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What are the most effective intervention techniques for changing physical activity self-efficacy and physical activity behaviour—and are they the same?

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Running head: Interventions for self-efficacy and physical activity

What are the most effective intervention techniques for changing physical activity self-efficacy and physical activity behaviour- and are they the same?

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Abstract

There is convincing evidence that targeting self-efficacy is an effective means of increasing physical activity. However evidence concerning which are the most effective techniques for changing self-efficacy and thereby physical activity is lacking. The present review aims to estimate the association between specific intervention techniques used in physical activity interventions, and change obtained in both self-efficacy and physical activity behaviour. A systematic search yielded 27 physical activity intervention studies for 'healthy' adults which reported self-efficacy and physical activity data. A small, yet significant ($P<0.01$) effect of the interventions was found on change in self-efficacy and physical activity ($d= 0.16$, and 0.21 respectively). When a technique was associated with a change in effect sizes for self-efficacy it also tended to be associated with a change ($r_s= .690$ $p<0.001$) in effect size for physical activity. Moderator analyses found that ‘action planning’, ‘provide instruction’ and ‘reinforcing effort towards behaviour’ were associated with significantly higher levels of both self-efficacy and physical activity. ‘Relapse prevention’ and ‘setting graded tasks’ were associated with significantly lower self-efficacy and physical activity levels. This meta-analysis provides evidence for which psychological techniques are most effective for changing self-efficacy and physical activity.

Introduction

Self-efficacy is defined as 'the belief in one's capabilities to organise and execute the courses of action required to produce given attainments' [1] and is a key construct within several theories popular within health psychology e.g. Social Cognitive Theory [2], Protection Motivation Theory [3], and Theory of Planned Behaviour (TPB) [4]. It has been consistently shown to be a predictor of the adoption and maintenance of physical activity behaviour in healthy adults [e.g. 5, 6, 7]. Experimental evidence has further demonstrated self-efficacy to be a mediator of the effects of interventions on objectively measured physical activity behaviour [8, 9, 10].

It therefore seems reasonable to target self-efficacy in order to change physical activity behaviour. It is thus imperative that effective techniques for changing self-efficacy are identified for inclusion in physical activity interventions. However, there is limited evidence for *how* to do this [11]. Without this evidence, intervention developers may develop ineffective physical activity interventions due to the techniques they employ not changing self-efficacy.

A recent systematic review with meta-analysis, synthesised evidence of the intervention techniques most effective for changing self-efficacy in physical activity interventions for healthy adults [12]. The review was the first to identify which specific behaviour change techniques, based on Social Cognitive Theory [1] are associated with an improvement or deterioration in self-efficacy for physical activity. The techniques identified in the review were elaborated from the four sources of self-efficacy behaviour proposed by Bandura [2]; enactive mastery experience, vicarious experience, verbal persuasion and physiological or affective states. The meta-analysis found that interventions which included feedback on past performance or feedback in comparison to others' performance, and vicarious experience, produced the highest levels of self-efficacy. In contrast, interventions which included persuasion, graded mastery or barrier identification were associated with lower levels of self-efficacy compared with those that did not include these techniques [12]. Some techniques used most commonly were found to be the least effective e.g. persuasion, and some used rarely were those found to be the most effective e.g. vicarious experience. This finding highlights the importance of re-

evaluating the effectiveness of the intervention techniques that are commonly used by intervention developers.

The Ashford et al [12] review focused on which techniques were associated with change in self-efficacy, not their association with physical activity behaviour change. Consequently, their findings should only be used to inform the development of future physical activity interventions if these techniques also affect physical activity behaviour. Further evidence is therefore required concerning which of these techniques are associated with change in physical activity behaviour. The potential impact of gathering such evidence is twofold. Firstly, the data would provide an evidence base for future intervention developers to draw upon, thus enhancing the effectiveness of interventions to promote physical activity. Secondly, if a comparison of the techniques associated with self-efficacy and physical activity shows the same techniques to be effective in changing both self-efficacy and physical activity this would provide further evidence of a causal pathway between the psychological construct and behaviour.

Two previous systematic reviews have examined which specific behaviour change techniques are associated with the effectiveness of physical activity interventions in altering physical activity behaviour [13; 72]. Both reviews used a taxonomy considered to be comprehensive for physical activity and diet behaviours [14] to reliably classify behaviour change techniques, and aimed to assess which specific behaviour change techniques were associated with intervention effectiveness. Univariate meta-regression in the Michie et al [13] review identified only one behaviour change technique that was significantly associated with physical activity or healthy eating outcomes; 'prompt self-monitoring of behaviour' [13]. Furthermore, this review found interventions that included self-monitoring plus one of five self-regulation techniques derived from Control Theory [15,16] were significantly more effective than those not including these techniques, according to meta-regression [13]. Similarly, SU.Dombrowski, FF.Sniehotta, A.Avenell et al [72] found no significant effects of behaviour change techniques on physical activity behaviour in their review.

The focus of each review differs from that of the present review in terms of the target population and behavioural outcome investigated. In the study by Michie et al [13] the univariate meta-regression

analyses were completed for physical activity or healthy eating outcomes together, consequently the contribution of each specific intervention technique to physical activity behaviour change in isolation was not assessed. Specifically it is not possible to tease out which intervention strategies were aimed at physical activity, and which were aimed at dietary behaviours in the studies included in this review. The interventions included in the review by Dombrowski and colleagues [72] were weight management interventions for adult obesity. Thus the findings of the two reviews do not allow us to establish which behaviour change techniques are effective for changing lifestyle physical inactivity behaviour in a non- clinical, 'healthy' population. This is a notable omission considering that physical inactivity is a leading cause of mortality, responsible for an estimated 16.6% of total deaths in the United States [17].

Self-efficacy outcomes were not measured in either systematic review, consequently on the basis of these reviews we are unable to make inferences regarding the effects of specific intervention techniques on both self-efficacy and physical activity in the same studies.

The present study reports additional analyses on the studies identified in the Ashford et al [12] systematic review, with two main aims;

a) Assess what intervention techniques are included in the least or most successful interventions to change physical activity behaviour.

b) Compare the contribution of specific intervention techniques to changes in both self-efficacy and physical activity behaviour.

Methods

Brief details of inclusion and exclusion criteria, and search methods, are provided below. Further details are published elsewhere [12].

Inclusion criteria

Types of studies: Published randomised experimental, non-randomised experimental, quasi-experimental or pre and post intervention studies. Studies assessing self-efficacy only as a predictor of physical activity, qualitative studies, or surveys were excluded. English language only papers were included for pragmatic reasons.

Type of participants: Studies which included participants on the basis of pre-existing medical conditions or based on clinically defined populations including obese individuals were excluded. Studies including children and student populations were not included; studies that recruited older adults only over 60 years or where the mean age was over 60 years were also excluded.

Type of intervention: Lifestyle and recreational physical activity interventions that aimed to increase physical activity self-efficacy. Sport or laboratory-based studies focused on competitive sports or fitness were excluded, as were papers if the intervention targeted more than one behaviour (e.g. physical activity and diet).

Type of outcome measures: Information needed to calculate effect sizes must have been made available for changes in both self-efficacy *and* physical activity. Both outcomes should have been measured pre and post intervention in single group studies. In studies with intervention and comparison groups, self-efficacy and physical activity should have been measured at least once following the end of the intervention. Self-report or objective measures (e.g. accelerometer readings) of physical activity were acceptable.

Search methods for identification of studies

The electronic databases Web of Science (1966-2007), PsycInfo (1966-2007), SPORTDiscus (1966-2007) and the Cochrane Library were searched using a comprehensive search strategy including self-efficacy, physical activity and trial search terms. The review was subsequently updated. Each

database search was updated, using the same search strategy, from January 2008 to December 2009. The full search strategy is published elsewhere or is available from the first author on request [12].

Searches were completed, and eligibility of each study was determined, by the first author. Abstracts were cross-checked against the inclusion criteria and where necessary, the full text was retrieved. Where the first author was unsure of relevance, decisions regarding inclusion and exclusion were resolved by discussion with the second author.

Data extraction

Relevant papers were automatically entered into reference software (Endnote version 5). Effect size data was extracted for physical activity self-efficacy and physical activity behaviour.

Intervention content was coded by the first author using an updated version [18] of a comprehensive taxonomy for behaviour change techniques [14]. This taxonomy is in contrast to the coding frame used by the Ashford et al [12] review, which was a theory-specific coding frame elaborated from the four sources of self-efficacy behaviour proposed by Bandura [2]. The taxonomy used in the present review can be considered all encompassing in terms of the theoretical basis of intervention techniques. The use of the updated Abraham & Michie taxonomy [14, 18] in the present review also facilitates comparisons with other similar reviews [13; 72].

The original taxonomy has previously been found to be reliable for coding behaviour change techniques in intervention descriptions [14]. The updated version used in this study [18, S.Michie, S.Ashford, FF. Sniehotta et al, in preparation] consisted of 39 behaviour change techniques (See table III for the full list of behaviour change techniques). It was developed on the basis of disentangling conceptual and empirical overlap between categories, in the original taxonomy. The revised version of the taxonomy is available from the authors upon request.

The first author coded all intervention descriptions using the most recent version of the taxonomy, coding was validated by a second coder following detailed instructions. Any disagreements were

resolved by discussion. Interrater reliability was also found to be acceptable (all kappas between 0.83-1). Coding of the additional studies included following the extended database searches was conducted by the first author only.

Data analysis

The effect size estimate employed was Cohen's *d* [19], the standardised mean difference. Effect sizes were calculated for self-efficacy and physical activity behaviour independently. Meta-analytic calculations were conducted using Schwarzer's [20] Meta computer program, using a random effects model. Meta analyses were conducted separately for physical activity self-efficacy and physical activity behaviour

Where there were two experimental groups within one study, control group data was compared with each experimental group separately to yield two effect size estimates. In the case of multiple measurement time-points we took the first measurement following the end of the intervention, as this is when the largest change attributable to the intervention should have occurred.

Heterogeneity was assessed using the Q coefficient. Moderator analyses were conducted to explore causes of heterogeneity, by comparing the mean variability in self-efficacy or physical activity effect size estimates of two groups of studies characterised by the presence or not of particular study features, e.g. intervention techniques. Pairwise Z tests were used to determine which intervention techniques accounted for significantly different effect size estimates.

A one-way Spearman's Rho correlation coefficient was conducted to assess the extent to which change in self-efficacy, as a consequence of particular intervention characteristics, was associated with change in physical activity behaviour. The z-score for each intervention technique was assigned as positive if interventions that included the technique produced a higher effect size than those interventions that did not. Likewise, when interventions that did not include a particular technique produced a higher effect size than those that did, the z-score was considered negative for the purposes of this analysis. Paired Z-scores for each intervention technique were then correlated to

assess the association between changes in self-efficacy effect size estimates and changes in physical activity effect size estimates, for each intervention technique.

Results

The search strategy identified 2105 potentially relevant papers; we extracted full text publications for 265 papers. Of the 27 unique intervention studies included in the Ashford et al [12] review, 16 were included in the present meta-analysis and 11 were excluded as they did not provide physical activity data. A total of 24 intervention groups from 16 unique studies provided self-efficacy and physical activity data. An additional 853 relevant papers were identified by the updated searches, of which 31 full text publications were extracted for further examination. Of these, 11 unique studies were subsequently included in this review. Therefore a total of 36 intervention groups from 27 unique studies provided self-efficacy and physical activity data.

Study characteristics

The mean number of participants included in each study was 199, range 33-874 (see table I). There were ten randomised experiments, four pre and post intervention studies, one non-randomised experiment and one quasi-experimental study. The mean age of participants was 43.17 (SD=7.7), average number of females included in each study was 132, and the average number of males was 60. There were 139 white participants on average in each study. However not all studies provided full demographic information.

Intervention characteristics

The majority of the intervention studies focused on lifestyle physical activity e.g. walking and gardening (n=24), a further 3 studies targeted recreational physical activity e.g. aerobics class, gym sessions. There were 19 individual interventions, 8 interventions were delivered in group setting. Modes of delivery included training sessions, discussion groups, telephone, and mass media. Workplace, primary care, media and university settings were most often utilised. Most commonly a researcher or health professional was assigned the role of intervention deliverer (See table II for details).

A theoretical rationale was explicitly mentioned in 24 of the included studies, although 3 studies mentioned no theoretical rationale in their study description.

See table III for the frequency of behaviour change techniques included in the intervention studies.

Further information on design, participant and intervention characteristics of included studies are published elsewhere [12].

Meta-analysis results

There were a total of 36 experimental groups that reported changes in self-efficacy and physical activity behaviour. There were small but significant effects of interventions on physical activity self-efficacy (d= 0.16, 95% CI: 0.08-0.24, $p<0.001$), and on physical activity behaviour (d= 0.21, 95% CI 0.11-0.31, $p<0.001$).

Moderator analyses

Greater variability in effect size estimates existed than that explained by random sampling error alone (SE: Q= 57.57, $p<0.01$; PA: Q= 116.47, $p<0.001$). Therefore moderator analyses were conducted to search for the sources of heterogeneity separately for self-efficacy and physical activity, to allow us to examine the differences and similarities in the moderators associated with change in these variables. We conducted 20 moderator analyses using the techniques included in the revised taxonomy of behaviour change as grouping variable [18] (See table IV). It was not sensible to conduct moderator analyses on the remaining 19 techniques as they were used by one or zero intervention groups. Refer to table V for details on the intervention techniques used by individual studies.

Intervention techniques associated with changes in physical activity behaviour

Six techniques were significantly associated with higher physical activity behaviour effect sizes; ‘provide information on consequences of the behaviour in general’ (included d= 0.27; not included d= 0.08, p= p<0.001), 'action planning' (included d= 0.38; not included d= 0.16, p=0.009), ‘reinforcing effort or progress towards behaviour’ (included d= 0.33; not included d= 0.16, p= 0.011), 'provide instruction' (included d= 0.26; not included d=0.12, p=0.004), 'facilitate social comparison' (included d=0.46; not included= 0.18, p=0.022) and ‘time management’ (included d= 0.33; not included d=0.17, p=0.039)

Three intervention techniques were significantly associated with lower physical activity effect sizes; 'set graded tasks' (included d= -0.01, not included d= 0.21, p= 0.001), 'use of follow up prompts' (included d= 0.02, not included d=0.21, p= 0.021) and 'relapse prevention' (included d= 0.01, not included d= 0.26, p<0.001).

The remaining 11 techniques included in the moderator analysis were not associated with significant differences in physical activity effect size estimates between studies which included those techniques and studies which did not.

Intervention techniques associated with changes in self-efficacy

Three intervention techniques were significantly associated with higher self-efficacy effect sizes; ‘action planning’ (included d= 0.49; not included d= 0.11, p<0.001), ‘reinforcing effort or progress towards behaviour’ (included d= 0.31; not included d=0.11, p=0.003), and ‘provide instruction’ (included d= 0.21; not included d= 0.11, p=0.017).

Five intervention techniques were significantly associated with lower self-efficacy effect sizes; ’set graded tasks’ (included d= -0.52; not included d= 0.20, p=0.01); ‘prompt self-monitoring of behaviour’ (included d= 0.06, not included d= 0.19, p= 0.004); ‘prompt practice’ (included d= 0.13, not included d= 0.22, p= 0.026); 'plan social support/social change' (included d= 0.06; not included d= 0.20, p=0.010); and 'relapse prevention' (included d= 0.05; not included d= 0.22, p<0.001).

A further twelve techniques included in the moderator analysis were not associated with significant differences in effect size estimates between studies which included those techniques and those that did.

Comparison of techniques associated with self-efficacy and physical activity

There was a significant moderate to large positive relationship between the change in self-efficacy and the change in physical activity for the 20 intervention techniques examined (Spearman's Rho= .690, p (one-tailed) < 0.001).

Of the 20 techniques in the moderator analyses 13 of these were congruent i.e. when a technique was associated with increases in effect sizes for self-efficacy it was also associated with an increase in effect size for physical activity, and vice versa. Five techniques were found to be significantly associated with self-efficacy and physical activity, and in the same direction. These were 'action planning', set graded tasks', reinforcing effort or progress towards behaviour', provide instruction'' and 'relapse prevention'. Interventions that included 'action planning', 'reinforcing effort or progress towards behaviour' and 'provide instruction' produced a significantly higher self-efficacy effect sizes as well as physical activity compared to interventions that did not include this technique. By contrast, interventions that included 'set graded tasks' and 'relapse prevention' techniques produced significantly lower self-efficacy and physical activity effect sizes compared to interventions that did not include these techniques. The remaining 8 techniques associated with changes in self-efficacy and physical activity effect sizes in the same direction produced non-significant effect sizes (p>0.05) in at least one of these two constructs. There were 7 non-congruent techniques (goal setting (behaviour)', 'barrier identification', 'prompt review of behavioural goals', 'prompt practice', 'plan social support/social change', 'provide feedback on performance', 'time management') i.e. their impact on effect size estimates was in opposing directions for self-efficacy and physical activity. However changes in self-efficacy and physical activity behaviour effect size estimates were non-significant for three of these techniques ('goal setting (behaviour)', 'barrier identification' and 'prompt review of behavioural goals', 'provide feedback on performance') Two of the non-congruent techniques ('prompt practice', 'plan social support/social change') produced significant changes in effect size for self-

efficacy but non-significant change in physical activity behaviour. One non-congruent technique produced significant changes in effect size for physical activity but non-significant change in self-efficacy (‘time management’).

Discussion

This meta-analysis of physical activity interventions for 'healthy' adults found a small but significant effect of interventions on self-efficacy (d=0.16) and physical activity (d=0.21). The moderator analyses identified that significantly higher physical activity effect sizes were produced when interventions included ‘provide information on consequences of behaviour in general’, 'action planning', ‘reinforcing effort or progress towards behaviour’, 'provide instruction', 'facilitate social comparison' and time management’ techniques. In contrast significantly lower physical activity effect size estimates were found when each of the following three techniques were included; 'set graded tasks', 'use of follow up prompts', and 'relapse prevention'. A significant large association between changes in self-efficacy and changes in physical activity was found (r_s=.690).

Intervention techniques associated with changes in self-efficacy and physical activity

Intervention studies that included 'action planning', defined in this study as specific detailed planning of when, where and how the specific behaviour is going to be performed produced significantly higher self-efficacy and physical activity behaviour scores. This is contrast to a previous meta-analysis which showed that implementation intentions, in which if-then plans that also specify when, where and how one with achieve a goal, did not produce significant positive effects on self-efficacy [54]. However the studies included in the Webb & Sheeran [54] meta-analysis targeted numerous behaviours and thus the findings for physical activity interventions only is unclear. Furthermore the Webb & Sheeran [54] review contained several studies of simple implementation intention interventions, which are based on laboratory experiments and tend to be provided by experimenters. These might have limited effectiveness in applied settings and for interventions targeting health behaviours, in which more complex elaborate planning is required and is more effective, as demonstrated in this study [55].

There are a number of potential explanations for this effect. As theories of goal setting [21] suggest, setting specific difficult goals are likely to lead to better performance than non-specific goals, for example ‘do more physical activity’. This is a consequence of a reduction in the ambiguity of what is to be attained offered with specific goals [22]. Greater specification of how goals are to be achieved may increase self-efficacy by making clear exactly what the individual needs to do [2]. Likewise, successful mastery performance of the behaviour as a consequence of a specific goal or plan will lead to improved self-efficacy. People with high self-efficacy are also likely to be more committed to assigned goals and use better strategies to attain the goals than those with lower self efficacy [21] so are more likely to successfully perform the behaviour. Finally, specific goal setting, or rather action planning, is likely to have an impact at the volitional phase of behaviour change i.e. by translating intentions into behaviour, explaining its subsequent impact on physical activity behaviour.

The provision of specific instructions on where, when and how to perform the behaviour, e.g. by providing information on local places people can access for exercise, was also associated with an increase in both self-efficacy and physical activity (both $p<0.01$). It is likely that the same mechanism is responsible for the effects of this technique as is responsible for the effects of action planning. When, where and how to perform a behaviour are important components of effective action plans, so providing explicit direction about this allows the participant to identify *how* they are able to achieve the target behaviour which thus supports effective implementation of behaviour. Although action plans may be more effective when self-generated and are therefore tailored to that individual, it possible that some participant generated action plans include insufficient or inappropriate detail. Thus providing participants with specific instructions on how, where and when they might become physically active should offer specific, tangible, and appropriate options for inclusion in an action plan.

Praising or rewarding participants for their *attempts* at achieving a behavioural goal was associated with significantly higher self-efficacy and physical activity effect sizes ($p<0.05$). This finding that providing positive feedback enhances self-efficacy, focusing on small successes and progress towards a behavioural goal rather than actual achievement of final target behaviour, supports Bandura’s view that personal performance successes enhance perceived self-efficacy [1]. This is

particularly pertinent at the early initial stages of behaviour change, as measured in this review, where the participant hasn't quite achieved mastery of the behaviour and is therefore not fully confident in their own abilities to be able to do this. Thus focusing on small success might serve to enhance this initial self-efficacy and subsequently impact physical activity behaviour. Providing rewards and reinforcement contingent on successful behaviour change and achievement of a specific goal might serve to maintain self-efficacy and physical activity in the longer term, once initial mastery has been achieved.

Intervention studies that included 'set graded tasks', in which the target behaviour or increments towards target behaviour become increasingly difficult, were associated with significantly lower physical activity self-efficacy and physical activity behaviour effect sizes. Previous studies in laboratory settings have found that breaking down a distal goal into achievable sub goals that are approached in a hierarchical manner increases self-efficacy [70]. Whilst this is in opposition to the findings of the present review, it is possible that continuously increasing the level of difficulty in physical activity tasks might compromise initial self-efficacy and physical activity levels. This might be the case particularly if participants are encouraged to increase the difficulty of physical activity (e.g. increased duration) before they have successfully mastered their previous task or met their previous physical activity target. Thus it is possible that this technique might lead to low self-efficacy and physical activity behaviour initially, as reflected in the results of the present review, but might be more helpful in the longer term once initial successful mastery of the behaviour has been achieved. However we cannot confirm this as self-efficacy and physical activity were measured only at one time point, i.e. immediately post-intervention in this review.

Significantly lower self-efficacy and physical activity behaviour effect sizes were produced when 'relapse prevention' was used in intervention studies. Relapse prevention, as defined in this study, involves planning how to maintain a behaviour that has already been changed via the identification of potential barriers to maintenance in advance of such situations arising. The technique also involves developing strategies to avoid or cope with that given situation. Problem solving techniques such as this are commonly used in physical activity interventions; a third of the included studies in this review included 'relapse prevention'.

An explicit exploration of the reasons why the individual *cannot* perform the behaviour might undermine self-efficacy possibly due to the fact it will provide further evidence of the barriers, and thus their inability to perform the behaviour [12]. Given that self-efficacy is a predictor of physical activity, the reduction in self-efficacy owing to this technique will likely have a subsequent impact on physical activity behaviour itself. Alternatively given that this technique is explicitly concerned with the maintenance of behaviour, it may be helpful in the longer term, but not in the short-term as assessed in the present meta-analysis. It is also possible that relapse prevention techniques may not be suitable for interventions aimed at changing physical activity behaviour. Due to the nature of physical activity, interventions are aimed at initiation and activation, whereas other behaviours e.g. addictive behaviours, in which there is a need for coping strategies to prevent giving in to urges, may be more amenable to the use of relapse prevention techniques. Furthermore it may be that the way in which the technique is implemented which hinders its effectiveness rather than the technique itself. Thus it is possible that it was the ineffective execution of the technique in the face of an adverse situation, rather than the technique itself that is ineffective, that might have led to lower self-efficacy and thus physical activity effect sizes.

In addition to the five techniques that were significantly associated with self-efficacy and physical activity in the same direction as previously discussed, there were another eight congruent techniques i.e. the impact on self-efficacy and physical activity change was in the same direction. There were seven non-congruent techniques i.e. their impact was in opposing directions for self-efficacy and physical activity. Therefore in most instances when a technique was associated with improvements in effect sizes for self-efficacy it also tended to be associated with an improvement in effect size for physical activity. This review thus lends further support for the targeting of self-efficacy in physical activity interventions in order to induce physical activity behaviour change, and in doing so further endorses the applicability of Social Cognitive Theory [1] to behaviour change interventions.

Additional intervention techniques associated with physical activity

Providing information on the consequences of performing physical activity e.g. the benefits and costs was associated with higher physical activity effect size estimates. This supports the view that an individual is more likely to initiate successful behaviour change if they perceive that there are positive favourable outcomes associated with it [71]. This is particularly pertinent for the initiation of behaviour, as assessed in the current review, yet is likely to be less effective for maintaining physical activity. In this case decision to maintain behaviour is a consequence of satisfaction with such outcomes, not just the presence of the favourable outcomes [71]. We also found that interventions that included 'facilitate social comparison', which involves explicitly drawing an individual's attention to others' performance to elicit comparisons, produced significantly larger effect size estimates of physical activity than those that did not, though this technique was rarely used. The impact of this technique on self-efficacy was positive, albeit non-significant. This supports the view that one route to enhancing efficacy beliefs, and thus performance, is by observing similar others successfully perform the target behaviour and comparing one's own performance with that of others [2]. Similarly, 'time management', referring to techniques designed to teach the person how to manage their time in order to make time to perform the behaviour, was used by only five intervention groups. However the inclusion of this technique produced significantly higher physical activity effect sizes.

In the opposite direction we found 'follow up prompts' to be an ineffective technique, with interventions that included this techniques producing significantly lower physical activity effect sizes.

Strengths and limitations

This is the first study to demonstrate, via meta-analysis with moderator analyses, which behaviour change techniques [12] are associated with changes in self-efficacy, and physical activity behaviour change. An understanding of how, and the mechanisms by which, interventions work is required in order to progress the science of behaviour change [23]. The present review has contributed to the growing theoretical understanding of the mechanisms by which physical activity behaviour change occurs. The present review not only provides guidance on which techniques are likely to be most suitable for changing this behaviour, but has also provided hypotheses for future experimental studies to test.

However, the findings presented in this paper must be interpreted with caution due to a number of limitations. Significant heterogeneity was still present in the meta-analysis even after moderator analyses were conducted, so caution should exercised when interpreting the pooled effect sizes for self-efficacy and physical activity. It must also be highlighted that given the number of independent moderators assessed in this review, and therefore the number of comparisons conducted, it is plausible that the significant effects produced by some moderators are a result of chance alone. Potential confounders, including study, population and intervention characteristics of included studies were not statistically controlled for; likewise differing combinations of intervention techniques were not analysed for their impact on self-efficacy and physical activity behaviour. Finally, where there was more than one experimental group within one study each group was compared to the comparison group separately. Therefore the effect size estimates produced by these comparisons may be somewhat unreliable. However, it should be noted that aim of the present review is to generate hypotheses on the basis of a small number of eligible studies, so we aimed to include as many intervention groups as possible

The intervention studies included in this meta-analysis were not described particularly well, specifically the reporting of intervention techniques were inadequate. It is therefore possible that there are differences in the definitions of specific behaviour change techniques used by the authors of the included studies, and the definitions included in the behaviour change taxonomy [14] used to code these. We are therefore limited by the descriptions of the interventions included in this review. Intervention developers should be encouraged to follow current guidelines for the reporting of study and intervention components [24, 25, 26] to allow for subsequent replication of successful interventions and to enhance our understanding of which techniques are responsible for behaviour change.

Finally, the focus of the present review was physical activity interventions for ‘healthy’ adults. The authors therefore acknowledge that the findings of the present review cannot be generalised to other health behaviours or populations.

Implications and future research

A number of techniques found to be associated with physical activity behaviour change were also found to be associated with self-efficacy change, and in the same direction. Furthermore a significant statistical association between the techniques associated with self-efficacy and those associated with physical activity was found. On the basis of this review the authors would therefore encourage the targeting of self-efficacy in physical activity interventions, and the assessment of self-efficacy as a likely mediator of such interventions. The authors also provide tentative recommendations for the inclusion of particular intervention techniques in physical activity interventions, and suggest techniques which future research might investigate to optimise efficacy.

It was found that setting a specific detailed plan of when, where and how to perform the behaviour and also providing instruction on these same categories of information was effective at bringing about a positive change in self-efficacy and physical activity behaviour. This finding supports previous literature regarding the importance of goal specificity [21]. We therefore suggest that future physical activity interventions encourage participants to make specific, detailed plans of *how* they are going to bring about behaviour change, rather than encouraging participants to set a general goal or make a general intention.

Furthermore, we suggest that intervention deliverers provide specific recommendations on when, where and how a participant might become physically active. For example, by providing information on local exercise facilities and groups participants can access. We also recommend that intervention deliverers provide positive feedback, and reinforce participants' efforts in attempting to become more physically active, independent of achievement of a specific physical activity goal.

As a result of our finding that relapse prevention techniques had a deleterious impact on physical activity, we would not recommend the use of such techniques in future interventions aimed at increasing physical activity by changing self-efficacy. However, this recommendation is limited to social cognitive interventions to increase physical activity, as relapse prevention techniques might have been used effectively in interventions that were not eligible for inclusion in this review and for which we have no data on. Yet, for physical activity interventions based on Social Cognitive Theory [2]

we would recommend that those delivering such an intervention facilitate a discussion of the reasons why the participant *can* perform the behaviour, and avoid emphasising the reasons why they *cannot*.

We would also recommend caution in using graded tasks i.e. incremental increases from baseline towards a target behaviour or goal, at the early stages of behaviour change. Instead we recommend this is used once initial mastery of the behaviour has been achieved, and recommend that any incremental increases should be decided in consultation with the participant to ensure they remain confident in their abilities to achieve such increases.

Likewise, we recommend that intervention developers draw participant's attention towards the performance of others in order to induce physical activity change. We would also suggest that caution be used when using 'follow up prompts' as strategies to enhance both self-efficacy and physical activity behaviour.

Whilst the findings of the present review are informative, they are not considered to be definitive. It is possible that certain techniques are ineffective e.g. relapse prevention, as a consequence of poor implementation rather than the result of the technique itself. Furthermore, the present review findings are based on self-efficacy and physical activity measurements immediately post intervention, therefore it is possible that some techniques are helpful at maintaining self-efficacy and physical activity but are ineffective at initiating this change.

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Table I: Summary of the study characteristics of included studies

Study characteristics	**Frequencies**
Participant characteristics	
Mean age of participants	43.17
Mean number of females per study	132
Mean number of males per study	60
Mean number of white participants per study	139
Mean number of non-white participants per study	72
Study design	
Experiment (randomised)	19
Experiment (non-randomised)	1
Quasi-experimental	3
Pre-post design	4

Note: Gender and ethnicity data was not provided for all studies

Table II. Summary of intervention characteristics of included studies

Intervention characteristics	Frequency
Theoretical basis explicitly mentioned	24
No theoretical basis explicitly mentioned	3
Theoretical model	
Social Cognitive Theory	14
Transtheoretical Model	9
Theory of Planned Behaviour	2
Type of activities:	
Individual	19
Group	8
Focus:	
Recreational physical activity (e.g. aerobics class, gym, jogging)	3
Lifestyle physical activity (e.g. walking, gardening)	24
Delivered by:	
a) Researcher	10
b) Nurse	2
c) GP	3
d) Health and fitness professional	5
e) Peers	1
f) Not stated	3
g) Other	2
Setting:	
Workplace	5
College/University	2
GP Surgery	4
By post	2
Other	13

Delivery mode:	
Training sessions	6
Discussion group	3
Telephone	6
Self-help manuals	3
Mass media	2
Other	8

Table III. Frequencies of intervention techniques that were used in the interventions.

Technique	No. intervention groups (max.36)	**%**
1. Provide information on consequences of behaviour in general	15	41.6
2. Provide information on consequences of behaviour for the individual	2	5.6
3. Provide information about others' approval	0	0
4. Provide normative information about others' behaviour	0	0
5. Goal setting (behaviour)	16	44.4
6. Goal setting (outcome)	1	2.7
7. Action Planning	4	11.1
8. Barrier Identification/Problem solving	18	50
9. Set graded tasks	3	8.3
10. Prompt review of behavioural goals	8	22.2
11. Prompt review of outcome goals	0	0
12. Reinforcing effort or progress towards behaviour	8	22.2
13. Provide rewards contingent on successful behaviour	1	2.7
14. Shaping	0	0
15. Prompt generalisation of a target behaviour	0	0
16. Prompt self-monitoring of behaviour	13	36.1
17. Prompt self-monitoring of behavioural outcome	0	0
18. Prompting focus on past success	0	0
19. Provide feedback on performance	8	22.2
20. Provide instruction	17	47.2
21. Model/demonstrate the behaviour	1	2.7
22. Teach to use prompts/cues	1	2.7
23. Environmental restructuring	0	0
24. Agree behavioural contract	0	0
25. Prompt Practice	19	52.77
26. Use of follow up prompts	3	8.3

27. Facilitate social comparison	2	5.6
28. Plan social support/social change	6	16.7
29. Prompt identification as a role model/position advocate	1	2.7
30. Prompt anticipated regret	0	0
31. Fear arousal	1	2.7
32. Prompt self-talk	4	11.1
33. Prompt use of imagery	1	2.7
34. Relapse prevention/coping planning	11	30.6
35. Stress management	0	0
36. Emotional control training	3	8.3
37. Motivational Interviewing	1	2.7
38. Time management	5	13.9
39. General communication skills training	1	2.7

Table IV. Comparison between self-efficacy and physical activity behaviour, according to whether specific techniques are included in the physical activity intervention and when the technique is not included.

Technique	Self-efficacy							Physical Activity						
	Present			Not present				Present			Not present			
	n	K	d	n	k	d	Z	n	K	d	n	k	d	Z
1. Provide information on consequences of behaviour in general	3279	15	0.16	3150	21	0.13	0.75	3279	15	0.27	3167	21	0.08	3.69***
2. Provide information on consequences of behaviour for the individual	196	2	0.18	6233	34	0.16	0.12	196	2	0.22	6250	34	0.19	0.25
5. Goal setting (behaviour)	3633	16	0.14	2796	20	0.17	0.58	3641	16	0.22	2805	20	0.19	0.46
7. Action planning	532	4	0.49	5897	32	0.11	4.09***	541	4	0.38	5905	32	0.16	2.38**
8. Barrier Identification/Problem solving	3243	18	0.16	3186	18	0.17	0.23	3251	18	0.20	3195	18	0.19	0.18
9. Set graded tasks	983	3	-0.05	5446	33	0.20	2.12*	991	3	-0.01	5455	33	0.21	2.96**
10. Prompt review of behavioural goals	1863	8	0.12	4566	28	0.20	1.48	1871	8	0.16	4575	28	0.20	0.77
12. Reinforcing effort or progress towards behaviour	911	8	0.31	5518	28	0.11	2.72**	907	8	0.33	5539	28	0.16	2.29*
16. Prompt self-monitoring of behaviour	3112	13	0.06	3317	23	0.19	2.65**	3120	13	0.14	3326	23	0.19	0.88

18.Prompting focus on past success	233	2	-0.03	6196	34	0.17	1.03	233	2	0.00	6213	34	0.20	1.51
19. Provide feedback on performance	1877	8	0.18	4552	28	0.15	0.55	1873	8	0.19	4573	28	0.19	0.02
20. Provide instruction	2566	17	0.21	3863	19	0.11	2.10*	2566	17	0.26	3880	19	0.12	2.63**
25. Prompt practice	2992	19	0.13	3437	17	0.22	1.93*	3000	19	0.22	3446	17	0.14	1.61
26. Use of follow up prompts	1298	3	0.16	5131	33	0.18	0.27	1298	3	0.02	5148	33	0.21	3.12***
27. Facilitate social comparison	216	2	0.34	6213	34	0.16	1.27	216	2	0.46	6230	34	0.18	2.16*
28. Plan social support/social change	1548	6	0.06	4881	30	0.20	2.30*	1556	6	0.22	4890	30	0.18	0.67
32. Prompt self-talk	224	2	0.004	6205	34	0.18	1.27	220	2	-0.049	6226	34	0.18	0.94
34. Relapse prevention/coping planning	3264	11	0.05	3165	25	0.22	3.31***	3272	11	0.01	3174	25	0.26	4.95***
36. Emotional control training	593	3	0.18	5836	33	0.17	0.24	605	3	0.26	5841	33	0.18	0.89
38. Time management	527	5	0.13	5902	31	0.18	0.59	527	5	0.33	5919	31	0.17	1.75*

n= number of participants, k= number of tests of the relationship, CI= 95% confidence interval, Q= test statistic of homogeneity, d= Mean effect size, Z= moderator analysis test statistic

*P<0.05 **p<0.01 ***p<0.001

Note: Total number of participants included for self-efficacy= 6429, total number of participants included for physical activity = 6446.
Table refers only to the moderator analyses on 20 techniques included in the revised taxonomy of behaviour change. 19 techniques are not included here as they were used by one or fewer intervention groups.

Table IV. Intervention techniques included in each intervention group

Study	Intervention techniques
Marcus et al, [27]; Bock et al, [28]; Lewis et al [29]	2, 8, 12, 19, 25, 27
Castro, [30]; Chen et al, [31]	1, 5, 8, 9, 10, 12, 16, 19, 25, 28, 32, 34
Naylor et al, [32]	
Group 1	16, 20, 25
Group 2	16, 20, 25
Group 3	16, 20, 25
Bauman et al, [33]	1, 20, 25
Hager et al, [34]; Peterson & Aldana,[35]	
Group 1	1, 5, 8, 25, 29, 33, 34
Group 2	1, 5, 25, 34
Rejeski et al, [36]; Anderson et al, [37]; King et al, [38]; Blair et al, [39]	
Group 1	2, 5, 8, 10, 12, 16, 19, 20, 25, 26, 28, 34
Group 2	2, 5, 8, 9,10, 12, 16, 19, 20, 25, 26, 28, 34
Speck & Looney, [40]	16
Renger et al, [41]	1, 8, 25, 27
Elbel et al, [42]	
Group 1	1, 5, 8, 12, 20, 25, 34, 38
Group 2	1, 5, 8, 12, 20, 25, 34, 38
Collins [43]	1, 5, 7, 8, 20, 25, 36, 39
Dinger, Heesch & McClary, [44]	1, 5, 10, 16, 22, 25, 28, 38
Graham et al [45]	
Group 1	1, 5, 20, 25
Group 2	2, 5, 8, 10, 12, 16, 19, 20, 25, 28, 32, 34, 36, 38
Blanchard et al, [46]; Fortier et al [47]	
Marcus et al, [48]; Marcus et al, [49]; Sevick et al [50]	
Group 1	7, 12, 16, 19, 20, 25, 26
Group 2	7, 12, 16, 19, 20, 25

Steele et al, [51]; Steele et al, [52]	
Group 1	1, 5, 8, 16, 19, 25, 28, 32, 34, 35, 38
Group 2	1, 5, 8, 16, 19, 25, 28, 32, 34, 35, 38
Stovitz et al, [53]	1, 5, 9, 16, 25, 26
Constanzo [56, 57]	1, 2, 5, 8, 10, 16, 18, 19, 21, 25, 28
Bennett [58]	5, 8, 10, 12, 20, 25, 37
Cramp [59, 60]	1, 5, 8, 16, 25
Murrock [61]	25
Hardeman [64]	1, 5, 8, 9,10,16, 25, 28, 34, 36
Opdenacker [65]	1, 5, 8, 16, 20, 25
Opdenacker [62, 63]	1, 5, 8, 16, 20, 25
Latimer [66] Group 1	1
Group 2	1, 31
Kim YH [67]	1, 5, 13, 16, 28, 34
Arbour [68]	5, 7, 16, 20
Luszczynska et al [69]	8, 18, 36