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Efficacy of habit-based weight loss interventions: a systematic review and meta-analysis

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Abstract

Purpose: Habit-based interventions are a novel and emerging strategy to help reduce excess weight in individuals with overweight or obesity. This systematic review and meta-analysis aims to determine the efficacy of habit-based interventions on weight loss.

Methods: We identified potential studies through electronic searches in February 2019. Included studies were randomized /quasi randomized controlled trials comparing weight loss interventions founded on habit-theory with a control (active or non-active) and enrolled adults with overweight or obesity (body mass index $\geq 25 \text{kg/m}^2$).

Results: Five trials (630 participants) met our inclusion criteria. After the intervention period (range 8-14 weeks), weight loss was modest but statistically different between groups (1.4kg [95% confidence interval 0.5, 2.3; $P = 0.004$]) favoring habit-based interventions. Intervention groups averaged 2.5kg weight loss (range 1.7 to 6.7kg) compared with control 1.5kg (range 0.4 to 5.8kg) and were 2.4 times more likely to achieve clinically beneficial weight loss ($\geq 5\%$ weight reduction).

Conclusions: Average weight losses in adults with overweight and obesity using habit-based interventions appear to be of clinical benefit. There were statistically significant differences in weight loss between habit-based interventions and controls, post-intervention. Longer studies powered to examine at least 12-month follow-up are required to more accurately determine the role of habit-based interventions on long-term weight loss maintenance.

Key words: behavioral science; habits; obesity; overweight; systematic review; weight loss

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Background

Given the increasing prevalence of overweight and obesity, and the lack of consistent long-term weight loss success (Curioni & Lourenceo, 2005; Montesi et al, 2016), the scope of research to explore novel strategies for effective intervention has broadened. A synthesis and comparison of these emergent weight management strategies is essential.

There is overwhelming evidence that in individuals with overweight and obesity, modest weight loss of ≥5% reduction in body weight is associated with significant health benefits, especially when maintained over time (Avenell et al, 2004; NHMRC, 2013). Recent studies have demonstrated the potential for habit-based interventions to positively influence health behaviors and reduce excess weight (Cleo et al, 2017; Lally et al, 2010; McGowan et al, 2013). Habits are automatic behaviors which have been triggered in response to a contextual cue (Kwasnicka et al, 2016). Habits are formed by repeatedly performing a behavior in a consistent context; this creates a mental association between the behavior and the context (Neal et al, 2006). The reinforcement of this context-behavior association creates an easily accessible response in our memory, such that alternative behaviors become less accessible (Gardner, 2014). Eventually, the mere perception of the context automatically triggers the responding behavior. Unlike lifestyle behaviors, which require deliberative and intentional thought, habitual behaviors are subconscious reactions that were initially instigated with intention but now are performed mindlessly (e.g., eating popcorn at the cinema or lunch at midday) (Rothman et al, 2009). Habit formation involves a gradual shift in cognitive control from intentional to automatic processes (Nilsen et al, 2012). Daily eating and exercise behaviors largely consist of mindless, automatic habits as are triggered by common cues such as time of day, location or preceding action (Van't Reit et al, 2011). These automatic behaviors occur without reflective decision making and increase with repetition of the behavior. Since habitual behavior is detached from motivational or volitional control (Gardner, 2016), habits are more likely to override intention in predicting behavior; the frequency of past behavior plays a significant role in predicting future behavior (Danner et al, 2008; Ji MF & Wood, 2007).

Habit-based interventions will generally include an 'initiation', 'learning' and 'stability' phase (Gardner et al, 2012). Habit formation begins with an 'initiation phase', during which the new chosen behaviour and the context in which that behaviour will be performed are selected; for example, 'eat a piece of fruit with breakfast', or 'go for a 30-minute walk at 7am'. Automaticity develops in the subsequent 'learning phase', during which the behaviour is repeated in the chosen context to strengthen the context-behaviour association (self-monitoring through a habit tracker is beneficial [Burke, 2011]). Finally, habit formation is accomplished in the 'stability phase', at which the behaviour persists over time with minimal conscious thought or effort (Gardner et al, 2012). Interventions that are founded on habit-change theory may therefore be important for weight-management as habitual behaviors are elicited automatically and are as a result, likely to be maintained (Duhigg, 2013; Lally et al, 2011).

This systematic review and meta-analysis is the first to assess the efficacy of habit-based weight loss interventions on weight loss outcomes. Our primary objective is to determine the efficacy of habit-based interventions on *weight reduction* in adults with overweight and obesity. Secondary outcomes are to determine: 1) the efficacy of habit-based interventions on *weight loss maintenance* in adults with overweight and obesity compared with control; 2) the proportion of participants achieving clinically beneficial weight loss and weight loss maintenance (≥5% total body weight loss) and; 3) subgroup analysis comparing habit-based interventions with active and non-active controls.

Methods

Data sources and searches

An experienced medical librarian conducted electronic searches within five databases, PubMed, Embase, CINAHL, Cochrane CENTRAL and Web of Science, in February 2019. Key search terms used were: habit (formation or disruption or based or breaking or break) and weight loss (or weight control or weight reduction). The systematic review protocol registration and search strategy are

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provided in the supplementary File 1 and File 2 respectively. A manual search through reference lists of included studies and other relevant articles was also performed. No language restrictions or publication dates were applied.

Studies included in this review were randomized or quasi-randomized. These studies used habit-based weight-loss interventions that focused specifically on habit-change as the conceptual theory; therefore, habit-change was the primary strategy for behavior change and subsequent weight loss. Habit-based interventions included explicitly forming new habits (through triggered repetition of the desired behavior), breaking old habits (through intentional routine/trigger disruption), or both. Randomized studies were eligible if they 1) enrolled participants with overweight or obesity defined as BMI $\geq 25.0 kg/m^2$; 2) included participants over 18 years of age; 3) included a control group; and 4) reported quantified weight change outcomes at post-intervention.

Study selection and data extraction

All studies were screened independently against eligibility criteria by two reviewers. Screening of titles, abstracts and full-texts was conducted using EndNote X7.2.1. Articles that did not meet inclusion criteria were excluded. If uncertainty existed, the full text article was reviewed. The same two reviewers independently extracted and recorded data in pre-piloted data extraction forms. Disagreements were resolved by consensus and discussion. Extracted data included study design, setting, participant characteristics, intervention and comparator characteristics and weight change outcomes. If there were inadequate data for a given outcome, the corresponding author was contacted via e-mail at least twice and the data were requested. This manuscript followed the PRISMA 2009 Checklist (available in the Supplementary Material).

Quality assessment

Risk of bias of included studies was independently assessed by two reviewers using the Cochrane Collaboration Risk of Bias tool (Higgins & Green, 2011). Additionally, we uploaded included studies to RobotReviewer (www.robotreviewer.net/) to confirm accuracy of manual risk of bias assessment. To enhance the usability of this review, we extracted and reported summaries of the main intervention components for each study using the items from the Template for Intervention Description and Replication (TIDieR) checklist (Hoffmann et al, 2017).

Data analyses

Data were analyzed using available cases in Review Manager 5.3 (The Cochrane Collaboration, 2014). For analyses of weight change, between group mean differences were extracted or calculated per group, from baseline to post-intervention (primary outcome) and from baseline to last available follow-up (secondary outcome). The proportion of participants achieving ≥5% total body weight reduction (clinically important weight loss) was extracted from reported data and presented as a risk ratio comparing intervention with control. We conducted subgroup analyses to examine mean differences in weight change between the intervention groups and active compared with non-active controls. We also conducted post-hoc subgroup analyses comparing mean differences in interventions which used only forming habits as their theoretical basis compared with interventions that used forming habits in combination with breaking habits. If multiple follow-up assessments were reported, the last available follow-up (i.e., longest duration from baseline) was used.

Effect size heterogeneity

The I^2 statistic was used to assess variability in effect size among studies (heterogeneity). We expected statistically significant heterogeneity due to methodological differences in the studies, including variations in study duration and intervention characteristics. A random effects model was therefore used to synthesize the data. There were too few studies to explore the impact of study

variables on heterogeneity using meta-regression analysis; therefore, we described the differences in methods, duration and intervention characteristics in narrative and tabular form.

Results

The systematic search identified 730 potentially relevant studies (Figure 1). Of these, 229 were duplicates. Therefore, 501 titles and abstracts were screened for eligibility; 490 did not meet inclusion criteria. Of the 11 full text articles assessed, 2 were excluded as they were duplicates or preliminary findings of the included studies, 2 because the intervention used was not habit-based, and 2 because the study was not randomized (study details provided in supplementary file [See Supplementary Table 1 for descriptive data of excluded studies]). Five articles were included in the analyses.

Study characteristics

The studies reported results from Australia (Cleo et al, 2018), USA (Carels et al, 2011; Carels et al, 2014) and UK (Beeken et al, 2017; Lally & Gardner, 2013). Most studies were conducted in university clinics (Carels et al, 2011; Carels et al, 2014; Cleo et al, 2018; Lally et al, 2008) and one study in a primary care setting (general practice clinics) (Beeken et al, 2017). The five studies included 630 participants (study size ranged from 43 to 383), with a pre-intervention mean body weight, ranging from 90 to 109kg (BMI 31-38kg/m^2), mean age ranged from 44 to 66 years and all studies reported a majority of female participants, 66-80%. Table 1 displays the included studies and their characteristics.

Interventions

Studies based their interventions on forming new habits (Ten Tops Tips) (Beeken et al, 2017; Cleo et al, 2018; Lally et al, 2008), breaking old habits (Do Something Different) (Cleo et al, 2018), or a

combination of both (Transforming Your Life) (Carels et al, 2011; Carels et al, 2014) (Table 1). One study (Cleo et al, 2018) compared two different interventions (one which formed new habits and the other broke old habits) with a control group. There were no significant differences in weight loss and weight loss maintenance between the two habit-based interventions groups. Therefore, we grouped the intervention results together for the primary and secondary outcome measures.

Ten Top Tips (TTT): based on habit-formation theory, TTT encouraged daily repetition of ten behaviors, proposed to create a negative energy balance and subsequent weight loss. The behaviors (tips), included: keep to a meal routine; eat reduced fat foods; walk 10,000 steps a day; pack a healthy snack; check food labels; watch portion sizes; stand up for 10 minutes in every hour; choose low calorie drinks; be mindful when eating, and; eat 5 portions of fruit and vegetables a day. To encourage habit development, participants were advised to plan ahead to effectively incorporate the tips into their daily routines and repeat the behaviors in a consistent context. Participants were encouraged to repeat as many of the tips as they could, every day for the intervention period (8-12 weeks).

Do Something Different (DSD): focused on increasing participants' behavioral flexibility by breaking daily habits purported to play a role in unhealthy dietary and exercise behaviors. Participants were sent an unpredictable task to perform, via text message and/or email, three to four times a week. The tasks required them to do something different to expand their behavioral repertoire and were not diet or exercise related. Examples include: 'drive a different way to work today', 'choose a charity or local group to help' or 'write a short story on any subject'.

Transforming Your Life (TYL): used environmental modification to promote the formation of new, healthy habits (through development of predictable and sustainable weight-loss related routines), as well as disruption of old, unhealthy habits (by changing established routines that support unhealthy habits). Individuals were taught to create their personal food and exercise environment in a manner that minimizes unhealthy eating and sedentary behavior cues, maximizes healthy eating and exercise-related cues, and encourages automatic responding to goal-related cues. Each week, selected

environmental factors that have been empirically recognized to influence eating (e.g. visibility, variety, serving utensils, abundance, and convenience) were systematically targeted for modification.

Intervention duration ranged from 8 to 14 weeks and follow-up 6 to 24 months. Control groups in the included studies were either, active (non-habit-based weight loss programs [Carels et al, 2011; Carels et al, 2014] and lifestyle advice with or without community referral [Beeken et al, 2017]) or non-active (wait list [Cleo et al, 2018; Lally et al, 2008]).

Weight change

Primary outcome. Participants who completed a habit-based intervention, ranging between 8 and 14 weeks, weighed on average 1.4kg lighter than the control participants at post-intervention (Figure 2). Intervention participants achieved an overall average weight loss of 2.5kg (range 1.7 to 6.7kg) compared with the 1.5kg mean loss of control participants (range 0.4 to 5.8kg). Weight loss was significantly different between intervention and control groups (mean difference -1.4kg [95% CI -2.3, -0.5; $P = 0.004$]).

As expected, there was a statistically significant heterogeneity among studies post-intervention ($I^2 = 71\%$). Statistical exploration of heterogeneity was unable to be conducted due to a small number of included studies. However, as a sensitivity analysis, we removed Cleo et al, 2018 and Lally et al, 2008 from the forest plot as they were the only two studies which used wait-list control groups instead of active-controls. When we removed these two studies, the I^2 was 0%. We therefore suspect heterogeneity between studies was due to the difference in the use of active and non-active control groups.

Secondary outcomes. Three of the five studies measured weight loss maintenance in both the intervention and control groups at follow-up and were included in a meta-analysis (Beeken et al, 2017; Carels et al, 2011; Carels et al, 2014). All control groups included in the meta-analysis were active. After a 6-24-month follow-up, weight loss maintenance in the intervention group was 3.4kg

(range 2.2 to 8.9kg) and 3.1kg (range 3.0 to 4.2kg) in active-controls (See Supplementary Figure 1 for comparison of weight loss at follow-up between intervention and control groups). However, weight loss maintenance was not statistically significant between the intervention and active-control groups (mean difference 0.1kg [95% CI -2.5, 2.4; $P = 0.96$]).

The two studies (Cleo and Lally) where only intervention group data were reported at follow-up (and not control group data) achieved mean weight loss maintenance of 5.1kg and 3.8kg after 12 and 8 months follow-up, respectively.

Three of the five studies reported on the proportion of participants achieving clinically beneficial weight loss (≥5% total body weight reduction); two of the three at post-intervention (Beeken et al, 2017; Cleo et al, 2018) and all three at follow-up (Beeken et al, 2017; Cleo et al, 2018; Lally et al, 2008) (Supplementary Figure 2). At post-intervention, 16-35% of participants in the intervention group and 4-8% in the control group had achieved clinically beneficial weight loss. Participants in the intervention group were therefore, 2.4 times (risk ratio) more likely to achieve clinically beneficial weight loss than control participants (Figure 3). At follow up, 27-65% of participants in the intervention group and 26% in an active-control group had achieved and maintained a reduction of ≥5% total body weight (Supplementary Figure 2).

We observed a moderate heterogeneity amongst studies in the follow-up analysis, however this was not statistically significant ($I^2 = 50\%$).

Subgroup analysis

Analyses were completed for two subgroups: active vs non-active control groups and forming habits vs forming + breaking habits. There was a 0.8kg mean difference favoring the intervention group, when comparing habit-based interventions with active controls ($P = 0.01$). The mean difference increased to 2.1kg when comparing habit-based interventions with non-active controls ($P = <0.001$) (Figure 4).

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Interventions which used forming new habits as the theoretical basis of their intervention (Beeken et al, 2017; Cleo et al, 2018; Lally et al, 2008), showed a statistically significant mean difference when compared with controls (mean difference 1.4kg; $P = 0.001$), however two of three of these used wait-list controls. Interventions which used forming new habits in combination with breaking old habits did not show a statistically or clinically meaningful difference compared with controls (mean difference -1.2kg; $P = 0.37$) (Carels et al, 2011; Carels et al, 2014; Cleo et al, 2018) (See Supplementary Figure 3 for subgroup analysis).

Quality of included studies

Four studies were randomized controlled trials (Beeken et al, 2017; Carels, 2011; Carels, 2014; Cleo et al, 2018; Lally et al, 2008) and one was randomized according to intervention commencement date (Lally et al, 2008) (Table 1). As expected, participants and investigators of all studies were aware of the intervention they were receiving or delivering resulting in all studies rating as 'high risk' of bias for blinding of participants and study personnel. We displayed risk of bias outcomes for random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data and selective reporting (Figure 5). A TIDieR intervention summary was completed for each of the 5 studies included in this review (Table 2). This summary describes why the intervention was initiated, what methods and materials were used, and details of intervention fidelity, amongst other intervention information.

Discussion

Despite our intentions, habits influence a large proportion of our daily behaviors. If we were able to change our eating habits – where, when and why we eat, – we might be able to manage our weight more effectively. Therefore, determining if habit-change interventions are effective for weight loss and weight loss maintenance is important. We systematically evaluated the efficacy of habit-based

interventions for weight loss and weight loss maintenance in individuals with overweight and obesity. There was a statistically significant difference in weight loss between intervention and control participants after an 8 to 14 week intervention period. Participants in the intervention group were 2.4 times more likely to achieve clinically beneficial weight loss than the control group.

The long-term effects of habit-based interventions on weight loss maintenance were difficult to conclude as the interventions were compared with active-control groups (non-habit-based weight loss programs (Carels et al, 2014; Lally et al, 2008) and lifestyle advice with or without community referral (Beeken et al, 2017)). The two studies which used non-active controls (wait-list) were not included in the follow-up analysis as they did not measure or analyze these data. However, the single-armed results from these two studies show that the participants had in fact achieved weight-loss maintenance (Cleo et al, 2018; Lally et al, 2008).

In the current analyses, forming habits achieved greater weight loss when compared with forming+breaking habit interventions. However, both studies of forming+breaking habits (Carels et al, 2014; Carels et al, 2011) were compared with active controls. Therefore, studies comparing forming+breaking habits compared with non-active controls are required to determine robust measures of outcomes.

Our study is strengthened by our procedures. We searched five databases and contacted authors for missing data or unclear practices. We also assessed the quality of the studies using the Cochrane Risk of Bias tool (Higgins & Green, 2011). Overall, the risk of bias was well-reported in the studies; however, there were some inconsistencies. One study reported the outcome assessor was not blind to group allocation when conducting post-assessments and two studies did not report on this (Carels et al, 2011; Carels et al, 2014) and were rated as unclear risk for detection bias. Due to the nature of the interventions, it is not possible to blind participants and personnel to treatment allocations, therefore all studies were rated as high risk of bias for blinding. However, clinic-measured weight is objective rather than self-reported so the magnitude of bias associated with inadequate blinding of participants is not likely to affect outcomes (Higgins & Green, 2011). Finally, knowing an intervention is effective

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is inconsequential if it is not described well for clinicians to use. A key strength of this review was including a TIDieR summary of interventions. This summary provided a description of the main intervention components for each of the included studies for clinicians to make important judgements about their ability to implement these interventions in their place of work.

The published literature on habit-based weight loss interventions is scant. This systematic review was limited by the small number of published studies, using habit-based interventions for weight management in individuals with overweight and obesity. Interventions which focus on habit-change theory are a novel and emerging approach to weight management. We anticipate seeing more included studies in future updates of this review. Also, there were varied levels of heterogeneity ($I^2 = 0\%$ to 82% ['might not be important' to 'considerable heterogeneity']) (Higgins & Green, 2011) in the included studies. There is considerable conceptual heterogeneity among the included studies, with different behavior change techniques required for forming new habits compared with disrupting old habits (Lally & Gardner, 2013). Despite these differences, we meta-analyzed the data as the novelty in all the included studies is that they are founded on habit-change theory (whether forming new habits or breaking old ones). Due to the limited number of studies, meta-regression could not be conducted to explore study variability that might have contributed to the heterogeneity.

The weight loss-weight regain cycle is common. Previous systematic reviews show that after a lifestyle program, commonly diet and exercise, an average of 46-50% of weight loss is regained just 12-months post-treatment (Anderson et al, 2001; Barte et al, 2010; Curioni & Lourenco, 2005) and much of the rest over the subsequent 3 years (Roque et al, 2013). However, unlike diet and exercise programs, interventions which are founded on habit-change theory encourage behavior to become 'second nature'; therefore, the new, healthy behaviors are more resistant to change.

Although more research is required to accurately determine the efficacy of habit-based interventions when compared with non-active control groups long-term, habit-change theory proposes that the addition of habit-change techniques to current clinical practice may increase the chances of long-term weight loss maintenance (Duhigg, 2013; Lally et al, 2011). For example, including contextual cues

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when goal setting. A contextual cue is used as a trigger for the subsequent habitual behavior and must be personalized to each individual's lifestyle and daily routines, e.g., *"when I am eating, I will put away any distractions"*, or *"at 7am, I will go for a 30-minute brisk walk"*. Using current clinical practice guidelines, with the addition of contextual cues, encourages an automatic response to those cues. Therefore, an individual is exposed to daily triggers which prompt them to perform the new desired behavior without depending on their memory or motivation.

Conclusions

Habit-based weight loss programs are more effective at achieving clinically beneficial weight loss than lifestyle advice, non-habit-based programs and waitlist post-intervention. The results presented in this systematic review are novel and provide a unique perspective from which to derive a new approach to weight management. Longer and more methodologically rigorous studies that are powered to examine at least a 12-month follow-up are required to determine the role of habit formation and disruption on weight loss maintenance.

Supplementary Material

PRISMA Checklist

Supplementary File 1: PROSPERO International prospective register of systematic reviews

Supplementary File 2: Search Strategy

Supplementary Table 1: Descriptive data of excluded studies

Supplementary Figure 1: Comparing weight loss (kg) at follow-up between intervention and control groups

Supplementary Figure 2: Proportion of participants achieving ≥5% total body weight reduction at post-intervention and follow-up

Supplementary Figure 3: Subgroup analysis comparing weight loss (kg) between forming habits and a combination of forming and breaking habits

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Figure 1 PRISMA Flow Diagram

Figure 2 Comparing weight loss (kg) at post-intervention between habit-based intervention and control groups

Study or Subgroup	Intervention Events	Total	Control Events	Total	Risk Ratio (Non-event) M–H, Fixed, 95% CI
3.1.1 Proportion of participants achieving ≥5% total body weight reduction post-intervention					
Beeken, 2017	30	187	16	196	0.91 [0.85, 0.99]
Cleo, 2018	15	43	1	23	0.68 [0.54, 0.86]
3.1.2 Proportion of participants achieving ≥5% total body weight reduction at follow-up					
Beeken, 2017	38	143	39	149	0.99 [0.87, 1.14]

Risk Ratio (Non-event) M–H, Fixed, 95% CI
0.5 0.7 1 1.5 2
Favours intervention Favours control

Figure 3 Subgroup analysis comparing effect size of the proportion of participants achieving ≥5% total body weight reduction at post-intervention and at follow-up

Study or Subgroup	Favours intervention Mean	SD	Total	Control Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
4.1.1 Weight loss post-intervention: active controls								
Beeken, 2017	-1.68	3.21	187	-0.84	2.83	196	93.9%	-0.84 [-1.45, -0.23]
Carels, 2011	-4.94	4.9	25	-5.81	4.72	24	4.8%	0.87 [-1.82, 3.56]
Carels, 2014	-6.71	8.69	20	-5.62	8.69	23	1.3%	-1.09 [-6.30, 4.12]
Subtotal (95% CI)			232			243	100.0%	-0.76 [-1.35, -0.17]

Heterogeneity: Tau² = 0.00; Chi² = 1.49, df = 2 (P = 0.48); I² = 0%
Test for overall effect: Z = 2.54 (P = 0.01)

4.1.2 Weight loss post-intervention: non-active controls								
Cleo, 2018	-3.09	1.95	43	-0.43	1.7	23	46.8%	-2.66 [-3.57, -1.75]
Lally, 2008	-1.99	1.89	56	-0.42	1.56	33	53.2%	-1.57 [-2.30, -0.84]
Subtotal (95% CI)			99			56	100.0%	-2.08 [-3.15, -1.01]

Heterogeneity: Tau² = 0.42; Chi² = 3.38, df = 1 (P = 0.07); I² = 70%
Test for overall effect: Z = 3.82 (P = 0.0001)

Mean Difference IV, Random, 95% CI
-4 -2 0 2 4
Favours intervention Favours control

Test for subgroup differences: Chi² = 4.50, df = 1 (P = 0.03), I² = 77.8%

Figure 4 Subgroup analysis comparing weight loss (kg) post-intervention between habit-based intervention and active vs non-active control groups

Study or Subgroup	Favours intervention Mean	SD	Total	Control Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
4.1.1 Weight loss post-intervention: active controls								
Beeken, 2017	-1.68	3.21	187	-0.84	2.83	196	93.9%	-0.84 [-1.45, -0.23]
Carels, 2011	-4.94	4.9	25	-5.81	4.72	24	4.8%	0.87 [-1.82, 3.56]
Carels, 2014	-6.71	8.69	20	-5.62	8.69	23	1.3%	-1.09 [-6.30, 4.12]
Subtotal (95% CI)			232			243	100.0%	-0.76 [-1.35, -0.17]

Heterogeneity: Tau² = 0.00; Chi² = 1.49, df = 2 (P = 0.48); I² = 0%
Test for overall effect: Z = 2.54 (P = 0.01)

4.1.2 Weight loss post-intervention: non-active controls								
Cleo, 2018	-3.09	1.95	43	-0.43	1.7	23	46.8%	-2.66 [-3.57, -1.75]
Lally, 2008	-1.99	1.89	56	-0.42	1.56	33	53.2%	-1.57 [-2.30, -0.84]
Subtotal (95% CI)			99			56	100.0%	-2.08 [-3.15, -1.01]

Heterogeneity: Tau² = 0.42; Chi² = 3.38, df = 1 (P = 0.07); I² = 70%
Test for overall effect: Z = 3.82 (P = 0.0001)

Mean Difference IV, Random, 95% CI
-4 -2 0 2 4
Favours intervention Favours control

Test for subgroup differences: Chi² = 4.50, df = 1 (P = 0.03), I² = 77.8%

20

Figure 5 Risk of bias summary

Table 1 Characteristics of included studies

	Beeken, 2017	Carels, 2011	Carels, 2014	Cleo, 2018	Lally, 2008
Study design	Two-armed randomised controlled trial	Two-armed randomised controlled trial	Two-armed randomised controlled trial	Three-armed randomised controlled trial	Quasi randomised controlled trial
Study setting	Medical clinic, UK	University clinic, USA	University clinic, USA	University clinic, Australia	University clinic, UK
Risk of Bias	R (green) A (yellow) P (yellow) B (green) I (green) S (green)	R (green) A (yellow) P (yellow) B (green) I (green) S (green)	R (green) A (green) P (yellow) I (yellow) S (green)	R (green) A (green) P (red) B (green) I (green) S (green)	R (green) A (red) P (red) B (red) I (green) S (green)
Inclusion criteria	BMI ≥30kg/m², age ≥ 18 years	BMI ≥27kg/m², non-smokers, free from cardiovascular disease and insulin dependent diabetes	BMI ≥27kg/m², free from major medical conditions	BMI ≥25kg/m², age 18-75 years, had daily access to email and/or phone, free from exercise limiting comorbidities	BMI ≥25kg/m², age ≥ 18 years
N assessed	383	49	43	66	89
Intervention	Ten Top Tips (TTT) - habit formation	Transforming Your Life (TYL) - habit formation	Ten Top Tips (TTT) - habit formation and habit disruption	Ten Top Tips (TTT) – habit formation and Do Something Different (DSD) - habit disruption	Ten Top Tips (TTT) - habit formation
Intervention method and delivery	Based on habit formation theory to promote automaticity. Participants attended an information meeting and provided with a leaflet which outlined the ten tips as well as a daily self-monitoring form. The program was self-guided at home	An environmental modification approach, which combined promoting healthy habits, as well as breaking unhealthy habits. Groups of 12-16 individuals met weekly for a 90-minute, face-to-face session conducted by a licensed clinical health psychologist and/or graduate students in psychology. Sessions included weight assessment and provided a combination of didactic instruction, group and individual in-class activities, and take home assignments		TTT was delivered as a 12-week self, guided intervention (as per the description of Beeken, in this table). DSD was a 9-week intervention aimed to break habits proposed to play a role in unhealthy dietary and exercise behaviours. Participants were sent text messages with random tasks to perform something different every day. The tasks were not diet and exercise related	Based on habit formation theory to promote automaticity. Participants attended an information meeting and provided with a leaflet which outlined the ten tips as well as a daily self-monitoring form. The program was self-guided at home
Control intervention	Active: Referred to their general practitioner's usual care treatment	Active: LEARN weight loss program, encourages increasing physical activity and decreasing energy and fat intake	Active: New Perspectives weight loss program emphasises reducing unhealthy relationships with food, body image dissatisfaction and internal weight bias	Non-active: Waitlist control group were offered either intervention after 12 weeks	Non-active: Waitlist control group were offered the intervention after 8 weeks
Facilitator	Nurse or healthcare assistant	Psychologist or psychology doctoral students	Psychologist and/or graduate psychology students	Dietitian	Clinical psychologist and/or research team
Outcomes measured	Weight, BMI, waist circumference, blood pressure, cholesterol/LDL, blood glucose, Self-Reported Habit Index (SRHI), cost analysis	Weight; self-reported: daily energy intake (kcal), energy expenditure from physical activity, exercise duration; average daily energy expenditure (kcal) (Caltrac accelerometer)	Weight, BMI; self-reported daily energy intake (kcal), average daily energy expenditure (kcal) (Caltrac accelerometer), Binge Eating Scale, Emotional Eating Scale, several other scales	Weight, BMI, waist circumference, daily fruit and vegetables serves, weekly exercise hours, psychometric data (wellbeing, depression, anxiety, habits, and openness to change)	Weight, BMI, satisfaction with life, development of habits using Self-Reported Habit Index (SRHI)
Mean baseline weight	100.8kg (± 17.2)	Not reported	109.8kg (± 32.2)	96.1kg (± 20.4)	89.8kg (± 15.0)
Baseline BMI	Median (IQR) 35 kg/m² (32.6-39.2)	Mean 37.2 kg/m² (± 6.7)	Mean 39.7kg/m² (± 10.3)	Mean 34.5kg/m² (± 6.2)	Mean 30.9 kg/m² (± 4.5)
Participant age	Median (IQR) 59.4 years (48.7-66.8)	Mean 47.3 years (± 11.2)	Mean 44.3 years (± 13.2)	Mean 50.5 years (± 11.2)	Mean 40.5 years (±10.4)
Female, %	66	80	78	79	66
Trial duration and mean weight loss post-intervention	12 weeks: Intervention : -1.7kg (± 3.2); Control: -0.8kg (± 2.8)	14 weeks: Intervention: -4.9kg (± 4.9); Control: -5.8 (± 4.7)	12 weeks: Intervention: -6.7kg (± 8.7); Control: -5.6kg (± 8.7)	12 weeks: TTT: -3.3kg (± 4.3); DSD -2.9kg (± 3.3); Combined intervention: -3.1kg (± 2.0); Control: -0.4kg (± 1.7)	8 weeks: Intervention: -2.0kg (± 1.9); Control: -0.4kg (± 1.6)
Mean weight loss at follow-up from baseline	24 months: Intervention : -2.2kg (± 5.8); Control: -3.0kg (± 7.2)	6 months: Intervention: -3.5kg (± 5.8); Control: -4.2 (± 4.4)	6 months: Intervention: -8.9kg (± 12.0); Control: -3.5 (± 5.4)	12 months: TTT: -5.7kg (± 5.3); DSD -4.6kg (± 4.5); Combined intervention: -5.1 (± 2.2)	8 months: Intervention : -3.8kg (± 1.9)

Risk of bias legend: R = Random sequence generation (selection bias); A = Allocation concealment (selection bias); P = Blinding of participants and personnel (performance bias); B = Blinding of outcome assessment (detection bias); I = Incomplete outcome data (attrition bias); S = Selective reporting (reporting bias).

● = Low risk   ● = Unclear risk   ● = High risk

Abbreviations: TTT = Ten Top Tips; DSD = Do Something Different; TYL = Transforming Your Life; BMI = Body Mass Index; QOL = Quality of Life; ± = Standard Deviation; IQR = Interquartile range.

Table 2 TIDieR intervention summary

Author Year	Brief name	Recipient	Why	What (materials)	What (procedures)	Who provided	How (mode of delivery; individual or group)	Where	When and how much	Tailoring	Modification of intervention throughout trial	Strategies to improve or maintain intervention fidelity	Extent of intervention fidelity
Beeken, 2017	- Habit-based advice for weight loss: Ten Top Tips (TTT)	- Adults with obesity (BMI ≥30kg/m²)	- Primary care is 'first port of call' for weight control advice - There's a need for simple, effective interventions that can be delivered without specialist skills	- Written materials provided including: self-guided leaflet detailing the intervention and logbook, for self-monitoring target behaviors and weight (www.weightconcern.org.uk/tentoptips)	- 12 week, self-guided, intervention - 10 behaviors associated with achieving negative energy balance, improving awareness of food intake and promote routines	- Nurses or health-care assistants working with 14 GPs - Training session provided with a script to enable standardised delivery of interventions	- Baseline face to face individual meeting - Remainder of intervention self-guided with no further clinical contact	- 14 GPs across England recruited through MRC GP Research Framework. - 9 in Southern England, 3 in the Midlands and 2 in the North	- 30 min with nurse or at baseline to explain intervention leaflet - At 3 months, patients mailed 2nd copy of leaflet and able to request additional copies of logbook - F/up at 6, 12, 18 and 24 months post-intervention with no contact between f/up appointments	- All participants received same intervention	- Not described	- Quality checks involving site visits to observe intervention delivery to ensure compliance	- Intervention fidelity was not formally measured - Participants reported automaticity of target behaviors, suggesting TTT was effective at establishing new habits
Carels, 2011	- Transforming Your Life (TYL): An environmental modification approach to weight loss	- Adults with overweight or obesity (BMI ≥27kg/m²)	- Environmental modification is critical to habit formation and disruption - Compared traditional weight loss program with environmental modification	- Not described	- Information to develop and maintain healthy habits, disrupt unhealthy habits, create environments that encourage goal-related cues	- Licensed clinical health psychologist or psychology doctoral students experienced in leading weight loss interventions	- 90 min, face to face, weekly group sessions	- Not specified, assumed at university clinic; USA	- 14 week program administered in 90 min group sessions, weekly - F/up 6 months post-intervention with no treatment during this period	- All participants received same intervention	- Not described	- Participants submitted daily records of energy intake, physical activity and energy expenditure - Participants shared insights to promote group cohesion and adherence	- Intervention fidelity partially measured: Participants provided, on average, 53.8 (SD = 39.1) of 98 potential diet and exercise diaries over 14 weeks (54.1%)
Carels, 2014	- Differences in weight loss maintenance using New Perspectives (NP) or Transforming Your Life (TYL) interventions	- Adults with overweight or obesity (BMI ≥27kg/m²)	- Healthy habits program (TYL) compared with a novel weight loss program (NP), directed at changing unhealthy relationships with food, body image, and attitudes about weight	- Not described	- Information to develop and maintain healthy habits, disrupt unhealthy habits, create environments that encourage goal-related cues	- Licensed clinical health psychologist and/or graduate students in psychology	- 90 min, face to face, weekly group sessions	- Not specified, assumed at university clinic; USA	- 12 week program administered in 90 min group sessions, weekly - F/up at 6 months post-intervention with no treatment during this period	- All participants received same intervention	- Not described	- Not described	- 43 (73%) participants remained in program (TYL = 20; Control = 23) - Across groups, participants recorded 52.7 (SD = 36.1; 62.7%) out of 84 possible diet and exercise diaries over 12 weeks

Cleo, 2018	- Habit-based weight loss interventions: Ten Top Tips (TTT) and Do Something Different (DSD)	- Adults with overweight or obesity (BMI ≥25kg/m²)	- Habitual behaviors strongly influence health outcomes - Habit based weight-loss studies with data beyond 6 months post-intervention are scarce	- TTT: Written materials provided including: self-guided leaflet detailing the intervention and logbook, for self-monitoring target behaviors and weight (www.weightconcern.org.uk/tentoptips) - DSD implemented via online software (www.dsd.me)	- TTT: 12 week, self-guided, intervention - 10 behaviors associated with achieving negative energy balance, improving awareness of food intake and promote routines - DSD: 9 week intervention to break unhealthy habits	- Dietitian experienced in weight management	- Baseline face to face meeting in groups of 5 - Remainder of intervention was self-guided with supportive weekly phone calls from dietitian	- Bond University, Institute of Health and Sport, Gold Coast, Australia	- TTT and DSD: Participants attended group baseline meeting and contacted via telephone weekly for the intervention period - DSD: Participants received tasks via email and/or text message, 3-4 times per week for the intervention period - F/up at 6 and 12 months post-intervention with no contact between f/up sessions	- TTT: all participants received same intervention - DSD: participants completed questionnaires assessing personal behaviors and habits and tailored program to each individual	- Interventions delivered as intended	- Researchers followed procedure manuals by original developers and standardized introductory presentations and resources - Weekly phone calls by dietitian discussing barriers and facilitators of program adherence. Problem solving strategies discussed	- Intervention fidelity not formally measured - Dietitian able to monitor through weekly phone calls and weekly self-monitoring tools participants completed
ally, 2008	- Healthy habits: Efficacy of Ten Top Tips (TTT) on weight control	- Adults with overweight or obesity (BMI ≥25kg/m²)	- Few behavioural interventions have been underpinned by theory related to habit formation	- Written materials provided including: self-guided leaflet detailing intervention and logbook, for self-monitoring target behaviors and weight (www.weightconcern.org.uk/tentoptips)	- 12 week, self-guided, intervention - 10 behaviors associated with achieving negative energy balance, improving awareness of food intake and promote routines	- Research psychologist	- Baseline face to face meeting, with whole intervention group - Remainder of intervention was self-guided with no further clinical contact	- Health Behavior unit at University College London; UK	- Participants given leaflet at baseline and received no further therapeutic contact. - Weight measured at drop-in sessions at baseline, weeks 4 and 8 and either weekly or monthly for 6 months (to 32 weeks) - F/up was 8 months post-intervention with no contact between intervention and f/up	- All participants received same intervention	- Not described	- Not described	- 46% of participants that completed final qualitative report (n=24) stated all behaviors became habits, 33% reported some were habits and remainder none were habits

Abbreviations: TTT = Ten Top Tips; BMI = Body Mass Index; GPs = General Practitioners; MRC = Medical Research Council; min = minute; f/up = follow up; TYL = Transforming Your Life; NP = New Perspectives; DSD = Do Something Different.

Cleo, 2019. Supplementary Material.

Title: Efficacy of habit-based weight loss interventions: a systematic review and meta-analysis

Authors: Gina Cleo, Elaine Beller, Paul Glasziou, Elisabeth Isenring, Rae Thomas

Supplementary Material

Supplementary File 1: PROSPERO International prospective register of systematic reviews

Supplementary File 2: Search Strategy

Supplementary Table 1: Descriptive data of excluded studies

Supplementary Figure 1: Comparing weight loss (kg) at follow-up between intervention and control groups

Supplementary Figure 2: Proportion of participants achieving ≥5% total body weight reduction at post-intervention and follow-up

Supplementary Figure 3: Subgroup analysis comparing weight loss (kg) between forming habits and a combination of forming and breaking habits

Supplementary File 1: PROSPERO International prospective register of systematic reviews

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PROSPERO International prospective register of systematic reviews

Review title and timescale

1 Review title
Give the working title of the review. This must be in English. Ideally it should state succinctly the interventions or exposures being reviewed and the associated health or social problem being addressed in the review.
Efficacy of habit-based weight loss interventions: a systematic review and meta analysis

2 Original language title
For reviews in languages other than English, this field should be used to enter the title in the language of the review. This will be displayed together with the English language title.

3 Anticipated or actual start date
Give the date when the systematic review commenced, or is expected to commence.
02/06/2017

4 Anticipated completion date
Give the date by which the review is expected to be completed.
08/09/2017

5 Stage of review at time of this submission
Indicate the stage of progress of the review by ticking the relevant boxes. Reviews that have progressed beyond the point of completing data extraction at the time of initial registration are not eligible for inclusion in PROSPERO. This field should be updated when any amendments are made to a published record.

The review has not yet started   ✗

Review stage	Started	Completed
Preliminary searches	Yes	Yes
Piloting of the study selection process	Yes	Yes
Formal screening of search results against eligibility criteria	Yes	Yes
Data extraction	Yes	No
Risk of bias (quality) assessment	No	No
Data analysis	No	No

Provide any other relevant information about the stage of the review here.

Review team details

6 Named contact
The named contact acts as the guarantor for the accuracy of the information presented in the register record.
Ms Cleo

7 Named contact email
Enter the electronic mail address of the named contact.
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8 Named contact address
Enter the full postal address for the named contact.
Center for Research in Evidence Based Practice Faculty of Health Sciences and Medicine Bond University 14 University Drive, ROBINA QLD 4226 AUSTRALIA

9 Named contact phone number
Enter the telephone number for the named contact, including international dialing code.
+61 75595 1588

10 Organisational affiliation of the review
Full title of the organisational affiliations for this review, and website address if available. This field may be completed as 'None' if the review is not affiliated to any organisation.

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Bond University

Website address:
https://bond.edu.au/

11 Review team members and their organisational affiliations
Give the title, first name and last name of all members of the team working directly on the review. Give the organisational affiliations of each member of the review team.

Title	First name	Last name	Affiliation
Ms	Gina	Cleo	Bond University
Professor	Paul	Glasziou	Bond University
Professor	Elaine	Beller	Bond University
Dr	Rae	Thomas	Bond University

12 Funding sources/sponsors
Give details of the individuals, organizations, groups or other legal entities who take responsibility for initiating, managing, sponsoring and/or financing the review. Any unique identification numbers assigned to the review by the individuals or bodies listed should be included.
This review received no funding sources or sponsors GC received no funding with respect to this study. RT and EB are supported by a NHMRC grant (APP1104136, APP1044904). PG is supported by a NHMRC Australian Fellowship grant (GNT1080042).

13 Conflicts of interest
List any conditions that could lead to actual or perceived undue influence on judgements concerning the main topic investigated in the review.
Are there any actual or potential conflicts of interest?
Yes

GC has conducted a randomized controlled trial comparing two habit-based interventions for weight loss. Manuscript is under review.

14 Collaborators
Give the name, affiliation and role of any individuals or organisations who are working on the review but who are not listed as review team members.

Title	First name	Last name	Organisation details
Ms	Rebecca	Sims	Bond University
Mr	Justin	Clark	Bond University

Review methods

15 Review question(s)
State the question(s) to be addressed / review objectives. Please complete a separate box for each question.
What is the effect of habit-based weight-loss interventions on weight reduction in overweight and obese adults?

What is the effect of habit-based weight-loss interventions on weight loss maintenance in overweight and obese adults after the conclusion of the study (at last follow-up)?

What is the proportion of participants achieving clinically important weight loss and weight loss maintenance (>/=5% total body weight loss) post-intervention and at last follow-up?

16 Searches
Give details of the sources to be searched, and any restrictions (e.g. language or publication period). The full search strategy is not required, but may be supplied as a link or attachment.
Electronic searches within PubMed, Embase, CINAHL, Cochrane CENTRAL and Web of Science, will be conducted to identify potential studies for inclusion. The search strategy will include only terms relating to or describing habit-based weight loss interventions. There will be no language or date restrictions. The searches will be re-run just before the final analyses and further studies retrieved for inclusion.

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17   URL to search strategy
If you have one, give the link to your search strategy here. Alternatively you can e-mail this to PROSPERO and we will store and link to it.
https://www.crd.york.ac.uk/PROSPEROFILES/65589_STRATEGY_20170619.pdf

I give permission for this file to be made publicly available
Yes

18   Condition or domain being studied
Give a short description of the disease, condition or healthcare domain being studied. This could include health and wellbeing outcomes.
Overweight and/or obesity

19   Participants/population
Give summary criteria for the participants or populations being studied by the review. The preferred format includes details of both inclusion and exclusion criteria.
Inclusion: Adults (18 years of age and above); overweight or obese by BMI classification (>/=25.0kg/m^2) Exclusion: Children or adolescents (under 18 years of age).

20   Intervention(s), exposure(s)
Give full and clear descriptions of the nature of the interventions or the exposures to be reviewed
The search strategy will restrict the search to habit-based weight-loss interventions that focus specifically on habit-change as the conceptual theory; therefore, habit-change is the primary strategy for behavior change and weight loss. The inclusion criteria of studies for review are: randomized clinical trials and quasi randomized clinical trials that quantify weight change outcomes in overweight or obese adults (at a minimum for pre-intervention and post-intervention), any year, country or language. If multiple post-intervention follow-up assessments are reported, then the longest follow-up (i.e., longest duration from the conclusion of the intervention) will be used for the purpose of this review.

21   Comparator(s)/control
Where relevant, give details of the alternatives against which the main subject/topic of the review will be compared (e.g. another intervention or a non-exposed control group).
The comparator is likely to be a waitlist comparison group, usual care group, or an alternative active intervention group.

22   Types of study to be included
Give details of the study designs to be included in the review. If there are no restrictions on the types of study design eligible for inclusion, this should be stated.
We will include randomized clinical trials and quasi randomised clinical trials which report weight change outcomes. The trial must include an intervention and a control group.

23   Context
Give summary details of the setting and other relevant characteristics which help define the inclusion or exclusion criteria.
Trials conducted in any setting and any country will be included.

24   Primary outcome(s)
Give the most important outcomes.
Change in weight (kg)

Give information on timing and effect measures, as appropriate.
Changes in weight from (1) baseline to post-intervention and (2) baseline to last available follow-up.

25   Secondary outcomes
List any additional outcomes that will be addressed. If there are no secondary outcomes enter None.
Clinically beneficial weight change (weight loss = >/= 5% total body weight)

Give information on timing and effect measures, as appropriate.
Proportion of participants losing >/=5% total body weight lost at last available follow-up

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26   Data extraction (selection and coding)
Give the procedure for selecting studies for the review and extracting data, including the number of researchers involved and how discrepancies will be resolved. List the data to be extracted.
Titles and/or abstracts of studies retrieved using the search strategy and those from additional sources will be screened independently by two reviewers to identify studies that potentially meet the inclusion criteria outlined above. The full text of these potentially eligible studies will be retrieved and independently assessed for eligibility by two review team members. Any disagreements will be resolved through discussion with a third reviewer. A standardized, pre-piloted form will be used to extract data from the included studies for assessment of study quality and evidence synthesis. Extracted information will include: study setting; study population and participant demographics and baseline characteristics; details of the intervention and control conditions; type of study used; recruitment and study completion dates; outcomes and times of measurement; information for assessment of the risk of bias. Two reviewers will extract data independently, discrepancies will be identified and resolved through discussion, consensus, or arbiter. Missing data will be requested from study authors via email at least twice.

27   Risk of bias (quality) assessment
State whether and how risk of bias will be assessed, how the quality of individual studies will be assessed, and whether and how this will influence the planned synthesis.
Two independent reviewers will assess the risk of bias in included studies by using the Cochrane Risk of Bias tool (Higgins & Green 2011). This includes: random sequence generation (selection bias); allocation concealment (selection bias); blinding of participants and personnel (performance bias); blinding of outcome assessment (detection bias); incomplete outcome data (attrition bias); selective reporting (reporting bias); other sources of bias. Each of these domains will be described as reported in the trial and then assigned a judgement about the adequacy of each item: 'low', 'high', or 'unclear' risk of bias. Disagreements between reviewers will be resolved by discussion, consensus, or arbiter.

28   Strategy for data synthesis
Give the planned general approach to be used, for example whether the data to be used will be aggregate or at the level of individual participants, and whether a quantitative or narrative (descriptive) synthesis is planned. Where appropriate a brief outline of analytic approach should be given.
We anticipate that there will be limited scope for meta-analysis due to heterogeneity of intervention duration and methods. However, where studies have used the same type of intervention and comparator, we will pool the results using a random-effects meta-analysis and calculate 95% confidence intervals and two sided P values for each outcome. We will also provide a narrative synthesis of the findings from the included studies, structured around the type of intervention, target population characteristics, type of outcome and intervention content. We will provide summaries of intervention effects for each study by calculating mean differences for changes in weight. We will describe the proportion of participants who have lost ./=5% total body weight from baseline to post-intervention and baseline to last available follow-up.

29   Analysis of subgroups or subsets
Give any planned exploration of subgroups or subsets within the review. 'None planned' is a valid response if no subgroup analyses are planned.
Active vs non-active controls

Review general information

30   Type and method of review
Select the type of review and the review method from the drop down list.
Systematic review

31   Language
Select the language(s) in which the review is being written and will be made available, from the drop down list. Use the control key to select more than one language.
English

Will a summary/abstract be made available in English?
Yes

32   Country
Select the country in which the review is being carried out from the drop down list. For multi-national collaborations select all the countries involved. Use the control key to select more than one country.
Australia

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33   Other registration details
Give the name of any organisation where the systematic review title or protocol is registered together with any unique identification number assigned. If extracted data will be stored and made available through a repository such as the Systematic Review Data Repository (SRDR), details and a link should be included here.

34   Reference and/or URL for published protocol
Give the citation for the published protocol, if there is one.
Give the link to the published protocol, if there is one. This may be to an external site or to a protocol deposited with CRD in pdf format.

I give permission for this file to be made publicly available
Yes

35   Dissemination plans
Give brief details of plans for communicating essential messages from the review to the appropriate audiences.
Outcomes of this review and meta-analysis are expected to be published in a peer-reviewed journal.

Do you intend to publish the review on completion?
Yes

36   Keywords
Give words or phrases that best describe the review. (One word per box, create a new box for each term)
weight management

behaviour change

habit-change

habit-based intervention

weight loss intervention

weight loss maintenance

systematic review

forming habits

breaking habits

37   Details of any existing review of the same topic by the same authors
Give details of earlier versions of the systematic review if an update of an existing review is being registered, including full bibliographic reference if possible.

38   Current review status
Review status should be updated when the review is completed and when it is published.
Ongoing

39   Any additional information
Provide any further information the review team consider relevant to the registration of the review.

40   Details of final report/publication(s)
This field should be left empty until details of the completed review are available.
Give the full citation for the final report or publication of the systematic review.
Give the URL where available.

Cleo, 2019. Supplementary Material.

Supplementary File 2: Search Strategy

We used the following search strategies to search Pubmed to search the Cochrane Central Register of Controlled Trials (CENTRAL), Embase, CINAHL and Web of Science. There were no language or date restrictions.

PubMed search

("Habits"[Mesh] OR "Habits"[tiab] OR Habit[tiab])

AND

(Formation[tiab] OR Disruption[tiab] OR Based[tiab] OR Breaking[tiab] OR Break[tiab])

AND

("Weight Loss"[Mesh] OR "Weight loss"[tiab] OR "Weight control"[tiab] OR "Weight reduction"[tiab])

AND

("Patient Education as Topic"[Mesh] OR "Pamphlets"[Mesh] OR "Diet, Reducing"[Mesh] OR "Weight Reduction Programs"[Mesh] OR "Environment Design"[Mesh] OR "Patient education"[tiab] OR Pamphlet[tiab] OR Pamphlets[tiab] OR Leaflet[tiab] OR Leaflets[tiab] OR Dietary[tiab] OR Diet[tiab] OR Diets[tiab] OR Food[tiab] OR Foods[tiab] OR "Weight Reduction Programs"[tiab] OR "Weight Reducing Programs"[tiab] OR "Weight Reduction Program"[tiab] OR "Weight Reducing Program"[tiab] OR "Environment Design"[tiab] OR "Environmental modification"[tiab])

AND

("randomized controlled trial"[pt] OR "controlled clinical trial"[pt] OR randomized[tiab] OR randomised[tiab] OR placebo[tiab] OR randomly[tiab] OR trial[tiab] OR groups[tiab] OR "Epidemiologic Studies"[Mesh] OR "case-control studies"[Mesh] OR "Cohort Studies"[Mesh] OR "case control"[tiab] OR Cohort[tiab] OR "Follow up"[tiab] OR Observational[tiab] OR longitudinal[tiab] OR Prospective[tiab] OR retrospective[tiab] OR "cross sectional"[tiab] OR "Cross-Sectional Studies"[Mesh] OR Investigated[tiab] OR Analysis[tiab] OR Statistics[tiab] OR Data[tiab] OR "statistics and numerical data"[sh] OR "epidemiology"[sh])

Cleo, 2019. Supplementary Material.

Cochrane CENTRAL

([mh Habits] OR Habits:ti,ab OR Habit:ti,ab)

AND

(Formation:ti,ab OR Disruption:ti,ab OR Based:ti,ab OR Breaking:ti,ab OR Break:ti,ab)

AND

([mh "Weight Loss"] OR "Weight loss":ti,ab OR "Weight control":ti,ab OR "Weight reduction":ti,ab)

AND

([mh "Patient Education as Topic"] OR [mh Pamphlets] OR [mh "Diet, Reducing"] OR [mh "Weight Reduction Programs"] OR [mh "Environment Design"] OR "Patient education":ti,ab OR Pamphlet:ti,ab OR Pamphlets:ti,ab OR Leaflet:ti,ab OR Leaflets:ti,ab OR Dietary:ti,ab OR Diet:ti,ab OR Diets:ti,ab OR Food:ti,ab OR Foods:ti,ab OR "Weight Reduction Programs":ti,ab OR "Weight Reducing Programs":ti,ab OR "Weight Reduction Program":ti,ab OR "Weight Reducing Program":ti,ab OR "Environment Design":ti,ab OR "Environmental modification":ti,ab)

Embase

('Habit'/exp OR Habits:ti,ab OR Habit:ti,ab)

AND

(Formation:ti,ab OR Disruption:ti,ab OR Based:ti,ab OR Breaking:ti,ab OR Break:ti,ab)

AND

('weight reduction'/exp OR "Weight loss":ti,ab OR "Weight control":ti,ab OR "Weight reduction":ti,ab)

AND

('Patient Education'/exp OR 'publication'/exp OR 'diet therapy'/exp OR 'weight loss program'/exp OR 'environmental planning'/exp OR "Patient education":ti,ab OR Pamphlet:ti,ab OR Pamphlets:ti,ab OR Leaflet:ti,ab OR Leaflets:ti,ab OR Dietary:ti,ab OR Diet:ti,ab OR Diets:ti,ab OR Food:ti,ab OR Foods:ti,ab OR "Weight Reduction Programs":ti,ab OR "Weight Reducing Programs":ti,ab OR "Weight Reduction Program":ti,ab OR "Weight Reducing Program":ti,ab OR "Environment Design":ti,ab OR "Environmental modification":ti,ab)

AND

(random* OR factorial OR crossover OR placebo OR blind OR blinded OR assign OR assigned OR allocate OR allocated OR 'crossover procedure'/exp OR 'double-blind procedure'/exp OR 'randomized controlled trial'/exp OR 'single-blind procedure'/exp OR 'epidemiology'/exp OR 'controlled study'/exp OR 'cohort analysis'/exp OR "case control":ti,ab OR Cohort:ti,ab OR "Follow

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up":ti,ab OR Observational:ti,ab OR longitudinal:ti,ab OR Prospective:ti,ab OR retrospective:ti,ab OR "cross sectional":ti,ab OR 'Cross-Sectional Studies'/exp OR Investigated:ti,ab OR Analysis:ti,ab OR Statistics:ti,ab OR Data:ti,ab)

CINAHL

((MH "Habits+") OR TI Habits OR AB Habits OR TI Habit OR AB Habit)

AND

(TI Formation OR AB Formation OR TI Disruption OR AB Disruption OR TI Based OR AB Based OR TI Breaking OR AB Breaking OR TI Break OR AB Break)

AND

((MH "Weight Loss+") OR TI "Weight loss" OR AB "Weight loss" OR TI "Weight control" OR AB "Weight control" OR TI "Weight reduction" OR AB "Weight reduction")

AND

((MH "Patient Education+") OR (MH "Pamphlets+") OR (MH "Diet, Reducing+") OR (MH "Weight Reduction Programs+") OR TI "Patient education" OR AB "Patient education" OR TI Pamphlet OR AB Pamphlet OR TI Pamphlets OR AB Pamphlets OR TI Leaflet OR AB Leaflet OR TI Leaflets OR AB Leaflets OR TI Dietary OR AB Dietary OR TI Diet OR AB Diet OR TI Diets OR AB Diets OR TI Food OR AB Food OR TI Foods OR AB Foods OR TI "Weight Reduction Programs" OR AB "Weight Reduction Programs" OR TI "Weight Reducing Programs" OR AB "Weight Reducing Programs" OR TI "Weight Reduction Program" OR AB "Weight Reduction Program" OR TI "Weight Reducing Program" OR AB "Weight Reducing Program" OR TI "Environment Design" OR AB "Environment Design" OR TI "Environmental modification" OR AB "Environmental modification")

AND

((MH "Clinical Trials+") OR (MH "Quantitative Studies") OR TI placebo* OR AB placebo* OR (MH "Placebos") OR (MH "Random Assignment") OR TI random* OR AB random* OR TI ((singl* or doubl* or tripl* or trebl*) W1 (blind* or mask*)) OR AB ((singl* or doubl* or tripl* or trebl*) W1 (blind* or mask*)) OR TI clinic* trial* OR AB clinic* trial* OR PT clinical trial OR (MH "Epidemiological Research+") OR (MH "Study Design+") OR TI "case control" OR AB "case control" OR TI Cohort OR AB Cohort OR TI "Follow up" OR AB "Follow up" OR TI Observational OR AB Observational OR TI longitudinal OR AB longitudinal OR TI Prospective OR AB Prospective OR TI retrospective OR AB retrospective OR TI "cross sectional" OR AB "cross sectional" OR TI Investigated OR AB Investigated OR TI Analysis OR AB Analysis OR TI Statistics OR AB Statistics OR TI Data OR AB Data)

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Web of Science

(Habits OR Habit)

AND

(Formation OR Disruption OR Breaking OR Break)

AND

("Weight Loss" OR "Weight loss" OR "Weight control" OR "Weight reduction")

AND

("Patient Education as Topic" OR Pamphlets OR "Diet, Reducing" OR "Weight Reduction Programs" OR "Environment Design" OR "Patient education" OR Pamphlet OR Pamphlets OR Leaflet OR Leaflets OR Dietary OR Diet OR Diets OR "Weight Reduction Programs" OR "Weight Reducing Programs" OR "Weight Reduction Program" OR "Weight Reducing Program" OR "Environment Design" OR "Environmental modification")
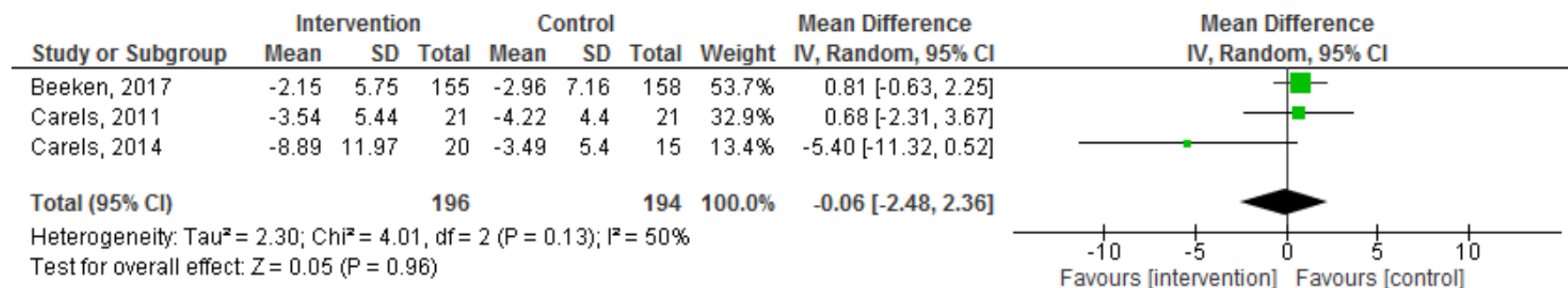
AND

(Trial OR randomized OR randomised OR placebo OR randomly OR groups OR "Epidemiologic Studies" OR Epidemiological OR "case-control studies" OR "Cohort Studies" OR "case control" OR Cohort OR "Follow up" OR Observational OR longitudinal OR Prospective OR retrospective OR "cross sectional" OR "Cross-Sectional Studies" OR Investigated OR Analysis OR Statistics OR Data)

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Supplementary Table 1 Descriptive data of excluded studies

Study reference	Baseline weight, kg*	Mean age, years	Intervention theory	Duration of intervention (weeks)	Follow-up (months)	Reason for exclusion
Beeken, 2011	Pre-intervention (no data)	Pre-intervention (no data)	Forming habits	12	24	Duplicate
Beeken, 2014	100.8 (±17.2)	59 (IQR 48.7-66.8)	Forming habits	12	24	Duplicate
Fletcher, 2011	$29.6kg/m^2$ (± 4.8)	44.2 (± 7.3)	Breaking habits	4	2	Non-randomised
Kraschnewski, 2010	93.2 (±14.4)	50 (± 10.9)	Lifestyle program	12	nil	Not habit-based
Page, 2008	$30kg/m^2$ (± 5.7)	44.4 (±8.7)	Breaking habits	4	2-3	Non-randomised
Ter Bogt, 2011	88	56 (± 7.7)	Lifestyle program	1 x baseline session	8 (visits) 12 (telephone)	Not habit-based

Abbreviations: kg = kilogram; BMI = Body Mass Index; IQR = Interquartile range.

* BMI (kg/m^2) was used if weight (kg) not reported

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Study or Subgroup	Intervention Mean	SD	Total	Control Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI	Mean Difference IV, Random, 95% CI
Beeken, 2017	-2.15	5.75	155	-2.96	7.16	158	53.7%	0.81 [-0.63, 2.25]	
Carels, 2011	-3.54	5.44	21	-4.22	4.4	21	32.9%	0.68 [-2.31, 3.67]	
Carels, 2014	-8.89	11.97	20	-3.49	5.4	15	13.4%	-5.40 [-11.32, 0.52]	
Total (95% CI)			196			194	100.0%	-0.06 [-2.48, 2.36]	

Heterogeneity: Tau² = 2.30; Chi² = 4.01, df = 2 (P = 0.13); I² = 50%
Test for overall effect: Z = 0.05 (P = 0.96)

-10 -5 0 5 10
Favours [intervention]   Favours [control]

Supplementary Figure 1 Comparing weight loss (kg) at follow-up between intervention and control groups

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Supplementary Figure 2 Proportion of participants achieving ≥5% total body weight reduction at post-intervention and follow-up

Study or Subgroup	Intervention			Control			Weight	Mean Difference IV, Random, 95% CI
	Mean	SD	Total	Mean	SD	Total		
3.1.1 Forming new habits								
Beeken, 2017	-1.68	3.21	187	-0.84	2.83	196	44.5%	-0.84 [-1.45, -0.23]
Cleo, 2018 (1)	-3.33	4.25	22	-0.43	1.7	23	14.9%	-2.90 [-4.81, -0.99]
Lally, 2008	-1.99	1.89	56	-0.42	1.56	33	40.6%	-1.57 [-2.30, -0.84]
Subtotal (95% CI)			265			252	100.0%	**-1.44 [-2.30, -0.59]**
3.1.2 Forming new habits + breaking old habits								
Carels, 2011	-4.94	4.9	25	-5.81	4.72	24	33.7%	0.87 [-1.82, 3.56]
Carels, 2014	-6.71	8.69	20	-5.62	8.69	23	17.1%	-1.09 [-6.30, 4.12]
Cleo, 2018 (2)	-3.09	1.95	43	-0.43	1.7	23	49.2%	-2.66 [-3.57, -1.75]
Subtotal (95% CI)			88			70	100.0%	**-1.20 [-3.83, 1.42]**

Heterogeneity: Tau² = 0.33; Chi² = 5.37, df = 2 (P = 0.07); I² = 63%
Test for overall effect: Z = 3.30 (P = 0.0010)

Heterogeneity: Tau² = 3.44; Chi² = 6.13, df = 2 (P = 0.05); I² = 67%
Test for overall effect: Z = 0.90 (P = 0.37)

Test for subgroup differences: Chi² = 0.03, df = 1 (P = 0.86), I² = 0%

Footnotes
(1) Data relate only to the habit forming intervention, Ten Top Tips, as reported in the publication.
(2) Data relate to the combined outcomes of the habit forming (Ten Top Tips) and habit breaking (Do Something Different) interventions.

Supplementary Figure 3 Subgroup analysis comparing weight loss (kg) between forming habits and a combination of forming and breaking habits