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Behavioural incentive interventions for health behaviour change in young people (5-18 years old): A systematic review and meta-analysis

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Abstract

Physical inactivity, an unhealthy diet, smoking, and alcohol consumption are key determinants of morbidity and mortality. These health behaviours often begin at a young age and track into adulthood, emphasising a need for interventions in children and young people. Previous research has demonstrated the potential effectiveness of behavioural incentive (BI) interventions in adults. However, little is known about their effectiveness in children and adolescents.

Eight bibliographic databases were searched. Eligibility criteria included controlled trials using behavioural incentives (rewards provided contingent on successful performance of the target behaviour) as an intervention component for health behaviour change in children and adolescents. Intervention effects (standardised mean differences or odds ratios) were calculated and pooled by health behaviour, using a random effects model.

Twenty-two studies were included (of n=8,392 identified), 19 of which were eligible for meta-analysis: physical activity (n=8); healthier eating (n=3); and smoking (n=8). There was strong evidence that behavioural incentives may encourage healthier eating behaviours, some evidence that behavioural incentives were effective for encouraging physical activity behaviour, and limited evidence to support the use of behavioural incentives for smoking cessation and prevention in adolescents.

Findings suggest that behavioural incentives may encourage uptake and initiation of healthy eating and physical activity in young people. However, this is a limited evidence base and a wide range of incentive designs have yet to be explored. Future research should further investigate the acceptability of these intervention approaches for young people.

Keywords

Incentives; Child; Adolescent; Physical Activity; Smoking; Diet; Behaviour; Meta-analysis

Introduction

Many unhealthy lifestyle behaviours in youth, such as physical inactivity, an unhealthy diet, smoking, and alcohol consumption, track into adulthood, and are key determinants of morbidity and mortality. Childhood and adolescence is also an important time to shape habitual lifestyle behaviours (Kelder et al., 1994). Therefore, reducing these modifiable risk factors is a major public health priority, necessitating innovative approaches.

Behavioural incentives (BIs) are an example of such an innovative approach for health behaviour change. Using BIs involves explicitly informing participants that future rewards, or removal of future punishments, will be contingent on performance of the health behaviour (Michie et al., 2013). The use of BIs has its foundations in operant conditioning (Skinner, 1938). Operant conditioning posits that behaviours are affected by their consequences (Staddon and Cerutti, 2003). In operant conditioning theory, BIs can be used as a stimulus to reinforce and increase future occurrences of the behaviour (Skinner, 1953). Reinforcements can be positive (e.g. presenting a BI on completion of the behaviour), or negative (e.g. removing a BI when the behaviour is not performed). Further definitions and examples of key terms used in this paper are shown in Appendix A.

Recent evidence suggests BIs may be effective at encouraging health-related behaviour change (Giles et al., 2014; Mantzari et al., 2015). Although the reviews by Giles et al. (2014) and Mantzari et al. (2015) have shown potential short term benefits of using BIs, these studies focused solely on adults, and only used financial incentives. A systematic review on the use of BIs in those aged 11-19 years found BIs may be effective for non-complex health behaviours (e.g. attendance for vaccination; attendance for screening), but the effectiveness for complex health behaviours such as smoking, alcohol intake, dietary change or physical activity, remains unclear (Kavanagh et al., 2011). However, the review by Kavanagh et al. (2011) only included studies where BIs were the sole component or in combination with only one other intervention component. Consequently, common approaches involving complex multi-component interventions (including an incentive explicitly linked to the achievement of the target behaviour) remains unexplored. The review by Kavanagh et al. (2015) focused on young people aged 11-19 years old, suggesting that there is a gap in the literature exploring the effectiveness of BI interventions for children. Incentives given in this context may be washed out by what goes on in the home environment where parental and/or sibling modelling and support may counteract or attenuate gains the child makes on a given day or over time.

Further, the evidence justifying interventions using BIs for maintenance of behaviour change is inconclusive (Giles et al., 2014; Kavanagh et al., 2011; Mantzari et al., 2015; Mitchell et al., 2013).

Although a meta-analysis suggests that extrinsic rewards can undermine intrinsic motivation, the majority of included studies are laboratory-based, dealing with artificial choices and their relevance to real world health behaviours is unknown (Deci et al., 1999).Nevertheless, BIs may be important for the initiation of health-related behaviours, and be supportive for maintaining behaviours that require self-control, such as smoking cessation and reduced calorie consumption (Promberger and Marteau, 2013).

To address these evidence gaps, the aim of the current systematic review and meta-analysis was to investigate the effectiveness of controlled trials using BI interventions for encouraging physical activity, diet, alcohol, or smoking behaviour change in young people (5-18 year olds). Further objectives included investigating the effectiveness of BIs for maintenance of behaviour change, and the effects of different intervention lengths, follow-ups, incentive designs, and behaviour change techniques (BCTs) used.

Methods

Eligibility criteria

The following eligibility criteria was defined *a priori*:

Participants: A non-clinical population of children and adolescents (mean age between 5-18 years old) were included. Populations with diagnosed diseases/conditions (e.g. diabetes, cancer) were excluded.

Study Design: All controlled trials (e.g. randomised controlled trials (RCTs), cluster RCTs, pre-post controlled trials) were included. Included studies compared the use of a BI-based intervention to promote health behaviour change versus a control or comparison group such as no intervention, usual treatment, or the same treatment without a BI component.

Intervention: Interventions incorporating BIs (i.e. material incentives, self-incentives; and non-material incentives such as social incentives and non-specific incentives) were included (Michie et al., 2013; see Appendix A for definitions). Interventions in which participants were initially unaware of the potential for a reward, or rewards were not contingent on effort and/or progress in performing the behaviour were excluded.

Outcome Measure(s): Studies involving a measure of health behaviour change (physical activity, healthier eating, alcohol, and smoking) using validated measures were included. A measure was considered valid if it was specifically stated in the article that the measure was valid (and supported by relevant references for the target population) or if the authors could identify at least one appropriate study that provided evidence of the validity of the instrument for measuring health behaviour for the target population.

Search strategy

Eight electronic databases (Medline, Embase, CINAHL Plus, PsycINFO, Cochrane Central Register of Controlled Trials (CENTRAL), EconLit, Business Source Premier, and Education Resources Information Centre (ERIC) were searched from date of inception until November 2016. Reference lists of included studies, and review articles were hand searched to identify other relevant studies. Search terms included type of health behaviour, type of incentive, study design, and children and adolescents (see Appendix B). Only studies in English were included. Two researchers (RC and RH) undertook independent screening of titles and abstracts, and full texts for eligibility. Any disagreements regarding inclusion of studies were resolved by consensus. Percentage agreement and Cohen's Kappa were calculated for title/abstract and full text screening.

Data extraction

Extracted data included: study design, participant characteristics, description of the interventions(s) and control group, follow up periods, outcome measures, and results of the intervention.

The domain framework for financial incentives (Adams et al., 2014) was applied to describe the incentive interventions and modified to include non-financial incentives; BCTs were classified using Michie et al's 93-item taxonomy (Michie et al., 2013). RC and RH independently assessed the risk of bias using the Cochrane Collaboration's tool (Higgins et al., 2011).

Evidence synthesis

Extracted study characteristics, intervention designs, outcomes of the study, BCTs and incentive domains were summarised in tabular form and described. Studies were synthesised per targeted health behaviour. Short-term effects were those < 6 months, and maintained intervention effects were defined as ≥ 6 months (Prochaska and DiClemente, 1983).

Meta-analyses using a random effects model were conducted using Review Manager (Revman [Computer program]. Version 5.3.5. Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2014). Meta-analyses were undertaken by health behaviour if analyses of at least two similar interventions/comparisons could be performed (Valentine et al., 2011) and relevant data available. Standardised mean differences (SMD) using final value scores and Hedges g were used as the measure of effect size for continuous data, and odds ratios (OR) for dichotomous data. Heterogeneity was measured by the I^2 statistic (Higgins et al., 2003). Studies were described as providing strong evidence if at least 80% of included studies demonstrated a significant intervention effect; promising evidence if 50-79%;

some evidence if ≤49%; no evidence if none of the included studies demonstrated a significant intervention effect; and, lack of evidence if there were no identified studies in the pre-defined category (Hunter et al, 2015).

BCT (behaviour change technique) frequency was analysed, and BCT effectiveness measured using the method described in Hynynen et al. (2016). Effect sizes were calculated for each study. Effective BCTs were defined as those that were present in 50% of the effective interventions (significant intervention effect ($p < .05$) versus comparison group) but not at all present, or present in only one of the non-effective trials. BCT effectiveness was presented as an effectiveness ratio, calculated as the ratio of the number of times a BCT was present in an effective intervention compared to the number of times it was present as a component of all interventions (Hynynen et al, 2016).

Results

Protocol and registration

The study protocol was registered with PROSPERO (CRD42015024468) and reported following the PRISMA guidelines (Liberati et al., 2009).

Study selection

The search strategy identified 8392 records; 22 studies were included in the review, and 19 studies in the meta-analysis (see Appendix C). Percentage agreement between researchers (90.8%) and inter-rater agreement for title/abstract and full-text screening (Cohen's Kappa = 0.79) was good. Table 1 presents a summary of study characteristics; Appendix D reports the interventions by type of incentive design.

In total, 24,560 participants (50% female, 22% ethnic minority population) were included in all studies; 6,960 participants were children with an average age of ≤12 years. The median sample size was 261 participants, median intervention duration was 42 days and a median follow-up period was 210 days across all included studies. Eight studies focused on increasing physical activity; six on increasing consumption of fruit, vegetables, and fruit juice (FVJ); and eight on reducing smoking. No alcohol-related studies met the eligibility criteria.

Physical activity

There was some evidence of the effectiveness of BIs for physical activity behaviour change with two of eight studies demonstrating significant intervention effects; one in the short-term (Goldfield et al., 2006) (≤6 months from baseline), and one study showing a maintained effect (Finkelstein et al., 2013). Finkelstein et al. (2013) awarded toy store vouchers (worth ~$19 USD) when pedometer goals were met, in addition to the chance to win other prizes with a value of ~$74 USD (e.g. tickets to the zoo) via monthly lotteries. Goldfield et al. (2006) incentivised physical activity with access to television; accruing approximately sixty minutes of physical activity equated to sixty minutes of television access.

Six studies showed no significant intervention effect of BIs for physical activity behaviour change. One study used academic BIs of four points added to the participant's nine week grade if a three-week fitness challenge was fully completed (Brinker, 2008). Two studies used the Fit 'n' Fun Dudes intervention, consisting of peer modelling, pedometer step goals, and BIs (Hardman et al., 2011; Horne et al., 2009a). Material BIs such as balls, erasers, and Frisbees were awarded for meeting daily step count. One Fit 'n' Fun Dudes study showed a significant intervention effect for girls; however, when pooled with boys (Figure 1), the significant intervention effect was reduced (Horne et al., 2009a). A pedometer class competition to incentivise physical activity was used in another study (Suchert et al., 2015); classes with the most steps were awarded, and those with the largest increase in steps were awarded cash prizes (~$3477 USD in total). There was a significant increase from baseline for the intervention group for self-reported MVPA and active commuting at post-intervention, although not when final values were compared with the comparison group (Figure 1). Two studies incentivised physical activity by using access to television as a reward (Roemmich et al., 2004; Roemmich et al., 2012). Although there was a significant difference in MVPA with the intervention group (Roemmich et al., 2012) this was not significant at follow up, nor when compared with the comparison group (Figure 1).

The meta-analysis (Figure 1) detected small, non-significant, positive intervention effects (SMD 0.31; 95% CI -0.27 to 0.88; n= 1834) with a high level of heterogeneity (I^2=95%; p<0.001). A sensitivity analysis related to type of BIs used was performed. Only two studies incorporated financial incentives (Finkelstein et al., 2013; Suchert et al., 2015). The six studies using non-financial incentives (Brinker, 2008; Goldfield et al., 2006; Hardman et al., 2011; Horne et al., 2009a; Roemmich et al., 2004; Roemmich et al., 2012) found small, non-significant positive intervention effects (SMD 0.11; 95% CI -0.26 to 0.48; N= 438) with a decreased I^2 of 63% (p=0.02) (Figure 2).

Healthier Eating

There was strong evidence for the effectiveness of BIs to encourage young people to increase FVJ consumption with 5 out of 6 studies demonstrating a significant intervention effect; three in the short-term (Baranowski et al., 2002; Horne et al., 2004; Presti et al., 2015), and two showing a maintained effect (Horne et al., 2009b; Morrill et al., 2016). One study recruited participants from African American boy scout troops (Baranowski et al., 2002). The scout troops received lessons, and tasks to complete at home with the goal to increase availability and accessibility of FJV at home, increase preferences for vegetables, and learn simple recipes. Scouts were given weekly goals and if these goals were achieved the participants received BIs worth ~$1 USD at the next meeting. If all dietary goals were met, scouts received a 5-a-Day achievement badge. Four studies using the 'Food Dudes' intervention resulted in a positive intervention effect (Horne et al., 2009b; Horne et al., 2004; Morrill et al., 2016; Presti et al., 2015). Interventions were comprised of peer modelling, goal setting, self-monitoring, and material BIs such as customised 'Food Dudes' stationery, certificates and stickers. Two 'Food Dude' studies investigated intervention effects by sub-groups; age (5 to 7 years) (Horne et al., 2004) and weight (overweight or non-overweight using BMI) (Presti et al., 2015). Results showed significantly greater consumption of FVJ at follow-up for intervention participants for both studies. Two 'Food Dude' studies evaluated the maintained effect of the intervention, and found a significant positive intervention effect at 10 months (Morrill et al., 2016), and 12 months (Horne et al., 2009b) for lunchbox consumed fruit and vegetables. A further study found no significant intervention effect for lunchtime consumption of fruit and vegetables provided by schools (Upton et al., 2013). There was significant change in fruit and vegetable consumption in the intervention schools at three months post-baseline but this was not maintained at 12 months.

Three studies (3/6 studies) were included in the meta-analysis (Baranowski et al., 2002; Horne et al., 2009b; Morrill et al., 2016) shown in Figure 3. Results showed large significant positive intervention

effect (SMD 1.12; 95% CI 0.19 to 2.05; n= 1717) with a high level of heterogeneity I^2 of 98% (p=0.01). A sensitivity analysis related to methodology and target population was performed (Figure 4). Results of this meta-analysis showed a significant positive intervention effect (SMD 0.45; 95% CI 0.35 to 0.55) with a decreased I^2 of 0% (p=0.42). However, findings from both should be interpreted with caution due to the small number of studies.

Smoking

There was limited evidence for the effectiveness of BIs to reduce smoking in young people. One study (1 out of 8 studies) showed a significant intervention effect in the short term (12 weeks) (Krishnan-Sarin et al., 2006). The intervention used an incentive design comprised of material incentives in the form of cash. Payments to participants would increase after each consecutive negative breath sample, but this was reset to the original level if a sample was above the threshold for determining abstinence or participants failed to provide a sample. Participants were required to visit the laboratory for breath tests to verify abstinence.

Other smoking interventions did not show a significant intervention effect (7 out of 8 studies). All participants were aged 13-18 years. Five of these studies tested smoke free class competitions (SFCC) format (Crone et al., 2003; Isensee et al., 2012; Schulze et al., 2006; Vartiainen et al., 1996; Wiborg and Hanewinkel, 2002); with 90% to remain abstinent by intervention end in order to enter a lottery/draw for a chance to win various prizes for their class. Two studies used cash (payments increased for each subsequent breath test showing abstinence) and a reset contingency (if a participant's abstinence could not be verified, payment was reset to the initial level) (Krishnan-Sarin et al., 2013; Reynolds et al., 2015).

The meta-analysis adjusted for clustering at the school level by inflating standard errors (Higgins and Green, 2008), and using an intra-class correlation coefficient (ICC) of 0.097 obtained from Siddiqui (Siddiqui et al., 1996). Where only the number of classes at follow up were available, estimated number of schools was derived as shown in a recent Cochrane review (Johnston et al., 2012) (classes/school ratio of 5:2). The meta-analysis of all studies (Figure 5) demonstrated small statistically significant intervention effects for reducing smoking with a low level of heterogeneity (OR 0.80; 95% CI 0.65, 0.98 (I^2=0%; p=0.51; n=8881). Five studies using SFCC demonstrated no statistically significant intervention effects for reducing smoking with a low level of heterogeneity (OR 0.83; 95% CI 0.67, 1.03; I^2=0%; p= 0.87; n= 8750). Material incentives comprised of only financial payments found large effects in favour of BIs but this was not statistically significant with moderate heterogeneity, OR 0.29; 95% CI 0.06, 1.42 (I^2=41%; p= 0.18; n= 131). Studies using financial incentives verified abstinence using an objective measure of smoking status whereas studies involving competition used self-report smoking measures.

Behaviour Change Techniques (BCTs)

Frequency of BCTs

Figure 6 details the frequency of employed BCTs. Material incentives and material rewards were the most commonly used (n=17), followed by non-specific incentives (use of a class competition (n=6); academic incentives (n=1); and access to television (n=4). Most studies also provided social support in the form of encouragement, advice, or non-contingent praise (n=15); goal setting to achieve a predefined outcome (n=14); feedback on the outcome of behaviour (n=14); and opportunities to self-monitor behaviour (n=13).

Effectiveness of BCTs

Effective BCTs were defined as those that were present in 50% of the effective interventions (significant intervention effect ($p < .05$) versus comparison group) but not at all present, or present in only one of the non-effective trials. Result of the analyses showed no distinct patterns of BCTs meeting these criteria (See Appendix E). Although no BCTs were deemed effective per these definitions, the most common BCTs were *'adding objects to the environment'* and *'self-monitoring of behavior'* (ratio of BCTs present in effective studies divided by the number of times the BCT is present in all studies, shown in Appendix E). Heterogeneity in study design, range of BCTs used in the multi-component interventions, and the small number of included studies may explain the lack of a clear pattern for effective BCTs. This makes it difficult to disentangle the effective components, which indeed may not be appropriate given the interplay and interaction between BCTs (i.e. these are not discrete entities/components acting in isolation). In addition, assumptions were made that BCTs contained in the intervention description are successfully implemented, which of course may not have been the case; therefore, these results should be interpreted with caution.

Risk of bias

Overall, the risk of bias for each domain was low or unclear in most areas in most studies (See Appendix F). Random sequence generation, allocation concealment, and incomplete outcome data were the main potential sources of bias. As 22.7 % of studies (5/22 studies) were deemed to be of high risk of bias, caution is necessary with interpretation of findings. Moreover, 63.6% of studies (14/22 studies) were deemed to be of unclear risk of bias, suggesting the need for improved reporting of intervention methods.

Discussion

Findings from this review show that BIs may be effective for encouraging behaviour change for particular health behaviours in young people. Studies showed some evidence that providing money or access to television could be effective for encouraging physical activity. There was strong evidence to support the use of valued objects such as achievement badges and customised 'Food Dude' incentives for increasing FVJ consumption, and limited evidence to support the use of incentives for smoking cessation and prevention in adolescents. All included studies investigating physical activity and dietary behaviour were conducted with pre-adolescents, and all included studies focusing on smoking were with adolescents.

The evidence for the effectiveness of incentive-based interventions for maintained health behaviour change in young people is largely inconclusive. Maintained behaviour change could be possible if BIs are in place for a sufficient period of time to create habits (Oliver and Brown, 2012), yet the appropriate length of time is unclear. It has been proposed that people do not always act in the way that they want, so BIs could provide motivation to behave in a way that accurately represents their long-term goals, enhancing autonomy (Kimmel and Troxel, 2012; Marteau et al., 2009; Paloyo et al., 2015), and eliminating social pressures from peers' potentially negative reactions (Wolff, 2014). Consequently, what is intrinsically desired can be attempted under the guise of an extrinsic motivator (Kifmann, 2014). Complex interventions such as these have multiple strands operating at several levels and this needs to be further explored to allow the identification of assumed pathways of change and to help uncover the balance between extrinsic and intrinsic motivation in effecting change. Two possible mechanisms are: a) behaviour may be habitual by the time incentives are withdrawn (as per the automaticity work of Bargh (1992)); and/or b) participants are satisfied with the benefits of the behaviour change (e.g. feel better), and so wish to maintain it to continue to receive these benefits (as per Rothman's theory of maintenance (Rothman et al., 2011)). Alternatively, it may be that for incentives to work optimally, persons in the home environment - who are ultimately responsible - for the child's welfare also need to be able to earn incentives for appropriate/desirable behaviour.

Effectiveness of material incentives

All four studies using material incentives of a financial nature demonstrated a greater intervention effect when compared to the control. (Finkelstein et al., 2013; Krishnan-Sarin et al., 2013; Krishnan-Sarin et al., 2006; Reynolds et al., 2015).

Other non-financial incentives (i.e. material incentives with a low financial value, social incentives, and non-specific incentives such as access to television), were on a whole, no more effective for reducing smoking or increasing physical activity than the comparison group. Yet, a similar intervention to that used in two physical activity studies (Hardman et al., 2011; Horne et al., 2009a) was found to be effective for

increasing FJV consumption at school (Horne et al., 2009b; Horne et al., 2004; Morrill et al., 2016; Presti et al., 2015). Perhaps, the goal of increasing FJV consumption is easier to achieve than increasing physical activity; so, the health behaviour rather than the form of BI may play a bigger role here. The 'Food Dude' interventions measured FJV at snack time and lunchtime in schools, with participants receiving immediate rewards if successful. Meeting physical activity goals as set in the 'Fit n Fun Dudes' interventions is more complex and would require more time.

Effectiveness of competition

The findings of this review are in line with a previous Cochrane review (Johnston et al., 2012) which did not demonstrate evidence to support the use of SFCC for smoking prevention. In contrast, two meta-analyses found SFCC to be effective in young people. However, these studies had certain limitations such as the inclusion of only two studies (Kavanagh et al., 2011), and not adjusting for clustering (Isensee and Hanewinkel, 2012). There are also some concerns about class competitions fostering an atmosphere of dishonesty, suspicion (Etter and Bouvier, 2006; Kairouz et al., 2009) and bullying, although other studies have not found negative peer pressure or bullying (Hanewinkel et al., 2010). Given the strong peer influence among adolescents, interventions at the class, year group or whole of school level that provides a supportive social environment may be a key element to motivate behaviour change (Silva et al., 2014).

Ethics and acceptability

Research on the issue of acceptability conducted by Giles et al. (2015) found that participants (adults) thought financial BIs were unfair by rewarding 'bad behaviour'. There were concerns that people may begin the unhealthy behaviour to receive financial incentives when they stop. Further, interventions incorporating BIs raise particular ethical implications such as "perceived bribery, coercion, and paternalism," thus undermining the autonomy of the individual (Marteau et al., 2009). Currently, there is no consensus whether BIs are ethically sound and acceptable (Oliver et al., 2009), particularly for young people, though research is lacking.

Limitations

Strengths of the review include searching a range of bibliographic databases from different disciplines, and in-depth exploration of effective BCTs. Due to the small number of studies, small sample sizes in several studies, heterogeneity, and variable quality of studies, results should be interpreted with caution.

Future research

Health behaviours examined here are 'complex' (Kane et al., 2004) with numerous and varied determinants, and the effectiveness of BIs to affect behaviour change could be influenced by a variety of factors (Lynagh et al., 2013), and work via different mechanisms (Boyce et al., 2008). Variability shown in intervention designs and BCTs used in studies, shows that there is not a 'one size fits all approach'. Questions regarding BIs such as 'who do they work for?', 'how do they work?' and 'is it acceptable and appropriate to use them?' require further investigation.

Using competition as a BI in complex public health interventions in young people is still a relatively under-investigated area. Disentangling the various 'active ingredients' in competition-based interventions to better understand distinct mechanisms of action are needed. Habit formation is complex (Gardner, 2015), likely with different mechanisms at play for building 'good' habits, and removing 'bad' habits. In particular, longer interventions, interventions with a tapered withdrawal of BIs, or incorporating on-going behavioural support (Sigmon and Patrick, 2012) could lead to maintained behaviour change (Lynagh et al., 2014).

Conclusion

The findings from this review show promising evidence that BIs may be effective for encouraging physical activity behaviour change and healthy eating in young people. However, this is a limited evidence base and a wide range of incentive designs have yet to be explored.

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Table 1: Characteristics of included studies included in the systematic review

	Baseline Participant Characteristics	**Intervention Group**	**Comparison Group**	**Follow up** (Post-baseline)	**Outcome**	**Results (Furthest follow up)**	**Risk of Bias Summary**
Target Behaviour: Physical Activity							
Brinker (2008) **Country:** USA **Study design:** Controlled trial	N=24 Age range 12-14 years % female unavailable; % ethnicity unavailable School setting	N=13 Duration: 3 weeks Academic points (4 points added to their 9-week grade)	N=11 No intervention	3 weeks	Number of days/week did at least 60 mins MVPA	Intervention group: Mean 5.8 (SD 1.6) Comparison group: Mean 6.0 (SD 1.3)	High risk
Finkelstein et al (2013) **Country:** Singapore **Study design:** RCT	N=285 Mean age 8.2 (SD 1.5); 46% female; 86.3% Chinese Home and community setting	N=145 Duration: 9 months Toy store vouchers, and prizes such as entrance to a zoo	N=89 Usual activities	9 months	Pedometer step count over weekdays	Intervention group: Mean 8660 (SD 567) Comparison group: Mean 7767 (SD 382)	Low risk
Goldfield et al (2006) **Country:** Canada **Study design:** RCT	N=30 Mean age 10.4 (SD 1.3); 56.6% female; % ethnicity unavailable; all participants BMI above	N=14 Duration: 8 weeks Feedback and reinforced for PA with access to	N=16 Feedback on PA. No contingency for access to TV	8 weeks	Accelerometer determined MVPA (daily minutes of MVPA)	Intervention group: Mean 22.5 [SE 3.5] Comparison group: Mean 10.0 [SE 3.3]	Unclear risk

	85th percentile Home setting	TV					
Hardman et al (2011) **Country:** Wales, UK **Study design:** Cluster RCT	N=236 Mean age 9.1 (SD 1.3); 55.5% female; % ethnicity unavailable School setting	N=118 Duration: 12 school days. Followed by taper phase of 14 weeks (incentives stopped, but still had pedometers and diary to self-record step counts. Occasional letters and certificates provided) Fit 'n' Fun Dudes Programme: Peer modelling, goal-setting, and incentives	N=67 No rewards intervention N=51 No intervention	13/14 weeks	Pedometer step count over 8 school days	Intervention group: Mean 13085 (SD 3058) Comparison group: Mean 13939 (SD 3672)	Unclear risk
Horne et al (2009a) **Country:** Wales, UK **Study design:** Cluster	N=89 Mean age 10.0 (SD 0.7); 51.7% female; % ethnicity unavailable School	N=38 Duration: 8 school days (12 weeks maintenance) Followed	N=51 No intervention	15/16 weeks	Pedometer step count over 8 school days	Intervention group: Mean 14218 (SD 4031) Comparison group:	Unclear risk

RCT	setting	by maintenance phase of 12 weeks (incentives stopped, but still had pedometers and diary to self-record step counts. Occasional letters and certificates provided) Fit 'n' Fun Dudes Programme: Peer modelling, goal-setting, and incentives				Mean 12543 (SD 4068)	
Roemmich et al (2004) **Country:** USA **Study design:** RCT	N=18 Mean age 11.4 (SD 0.4); 38.9% female; % ethnicity unavailable; all participants BMI less than 90th percentile Home setting	N=11 Duration: 6 weeks Feedback and reinforced for PA with access to TV	N=7 Goal of 60 mins/day in MVPA	6 weeks	Accelerometer determined MVPA (daily minutes of MVPA)	Intervention group: Mean 16 [SE 14.47] Comparison group: Mean 25 [SE 15.78]	Unclear risk
Roemmich et al (2012)	N=61 Mean age 10.7 (SD	N=20 Duration:	N=21 Suggested to spend	12 months	Accelerometer determined MVPA	Intervention group: Mean 69.3	Unclear risk

Country: USA **Study design:** RCT	1,6); 49.2% female; % ethnicity unavailable; all participants BMI between 85th and 3rd percentiles Home setting	4 months Feedback and reinforced for PA with access to TV	60 mins/day in MVPA		(daily minutes of MVPA)	[SE 0.6] Comparison group: Mean 68.6 [SE 7.3]	
Suchert et al (2015) **Country:** Germany **Study design:** Cluster RCT	N=1162 Mean age 13.7 (SD 0.7); 48.2% female; % ethnicity unavailable School setting	N=702 Duration: 12 weeks (Mar-May 2014) Class step competition with opportunity to win class prizes	N=460 Usual education	5 months (Jun/Jul 2014) (as soon as possible post-test)	Self-reported days/week with 60 mins MVPA	Intervention group: Mean 4.4 (SD 0.1) Comparison group: Mean 4.4 (SD 0.1)	Unclear risk
Target Behaviour: Healthier Eating							
Baranowski et al (2002) **Country**: USA **Study design:** Randomised cluster controlled trial	N=134 Mean age 10.0 (SD 6.4); 91% African-American; Home and community setting	N=75 Duration: 8 weeks 5 a Day Achievement Badge Programme: Education, recipe preparation, practicing skills, and incentives	N=59 No intervention	8 weeks	Fruit, juice, and vegetables (servings a day)	Intervention group: Mean 3.6 (SD 0.3) Comparison group: Mean 2.8 (SD 0.3)	Unclear risk

Horne et al (2004) **Country:** England, UK **Study design:** Cluster controlled trial	N=749 Age range 5-11 years; % female unavailable; 82.5% ethnic minorities School setting	N=364 Duration: 16 school days. Followed by maintenance phase of 4 months with a tapered withdrawal of incentives, and introduction of a wall chart to enable rewards to be delivered intermittently Food Dudes programme: Peer modelling, goal-setting, and incentives	N=385 Daily fruit/veg provided	4.5 months	Fruit/veg (% portion)	**Fruit (5-7 year olds):** Intervention group: Mean 56% (SD 27) Comparison group: Mean 9% (SD 16) **Fruit (7-11 year olds):** Intervention group: Mean 65% (SD 29) Comparison group: Mean 9% (SD 17) **Veg (5-7 year olds):** Intervention group: Mean 53% (SD 26) Comparison group: Mean 10% (SD 15)	High risk

						Veg (7-11 year olds): Intervention group: Mean 63% (SD 28) Comparison group: Mean 23% (SD 25)	
Horne et al (2009b) **Country:** Ireland **Study design:** Randomised cluster controlled trial	N=224 Age range 4-11 years; % female unavailable; % ethnic minorities unavailable School setting	N=127 Duration: 16 school days. Followed by maintenance phase of 12 months with a tapered withdrawal of incentives, and introduction of a wall chart to enable rewards to be delivered intermittently Food Dudes programme: Peer modelling,	N=97 Daily fruit/veg consumed from lunchbox	12 months	Fruit/veg (grams)	Intervention group: Mean 71.1 (SD 71.4) Comparison group: Mean 46.6 (SD 70.1)	Unclear risk

		goal-setting, and incentives					
Morrill et al (2016) **Country:** USA **Study design:** Randomised cluster controlled trial	N=2292 Children in grades 1-5; 45.9% female; 91% White School setting	N=671 Duration: 16 days. Followed by maintenance phase 10 weeks with a tapered withdrawal of incentives, and introduction of a wall chart to enable rewards to be delivered intermittently Food Dudes programme: Peer modelling, goal-setting, and incentives	N=668 No intervention .	10.5 months	Fruit/veg (cups)	Intervention group: Mean 0.4 [SE 0.0] Comparison group: Mean 0.3 [SE 0.0]	Unclear risk
Presti et al (2015) **Country:** Italy **Study design:** Cluster	N=409 Age range 5-11 years; 50.6 female; % ethnic minorities unavailable	N=230 Duration: 16 school days. Followed by a	N=164 Daily fruit/veg provided	12 months	Fruit/veg (grams)	**Overweight group:** Intervention group: Mean 121.7 (SD 10.7)	Unclear risk

controlled trial	School setting	maintenance phase of 1 month with a tapered withdrawal of incentives, and introduction of a wall chart to enable rewards to be delivered intermittently Food Dudes programme: Peer modelling, goal-setting, and incentives				Comparison group: Mean 8.8 (SD 13.0) **Non-overweight group:** Intervention group: Mean 136.3 (SD 9.0) Comparison group: Mean 1.8 (SD 13.7)	
Upton et al (2013) **Country:** England, UK **Study design:** Cluster controlled trial	N=2433 Age range 4-11 years; 47.1% female; 34.6% ethnic minorities School setting	N=1282 Duration: 16 school days. Followed by a maintenance phase of 9 months with a tapered withdrawal of incentives, and introduction of a wall	N=1151 Daily fruit/veg provided	12 months	Fruit/veg (grams)	Intervention group: Mean 49.0 Comparison group: Mean 33.0	High risk

		chart to enable rewards to be delivered intermittently Food Dudes programme: Peer modelling, goal-setting, and incentives					
Target Behaviour: Smoking							
Crone et al (2003) **Country:** The Netherlands **Study design:** Randomised cluster controlled trial	N=2562 Mean age 13 years; 44.8% female; 83.9% Dutch School setting	N=532 Duration: 5 months Smoke free class competition (admission to a lottery for prizes if 90% remain abstinent)	N=402 Usual activities	20 months	Self-reported current smoking (% of participants who smoked at least 1 cigarette a week)	Intervention group: 133/532 (25%) Comparison group: 117/402 (29%)	Unclear risk
Krishnan-Sarin et al (2006) **Country:** USA **Study design:** Randomised controlled trial	N=28 Mean age 17.5 (SD 1.8); 47.3 female; % ethnic minorities unavailable School setting	N=17 Duration: 4 weeks CBT, and financial incentives with a reset contingency	N=11 CBT	4 weeks	Objectively measured current smoking (% assessed as abstinent from smoking for 7 days using self-reports and confirmed using urine	Intervention group: 8/17 (47%) Comparison group: 11/11 (100%)	Unclear risk

					cotinine levels)		
Krishnan-Sarin et al (2013) **Country:** USA **Study design:** Randomised controlled trial	N=72 Mean age 16.1 (SD 1.8); 53.7% female; % ethnic minorities unavailable School setting	N=28 CBT, and financial incentives with a reset contingency N=21 Only financial incentives with a reset contingency Duration: 4 weeks	N=23 CBT	16 weeks	Objectively measured current smoking (% assessed as abstinent from smoking for 7 days using self-reports and confirmed using urine cotinine levels)	Intervention group: 45/49 (92%) Comparison group: 23/23 (100%)	Unclear risk
Isensee et al (2012) **Country:** Germany **Study design:** Randomised cluster controlled trial	N=3440 Mean age 12.7 (SD 0.7); 50.5% female; 96.3 German School setting	N=757 Duration: 6 months Smoke free class competition (admission to a lottery for prizes if 90% remain abstinent)	N=604 Allocated to intervention group but not participating N=1059 No intervention	19 months	Self-reported current smoking (% self report of "How often they smoked at present")	Intervention group: 179/757 (24%) Comparison group: 467/1663 (28%)	Low risk
Reynolds et al (2015) **Country:** USA **Study design:** Randomised	N=62 Mean age 16.6 (SD 1.4); 50% female; 91.8% White Home	N=31 Duration: 6 weeks Financial incentives (vouchers) to be redeemed at specific	N=31 Vouchers for breath samples (not contingent on abstinence)	12 weeks	Objectively measured current smoking (Urinary cotinine (ng/ml))	Intervention group: Mean 1080 [SE 146.7] Comparison group: Mean	Low risk

controlled trial	setting	stores				1280 [SE 146.7]	
Schulze et al (2006) **Country:** Germany **Study design:** Randomised cluster controlled trial	N=4043 Mean age 12.6 (SD 0.6); 53.9% female; % ethnic minorities unavailable School setting	N=948 Duration: 6 months Smoke free class competition (admission to a lottery for prizes if 90% remain abstinent)	N=756 Usual activities	24 months	Self-reported current smoking (% self-reporting that they currently smoked)	Intervention group: 367/948 (39%) Comparison group: 303/756 (40%)	Unclear risk
Vartiainen et al (1996) **Country:** Finland **Study design:** Cluster controlled trial	N=1835 8th grade pupils (14 year olds); % female unavailable; % ethnic minorities unavailable School setting	N=976 Duration: 6 months Smoke free class competition (admission to a lottery for prizes if 90% remain abstinent)	N=443 Usual activities	18 months	Self-reported current smoking (% self-reporting that they currently smoked)	Intervention group: 183/976 (19%) Comparison group: 100/443 (23%)	High risk
Wiborg et al (2002) **Country:** Germany **Study design:** Cluster controlled trial	N=4372 Mean age 12.9 (SD 1.0); 51.5% female; % ethnic minorities unavailable School setting	N=1495 Duration: 6 months Smoke free class competition (admission to a lottery for prizes if 90% remain	N=647 Usual activities	12 months	Self-reported current smoking (% self-reporting that they currently smoked)	Intervention group: 127/1495 (8%) Comparison group: 83/647 (13%)	High risk

		abstinent)					

Highlights

- Results found strong evidence for behavioural incentives and healthier eating
- Results found some evidence for behavioural incentives and physical activity
- Results found limited evidence for behavioural incentives and smoking
- Results found no evidence for behavioural incentives and alcohol use

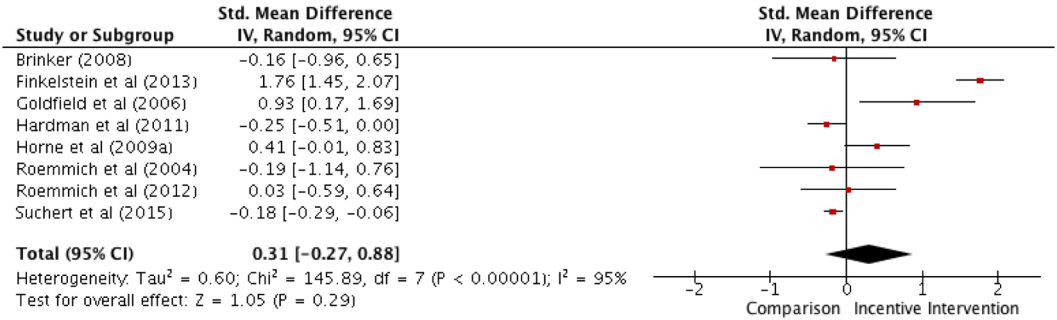
Study or Subgroup
Std. Mean Difference
IV, Random, 95% CI
Brinker (2008) -0.16 [-0.96, 0.65]
Finkelstein et al (2013) 1.76 [1.45, 2.07]
Goldfield et al (2006) 0.93 [0.17, 1.69]
Hardman et al (2011) -0.25 [-0.51, 0.00]
Horne et al (2009a) 0.41 [-0.01, 0.83]
Roemmich et al (2004) -0.19 [-1.14, 0.76]
Roemmich et al (2012) 0.03 [-0.59, 0.64]
Suchert et al (2015) -0.18 [-0.29, -0.06]
Total (95% CI) 0.31 [-0.27, 0.88]
Heterogeneity: Tau² = 0.60; Chi² = 145.89, df = 7 (P < 0.00001); I² = 95%
Test for overall effect: Z = 1.05 (P = 0.29)
Std. Mean Difference
IV, Random, 95% CI
-2
-1
0
1
2
Comparison Incentive Intervention

Figure 1

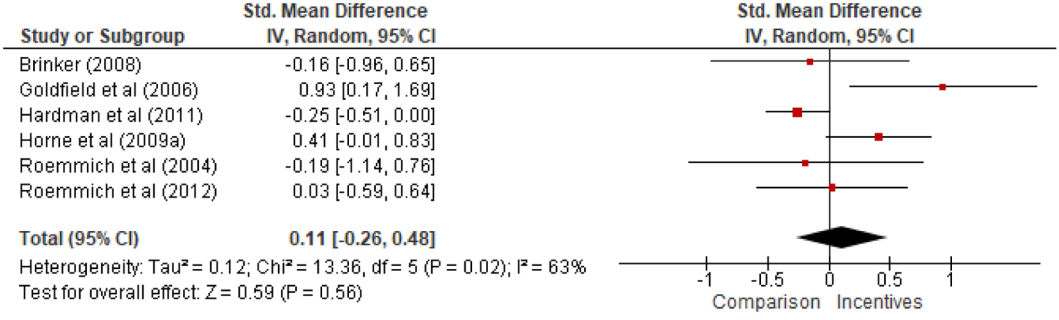
Std. Mean Difference
Study or Subgroup
IV, Random, 95% CI
Brinker (2008) -0.16 [-0.96, 0.65]
Goldfield et al (2006) 0.93 [0.17, 1.69]
Hardman et al (2011) -0.25 [-0.51, 0.00]
Horne et al (2009a) 0.41 [-0.01, 0.83]
Roemmich et al (2004) -0.19 [-1.14, 0.76]
Roemmich et al (2012) 0.03 [-0.59, 0.64]
Total (95% CI) 0.11 [-0.26, 0.48]
Heterogeneity: Tau² = 0.12; Chi² = 13.36, df = 5 (P = 0.02); I² = 63%
Test for overall effect: Z = 0.59 (P = 0.56)
Std. Mean Difference
IV, Random, 95% CI
-1
-0.5
0
0.5
1
Comparison Incentives

Figure 2

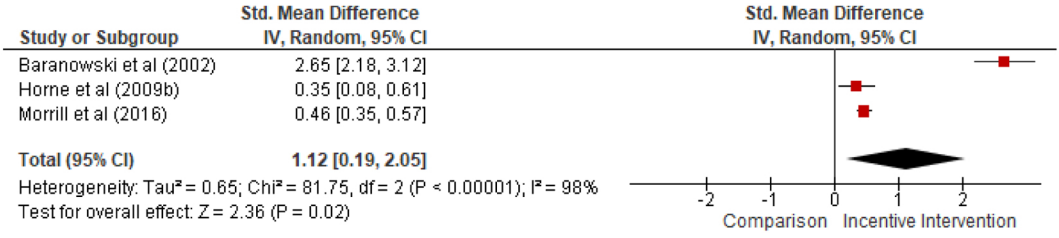
Study or Subgroup
Std. Mean Difference
IV, Random, 95% CI
Baranowski et al (2002) 2.65 [2.18, 3.12]
Horne et al (2009b) 0.35 [0.08, 0.61]
Morrill et al (2016) 0.46 [0.35, 0.57]
Total (95% CI) 1.12 [0.19, 2.05]
Heterogeneity: Tau² = 0.65; Chi² = 81.75, df = 2 (P < 0.00001); I² = 98%
Test for overall effect: Z = 2.36 (P = 0.02)
Std. Mean Difference
IV, Random, 95% CI
-2
-1
0
1
2
Comparison
Incentive Intervention

Figure 3


Std. Mean Difference
Study or Subgroup
IV, Random, 95% CI
Baranowski et al (2002) 2.65 [2.18, 3.12]
Horne et al (2009b) 0.35 [0.08, 0.61]
Morrill et al (2016) 0.46 [0.35, 0.57]
Total (95% CI) 0.45 [0.35, 0.55]
Heterogeneity: Tau² = 0.00; Chi² = 0.65, df = 1 (P = 0.42); I² = 0%
Test for overall effect: Z = 8.71 (P < 0.00001)
Std. Mean Difference
IV, Random, 95% CI
-0.5
-0.25
0
0.25
0.5
Comparison
Incentive Intervention

Figure 4

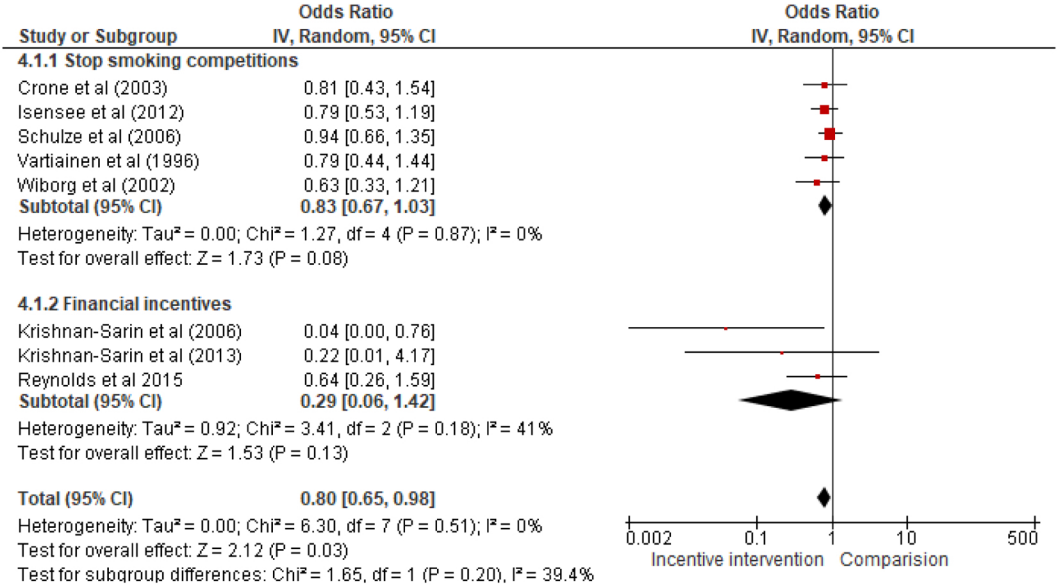
Odds Ratio
Odds Ratio
Study or Subgroup
IV, Random, 95% CI
IV, Random, 95% CI
4.1.1 Stop smoking competitions
Crone et al (2003) 0.81 [0.43, 1.54]
Isensee et al (2012) 0.79 [0.53, 1.19]
Schulze et al (2006) 0.94 [0.66, 1.35]
Vartiainen et al (1996) 0.79 [0.44, 1.44]
Wiborg et al (2002) 0.63 [0.33, 1.21]
Subtotal (95% CI) 0.83 [0.67, 1.03]
Heterogeneity: Tau² = 0.00; Chi² = 1.27, df = 4 (P = 0.87); I² = 0%
Test for overall effect: Z = 1.73 (P = 0.08)
4.1.2 Financial incentives
Krishnan-Sarin et al (2006) 0.04 [0.00, 0.76]
Krishnan-Sarin et al (2013) 0.22 [0.01, 4.17]
Reynolds et al 2015 0.64 [0.26, 1.59]
Subtotal (95% CI) 0.29 [0.06, 1.42]
Heterogeneity: Tau² = 0.92; Chi² = 3.41, df = 2 (P = 0.18); I² = 41%
Test for overall effect: Z = 1.53 (P = 0.13)
Total (95% CI) 0.80 [0.65, 0.98]
Heterogeneity: Tau² = 0.00; Chi² = 6.30, df = 7 (P = 0.51); I² = 0%
Test for overall effect: Z = 2.12 (P = 0.03)
Test for subgroup differences: Chi² = 1.65, df = 1 (P = 0.20), I² = 39.4%
0.002
0.1
1
10
500
Incentive intervention
Comparision

Figure 5

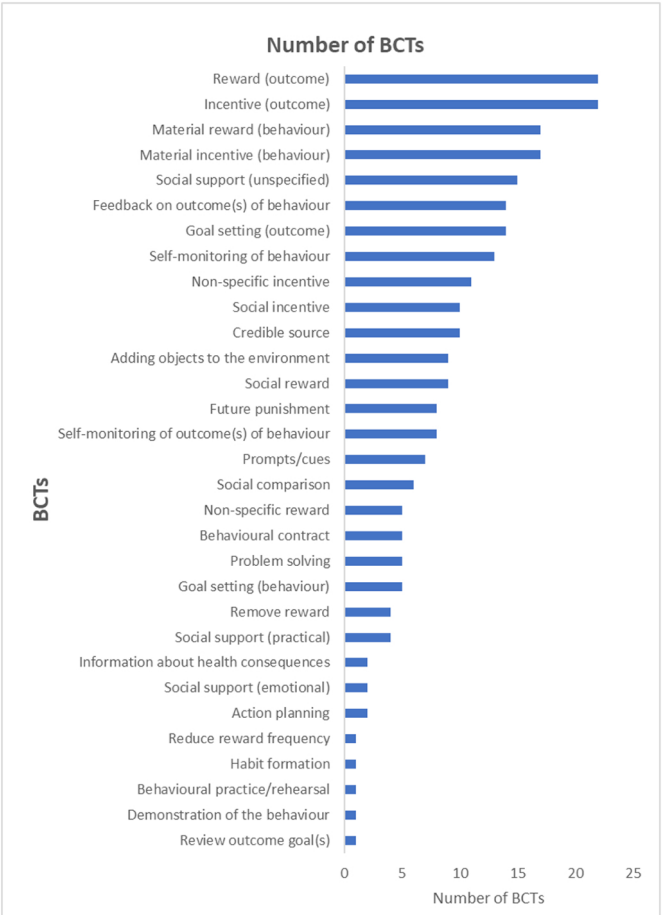
Number of BCTs
BCTs
Reward (outcome)
Incentive (outcome)
Material reward (behaviour)
Material incentive (behaviour)
Social support (unspecified)
Feedback on outcome(s) of behaviour
Goal setting (outcome)
Self-monitoring of behaviour
Non-specific incentive
Social incentive
Credible source
Adding objects to the environment
Social reward
Future punishment
Self-monitoring of outcome(s) of behaviour
Prompts/cues
Social comparison
Non-specific reward
Behavioural contract
Problem solving
Goal setting (behaviour)
Remove reward
Social support (practical)
Information about health consequences
Social support (emotional)
Action planning
Reduce reward frequency
Habit formation
Behavioural practice/rehearsal
Demonstration of the behaviour
Review outcome goal(s)
0
5
10
15
20
25
Number of BCTs

Figure 6