (1600 kcal/day) encouraged + **PA**: Offered physical training sessions + **CB**: Self-monitoring, stimuli control, eating techniques, reinforcement, cognitive restructuring, education on nutrition & benefits of PA, importance of social support, goal setting. Program tailored for men.
Borg *et al.* (2002)‡ (40)	2	(a) F2F (group)	8	*8*	-	-	-	4	(a) **Diet**: LED (1200 kcal/day; week 1 & 8) with meal replacements and VLED (500 kcal per day; weeks 2-7) with meal replacements + **CB**: Weight self-monitoring, dietary instruction, education on weight maintenance, relapse prevention strategies.
Di Marzo *et al.* (2009) (41)	12	(a) F2F (ind)	24	*24*	-	-	-	2	(a) Nondescript personalized nutritional & physical activity exercise management program.

Drummond *et al.* (2004) (42)	3	(a) F2F (ind) + resources	1	*1*	-	-	-	0.3	(a) **Diet**: RED (600-700 kcal daily energy deficit; low fat, high carbohydrate, sugar containing diet) + **CB**: Dietary advice, social support strategies.
Egger *et al.* (1996) (43)	1.5	(a) F2F (group) + resources	6	*6*	-	-	-	4	(a) **Diet**: Not prescriptive, encouraged to reduce fat intake & increase fiber intake + **CB**: Education on energy balance, benefits of incidental PA, goal setting, 'trading off' alcohol for extra movement. Program tailored for men.
James *et al.* (1998)‡§ (44)	0.75	(a) F2F (group)	60	*40*	*20*	-	-	80	(a) **Diet**: Not prescriptive, but shown how to eat regular, healthy meals/snacks + **PA**: Aerobic exercise sessions (walking, cycling, and swimming). Encouraged to exercise at 60-75% max heart rate + **CB**: realistic goal setting, importance of self monitoring, healthy lifestyle education, relaxation (3 week intensive program).
Maeda *et al.* (2006) (45)	3	(a) F2F (group)	13	*13*	-	-	-	4.3	(a) **Diet:** LED (1680 kcal/day; 50% carbohydrate, 25% protein, 25% fat) + **CB:** Nutritional advice & dietary self-monitoring.
Miyatake *et al.* (2002) (46)	12	(a) Resources	0	-	-	-	-	0	(a) **PA**: Instruction to increase average daily step count by 1000 steps & maintain the increase for 1 year (given a pedometer) + **CB**: Goal setting.
Nakanishi *et al.* (2000) (47)	12	(a) F2F (group)	2	*2*	-	-	-	0.2	(a) **CB:** Education on controlling body weight, reducing alcohol intake, considering a nutritional balance.
Pasman *et al.* (1999)‡ (48)	4	(a) F2F (group)	61	-	*61*	-	-	15.3	(a) **Diet**: 2-month VLED (480 kcal/day), ad libitum diet for last 2 months + **PA**: Endurance training program (running/cycling at moderate intensity for 60-min).
Weight Loss Maintenance: *Randomized Controlled Trials*									
Borg *et al.* (2002) (40)	6	(a) F2F (group) + resources	104	*26*	*78*	-	-	17.3	(a) **Diet**: Ad libitum, high carbohydrate, low fat weight maintenance diet + **PA**: Walking sessions at 60-70% of VO2max. + **CB**: Barriers to diet discussed, relapse prevention strategies covered. (b) **Diet & CB**: as in (a) + **PA**: Resistance training at 60-80% of rep maximum with 8 reps & 3 sets per exercise. (c) **Diet & CB**: as in (a).
		(b) F2F (group) + resources	104	*26*	*78*	-	-	17.3	
		(c) n/a (control)	-	-	-	-	-	-	

Pasman *et al.* (1999) (48)	12	(a) F2F (group) (a) n/a	182 -	- -	*182* -	- -	- -	15.3 -	(a) **PA**: Continuation of PA program from weight loss phase.
Weight Loss Maintenance: *Pre-test/post-test Trials*									
James *et al.* (1998) (44)	12	(a) F2F (group)	52	*52*	-	-	-	4.3	(a) **CB**: Weight, diet & PA self-monitoring with review, relapse prevention strategies, self regulation techniques.
Leslie *et al.* (2002) (29)	3	(a) Online (b) Online	5 5	- -	- -	*5* *5*	- -	1.7 1.7	(a) **Diet**: Weight maintenance diet + **CB**: Email contact to review of weight & eating habits & to discuss maintenance problems. (b) **Diet**: As in weight loss phase + **CB**: As in (a).

* Contact frequency calculation = total number of contacts / duration of study (contacts/month).

† Study contained another treatment arm that was not eligible for inclusion in review.

‡ Followed by a weight loss maintenance intervention.

§ Treatment contacts estimated from 3-week schedule of activities/meetings.

¶ Deficit on recommended dietary intake, not estimated energy requirements.

M, meetings; CB, Cognitive Behavioral components; PA, Physical activity; E, email contacts; Ph, phone contacts; Freq, contact frequency; F2F (ind), individual face-to-face; F2F (group), group face-to-face; RED, reduced energy diet; LED, low energy diet; VLED, very low energy diet; DASH, Dietary Approaches to Stop Hypertension.

Table 2 Methodological quality scores and risk of bias assessment in male-only weight loss and weight loss maintenance studies

Study	A) Baseline results reported separately for each group	B) Randomization clearly described and adequately done	C) Dropout ≤ 20% for ≤ 6m follow-up and ≤ 30% for > 6m follow-up	D) Assessor blinding	E) Adiposity assessed ≥ 6m after baseline	F) Intention-to-treat analysis	G) Confounders accounted for in analyses	H) Summary results presented + estimated effect sizes + precision estimates	I) Power calculation reported and study adequately powered	J) An objective measure of weight was used	Score [/10] (risk of bias)
***Weight Loss**: Randomized Controlled Trials*											
Dennis *et al.* (25)	✓	?	?	?	×	×	×	×	×	✓	2 (high)
Frey-Hewitt *et al.* (26)	✓	?	✓	?	✓	×	×	×	×	✓	4 (medium)
Hannum *et al.* (27)	✓	?	✓	×	×	✓	×	×	✓	✓	5 (medium)
Kraemer *et al.* (28)	✓	?	?	?	×	×	?	×	×	✓	2 (high)
Leslie *et al.* (29)	✓	?	×	?	✓	✓	×	✓	✓	✓	6 (medium)
Morgan *et al.* (30, 31)	✓	✓	✓	✓	✓	✓	✓	✓	?	✓	9 (low)
Morgan *et al.* (32)	✓	✓	✓	?	×	✓	✓	✓	✓	✓	8 (low)
Morgan *et al.* (33)	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	9 (low)
Nowson *et al.* (34)	✓	?	✓	?	×	×	✓	×	×	✓	4 (medium)
Pavlou *et al.* (35)	✓	?	×	?	×	×	×	×	×	✓	2 (high)
Pritchard *et al.* (36)	✓	?	✓	×	✓	×	×	×	×	✓	4 (medium)
Tanaka *et al.* (37)	✓	?	✓	?	✓	✓	×	×	×	✓	5 (medium)
***Weight Loss**: Pseudo-randomized Controlled Trials*											
Matsuo *et al.* (38)	✓	n/a	✓	?	×	×	✓	×	×	✓	4 (medium)
***Weight Loss**: Pre-test/post-test Trials*											
Andersson *et al.* (39)	n/a	n/a	×	×	✓	×	×	×	×	✓	2 (high)
Borg *et al.* (40)	n/a	n/a	✓	×	✓	×	×	×	×	✓	3 (high)
Di Marzo *et al.* (41)	n/a	n/a	?	×	✓	?	×	×	×	✓	2 (high)
Drummond *et al* (42)	n/a	n/a	×	×	×	×	×	×	✓	✓	2 (high)
Egger *et al.* (43)	n/a	n/a	✓	×	✓	×	×	×	×	×	2 (high)
James *et al.* (44)	n/a	n/a	?	×	✓	?	×	×	×	?	1 (high)
Maeda *et al.* (45)	n/a	n/a	✓	×	×	✓	×	×	×	✓	3 (high)
Miyatake *et al.* (46)	n/a	n/a	?	×	✓	×	×	×	×	✓	2 (high)

Study	A) Baseline results reported separately for each group	B) Randomization clearly described and adequately done	C) Dropout ≤ 20% for ≤ 6m follow-up and ≤ 30% for > 6m follow-up	D) Assessor blinding	E) Adiposity assessed ≥ 6m after baseline	F) Intention-to-treat analysis	G) Confounders accounted for in analyses	H) Summary results presented + estimated effect sizes + precision estimates	I) Power calculation reported and study adequately powered	J) An objective measure of weight was used	Score [/10] (risk of bias)
Nakanishi *et al.* (47)	n/a	n/a	✓	×	✓	×	×	×	×	✓	3 (high)
Pasman *et al.* (48)	n/a	n/a	✓	×	✓	×	×	×	×	✓	3 (high)
n (%)	13 (100*)	3 (25*)	14 (61)	1 (4)	14 (61)	7 (30)	5 (22)	4 (17)	5 (22)	21 (93)	
***Weight Loss Maintenance**: Randomized Controlled Trials*											
Borg et al. (40)	✓	?	✓	?	✓	×	✓	✓	×	✓	6 (medium)
Pasman et al. (48)	✓	?	✓	?	✓	×	×	×	×	✓	4 (medium)
***Weight Loss Maintenance**: Pre-test/post-test Trials*											
Leslie et al. (29)	✓	n/a	×	×	×	×	×	×	✓	✓	3 (high)
James et al. (44)	n/a	n/a	?	×	✓	?	×	×	×	?	1 (high)
n (%)	3 (100)*	0 (0)	2 (50)	0 (0)	3 (75)	0 (0)	1 (25)	1 (25)	1 (25)	3 (75)	

* Calculated only for trials where this item was applicable.
✓, present; ×, absent; ?, unclear or inadequately described; n/a, not applicable.
Risk of bias: 0-3 (high), 4-7 (medium), 8-10 (low).

Table 3 Weight-related outcomes for male only weight loss and weight loss maintenance interventions

Study	Retention	Measurement	Results (kg)	Significance	% change*
***Weight Loss**: Randomized Controlled Trials*					
Dennis *et al.* (25)	PT: Unclear (?/39)	Mean weight change from baseline	a) n = unclear, 4m: -8.6 (5.0) b) n = unclear, 4m: -5.0 (4.1)	Post-test (4m): a > b Follow-up: none	a) -8.0% b) -4.0%
Frey-Hewitt *et al.* (26)	PT: 75% (77/103)	Mean weight change from baseline	a) n = 36, 12m: -6.68 (3.94) b) n = 41, 12m: +0.38 (3.66)	Post-test (12m): a > b Follow-up: none	a) -7.1% b) 0.0%
Hannum *et al.* (27)	PT: 85% (51/60)	Mean weight change from baseline	a) n = 30†, 2m: -4.5 (4.1) b) n = 30†, 2m: -6.1 (4.0)	Post-test (2m): a = b Follow-up: none	a) -4.5% b) -6.1%
Kraemer *et al.* (28)	PT: Unclear (?/35)	Mean weight	a) n = unclear, 0: 106.85 (15.08) 3m: 97.21 (14.20) b) n = unclear, 0: 95.66 (12.55) 3m: 86.67 (11.34) c) n = unclear, 0: 92.07 (13.09) 3m: 82.17 (10.61) d) n = unclear, 0: 92.91 (11.45) 3m: 92.56 (13.57)	Post-test (3m): [a, b & c] > d Follow-up: none	a) -9.0% b) -9.4% c) -10.8% d) 0.0%
Leslie *et al.* ‡ (29)	PT: 75% (91/122)	Mean weight change from baseline	a) n = 40†, 3m: -4.6 (3.4) b) n = 38†, 3m: -5.6 (3.7) c) n = 44†, 3m: +0.5 (2.2)	Post-test (3m): [a & b] > c Follow-up: *maintenance intervention*	a) -4.7% b) -5.9% c) 0.0%
Morgan *et al.* (30, 31)	PT: 85% (55/65) FU1: 83% (54/65) FU2: 71% (46/65)	Mean weight change from baseline	a) n = 34†, 3m: -4.8 (4.4) 6m: -5.3 (5.7) 12m: -5.3 (6.4) b) n = 31†, 3m: -3.0 (4.4) 6m: -3.5 (5.9) 12m: -3.1 (6.7)	Post-test (3m): a = b Follow-up (3m): a = b Follow-up (9m): a = b	a) -5.3% b) -3.2%
Morgan *et al.* (32)	PT: 81% (89/110)	Mean weight change from baseline	a) n = 65†, 3.5m: -4.0 (4.4) b) n = 45†, 3.5m: +0.3 (3.0)	Post-test (3.5m): a > b Follow-up: none	a) -4.2% b) 0.0%
Morgan *et al.* (33)	PT: 83% (44/53) FU: 83% (44/53)	Mean weight change from baseline	a) n = 27†, 3m: -6.7 (3.9) 6m: -7.6 (4.0) b) n = 26†, 3m: -0.4 (3.7) 6m: 0.0 (3.7)	Post-test (3m): a > b Follow-up (3m): a > b	a) -7.1% b) 0.0%
Nowson *et al.* (34)	PT: 86% (54/63)	Mean weight	a) n = 27, 0: 88.2 (10.2) 3m: 83.3 (9.4) b) n = 27, 0: 98.2 (10.6) 3m: 93.6 (9.4)	Post-test (3m): a = b Follow-up: none	a) -5.6% b) -4.7%

Study	Retention	Measurement	Results (kg)	Significance	% change*
Pavlou *et al.* (35)	PT: 45% (72/160)	Mean weight change from baseline	a) n = 31, 2m: -11.8 (3.34) b) n = 41, 2m: -9.2 (1.9)	Post-test (2m): a = b Follow-up: none	a) -11.9% b) -9.1%
Pritchard *et al.* (36)	PT: 88% (58/66)	Mean weight	a) n = 18, 0:88.1 (10.5) 12m: 81.8 (9.9) b) n = 21, 0: 87.8 (10.1) 12m: 85.2 (10.4) c) n = 19, 0: 87.0 (10.9) 12m: 87.9 (10.5)	Post-test (12m): a > b > c Follow-up: none	a) -7.2% b) -3.0% c) +1.0%
Tanaka *et al.* (37)	PT: 96% (49/51) FU1: 92% (47/51) FU2: 90% (46/51)	Mean weight change from baseline	a) n = 23[a], 1m: -1.1 (1.4) 3m: -2.2 (2.5) 7m: -2.4 (3.2) b) n = 28[a], 1m: -0.3 (1.0) 3m: -1.2 (1.8) 7m: -1.6 (2.8)	Post-test (1m): a > b Follow-up (2m): NR Follow-up (6m): a = b	a) -3.2% b) -2.2%
***Weight Loss**: Pseudo-randomized Controlled Trials*					
Matsuo *et al.* (38)	PT: 84% (104/124)	Mean weight change from baseline	(a) n =34, 3.5m: -6.2 (3.3) (b) n = 36, 3.5m: -4.4 (3.7) (c) n = 34, 3.5m: -0.7 (1.4)	Post-test (3.5m): a > b > c Follow-up: none	a) -7.9% b) -5.7% c) -1.0%
***Weight Loss**: Pre-test/post-test Trials*					
Andersson *et al.* (39)	PT: 66% (57/86)	Mean weight	a) n = 57, 0: 121 (19) 24m: 115 (19)	Post-test (24m): Weight < baseline Follow-up: none	a) -5.0%
Borg *et al.* ‡ (40)	PT: 91% (82/90)	Mean weight	a) n = 82, 0: 106.0 (9.9) 2m: 91.7 (9.4)	Post-test (2m): Weight < baseline Follow-up: *maintenance intervention*	a) -13.5%
Di Marzo *et al.* (41)	PT: Unclear (?/49)	Mean weight	a) n = unclear, 0: 93.9 (12.5) 12m: 87.5 (13.4)	Post-test (12m): Weight < baseline Follow-up: none	a) -6.8%
Drummond *et al.* (42)	PT: 71% (76/107)	Mean weight	a) n = 76, 0: 106.0 (20.7) 3m: 100.5 (16.6)	Post-test (3m): Weight < baseline Follow-up: none	a) -5.2%
Egger *et al.* (43)	PT: 100% (52/52) FU(1): Unclear (?/52) FU(2): Unclear (?/52) FU(3): 81% (42/52)	Mean weight change from baseline	a) n = 42, 1.5m: NR 6m: NR 12m: NR 24m: -5.27 (NR)	Post-test (1.5m): NR Follow-up (4.5m): NR Follow-up (10.5m): NR Follow-up (22.5m): Weight < baseline	a) -5.5%
James *et al.* ‡ (44)	PT: Unclear (?/25)	Mean weight	a) n = unclear, 0: 110 (NR), 0.75m: 103 (NR)	Post-test: NR Follow-up: *maintenance intervention*	a) -6.4%

Study	Retention	Measurement	Results (kg)	Significance	% change*
Maeda *et al*. (45)	PT: 100% (7/7)	Mean weight	a) n = 7, 0: 78.0 (7.9) 3m: 68.0 (5.3)	Post-test (3m): Weight < baseline Follow-up: none	a) -12.8%
Miyatake *et al.* (46)	PT: Unclear (?/31)	Mean weight	a) n = unclear, 0: 82.3 (7.4) 12m: 78.6 (7.4)	Post-test (12m): Weight < baseline Follow-up: none	a) -4.5%
Nakanishi *et al.* (47)	PT: 83% (296/355)	Mean weight change from baseline	a) n = 296, 12m: +0.3 (2.4)	Post-test (3m): Weight = baseline Follow-up: none	a) +0.4%
Pasman *et al.* ‡ (48)	PT: 94% (15/16)	Mean weight change from baseline	a) n = 15, 4m: -12.6 (3.8)	Post-test (4m): Weight < baseline Follow-up: *maintenance intervention*	a) -13.2%
***Weight Loss Maintenance**: Randomized Controlled Trials*					
Borg et al. (40)	PT: 91% (82/90) FU: 76% (68/90)	Mean weight	a) n = 25, 6m: 93.7 (10.7) 29m: 102.0 (13.5) b) n = 28, 6m: 91.1 (8.0) 29m: 99.9 (10.9) c) n = 29, 6m: 93.9 (11.1) 29m: 100.7 (11.4)	Post-test (6m): a = b = c Follow-up (23m): a = b = c	a) -3.8% b) -5.6% c) -5.0%
Pasman et al. (48)	PT: 94% (15/16)	% of baseline weight	a) n = 7, 12m: 94.0% (3.6) b) n = 8, 12m: 96.0% (3.0)	Post-test (12m): a = b Follow-up: none	a) -6.0% b) -4.0%
***Weight Loss Maintenance**: Pre-test/post-test Trials*					
James et al. (44)	PT: unclear	Mean weight	a) n = unclear, 0 : 103 (NR) 12m : 101 (NR)	Post-test: NR Follow-up: none	a) -8.0%
Leslie et al. (29)	PT: 70% (85/122)	Mean weight change (6m - 3m)	a) n = 45, 3m: +0.9 (2.0) b) n = 40, 3m: +1.4 (1.6) c) NR	Post-test (3m): a = b Follow-up: none	a) -3.8 b) -4.4 c) NR

* % weight change at final assessment of weight loss or weight loss maintenance phase. If ≥ 5% weight loss achieved (if not reported, then was calculated as: mean weight loss / mean starting weight x 100).

† Original sample size (intention-to-treat analysis was used)

‡ Weight loss intervention was followed by a maintenance intervention.

a = b: no difference between groups a & b ($P > 0.05$); a > b: greater weight loss in group a compared to group b ($P < 0.05$); [a & b] > c: greater weight loss in a and b compared to c ($P < 0.05$); a > b > c: greater weight loss in a compared to b ($P < 0.05$) and in b compared to c ($P < 0.05$). Weight < baseline: Mean weight at post-test significantly lower than at baseline (reported for studies with no control); Weight = baseline: No difference between mean weight at post-test and baseline.

NR, not reported; PT, post-test; FU, follow-up; FU (n), denotes follow-up number 'n'.

Table 4 Sample, methodological and intervention characteristics associated with effectiveness

	n	Effective n (%)
Sample Characteristics		
Mean age > 42.8*		
Yes	15	9 (60)
No	15	13 (87)
Not reported	1	
Mean BMI > 31.05*		
Yes	15	12 (80)
No	15	10 (67)
Not reported	1	
Methodology Characteristics		
Intervention length > 3 months*		
Yes	12	8 (67)
No	19	15 (79)
Total contacts > 8*		
Yes	17	14 (82)
No	14	9 (64)
Frequency of contact > 2.7 / month*		
Yes	15	14 (93)
No	16	9 (56)
Intervention Characteristics		
Prescribed energy restriction		
Yes	18	16 (89)
No	13	5 (46)
Prescribed physical activity plan		
Yes	10	7 (70)
No	21	16 (76)
Individual face-to-face contact		
Yes	10	7 (70)
No	21	16 (76)
Group face-to-face contact		
Yes	20	17 (85)
No	11	6 (55)
Resources provided		
Yes	10	7 (70)
No	21	16 (76)

* Median value for all intervention samples.

Figure 1 PRISMA flowchart of studies through the review process

Figure 2 A meta-analysis comparing the effects of male-only weight loss interventions with true controls at the last reported assessment prior to any additional maintenance intervention (n=7)