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How can self-efficacy be increased? Meta-analysis of dietary interventions.

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Abstract

Objective: Targeting individuals' beliefs that they are able to eat healthily can improve dietary-related behaviours. However, the most effective behaviour change techniques (BCTs) to promote dietary self-efficacy have not been systematically reviewed. This research addressed this gap.

Methods: Studies testing the effect of interventions on healthy eating and underlying dietary-related self-efficacy, within randomised controlled trials, were systematically reviewed in MEDLINE, EMBASE and PSYCINFO. Two reviewers independently coded intervention content in both intervention and comparison groups. Data pertaining to study quality were also extracted. Random effects meta-analysis was used to calculate an overall effect size on dietary self-efficacy for each study. The associations between 26 BCTs and self-efficacy effects were calculated using meta-regression.

Results: In some of the analyses, interventions that incorporated self-monitoring (tracking one's own food-related behaviour), provided feedback on performance, prompted review of behavioural goals, provided contingent rewards (rewarding diet success), or planned for social support/social change increased dietary self-efficacy significantly more than interventions that did not. Stress management was consistently associated with self-efficacy effects across all analyses.

Conclusions: There was strong evidence for stress management and weaker evidence for a number of other BCTs. The findings can be used to develop more effective, theory- and evidence-based behavioural interventions.

Keywords: self-efficacy; diet; review; meta-analysis; random; behaviour change

Introduction

Self-efficacy has been defined as 'beliefs in one's capabilities to organize and execute the courses of action required to produce given levels of attainment' (Bandura, 1997, p. 624). It has been argued to be a key determinant of behaviour on the basis of theory (e.g., Social Cognitive Theory, Bandura, 1986; Transtheoretical Model, Prochaska & Velicer, 1997; integrative theories: Fishbein et al., 2001; Michie et al., 2005) and, in the domain of healthy eating, correlational (e.g., Gutiérrez-Doña, Lippke, Renner, Kwon, & Schwarzer, 2009) and experimental (e.g., Burke, Beilin, Cutt, Mansour, & Mori, 2008; Fuemmeler et al., 2006; Langenberg et al., 2000; Luszczynska, Tryburcy, & Schwarzer, 2007) evidence. As such, identifying effective behaviour change techniques (BCTs) that can promote dietary self-efficacy is an important issue for the development of successful dietary interventions including those that are personalized, or tailored, to the needs of the individual. Identifying the BCTs that promote self-efficacy can also be informative about the potential mechanisms underlying the impact of BCTs on behaviour. BCTs that change self-efficacy may change behaviour because of their impact on self-efficacy. BCTs that do not change self-efficacy may change behaviour because of their impact on other determinants.

Bandura (1977) proposed four sources of self-efficacy: performance accomplishments, vicarious experience, verbal persuasion, and physiological states. Performance accomplishments, or mastery, refer to instances in which an individual has successfully enacted the behaviour which, in turn, should boost feelings of self-efficacy. Vicarious experiences, or modelling, are those in which an individual witnesses others successfully perform the desired behaviour. Seeing others perform the behaviour successfully helps encourage people to feel that they also have the requisite ability to perform the desired behaviour, as well as providing vital information regarding how success can be achieved. Persuasion helps to dispel feelings of self-doubt and helps structure attempts to

perform the behaviour ensuring individuals do not tackle too much too soon (see Bandura, 1997). High emotional arousal tends to disrupt performance (Bandura, 1977), and people interpret stress and tension as signals of inefficacy (Bandura, 1997), thus people are likely to have lower feelings of self-efficacy under aversive arousal.

Bandura's (1977) sources of self-efficacy could be reflected in a host of specific BCTs (i.e., the component of the intervention designed to change behaviour which is distinct from the mode of delivery, Michie & Johnston, in press). A popular taxonomy of behaviour change techniques (Abraham & Michie, 2008) specifies 26 BCTs commonly used to change physical activity and dietary behaviours. Some of these BCTs map onto the four sources of self-efficacy outlined by Bandura.

For performance accomplishments to influence self-efficacy, people need to practice the behaviour ('prompt practice' from Abraham & Michie's, 2008, taxonomy), monitor their behaviour/accomplishments ('prompt self-monitoring of behaviour'), and revise their goals accordingly ('prompt review of behavioural goals'). Vicarious experiences could, for example, incorporate the BCTs 'model/demonstrate the behaviour', 'provide opportunities for social comparison' and 'provide instruction'. Persuasion could make use of the BCTs 'provide general encouragement', 'provide feedback on performance' and, according to Bandura (1997), 'set graded tasks' to ensure people do not strive for targets that they would likely fail to reach. The BCT 'stress management' could be used to tackle emotional arousal. There is a need, therefore, to clearly identify the specific BCTs that can change self-efficacy using established taxonomies of BCTs (e.g., Abraham & Michie, 2008).

Through a consensus approach that incorporated a taxonomy defining specific BCTs, Michie et al. (2008) identified the BCTs most likely to change a range of specific behavioural determinants, including self-efficacy. This work provides a very useful starting point in linking theory to techniques and in developing theory-based interventions. However, as they

note, their work was not evidence-based, relying instead on personal judgements regarding the efficacy of specific BCTs in changing specific determinants. Conducting systematic reviews to establish which BCTs best change specific determinants of behaviour such as self-efficacy should help to develop more effective, theory- and evidence-based behavioural interventions (e.g., Michie & Johnston, 2012; Michie & West, 2013).

Few meta-analyses have, so far, been conducted to examine which BCTs change self-efficacy. Williams and French's (2011) review of 27 physical activity studies identified 'action planning', 'provide instruction', and 'reinforcing effort or progress towards behaviour' as being associated with higher self-efficacy (see also related reviews concerning changes in self-efficacy and physical activity: Ashford, Edmunds and French, 2010; Olander, Fletcher, Williams, Atkinson, Turner & French, 2013). While Williams and French's review presented a novel approach to identifying effective strategies to boost self-efficacy for physical activity, it has a number of limitations. First, the BCTs delivered to the comparison groups were not coded. Thus, studies incorporating a specific BCT only in the experimental group were coded the same as studies employing the same BCT in both the experimental and comparison groups (see Michie, Prestwich, & De Bruijn, 2010; Williams, 2010). This limitation is also applicable to reviews concerning the impact of BCTs on specific health behaviours (Michie et al., 2009; Dombrowski et al., 2012). Second, Williams and French's review included studies that did not employ a control group. Studies without control groups are limited in identifying causal factors as changes in cognitions or behaviours could be attributed to factors outside the intervention. Moreover, the association between the type of design (or other methodological or intervention-related factors) and self-efficacy effect sizes were not reported thus potential confounders could not be ruled out. Third, sensitivity analyses accounting for statistical considerations such as outliers or correcting for use of cluster designs were not reported.

Objectives

The current review attempted to identify whether dietary interventions (reported in RCTs) that incorporated specific BCTs were more effective in promoting dietary self-efficacy than interventions that did not incorporate the specific BCT. Overcoming the limitations of related reviews, the current review also accounted for the use of BCTs in both intervention and comparison groups, potential methodological confounds related to study design or other sources of bias, and other statistical considerations.

Method

Eligibility criteria

As the primary aim of the review was to identify the BCTs that cause the largest increases in dietary self-efficacy, to be included in the review, studies had to meet the following criteria 1. involve random assignment of participants to a treatment group who received an intervention and a control group who received either a control intervention or no intervention; 2.test the effect of an intervention promoting healthy eating/diet; 3. include a measure of self-efficacy or perceived behavioural control related to diet after the participants were exposed to the intervention (so that the effect of the intervention on the determinant could be tested).

Following screening of titles and abstracts, an additional inclusion criterion was added such that 4. Sufficient statistical information was available to calculate an effect size estimate of the impact of the intervention on self-efficacy. A secondary issue (to be reported elsewhere) concerned whether changes in dietary self-efficacy were associated with changes in dietary behaviour thus two further inclusion criteria were that the study 5. had a measure of dietary behaviour at follow-up that 6. was taken either after, or at the same time as, the post-intervention self-efficacy measure. Studies were excluded if: 1. the study had a non-human (animal) sample, or 2. the paper was an existing review, or 3. the main focus of the

intervention was a test of a drug therapy/treatment (as the focus was on behavioural strategies); 4. the sample comprised athletes (on the basis that dietary changes in athletes would likely be for the purpose of improved athletic performance rather than to improve health); 5. the study was not reported in the English language.

Search Strategy

MEDLINE (1996-), EMBASE (1996-), and PsycINFO (1806, restricted to 1996-) were searched using OVID (see Web Table 7). The search strategy was based around three filters to identify randomized controlled trials (Haynes et al., 2005) targeting dietary behaviours (Nield et al., 2007) that incorporate a measure of self-efficacy (Ashford et al., 2010). To increase sensitivity, additional search terms were added to Nield et al.'s (2007) dietary behaviour filter and to Ashford et al.'s (2010) self-efficacy filter. Where studies met the inclusion/exclusion criteria and referred to associated papers for further methodological, statistical, or intervention-related details, these associated papers were retrieved and taken into account in the coding. The searches were last run on the 28th May, 2011.

The titles and abstracts were independently double-screened. Studies identified as eligible for possible inclusion by either reviewer were included in the full-text screening. The full-texts were also independently double-screened and discrepancies were resolved through consensus. The review protocol has not been published.

Data Extraction

Data were extracted from each study by three members of the review team. Two reviewers initially coded the studies independently. A third reviewer resolved discrepancies across coders and checked the initial codes. Various features of the study (type of RCT (cluster vs. non-cluster), type of sample (university; clinical; community; workplace [non-university]; educational [non-university]; activity group (e.g., scout troops)), and setting (educational; clinical; community) were coded, along with various characteristics of the

interventions and study that could reflect bias. Studies that comprised exclusively of overweight/obese (BMI>25) people were coded as a 'clinical' sample for type of sample. This ensured that the clinical samples reflected people who directly need to change their diet because of weight concerns or a clinical condition (e.g., hypercholesterolemia) much more strongly than studies coded as using community, workplace, educational or activity group-based samples. There were some instances where samples classified as 'clinical' (e.g., people with Type 2 diabetes; overweight/obese people) were tested in community rather than clinical settings (e.g., Lorig et al., 2009; Turner-McGrievey et al., 2009).

Characteristics of Interventions

The following data were extracted from papers associated with each study: specific BCTs (using Abraham and Michie's (2008) taxonomy of 26 BCTs), the duration of the delivery of these BCTs (from the first to the last delivery), the number of sessions and mode of delivery (face-to-face; internet/PC; telephone; mail; printed materials; video-based; included group-based component; included individual-based component). These data were extracted both for the intervention and comparison groups allowing the generation of measures reflecting differences between the experimental and comparison groups. For example, differences in the use of specific BCTs equated to measures coded +1 (to reflect use of specific BCT in the intervention condition but not in the comparison condition), 0 (reflecting use of the BCT in both intervention and comparison groups, or in neither), -1 (to reflect use of the specific BCT in the comparison group but not the intervention group). Whether the intervention targeted only dietary behaviours or other health-related behaviours, and the goal focus of the intervention (to increase intake of particular foods, reduce intake, or a combination) were also recorded. How each measure was coded is reported in Web Table 3. The inter-rater reliability for the BCTs was moderate (median kappa = .51; median

percentage agreement = 87.9%) though all codes were checked, and discrepancies resolved, by a third coder.

Risk of bias in individual studies

Bias risk was assessed using the Cochrane Collaboration's tool for assessing risk of bias. This tool takes into account randomization sequence generation, allocation concealment, blinding, selective outcome reporting, handling of incomplete data, and other bias concerns.

Randomization sequence generation was regarded as adequate (i.e. low risk) if a true randomization method such as using a random number generator or coin toss was specified. It was coded inadequate (high risk) when a quasi-random method such as using the day of the week was used, or unclear if the method of randomization was not reported.

Allocation concealment was coded as adequate when participants and researchers enrolling participants could not foresee assignment because a suitable method (e.g., central allocation; sequentially numbered opaque envelopes) was used to conceal the allocation sequence. If explicitly unconcealed procedures (e.g., rotation, non-blinded, open-label) were used then it was coded as inadequate (high risk). If the method of concealment was not described, or insufficient details were provided, it was coded as unclear.

Blinding was judged adequate when a suitable method of blinding was employed which was unlikely to have been broken (low risk). If blinding was not claimed, or the blinding could be easily broken, it was judged inadequate (high risk). If blinding was claimed but a method of blinding was not adequately described, it was coded as unclear.

Incomplete outcome data was judged low risk if the attrition rates across experimental groups were clearly reported and there were no statistical differences; high risk if there were significant differences in attrition rates; and unclear if they were not statistically compared.

Selective outcome reporting was judged low risk where the study protocols (or related papers providing further methodological details) were available and the primary and secondary pre-specified outcomes were reported in the pre-specified way (or published report included all expected outcomes). Where study protocols (or related papers) were available, and there were discrepancies between the measures specified and the reported analyses across these papers or within the same paper, selective outcome reporting was judged high risk. Where there was insufficient information, the papers were coded as unclear.

Other bias concerns related to steps taken to reduce contamination between groups; potential differences between participants completing the trial and those dropping out; using measures of dietary self-efficacy that had not been validated by past research; not using intention-to-treat analyses; not obtaining informed consent or ethical approval; not using inclusion/exclusion criteria; not using reliable outcome measures; not statistically controlling for baseline differences between groups; attrition rates.

Data Synthesis

Comprehensive Meta-Analysis (Borenstein, Hedges, Higgins, & Rothstein, 2005) and the 'metafor' package (Viechtbauer, 2010) in R software (R Development Core Team, 2012) were used to calculate effect sizes (Hedges's g) and to conduct random-effects meta-analyses and random effects meta-regressions. In this review, effect sizes reflected the effect of interventions on dietary self-efficacy.

Where there were more than one intervention group reported within a study, the intervention that generated the largest effect on self-efficacy was selected due to the focus on identifying the most effective techniques to promote self-efficacy. Where there were multiple self-efficacy outcomes and/or multiple follow-ups post-intervention, the effect sizes for each measure/time-point were averaged using a random effects model to generate a single effect size for each study on the primary outcome. Where studies showed evidence of

clustering in the data or where they reported the use of cluster randomisation (if this was not taken into account in the study analysis), an attempt was made to correct the results. This correction took the form of multiplying the final standard error of the effect size by the square root of the design effect (where the design effect was calculated based on the average cluster size and an estimate of the ICC). In the absence of a reported ICC, the ICC was estimated to be 0.05 (see Michie et al., 2009). As the review primarily concerned the impact of specific BCTs on self-efficacy, follow-ups taken before each BCT included in the intervention had been delivered at least once were excluded.

The amount of heterogeneity between studies was assessed using an I^2-statistic and Q-test, based on the DerSimonian-Laird estimator. Publication bias was assessed using a funnel plot and a rank correlation test for funnel plot asymmetry (Begg & Mazumdar, 1994). Additionally, the trim and fill method (Duval & Tweedie, 2000) was used to estimate how many studies were missing from the meta-analysis due to publication bias.

In the meta-regressions, type of RCT, type of sample, setting, characteristics of interventions and risk of bias, were used as predictors of effect sizes on dietary self-efficacy outcomes (see Web Table 3). All of these predictors were used to identify factors which could confound the impact of specific BCTs on self-efficacy. In these initial analyses, each predictor was entered in separate meta-regressions to maximise power. Factors predicting self-efficacy effect sizes were controlled in subsequent meta-regressions testing the impact of each of the 26 BCTs on dietary self-efficacy (see Web Table 4). In all meta-regressions, β reflects the change in dietary self-efficacy effect size associated with one-unit increase in the predictor variable.

Post-hoc sensitivity analyses (see Web Table 5) were conducted to examine the impact of removing studies 1. where the unit of analysis was treated as the group rather than individuals; 2. that only reported effects as significant (assumed to be $p = .05$) or non-

significant (assumed to be p = .50) and thus provided non-specific p-values (see Michie et al., 2009, for similar treatment); 3. that were outliers based on the Sample-Adjusted Meta-Analytic Deviancy (SAMD) Statistic (Huffcut & Arthur, 1995). Five studies had SAMD values above 3 and therefore were identified as outliers (see Web Figure 4).

Given the BCTs were typically delivered in combination with other BCTs, the final set of analyses attempted to isolate the effect of specific BCTs on self-efficacy. This involved two steps. First, chi-square analyses were conducted to assess the associations between key BCTs (i.e., those significantly or marginally related to self-efficacy) and other BCTs to identify potential confounding between BCTs. Second, where there were significant associations between these BCTs, the associated BCTs were entered as predictors of self-efficacy in multivariate meta-regression analyses.

Results

The numbers of studies considered at each stage of the review are summarized in Web Figure 1.

Study characteristics

All of the studies were RCTs (14 cluster trials, 40 non-cluster trials) and reported dietary-related measures of self-efficacy, although 6 studies (11.1%) used self-efficacy measures that were not exclusively concerned with diet (diabetes management, k = 4, 7.4%; weight, k = 1, 1.9%; diet/health, k = 1, 1.9%).

The majority of samples were community (k = 12, 22.2%) or clinical (k = 23, 42.6%) based. The interventions were delivered within community (k = 19, 35.2%), clinical (k = 18, 33.3%) and educational (k = 14, 25.9%) settings in similar numbers (three studies tested their interventions in the workplace). The majority of the studies were conducted in the US or Canada (k = 35, 64.8%). Outside of the US, the UK was the next most common location (k = 8, 14.8%). The total number of participants upon which the analyses were based was N =

15,873. The average sample size of the included studies was N = 294 (SD=459). The studies recruited participants from clinical (42.6%), community (22.2%), university (13.0%), and other educational (11.1%) or workplace-based (5.6%) populations. Two studies (3.7%) recruited scouts and one (1.9%) recruited a church-based sample.

On average, the behaviour change content was delivered to intervention groups over more days (mean days= 138; median days=66.5) and sessions (mean sessions= 10.7; median sessions= 8) than the comparison groups (mean days= 81; median days= 1 day; mean sessions= 4.5; median sessions=1). More of the intervention conditions than comparison conditions comprised group-based components (29 vs. 13 studies) and individual-based components (43 vs. 27 studies).

Each of the 26 BCTs were delivered to the experimental groups in at least one study (except 'prompt self-talk'). The most common BCTs delivered to the intervention only (without delivery in the same study to the comparison condition) were: 'prompt goal intention' (k = 33, 61.1%), 'provide instruction' (k = 32, 59.3%), 'provide information on consequences' (k = 23, 42.6%), 'provide information on health-behaviour link' (k = 22, 40.7%), 'prompt barrier identification' (k = 22, 40.7%), 'provide general encouragement' (k = 21, 38.9%), 'provide opportunities for social comparison' (k = 21, 38.9%), 'plan social support/social change' (k = 21, 38.9%) and 'prompt self-monitoring' (k = 20, 37.0%).

Risk of bias

The majority of studies were at unclear or high risk of bias from inadequate sequence generation (k = 32, 59.3%), inadequate allocation concealment (k = 50, 92.6%), not reporting adequate blinding (of participants, k = 53, 98.1%; of deliverer, k = 54, 100%; of data collector, k = 52, 96.3%; of statistician, k = 54, 100%), incomplete data (k = 43, 79.6%) and selective reporting (k = 51, 94.4%). Most studies were also at unclear or high risk of bias from failing to adequately take steps to reduce contamination between groups (k = 47,

87.0%), potential differences between participants completing the trial and those dropping out (k = 38, 70.4%), using measures of dietary self-efficacy that had not been validated by past research (k = 38, 70.4%) and not using intention-to-treat analyses (k = 40, 74.1%).

Most studies reported obtaining informed consent (k = 32, 59.3%) and ethical approval (k = 36, 66.7%), as well as using inclusion/exclusion criteria in the recruitment of participants (k = 42, 77.8%) and measures of self-efficacy with evidence of internal consistency (k = 30, 55.6%). Most studies were not at risk of bias from potential differences between experimental groups at baseline (k = 40, 74.1%). Attrition rates were moderate (mean= 22.3%; median=20.2%).

Syntheses of results

Across the 54 individual studies that met the inclusion/exclusion criteria, the overall summary effect (Hedges g) of the interventions on dietary self-efficacy was estimated to be 0.24 (95% CI 0.17 to 0.31; $p < 0.0001$). The corresponding forest plot is shown in Web Figure 2. The I^2-statistic was calculated to be 77.4%, and the Q-test for heterogeneity was highly significant, $Q = 234.7$, $df = 53$, $p < 0.0001$, which indicates substantial heterogeneity between studies in terms of their true effect size. A corresponding funnel plot of standard error against effect size showed no clear evidence of publication bias (see Web Figure 3). Indeed, the trim and fill method suggests that zero studies are missing on the left side and only one on the right side of the observed effect size using the L_0 estimator (Duval & Tweedie, 2000). However, using the R_0 estimator, an estimated 9 studies were presumed missing on the left side, but the overall summary estimate of the augmented dataset in this case was still statistically significant (Hedges g 0.15, 95% CI 0.07 to 0.22, $p = 0.0001$). There was also fairly weak correlation between the standard error and effect size using the rank correlation method (Kendall's tau = 0.20), even though the p-value was significant ($p = 0.03$).

Statistically significant effects on dietary self-efficacy were obtained when the following BCTs were used exclusively in the intervention condition: 'stress management', Hedges g +0.39 (95% CI 0.26 to 0.53; p < .0001), 'prompt self-monitoring of behaviour', +0.14 (95% CI 0.01 to 0.26; p = .04), or 'prompt review of behavioural goals', +0.20 (95% CI 0.004 to 0.39; p = .045). 'Provide contingent rewards', +0.16 (95% CI -0.004 to 0.33; p = .06) and 'provide feedback on performance', +0.13 (95% CI -0.02 to 0.27; p = .09), were associated with marginally significant effects on dietary self-efficacy. Residual heterogeneity remained highly significant for all meta-regressions of BCTs (see Table 1).

Sensitivity or sub-group analyses

Larger effects on self-efficacy were detected for studies that: 1. were at a low risk of bias from inadequate sequence generation; 2. reported informed consent had been taken; 3. spent more days delivering content to the intervention relative to the comparison group ; 4. delivered more sessions to the intervention vs. the comparison group; 5. included group-based components in the intervention group not present in the comparison condition; 6. included face-to-face components in the intervention group but not in the comparison group (see Web table 3). When sensitivity analyses were conducted to examine the impact of statistically controlling each of these methodological features (see Web table 4), or to remove studies with statistical issues (insufficient reporting of p-values for statistical test; unit of analysis was treated as the group rather than individuals; outliers; see Web table 5), the effect of stress management on self-efficacy remained significant. 'Prompt self-monitoring of behaviour', 'prompt review of behavioural goals' and 'provide contingent rewards' remained significant across some, but not all, of these sensitivity analyses. 'Provide feedback on performance' became significant when either differences across groups in intervention duration or inclusion of a group-based component was statistically controlled. After removing outlier studies, the effect of 'plan social support/social change' became significant.

Potential confounding between BCTs

There were significant associations between BCTs. Studies using 'stress management' in their intervention were more likely to 'model/demonstrate the behaviour', $\chi^2(1)=4.31$, p=.04, and 'prompt practice', $\chi^2(1)=8.35$, p=.004. Despite this, in a multivariate meta-regression, stress management remained a statistically significant predictor after controlling for 'model/demonstrate the behaviour' and 'prompt practice' (Hedges g 0.42, 95% CI 0.26 to 0.59, $p < 0.0001$). When equivalent analyses were conducted on the other BCTs that were significantly or marginally related to self-efficacy, their impact became non-significant suggesting they may only have an effect on self-efficacy when used in combination with other BCTs.

Discussion

Based on the findings of this review, there appears to be reasonably strong evidence suggesting that stress management is a useful strategy to promote dietary self-efficacy. Interventions that incorporated stress management techniques yielded significantly larger effects on dietary self-efficacy than interventions that did not include stress management. This effect was maintained across all sensitivity analyses. 'Prompt self-monitoring of behaviour', 'prompt review of behavioural goals', 'provide feedback on performance', 'provide contingent rewards' and 'plan social support/social change' were significant in some, but not all, sensitivity analyses- thus the evidence supporting these techniques was more modest. Interventions incorporating any of the other BCTs (e.g., 'prompt barrier identification') were not significantly more effective than interventions that did not incorporate the BCT.

It is important to note that, in this review, there were no studies that compared an intervention comprising only stress management against a no-intervention control. Instead, stress management was delivered in combination with other BCTs. Consequently, although

the review indicates incorporating stress management into an intervention is likely to increase effects on self-efficacy, the findings relate to using stress management as part of an intervention package rather than using stress management alone.

Although the review highlights which BCTs potentially boost self-efficacy, it does not explain why these BCTs may be more effective. Bandura (1997) has argued that attempting to reduce stress, change negative emotional tendencies and misinterpretations of bodily states minimises stress and tension which could otherwise undermine feelings of self-efficacy. These types of stress-management strategies were incorporated within the studies in this review (e.g., Folta et al., 2009).

Bandura (1977, 1997) also argued that mastery experiences can enhance self-efficacy by highlighting instances where an individual has been successful in performing the desired behaviour. Self-monitoring, by requiring individuals to record the occasions they perform their behaviour (e.g., Folta et al., 2009), could thus boost self-efficacy in this way.

Feedback could also increase self-efficacy because, if the individual is successful, they receive positive feedback that enhances feelings of mastery and, if the individual is unsuccessful, they should receive important feedback about how to change (much like that which can be garnered via modelling, Bandura, 1977). However, the review provides more limited support for the use of 'provide feedback on performance' relative to other BCTs.

Informing an individual how to perform an action, according to Bandura (1977, 1997), is also a mechanism through which modelling can boost self-efficacy. 'Model/ demonstrate the behaviour' was effective but only when removing outlier studies. Interestingly though, studies that comprised a group-based component (which could indirectly prompt modelling) in the intervention but not the comparison groups had larger effects on self-efficacy than those that did not.

Of the remaining BCTs that showed at least some evidence that they increase self-efficacy, 'prompt review of behavioural goals' could boost self-efficacy in a similar way to 'providing feedback on performance'. Reviewing successful performance of one's goals should boost mastery and thus self-efficacy. Reviewing unsuccessful performance should lead to the revision of goals such that they become easier to achieve which aids confidence and self-efficacy. 'Provide contingent rewards' can include the delivery of praise and encouragement contingent on the successful performance of goals or sub-goals (Abraham & Michie, 2008). Providing 'rewards' in this manner, therefore, could help persuade the individual that they are capable of being successful in achieving their dietary goal. Similarly providing social support could also help persuade or encourage an individual of their abilities. Persuasion is the fourth approach, alongside mastery, modelling, and somatic/emotional states, that can influence self-efficacy (Bandura, 1977, 1997).

There was at least some evidence to suggest self-efficacy becomes stronger following exposure to interventions that incorporated stress management, self-monitoring, feedback on performance, reviewing behavioural goals, contingent rewards, or planned social support/social change than in interventions that did not incorporate these strategies. As a result, self-efficacy may be a mediator of the effect of these strategies on behaviour.

Michie et al. (2008) used a consensus approach whereby experts used their judgement (rather than evidence) to identify which BCTs would likely change specific determinants of behaviour including self-efficacy (termed 'beliefs about capabilities' in their review). Using their approach, Michie et al. (2008) anticipated that, of these strategies, self-monitoring, social support, and feedback would influence self-efficacy. However, Michie et al. also anticipated setting graded tasks would boost self-efficacy but this was not supported by the meta-regression analyses. The review presented here, therefore, provides some support for Michie et al.'s (2008) predictions but also offers new insights. In particular, the review

provides some moderate evidence for contingent rewards and stronger evidence for stress management in boosting self-efficacy. Alternatively, Michie et al. (2008) assigned a rating of 'uncertain' rather than agreeing that these techniques would change self-efficacy.

The impact of 'prompt self-talk', another strategy that Michie et al. (2008) noted should boost self-efficacy, could not be examined as it was not utilized uniquely in any of the intervention or comparison groups. In addition, some other BCTs were rarely used (e.g., 'prompt identification as role model/position advocate'; 'agree behavioural contract') and as such any interpretations associated with such techniques should be treated with caution. Examples of each of the BCTs for which there is at least some evidence suggesting they may be effective in boosting dietary self-efficacy are provided in Web Table 6.

The studies included in the review were identified via search terms in three databases. Re-running searches in additional databases, or including additional search terms, could have identified further papers. However, the search strategy was built on search filters utilised in other related reviews that were modified, where appropriate, to increase the sensitivity of the search. It also incorporated validated methodological filters (Haynes et al., 2005). Moreover, the papers identified through the searches were double-screened to reduce the likelihood that papers were excluded in error.

Coding of BCTs and risk of bias were based on reviewers' interpretations of the contents of the publication and, where available, associated publications, online materials and published protocols. As such, the codes are open to error. To minimize the potential impact of bias associated with coding errors, however, all of the papers were double-coded by two independent reviewers and checked by a third reviewer. To further take into account potential bias, in this review, studies with statistical issues connected with the estimation of treatment effects were removed through sensitivity analyses. In addition, methodological biases which could confound the impact of specific BCTs on self-efficacy were statistically controlled.

This approach, as well as accounting for features (e.g., BCTs, treatment duration) in the comparison group, helps to overcome limitations in related reviews that did not take into consideration these characteristics of the comparison groups (e.g., Ashford et al., 2010; Dombrowski et al., 2012; Michie et al., 2009). However, this approach does have the problem of inflating the risk of Type 1 error.

As with other reviews, this contribution could not deal with all sources of heterogeneity. For example, this review did not fully differentiate between various types of dietary behaviours (e.g., promoting fruit and vegetable consumption; reducing saturated fat intake) and specific populations. However, it did consider the goal focus of the behaviour (to increase intake of particular foods, reduce intake, or a combination) and broad categories of populations (university students/staff; clinical samples; community samples; workplace-based samples; educational (non-university samples); activity-group samples). These variables were unrelated to effect sizes (see Web Table 3).

The present review is unique in a number of ways. First, it tested the impact of BCTs on dietary self-efficacy rather than on behaviour. Second, it statistically controlled for methodological features that could confound the impact of specific BCTs on outcomes. The findings suggest that experimental interventions that involve face-to-face delivery or a group-based component not present in comparison interventions had larger effects on self-efficacy. Moreover, experimental interventions that were delivered for more time and comprised more sessions than comparison interventions yielded stronger effects on self-efficacy. Despite these potential confounds, stress management remained a significant predictor of increased dietary self-efficacy when controlling for these factors. As 'prompt self-monitoring of behaviour' significantly predicted self-efficacy effects in the initial analyses and remained typically significant across the sensitivity analyses in which problematic studies were removed, there was moderate evidence supporting the use of this BCT. More limited

evidence favoured the potential use of ‘prompt review of behavioural goals’, ‘provide contingent rewards’, ‘provide feedback on performance’, and ‘plan social support/social change’ on boosting dietary self-efficacy (see Table 1 & Web tables 4-5). Over time, by conducting rigorous reviews that identify the most effective BCTs to change key determinants of behaviour, evidence-based interventions tailored to the needs of individuals can be developed. Moreover, interventionists will be able to more easily develop theory-based interventions that map specific BCTs to specific theoretical constructs (Michie & Prestwich, 2010), and potential mechanisms underlying specific BCTs can be uncovered.

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Table 1: Meta-regressions. BCTs regressed on dietary self-efficacy effect sizes

Predictor	Number of studies			Q-test*	β	95% CI		p-value
	experimental group only (+1)	Both groups or neither (0)	Control group only (-1)			Lower limit	Upper limit	
1. Provide information on behaviour-health link	22	28	4	233.8	-.021	-.130	.088	0.704
2. Provide information on consequences	23	30	1	234.7	.004	-.124	.131	0.953
3. Provide information about others' approval	1	53	0	234.6	.004	-.502	.509	0.989
4. Prompt intention formation	33	21	0	232.9	.050	-.091	.191	0.488
5. Prompt barrier identification	22	32	0	233.8	.035	-.103	.174	0.619
6. Provide general encouragement	21	32	1	228.0	.084	-.043	.212	0.196
7. Set graded tasks	5	49	0	234.7	.021	-.224	.265	0.867
8. Provide instruction	32	22	0	233.9	-.019	-.162	.125	0.797
9. Model/demonstrate the behaviour	11	42	1	227.7	.092	-.053	.237	0.212
10. Prompt specific goal-setting	6	48	0	234.1	-.002	-.219	.215	0.988
11. Prompt review of behavioural goals	9	45	0	227.3	.199	.004	.393	0.045*
12. Prompt self-monitoring of behaviour	20	33	1	220.4	.136	.010	.263	0.035*
13. Provide feedback on performance	17	37	0	230.6	.127	-.020	.273	0.090†
14. Provide contingent rewards	11	43	0	225.1	.164	-.004	.332	0.056†
15. Teach to use prompts/cues	4	49	1	231.6	.095	-.134	.323	0.417
16. Agree behavioural contract	3	51	0	232.7	-.135	-.448	.179	0.400
17. Prompt practice	10	44	0	231.3	.102	-.063	.268	0.227
18. Use of follow-up prompts	5	49	0	231.4	-.011	-.247	.226	0.929
19. Provide opportunities for social comparison	21	33	0	231.2	.058	-.080	.196	0.411
20. Plan social support/social change	21	32	1	228.0	.084	-.048	.217	0.210
21. Prompt identification as role model/position advocate	1	53	0	234.0	-.145	-.597	.307	0.530
22. Prompt self-talk	0	54	0	-	-	-	-	-
23. Relapse prevention	4	50	0	230.6	.118	-.135	.370	0.360
24. Stress management	9	44	1	154.0	.393	.255	.532	<0.001**
25. Motivational interviewing	4	50	0	234.6	-.058	-.323	.206	0.667
26. Time management	5	49	0	230.6	.060	-.161	.282	0.594

Note: * p < .05; ** p < .01; † p < .10; * Q-test for residual heterogeneity. All have p<0.0001.

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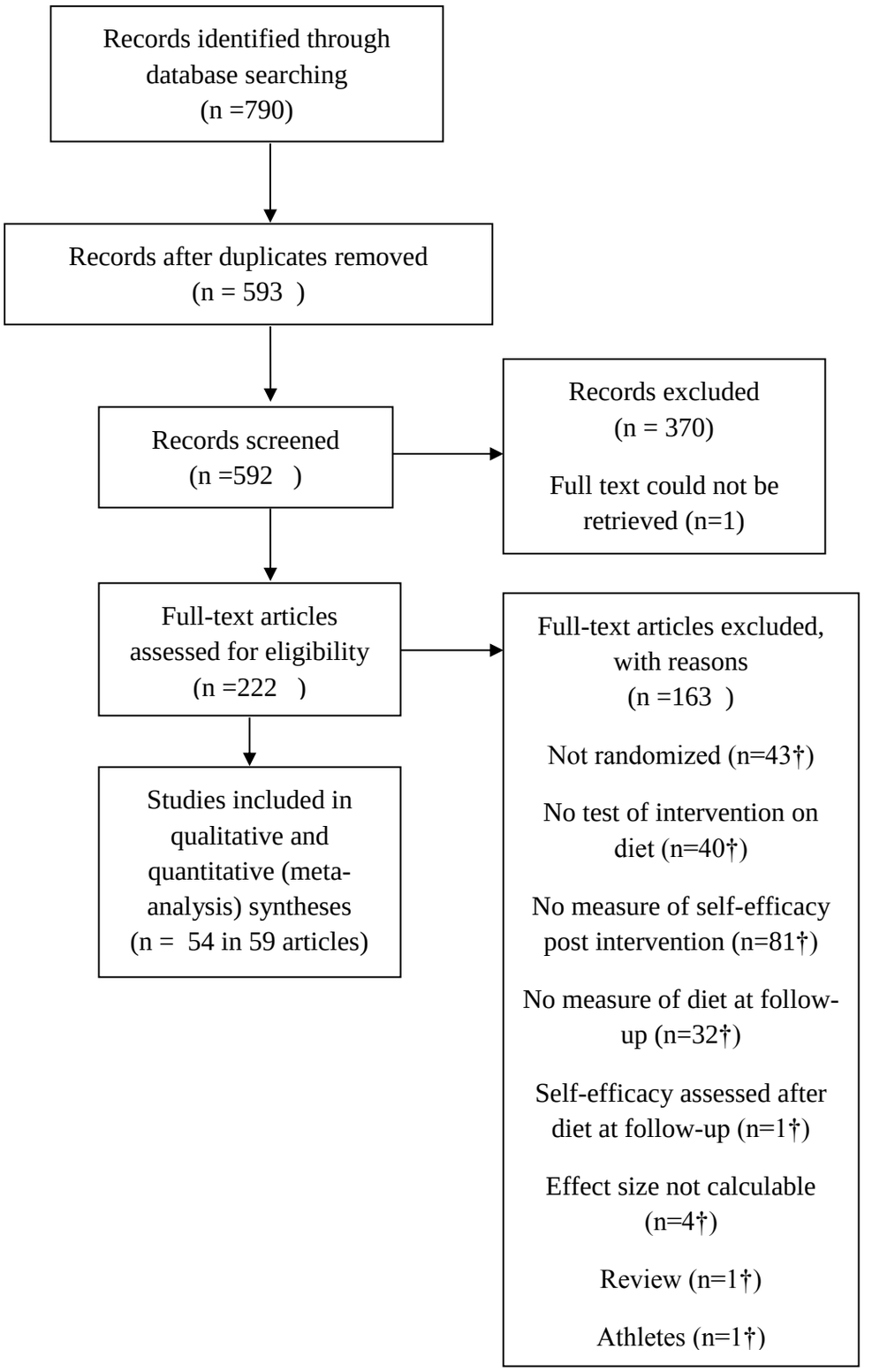
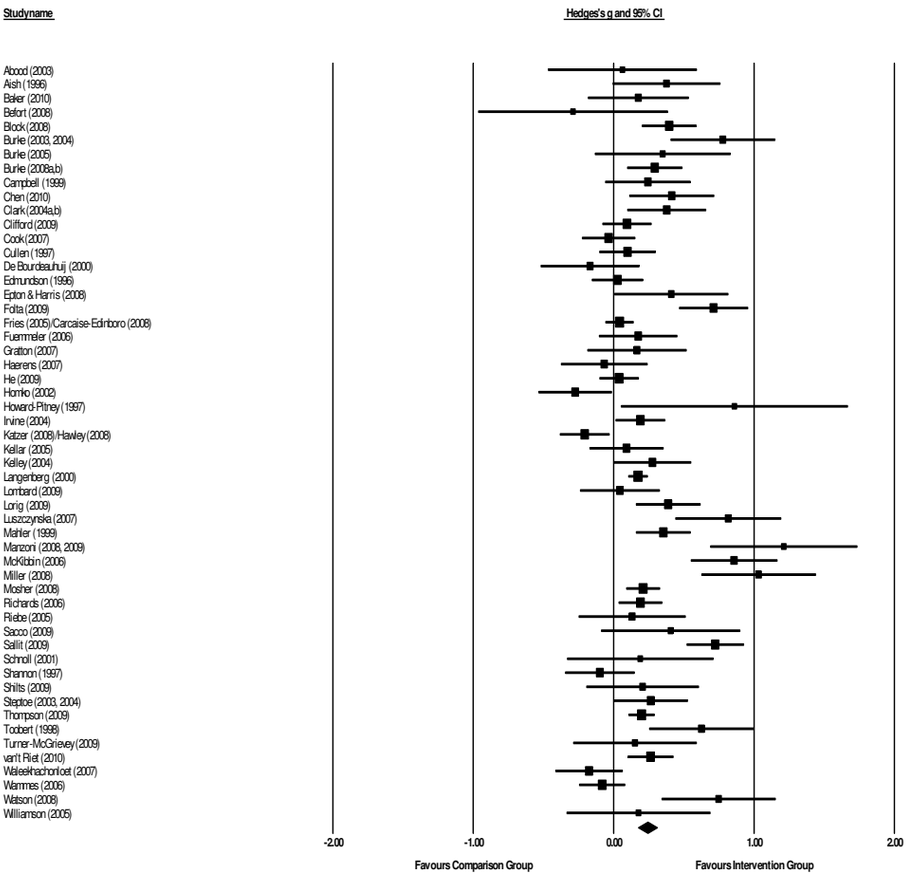
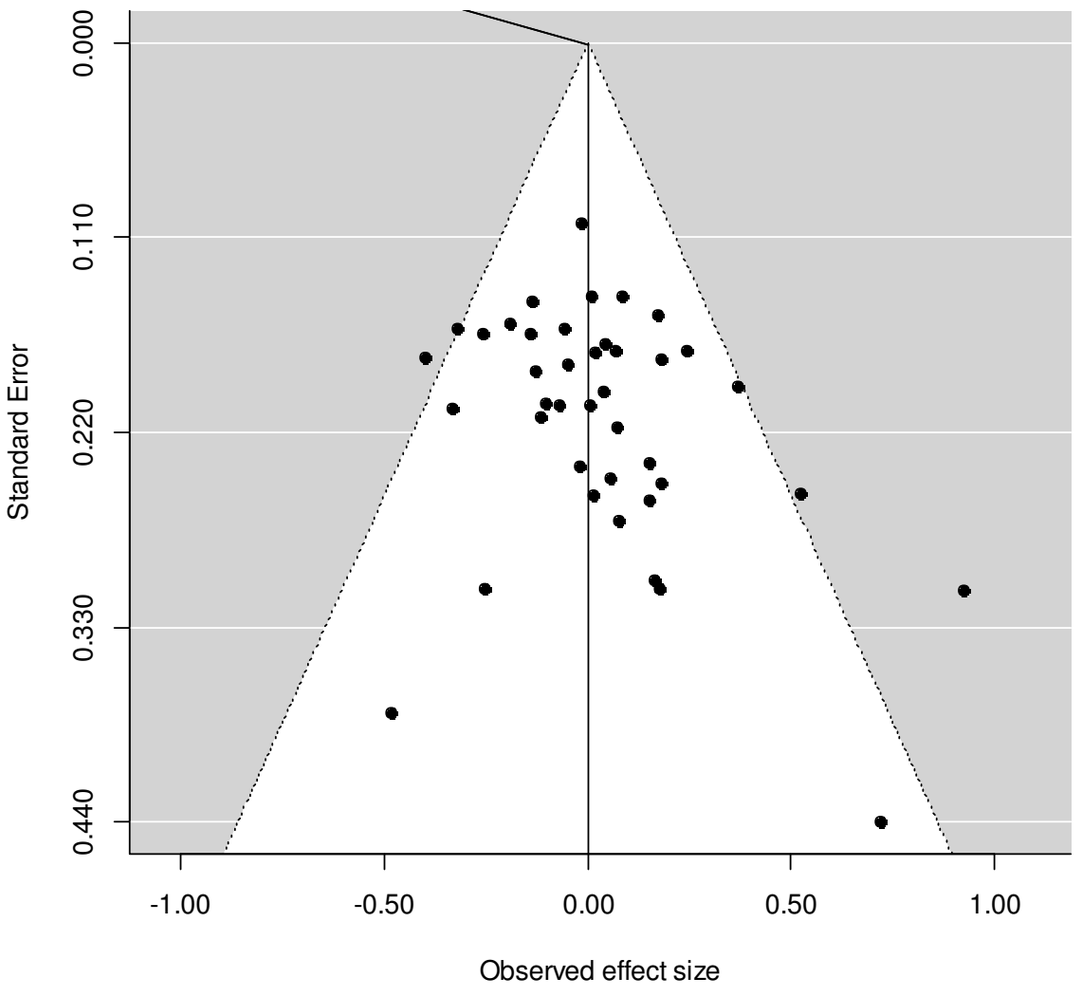


Online Supplementary Material, Web Figure 1: PRISMA flow diagram

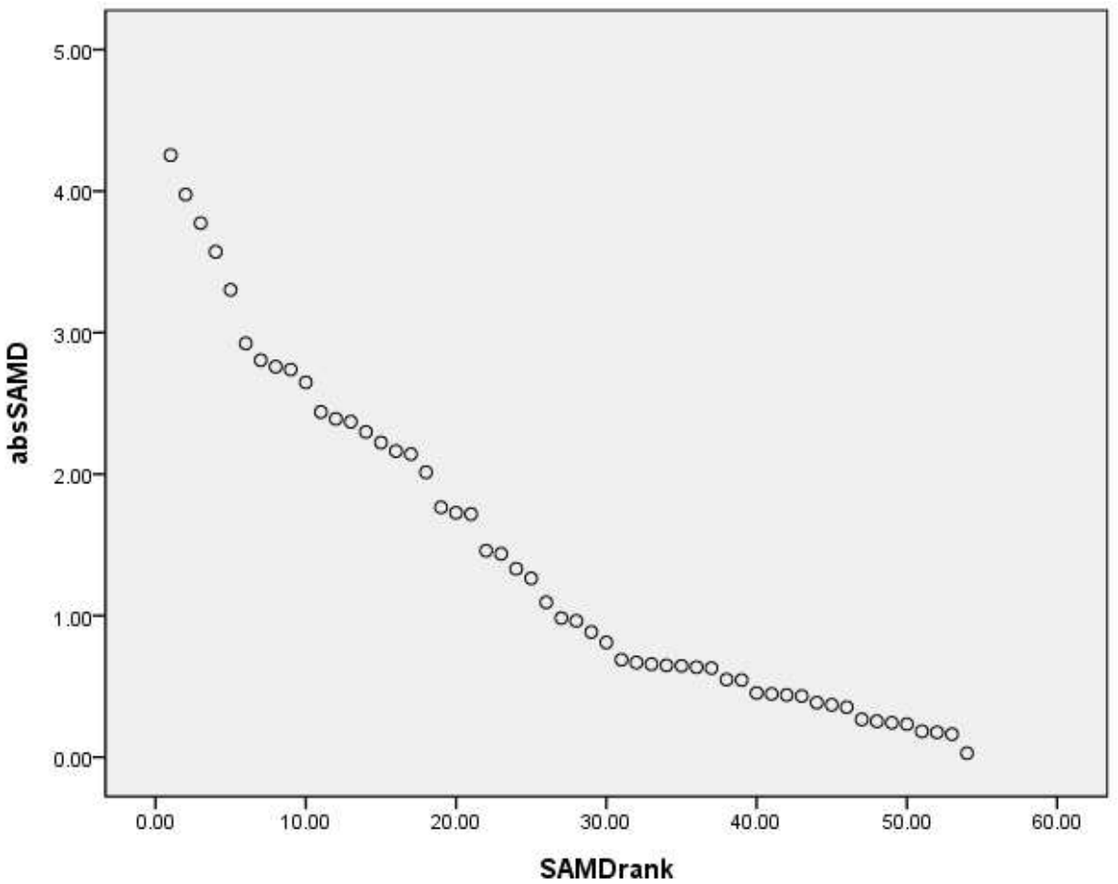
Note: † reflects minimum number of studies excluded for these reasons. n's exceed 164 as a number of studies were excluded for multiple reasons.



Online Supplementary Material, Web Figure 2: Forest plot



Online Supplementary Material, Web Figure 3: Funnel plot of observed effect size against standard error.



Online Supplementary Material, Web Figure 4: Scree plot SAMD study rank order (SAMDrank) with SAMD score (absSAMD)

Online Supplementary Material, Web Table 1: Characteristics of Included Studies

Study	Design	Baseline to follow-ups (days)	Setting	Participants	Country	BCTs (Experimental)	BCTs (Control)	SE measure
Abood (2003)	RCT	56	Educational	University staff	US	1,2,5,8,15,19	-	diet/health
Aish (1996)	RCT	49	Clinical	Myocardial infarction patients	US	1,4,6,8,12,13	-	diet
Baker (2010)	RCT	0,14	Educational	Undergraduates	UK	1,2,8,19	-	diet PBC/SE
Befort (2008)	RCT	112	Clinical	Obese women	US	1,2,4,5,6,8,12, 15,19,20,23,25	1,4,5,8,12,15, 19,20,23	diet
Block (2008)	Cluster	122	Workplace	Non-medical employees	US	1,2,4,5,8,12,13, 14,17,20,26	-	diet
Burke (2003, 2004)	Cluster	122,365	Community	Newly cohabiting couples	Australia	2,4,5,8,9,11,12,13, 14,17,19,20,23,24,26	-	diet
Burke (2005)	RCT	98	Clinical	Hypercholesterolemia patients	US	4,6,7,11,12,14,20	-	diet
Burke (2008a,b)	RCT	122,487	Clinical	Drug-treated hypertensives	Australia	1,2,4,6,8,9,11,13,17 19,20,23,24,26	1	diet
Campbell (1999)	RCT	0,61	Community	Low-income women	US	1,2,3,4,8,13	-	diet
Chen (2010)	RCT	61,183,243	Community	Chinese American children	US	1,2,4,5,8,12,17,19, 20,24	-	diet
Clark (2004a,b)	RCT	91,365	Clinical	Type 2 diabetics	UK	2,4,5,10,11,13,14,20, 23,25	-	diet
Clifford (2009)	RCT	28,150	Educational	College students	US	2,5,8,9,19	-	diet
Cook (2007)	RCT	91	Workplace	HR employees	US	1,2,4,5,8,9,13,24	1,2,8,12,13,24	diet
Cullen (1997)	Cluster	42,91	Community	Junior girl scouts	US	4,8,12,17,19,20,21	-	diet
De Bourdeauhuij (2000)	Cluster	42	Community	Family quartets	Belgium	1,2,4,5,6,8,13,19,26	1,2,8,19	diet
Edmundson (1996)	Cluster	365,730,1095	Educational	Schoolchildren	US	1,2,4,6,7,8,9,12,16, 17,19,20	-	diet
Epton & Harris (2008)	RCT	0	Educational	Female students	UK	1,2,4,8	1,2,4,8	diet
Folta (2009)	Cluster	84	Community	Overweight/obese	US	4,8,12,17,19,24	-	diet

				women				
Fries (2005)/Carcaise-Edinboro (2008)	RCT	31,183,365	Clinical	Healthy adult patients	US	1,2,4,6,8,13,18	-	diet
Fuemmeler (2006)	Cluster	183	Community	Church attendees	US	1,2,4,6,8,9,19,20,25	-	diet
Gratton (2007, volitional vs. control)	RCT	14	Educational	Schoolchildren	UK	10,12	12	diet PBC
Haerens (2007)	Cluster	274	Educational	Schoolchildren	Belgium	1,2,8,13,19,20	-	diet
He (2009)	Cluster	147	Educational	Schoolchildren	Canada	1,8,17	-	diet
Homko (2002)	RCT	45	Clinical	Gestational diabetics	US	1,4,8,12	1,4,8	diabetes
Howard-Pitney (1997)	Cluster	152	Educational	Low-literacy, low income adults	US	1,2,4,5,6,8,9,11,13, 18,20	1,2,4,8,9,19	diet
Irvine (2004)	RCT	30	Workplace	Employees	US	1,2,4,5,6,7,8,19	-	diet
Katzer (2008)/Hawley (2008)	RCT	70,122,365,730	Community	Overweight/obese women (at CVD risk)	New Zealand	1,4,8,12,15,19	1,6,9,15,19,24	diet
Kellar (2005)	RCT	0	Educational	Undergraduates	UK	4,6,10	-	diet PBC/SE
Kelley (2004)	RCT	14	Clinical	Elderly out-patients	UK	1,2,5,6,8,10,12,13	-	diet PBC
Langenberg (2000)	Cluster	243	Community	Pregnant, post-partum & breastfeeding women	US	1,2,4,5,8,9,15,19,20	1	diet
Lombard (2009)	Cluster	122	Educational	Young mothers	Australia	4,5,12,18,19,20,23	1	diet
Lorig (2009)	RCT	183	Community	Type 2 diabetics	US	1,4,5,6,8,12,19,24	-	diabetes
Luszczynska (2007, Self efficacy vs. Control	RCT	213	Community	Healthy adults	-	4,6,13	1,20	diet
Mahler (1999, Mastery vs. Control	RCT	0,30,91	Clinical	Coronary artery bypass graft patients	US	1,8,9,19	1	diet
Manzoni (2009)	RCT	35, 126	Clinical	Obese women	Italy	1,5,8,13,19,24	1,5,8,13,19	diet
McKibbin (2006)	RCT	183	Clinical	Schizophrenic diabetics	US	1,8,12,14	1	diabetes
Miller (2008)	RCT	63	Community	Type 2 diabetics	US	1,2,4,5,12,13,19,20	-	diet
Mosher (2008)	RCT	365	Clinical	Individuals with prostrate/breast cancer	North America	2,4,5,6,8,13,14,26	1	diet
Richards (2006)	RCT	122	Educational	College students	US	1,2,4,8,18,25	-	diet
Riebe (2005)	RCT	730	Clinical	Overweight/obese adults	US	1,2,4,6,8,12,13,14,18, 19,23	1,2,4,6,8,12,13, 14,18,19,20,23	diet
Sacco (2009)	RCT	183	Clinical	Type 2 diabetics	US	5,6,10,11,12,13,14, 20,24	-	diabetes
Sallit (2009)	RCT	84,175,358	Community	Weight-concerned	US	1,4,6,9,12,15,20,24	-	diet

				female smokers				
Schnoll (2001, goal-setting vs. control)	RCT	63	Educational	College students	US	1,4,7	-	diet
Shannon (1997)	Cluster	122	Clinical	Hypercholesterolemia patients	US	1,4,6,8,14,20	-	diet
Shilts (2009)	RCT	49	Educational	Middle-school students	US	1,4,5,11,12,13,14,16, 17,20,23	1,5,13,17,20,23	diet
Steptoe (2003,2004)	RCT	56	Clinical	Low-income adults	UK	4,5,8	1,2,4	diet
Thompson (2009)	Cluster	63,246	Community	Boy scouts	US	1,2,4,5,8,9,10,11, 12,13,14,17,19,20	-	diet
Toobert (1998)	RCT	122,365	Community	Women with coronary heart disease	US	1,2,5,6,8,9,17,18,19, 20,24	-	diet
Turner-McGrievey (2009)	RCT	84	Community	Overweight/obese adults	US	1,2,4,8,12	1,8,15	weight
Van't Riet (2010)	RCT	0	[Community]	Internet panel adults	Netherlands	1,2,6,8,15	1,2	diet
Waleekhachonloet (2007)	RCT	91,365	Community	Overweight/obese women	Thailand	1,2,4,6,8,10,12,14,15, 17,19,20,23,24	1,2,4,6,8,10,12, 14,15,17,20,23,24	diet PBC
Wammes (2006, Print vs. Control)	RCT	28	Community	Internet panel adults	Netherlands	1,5,8	-	diet
Watson (2008)	RCT	183,365	Clinical	Adults with cystic fibrosis	UK	4,6,7,8,11,14,19,20	-	diet
Williamson (2005)	RCT	183	Clinical	Overweight/obese girls	US	1,4,5,6,8,12,13,16, 19,20	1,6,8,12,13,19	diet

Note: BCTs= behaviour change techniques; RCT= randomized controlled trial; SE=self-efficacy; PBC=perceived behavioural control.

Note (for BCTs): 1=provide information on behaviour-health link; 2=provide information on consequences; 3=provide information about others' approval; 4=prompt intention formation; 5=prompt barrier identification; 6=provide general encouragement; 7=set graded tasks; 8=provide instruction; 9=model/demonstrate the behaviour; 10=prompt specific goal-setting; 11=prompt review of behavioural goals; 12=prompt self-monitoring of behaviour; 13=provide feedback on performance; 14=provide contingent rewards; 15=teach to use prompts/cues; 16=agree behavioural contract; 17=prompt practice; 18=use of follow-up prompts; 19=provide opportunities for social comparison; 20=plan social support/social change; 21=prompt identification as role model/position advocate; 22=prompt self-talk; 23=relapse prevention; 24=stress management; 25=motivational interviewing; 26=time management

Web Table 1 (Continued): Characteristics of Included Studies

Study	Delivery duration days (Experimental)	Delivery duration days (Control)	Mode of Delivery (Experimental)	Mode of Delivery (Control)
Abood (2003)	56	0	face-to-face, print	-
Aish (1996)	42	0	face-to-face, telephone, print	-
Baker (2010)	1	1	print	print
Befort (2008)	112	112	face-to-face, telephone, print	face-to-face, telephone, print
Block (2008)	122	0	internet/PC	-
Burke (2003, 2004)	112	0	face-to-face, mail, print	-
Burke (2005)	98	1	telephone, print	face-to-face
Burke (2008a,b)	487	426	face-to-face, telephone, print	face-to-face, print
Campbell (1999)	1	0	internet/PC, video	-
Chen (2010)	56	0	face-to-face, internet/PC, print, video	-
Clark (2004a,b)	168	0	face-to-face, telephone, print	-
Clifford (2009)	28	28	internet/PC, video	internet/PC, video
Cook (2007)	91	91	internet/PC, video	print
Cullen (1997)	28	0	face-to-face, telephone, mail, print	-
De Bourdeauhuij (2000)	1	1	mail, print	mail, print
Edmundson (1996)	1095	1095	face-to-face, print	face-to-face
Epton & Harris (2008)	1	1	print	print
Folta (2009)	84	0	face-to-face	-

Fries (2005)/Carcaise-Edinboro (2008)	28	0	telephone, mail, print	-
Fuemmeler (2006)	120	0	face-to-face, telephone, print, video	-
Gratton (2007, volitional vs. control)	1	1	print	print
Haerens (2007)	365	unclear	face-to-face, internet/PC, print	-
He (2009)	147	0	face-to-face	-
Homko (2002)	unclear	unclear	face-to-face	face-to-face
Howard-Pitney (1997)	126	42	face-to-face, telephone, mail, print, video	face-to-face, print
Irvine (2004)	30	0	internet/PC, print, video	-
Katzer (2008)/Hawley (2008)	435	435	face-to-face	face-to-face
Kellar (2005)	1	1	print	print
Kelley (2004)	1	0	print	-
Langenberg (2000)	183	1	face-to-face, mail, print, video	face-to-face
Lombard (2009)	122	1	face-to-face, internet/PC, telephone, print	face-to-face, print
Lorig (2009)	42	0	face-to-face, print	-
Luszczynska (2007, Self efficacy vs. Control	1	1	internet/PC	internet/PC
Mahler (1999, Mastery vs. Control	1	0	video	-
Manzoni (2009)	35	35	face-to-face, internet/PC, video	face-to-face
McKibbin (2006)	168	unclear	face-to-face, print	face-to-face, print
Miller (2008)	63	0	face-to-face, print	-
Mosher (2008)	304	304	mail, print	mail, print
Richards (2006)	122	0	face-to-face, internet/PC, mail, print	-
Riebe (2005)	730	730	face-to-face, internet/PC, mail, print	face-to-face, internet/PC, mail, print
Sacco (2009)	183	183	face-to-face, telephone	face-to-face
Sallit (2009)	84	0	face-to-face	

Schnoll (2001, goal-setting vs. control)	28	28	face-to-face, print	face-to-face
Shannon (1997)	unclear	unclear	face-to-face, print	-
Shilts (2009)	35	35	face-to-face, internet/PC, video	face-to-face
Steptoe (2003,2004)	14	14	face-to-face, print	face-to-face, print
Thompson (2009)	63	63	face-to-face, internet/PC, print	face-to-face, internet/PC, print
Toobert (1998)	737	0	face-to-face	
Turner-McGrievey (2009)	84	84	internet/PC, telephone, print	internet/PC, telephone, print
Van't Riet (2010)	1	1	internet/PC	internet/PC
Waleekhachonloet (2007)	56	56	face-to-face, print	face-to-face, print
Wammes (2006, Print vs. Control)	28	0	internet/PC, print	-
Watson (2008)	70	unclear	face-to-face, telephone, mail, print	face-to-face
Williamson (2005)	183	183	face-to-face, internet/PC	face-to-face, internet/PC

Online Supplementary Material, Web Table 2: Risk of Bias

Study	Adequate sequence generation	Adequate allocation concealment	Adequate researcher blinding reported?	Incomplete outcome data	Free of selective reporting?	Other markers of low bias risk
Abood (2003)	?	?	✓ (P)	?	x	CP, IC, EA, BD, RM
Aish (1996)	?	?	x	?	?	IC, IE, BD, RM, VM
Baker (2010)	✓	?	x	?	x	EA, IE, BD, DO
Befort (2008)	✓	✓	✓ (DC)	✓	?	CP, EA, IE, BD, RM
Block (2008)	✓	?	x	?	✓	IC, EA, IE, BD, ITT
Burke (2003,2004)	✓	?	x	?	?	IC, EA, IE, RM
Burke (2005)	✓	?	? (S)	?	?	EA, IE, BD, RM, VM, ITT
Burke (2008a,b)	✓	?	x	?	?	IC, EA, IE, BD, DO, ITT
Campbell (1999)	x	?	? (DC)	?	?	IC, IE, DO
Chen (2010)	✓	?	x	?	?	IC, EA, IE, DO, RM, VM
Clark (2004a,b)	✓	?	x	?	x	IC, EA, IE
Clifford (2009)	?	?	x	?	?	IC, EA, BD
Cook (2007)	?	?	x	?	x	EA, BD, DO, RM
Cullen (1997)	?	?	x	?	?	IC, EA, DO, RM, VM
De Bourdeauhuij (2000)	?	?	x	?	?	IE, RM
Edmundson (1996)	?	✓	? (DC)	✓	x	EA, IE, BD, DO, RM, VM, ITT
Epton & Harris (2008)	✓	?	? (DC, D x)	?	?	IC, BD, RM
Folta (2009)	?	?	x	?	?	CP, IC, EA, IE, BD, DO
Fries (2005)/Carcaise-Edinboro (2008)	?	?	? (D)	x	x	IC, EA, IE, BD
Fuemmeler (2006)	?	?	x	✓	?	IE, BD, DO, RM
Gratton (2007)	?	?	x	?	x	BD, RM, VM
Haerens (2007)	?	?	x	?	x	IC, EA
He (2009)	?	?	x	?	?	IC, EA, IE, BD, ITT
Homko (2002)	?	?	x	?	?	IE, BD, RM, VM, ITT
Howard-Pitney (1997)	?	?	x	✓	?	BD, RM, ITT
Irvine (2004)	?	?	x	?	x	IC, BD

Katzer (2008)/Hawley (2008)	✓	?	x	?	?	EA, IE, BD, ITT
Kellar (2005)	✓	?	x	✓	✓	CP, BD, RM
Kelley (2004)	✓	?	x	?	?	IC, IE, BD, RM
Langenberg (2000)	?	?	x	?	?	IC, EA, IE, RM, ITT
Lombard (2009)	✓	?	? (S)	?	✓	CP, IC, EA, IE, BD, RM
Lorig (2009)	✓	?	x	✓	?	IC, EA, IE, BD, RM, VM, ITT
Luszczynska (2007)	?	?	x	?	?	IC, IE, BD, DO, RM
Mahler (1999)	?	?	x	?	?	IE, BD, RM
Manzoni (2009)	✓	?	x	?	x	IC, EA, IE, BD, VM
McKibbin (2006)	?	?	x	✓	?	IC, EA, IE, BD, DO, VM
Miller (2008)	✓	x	✓ (DC)	?	?	IC, EA, IE, BD, DO, RM
Mosher (2008)	✓	✓	? (DC)	x	x	EA, IE, BD
Richards (2006)	?	?	x	?	?	EA, IE, BD
Riebe (2005)	?	?	x	?	?	IC, EA, IE, VM
Sacco (2009)	?	?	x	?	?	IC, IE, BD, DO, RM, VM, ITT
Sallit (2009)	✓	?	x	?	?	IC, EA, IE, VM
Schnoll (2001)	?	?	x	?	?	CP, EA, RM
Shannon (1997)	?	?	? (DC)	?	x	EA, IE, DO, RM, VM
Shilts (2009)	✓	?	? (P)	✓	?	EA, BD
Steptoe (2003,2004)	✓	✓	x	✓	x	IC, EA, IE, BD, RM
Thompson (2009)	✓	?	x	?	?	IC, EA, IE, RM
Toobert (1998)	?	?	x	?	x	IE, BD, VM
Turner-McGrievey (2009)	?	?	x	?	?	IC, EA, IE, DO, ITT
Van't Riet (2010)	✓	?	x	✓	?	IE, BD, DO, RM
Waleekhachonloet (2007)	?	x	x	?	?	CP, IC, EA, IE, BD, ITT
Wammes (2006)	?	?	x	?	?	IE, BD
Watson (2008)	✓	x	x	✓	x	IC, EA, IE, BD, RM
Williamson (2005)	?	?	x	?	?	IE, VM, ITT

Note: Blinding: P=participant; D=deliverer of intervention; DC= data collector; S= statistician. Other markers of low bias risk: CP=adequate contamination prevention; IC= informed consent reported; EA= ethical approval reported; IE= inclusion and/or exclusion criteria reported; BD= low risk of baseline differences; DO= low risk of differences between those dropping out vs. completing the study; RM= reliable (internally consistent) measure of self-efficacy; VM= validated measure of self-efficacy; ITT=ITT analysis (dropouts included in analyses).

Online Supplementary Material, Web Table 3: Associations between methodological (intervention characteristics and risk of bias) variables and dietary self-efficacy effect sizes

Predictor	Coding			B	95% CI		p-value
	-1	0	+1		Lower limit	Upper limit	
Cluster trial	-	No	Yes	-.076	-.229	.076	0.33
Adequate sequence generation	-	No; unclear	Yes	.171	.039	.303	0.01*
Adequate allocation concealment	-	No; unclear	Yes	-.132	-.387	.124	0.31
Adequate blinding reported (participant)	-	No; unclear	Yes	-.179	-.845	.487	0.60
Adequate blinding reported (deliverer)	-	No; unclear	Yes	-	-	-	-
Adequate blinding reported (data collector)	-	No; unclear	Yes	.347	-.115	.809	0.14
Adequate blinding reported (statistician)	-	No; unclear	Yes	-	-	-	-
Risk of incomplete data	-	Low	High; unclear	-.080	-.252	.092	0.36
Risk of selective reporting	-	Low	High; unclear	.053	-.227	.333	0.71
Adequate contamination prevention	-	No; unclear	Yes	-.123	-.339	.094	0.27
Informed consent reported	-	No; unclear	Yes	.225	.091	.360	.001**
Ethical approval reported	-	No; unclear	Yes	.018	-.128	.164	.81
Inclusion/exclusion criteria reported	-	No; unclear	Yes	.130	-.037	.297	.13
Risk of (uncontrolled) baseline differences across groups	-	Low	High; unclear	-.038	-.196	.120	.64
Risk of dropout vs. completer differences	-	Low	High; unclear	-.105	-.252	.041	.16
Risk of unreliable measure used	-	No	Yes; unclear	.001	-.136	.138	.99
Validated measure used	-	No; unclear	Yes	.103	-.047	.253	.18
Risk of not reporting ITT analysis	-	No	Yes; unclear	.150	-.004	.304	.06†
Overall attrition rate (%)	-	-	-	.002	-.003	.008	.42
Sample							
University sample	-	No	Yes	-.083	-.292	.126	.44
Clinical sample	-	No	Yes	.107	-.030	.244	.13
Community sample	-	No	Yes	.036	-.124	.196	.66
Workplace (non-university) sample	-	No	Yes	-.062	-.327	.203	.65
Educational (non-university) sample	-	No	Yes	-.151	-.371	.069	.18

Activity group sample	-	No	Yes	-.089	-.361	.184	.52
Setting							
Educational	-	No	Yes	-.144	-.300	.013	.07
Clinical	-	No	Yes	.053	-.094	.201	.48
Community	-	No	Yes	.080	-.060	.221	.26
Characteristics of the intervention							
Other health behaviours targeted	-	No	Yes	.122	-.013	.257	.08†
Goal to increase behaviour	-	No	Yes	-.075	-.228	.077	.33
Goal to decrease behaviour	-	No	Yes	.017	-.119	.154	.80
Experimental intervention duration (days) minus comparison intervention duration (days)	-	-	-	.0007	.000	.001	.04*
Experimental intervention number of sessions minus comparison intervention number of sessions	-	-	-	.014	.007	.022	.0001**
Mode							
Face-to-face	Control only	Both groups or neither	Experimental only	.132	.006	.271	.061†
Internet	Control only	Both groups or neither	Experimental only	-.056	-.220	.108	.51
Telephone	Control only	Both groups or neither	Experimental only	.040	-.135	.214	.66
Mail	Control only	Both groups or neither	Experimental only	.063	-.139	.265	.54
Print	Control only	Both groups or neither	Experimental only	.021	-.109	.150	.76
Video	Control only	Both groups or neither	Experimental only	.064	-.121	.249	.50
Group-based component	Control only	Both groups or neither	Experimental only	.188	.044	.332	.01*
Individual-based component	Control only	Both groups or neither	Experimental only	-.036	-.152	.081	.55

Note: * p < .05; ** p < .01; † p < .10

Online Supplementary Material, Web Table 4: Sensitivity analyses (co-variate approach).

Predictor	Adequate sequence generation k=54	Informed consent reported k=54	Difference in intervention duration k=49	Difference in number of sessions k=41	Difference in face-to-face delivery k=54	Difference in group component k=54
1. Provide information on behaviour-health link	.956	.598	.789	.437	.216	.252
2. Provide information on consequences	.985	.673	.825	.945	.891	.976
3. Provide information about others' approval	.756	.732	.878	.948	.865	.809
4. Prompt intention formation	.770	.572	.549	.554	.670	.470
5. Prompt barrier identification	.980	.946	.999	.703	.575	.395
6. Provide general encouragement	.236	.100	.225	.126	.185	.223
7. Set graded tasks	.728	.640	.582	.998	.490	.928
8. Provide instruction	.904	.539	.235	.701	.485	.455
9. Model/demonstrate the behaviour	.105	.242	.439	.330	.225	.351
10. Prompt specific goal-setting	.528	.848	.895	.827	.879	.557
11. Prompt review of behavioural goals	.239	.117	.154	.077†	.025*	.024*
12. Prompt self-monitoring of behaviour	.160	.195	.023*	.083†	.062†	.156
13. Provide feedback on performance	.252	.508	.022*	.092†	.104	.041*
14. Provide contingent rewards	.245	.067†	.227	.011*	.037*	.032*
15. Teach to use prompts/cues	.556	.457	.535	.505	.494	.525
16. Agree behavioural contract	.480	.954	.501	.334	.549	.267
17. Prompt practice	.300	.621	.556	.362	.467	.836
18. Use of follow-up prompts	.809	.911	.221	.794	.778	.895
19. Provide opportunities for social comparison	.348	.936	.790	.529	.671	.667
20. Plan social support/social change	.436	.437	.376	.266	.430	.613
21. Prompt identification as role model/position advocate	.754	.294	.549	.477	.276	.203
22. Prompt self-talk	-	-	-	-	-	-
23. Relapse prevention	.926	.863	.563	.458	.453	.274
24. Stress management	<.001**	<.001**	<.001**	<.001**	<.001**	<.001**
25. Motivational interviewing	.726	.845	.391	.553	.252	.701
26. Time management	.851	.555	.606	.330	.457	.397

Note: * $p < .05$; ** $p < .01$; † $p < .10$. Numbers represent p-values associated with the significance of the BCT in predicting self-efficacy effects while controlling for specified co-variate.

Online Supplementary Material, Web Table 5: Sensitivity analyses (removing studies).

Predictor	Removing studies			
	with unit of analysis issues k = 52	with non-specific p-values k = 48	that are outliers k = 49	with unit of analysis or p-value or outlier issues k = 45
1. Provide information on behaviour-health link	.852	.767	.657	.433
2. Provide information on consequences	.912	.805	.930	.932
3. Provide information about others' approval	.949	.980	.978	.918
4. Prompt intention formation	.503	.246	.891	.772
5. Prompt barrier identification	.926	.531	.706	.935
6. Provide general encouragement	.168	.167	.212	.141
7. Set graded tasks	.788	.848	.393	.316
8. Provide instruction	.774	.906	.307	.120
9. Model/demonstrate the behaviour	.351	.193	.082†	.133
10. Prompt specific goal-setting	.910	.989	.991	.838
11. Prompt review of behavioural goals	.212	.040*	.035*	.161
12. Prompt self-monitoring of behaviour	.054†	.012*	.046*	.026*
13. Provide feedback on performance	.218	.073†	.357	.641
14. Prompt contingent rewards	.123	.048*	.042*	.079†
15. Teach to use prompts/cues	.358	.427	.374	.288
16. Agree behavioural contract	.437	.406	.835	.961
17. Prompt practice	.403	.119	.080†	.075†
18. Use of follow-up prompts	.720	.948	.900	.728
19. Provide opportunities for social comparison	.521	.234	.359	.269
20. Plan social support/social change	.393	.110	.041*	.040*
21. Prompt identification as role model/position advocate	.559	-	.515	-
22. Prompt self-talk	-	-	-	-
23. Relapse prevention	.912	.346	.329	.849
24. Stress management	<.0001**	<.0001**	<.0001**	<.0001**
25. Motivational interviewing	.743	.682	.688	.804
26. Time management	.881	.573	.552	.962

Note: * p < .05; ** p < .01; † p < .10. Numbers represent p-values associated with the significance of the BCT in predicting self-efficacy effects after removing specified studies.

Online Supplementary Material, Web Table 6: Illustrative examples of BCTs displaying at least some evidence of efficacy across analyses

Behaviour Change Technique (BCT)	Text description
Stress Management	stress management plan comprised stretching/yoga poses, breathing (abdominal breathing and complete breathing), visualization and progressive relaxation, hints for managing stress in real life, using a relaxation log [Toobert et al., 1998]
Self-monitoring	monitored their diet through food logs and were informed about the USDA MyPyramid Diet Tracker (www.mypyramid.gov) and other ways of self-monitoring via their study website [Folta et al., 2009].
Prompt review of behavioural goals	'Classes began with a review of ...the low-fat goals set by participants.... assessed the types of low-fat eating that participants had been following since the previous contact....and helped participants to...set new goals for low-fat eating.' [Howard-Pitney et al., 1997]
Provide feedback on performance	'what the patient ate was compared with the nutritional goals for a heart healthy diet and the patient was informed by telephone about the extent to which goals were being met.' [Aish & Isenberg, 1996]
Provide contingent rewards	'reinforcements (i.e., raffle tickets for small health-related prizes) for attendance and behavioral change' [McKibbin et al., 2006]
Plan social support/social change	'encouraging attendance by both partners at all group sessions, as well as collaboration in shopping, meal preparation...' [Burke et al., 2004]

Online Supplementary Material, Web Table 7: Search strategy

Medline	Embase	Psychinfo
1. clinical trial.pt.	1. clinical trial.sh.	1. (treatment outcome clinical trial or
2. random$.mp.	2. random$.mp.	quantitative study).md.
3. tu.fs.	3. 1 or 2	2. random$.mp.
4. 1 or 2 or 3	4. Self-efficacy	3. 1 or 2
5. Self-efficacy	5. social cognitive theory	4. Self-efficacy
6. social cognitive theory	6. vicarious learning	5. social cognitive theory
7. vicarious learning	7. mastery experience	6. vicarious learning
8. mastery experience	8. verbal persuasion	7. mastery experience
9. verbal persuasion	9. persuasion	8. verbal persuasion
10. persuasion	10. protection motivation theory	9. persuasion
11. protection motivation theory	11. perceived behavio?ral control	10. protection motivation theory
12. perceived behavio?ral control	12. PBC	11. perceived behavio?ral control
13. PBC	13. theory of planned behavio?r	12. PBC
14. theory of planned behavio?r	14. health belief model	13. theory of planned behavio?r
15. health belief model	15. transtheoretical model	14. health belief model
16. transtheoretical model	16. stage$ of change	15. transtheoretical model
17. stage$ of change	17. 4 or 5 or 6 or 7 or 8 or 9 or 10	16. stage$ of change
18. 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17	or 11 or 12 or 13 or 14 or 15 or 16 18.Diet.sh	17. 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16
19. exp diet therapy/	19.Weight control.sh	18.Diets.sh
20. (diet$ adj5 diabet$).tw	20.Weight reduction.sh	19.Eating behavior.sh
21. (diet$ adj5 carbohydrat$).tw	21. (diet$ adj5 diabet$).tw	20.weight control.sh
22. (diet$ adj5 fat$).tw	22. (diet$ adj5 carbohydrat$).tw	21. (diet$ adj5 diabet$).tw
23. (diet$ adj5 weigh$).tw	23. (diet$ adj5 fat$).tw	22. (diet$ adj5 carbohydrat$).tw
24. (diet$ adj5 sugar$).tw	24. (diet$ adj5 weigh$).tw	23. (diet$ adj5 fat$).tw
25. (diet$ adj5 glyc?em$).tw	25. (diet$ adj5 sugar$).tw	24. (diet$ adj5 weigh$).tw
26. (diet$ adj5 fibre$).tw	26. (diet$ adj5 glyc?em$).tw	25. (diet$ adj5 sugar$).tw
27. (diet$ adj5 fiber$).tw	27. (diet$ adj5 fibre$).tw	26. (diet$ adj5 glyc?em$).tw

28. (diet$ adj5 salt$).tw	28.(diet$ adj5 fiber$).tw	27. (diet$ adj5 fibre$).tw
29. (diet$ adj5 calorie$).tw	29.(diet$ adj5 salt$).tw	28. (diet$ adj5 fiber$).tw
30. healthy eating.tw	30.(diet$ adj5 calorie$).tw	29.(diet$ adj5 salt$).tw
31. or/19-30	31.healthy eating.tw	30.(diet$ adj5 calorie$).tw
	32. or/18-31	31.healthy eating.tw
		32.or/18-31