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Citation: Martin, J. S., Chater, A. & Lorencatto, F. (2013). Effective behaviour change techniques in the prevention and management of childhood obesity. *International Journal of Obesity*, 37(10), pp. 1287-1294. doi: 10.1038/ijo.2013.107

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Link to published version: <https://doi.org/10.1038/ijo.2013.107>

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1 Effective behaviour change techniques in the prevention and management of childhood
2 obesity

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25

Abstract

26 Rates of childhood obesity are increasing, and it is essential to identify the active components
27 of interventions aiming to prevent and manage obesity in children. A systematic review of
28 behaviour change interventions was conducted to find evidence of behaviour change
29 techniques (BCTs) that are most effective in changing physical activity and/or eating
30 behaviour for the prevention or management of childhood obesity. An electronic search was
31 conducted for Randomised Controlled Trials (RCTs) published between January 1990 and
32 December 2009. Of 4,309 titles and abstracts screened, full texts of 135 articles were
33 assessed, of which 17 published articles were included in this review. Intervention
34 descriptions were coded according to the behaviour-specific CALO-RE taxonomy of BCTs
35 (1). BCTs were identified and compared across obesity management ($n = 9$) vs. prevention (n
36 $= 8$) trials. To assess the effectiveness of individual BCTs, trials were further divided into
37 those that were effective (defined as either a group reduction of at least 0.13 BMI units or a
38 significant difference in BMI between intervention and control groups at follow-up) vs. non-
39 effective (reported no significant differences between groups).

40 We reliably identified BCTs utilised in effective and non-effective prevention and
41 management trials. To illustrate the relative effectiveness of each BCT, effectiveness ratios
42 were calculated as the ratio of the number of times each BCT was a component of an
43 intervention in an effective trial divided by the number of times they were a component of all
44 trials. Results indicated six BCTs that may be effective components of future management
45 interventions (provide information on the consequences of behaviour to the individual,
46 environmental restructuring, prompt practice, prompt identification as role model/position
47 advocate, stress management/emotional control training, and general communication skills
48 training), and one that may be effective in prevention interventions (prompting generalisation
49 of a target behaviour). We identified that for management trials, providing information on the

50 consequences of behaviour in general was a feature of non-effective interventions and for
51 prevention trials, providing information on the consequences of behaviour in general,
52 providing rewards contingent on successful behaviour and facilitating social comparison
53 were non-effective.

54 To design effective behaviour change programmes for the prevention and
55 management of childhood obesity, we would recommend utilising the BCTs identified as
56 effective in this review. The impact on intervention effectiveness of combining BCTs should
57 be the topic of further research.

58

59	<i>Key words</i>
60	Childhood Obesity
61	Prevention
62	Management
63	Behaviour Change Techniques
64	Taxonomy
65	Effectiveness

66 Effective behaviour change techniques in the prevention and management of childhood
67 obesity

68

69 Introduction

70 Given the dramatic rise in childhood obesity over the last decade (2-4), it is essential to
71 design interventions that are effective in preventing and managing childhood obesity.

72 Behaviour modification or lifestyle change has become a burgeoning avenue of investigation
73 in this area. Systematic reviews of interventions and clinical guidelines clearly indicate that
74 successful interventions for preventing and managing obesity in children are complex and
75 multi-component - aimed at changing both physical (or sedentary) activity and diet or healthy
76 eating (e.g., 5-9) and comprise multiple, potentially interacting methods of changing
77 behaviour. Despite the vast amount of active investigation in this area, little research has
78 deconstructed interventions and identified which individual components are most successful
79 in changing obesity-related health behaviour in children. A lack of consistent terminology for
80 defining intervention components has also hindered interpretation and replication. It is
81 currently unclear what the active ingredients for bringing about obesity-related behavioural
82 change are and thus, evidence to support the content of effective obesity prevention and
83 management interventions in children is still relatively weak (5, 10-12).

84 There is no lack of evidence that positive changes in behaviours linked to obesity can
85 be effective in preventing and managing obesity in children. Hill, Wyatt, Reed and Peters
86 (13) report that even small changes in behaviour that amount to a decrease in calorie intake of
87 only 100Kcal per day can effectively prevent weight gain. Randomised Controlled Trials
88 (RCTs) of lifestyle interventions have reported moderate success in changing obesity-related
89 behaviour in prevention trials (5) and produce potentially clinically significant reductions in

90 overweight in management trials (7, 14). It is important that these positive findings can be
91 replicated, thus, there is clear value in identifying the specific behaviour change techniques
92 (BCTs) used in such interventions that are effective in achieving and sustaining behavioural
93 change. The complex and multi-component nature of such interventions further underlines
94 the need for developing methods to systematically deconstruct intervention content. This is a
95 particularly imperative task for the successful prevention and management of obesity in
96 childhood and adolescence, as it is important to identify specific BCTs that are particularly
97 effective for this age group that may be distinct from those used in adult interventions. There
98 may also be an important distinction between BCTs that are effective in preventing childhood
99 obesity and those that manage obesity in children who are already overweight or obese.

100 Formally evaluating the content of interventions is inherently difficult. Recent
101 guidelines in the field of health psychology aim to establish more open and detailed reporting
102 of interventions to aid the scientific development of behaviour change interventions
103 (CONSORT, 15; Workgroup for Intervention Development and Evaluation Research:
104 WIDER, 16), though these are not universally adhered to and current reporting of
105 intervention content is generally poor and inconsistent (17), thus limiting what we can learn
106 about behaviour change (18).

107 Categorising the components of behaviour change interventions in the field of
108 childhood obesity is complex and attempts to define BCTs are generally idiosyncratic (and
109 potentially non-replicable). For example, some authors have developed their own
110 classifications for extracting such data: Kamath et al. (5) extracted data concerning
111 “informational, cognitive, behavioural, environmental and social support components”
112 (p4607) of interventions, and Sargent, Pilotto and Baur (19) extracted information on
113 “strategies to achieve behaviour change” (p4). Such classifications lack the benefit of precise
114 and standard definitions that allow authentic replication and useful comparisons of BCTs

115 across intervention trials. More wholesome descriptions of common behaviour change
116 methods in obesity interventions do exist (see e.g., 6, 20, 21) but it is not always clear how
117 (or if) these descriptions apply to interventions aimed at children.

118 As part of the advancement of a science of behaviour change, Abraham and Michie
119 (22) developed a taxonomy of 26 conceptually distinct component BCTs, which are
120 described using consistent terminology and standard definitions. This taxonomy has been
121 reliably applied to identify and categorise BCTs featured in obesity prevention programmes
122 involving parents and children (23) and in healthy eating and physical activity interventions
123 with adults (24). More recently, the original taxonomy (22) has been revised and extended
124 into a behaviour specific taxonomy of 40 BCTs for physical activity and healthy eating
125 behaviours (CALO-RE: 1). The CALO-RE taxonomy was developed by three teams of
126 researchers to provide standard definitions to reliably identify techniques used for 1)
127 increasing physical activity and healthy eating in obese adults with additional risk factors for
128 morbidity, and 2) increasing self-efficacy to promote lifestyle and recreational physical
129 activity. A total of 72 studies across a variety of populations, behaviours and settings were
130 used as a basis of developing the taxonomy. The authors argue that the CALO-RE taxonomy
131 is more comprehensive than the original, with fewer conceptual problems and less overlap
132 between items, as well as clearer labels and definitions. This taxonomy can be used to
133 analyse the content of behaviour change interventions in depth and also provides a means of
134 improving reporting and aiding replication attempts by specifying BCTs. For the purposes of
135 this review, this taxonomy was used to identify BCTs in physical activity and healthy eating
136 interventions for the prevention and management of childhood obesity. To our knowledge,
137 this taxonomy has not yet been applied to obesity-related behaviour change interventions
138 with children and adolescents.

139 We conducted a systematic review to select RCTs of childhood obesity interventions
140 that utilised BCTs as a means to prevent or manage obesity in children and adolescents. From
141 this, we coded intervention descriptions using the CALO-RE taxonomy to identify BCTs that
142 were used in such interventions. In order to work towards aiding intervention designers in the
143 field to build effective BCTs into childhood obesity interventions, this paper aims to 1)
144 identify and code BCTs used in a sample of prevention and management interventions for
145 childhood obesity using the CALO-RE taxonomy, and 2) establish which individual BCTs
146 are components of effective interventions to manage and prevent childhood obesity.

147

148 Method

149 *Study selection*

150 A systematic review was conducted of RCTs of obesity management or prevention
151 conducted with children and adolescents (aged 2-18 years) that assessed the impact of
152 interventions including at least one BCT from the CALO-RE taxonomy compared with a no-
153 treatment control group. Interventions that solely tested the impact of physical activity,
154 education, and/or calorie controlled diets with no behaviour change element were excluded,
155 as were interventions that combined drug treatment or surgery with BCTs. Interventions
156 could be carried out in any setting (e.g., school, clinic, community) and be delivered by any
157 professional (e.g., health professional, teacher, therapist) over any length of time. It is
158 important that desired health outcomes are maintained over time therefore to assess the
159 maintenance of intervention effects; we selected only interventions that reported results 6
160 months beyond the point when active intervention ended. The Transtheoretical Model (TTM:
161 25) argues that long term changes in behaviour may be assessed only after this time period
162 has elapsed. The primary outcome measure was Body Mass Index (BMI). BMI is the only
163 indirect measure of adiposity in childhood that has been shown to be associated with future

164 risk of mortality from Coronary Heart Disease (CHD) in adulthood (11) and can be used as a
165 physiological proxy measure of later health outcomes (26-28). BMI was also the only single
166 comparative outcome reported across trials.

167 *Search Strategy and results*

168 An electronic search was conducted in the following electronic databases:
169 MEDLINE, EMBASE, PsycINFO, Cochrane library (Cochrane Central Register of
170 Controlled Trials), HMIC (Health Management Information Consortium), AMED (Allied and
171 Complementary Medicine Database), and CINAHL (Cumulative Index to Nursing and Allied
172 Health Literature) for Randomised Controlled Trials published between January 1990 and
173 December 2009. Search terms (available as a supplementary electronic file) covered the
174 concepts of ‘obesity’ ‘children’ ‘behaviour change interventions’ and ‘BMI’ and closely
175 followed the search strategies of similar reviews (e.g., 5, 7) and published guidelines for
176 identifying randomised controlled trials (29).

177 One reviewer (JM) screened 4,333 unique titles and abstracts for eligibility and a
178 second reviewer (AC) screened a random (10%) sample of records, yielding 100% agreement
179 between reviewers. After initial screening of title and abstract, full texts of 135 potentially
180 relevant studies were screened for eligibility independently by the two reviewers. Three
181 unpublished dissertations were unavailable for further screening and were excluded. We
182 explored unpublished literature and received a good response from experts, but no further
183 studies were included in the review from these avenues. Agreement regarding inclusion
184 between reviewers was 70%, and disagreements were resolved through careful discussion.
185 Seventeen published manuscripts were included in this review (30-46). The selection process
186 for studies is presented in Figure 1.

187

188

189 *Coding of Behaviour Change Techniques*

190 To obtain more complete intervention descriptions and assist data extraction for
191 BCTs, where intervention protocols were published or available elsewhere, the manuscript
192 was located ($n = 11$; 47-57) and the intervention characteristics were coded from both
193 sources. The authors of the further 6 intervention studies were contacted (on up to two
194 occasions) with a request for copies of the corresponding intervention protocol or any
195 additional documents detailing the intervention content. Three authors did not reply; one
196 author could not locate the original protocol; one author informed us that the protocol was
197 available in Finnish language only, and another author provided further details of the
198 intervention mechanisms, published elsewhere on which the intervention characteristics were
199 coded.

200 The content of interventions was assessed by two reviewers (JM & AC) who
201 independently coded the descriptions of each intervention using the CALO-RE taxonomy (1)
202 for inclusion of BCTs. Intervention descriptions were read line-by-line and assigned a BCT
203 label from the taxonomy where appropriate. A stringent coding method was applied so that in
204 cases where further information was required to assess whether a BCT was present or absent,
205 it was coded as absent. We chose not to seek further clarification from the authors, as we
206 wanted to assess published information only.

207 The two coders practised coding on eight intervention studies not selected for the
208 review, and discussed disagreements. All interventions were then coded independently and
209 inter-rater reliability, assessed using percent agreement, was high (93%). Disagreements
210 between the coders were discussed at length and a final decision on which BCTs were
211 assigned to interventions was agreed. Based on the nature of disagreements, we refined BCTs
212 in the taxonomy (see electronic supplementary material, Table 1 for a summary of our
213 revisions to the CALO-RE taxonomy). To summarise the revision process, we took the

214 following steps: 1) we revised descriptions of techniques where agreement was reduced due
215 to misapplication of the code; 2) we added examples specific to our sample of childhood
216 obesity trials within technique definitions; 3) we clarified the difference between similar
217 codes where we had encountered disagreements; and 4) one additional technique was
218 identified and defined. We verified that the revised taxonomy was also effective in
219 categorising BCTs in the same set of papers by having a third independent coder (FL) repeat
220 the coding task using the revised taxonomy. Agreement remained high (88%) showing that
221 these constructs exist independently in the selected set of papers.

222

223 *Assessing intervention and BCT effectiveness*

224 We divided coded interventions into those that aimed to prevent ($N = 8$) vs. manage
225 ($N = 9$) childhood obesity. Prevention trials included both overweight and normal weight
226 participants and management trials included overweight participants only.

227 We then divided up prevention and management trials into effective vs. non-effective
228 using BMI outcome data. Effective management trials ($N = 6$) were defined as trials in which
229 the standardised difference in the mean value of BMI between groups at follow-up was at
230 least ≥ -0.13 (this was the average effect size demonstrated from meta-analysis data, 58)
231 Less stringent criteria were applied to prevention studies to take into consideration that not
232 all of these trials targeted weight loss measured by a reduction in BMI. The criteria for
233 assessing effectiveness in prevention trials was defined as a significant difference ($p < .05$) in
234 BMI at follow-up between groups ($N = 4$).

235 To assess the effectiveness of BCTs, and to illustrate the relative weight of each BCT
236 taking into consideration it potentially being a component of both effective and non-effective
237 trials, a percentage effectiveness ‘ratio’ was calculated as the ratio of the number of times

238 each BCT was a component of an intervention in an effective trial divided by the number of
239 times they were a component of all trials, including non-effective trials.

240 Results

241 First, we present the BCTs coded in effective and non-effective prevention and management
242 interventions. Second, we present differences in BCTs and effectiveness ratios between
243 effective and non-effective interventions for prevention and management trials.

244 *BCTs in effective and non-effective prevention and management interventions*

245 Out of the 40 BCTs in the taxonomy, we agreed that there was no (or insufficient)
246 evidence that 11 of them were present in any of the interventions (representing 100%
247 agreement between coders). For the remaining 29 BCTs, inter-rater reliability was good (59)
248 for 17 (average kappa value = 0.71 [range = .485 to 1.00], average percentage agreement =
249 92% [range = 71% to 100%]) and sub-optimal for the remaining 12 due to missing data and
250 low counts of instances of BCTs across the studies. In the light of this, disagreements were
251 discussed at length between the coders before final codes were applied. The coders also
252 agreed a new code which was added to the CALO-RE taxonomy (Exposure to healthy
253 choices) from our revisions ($n = 41$ BCTs in total in revised CALO-RE taxonomy). This BCT
254 was encountered as an additional method of achieving behaviour change within the pool of
255 studies (see the supplementary file). The coding exercise did not identify any BCTs in any of
256 the control groups.

257 Table 1 presents BCTs (and their frequency) coded in effective and non-effective
258 prevention and management trials. BCTs that were unique features of management trials (i.e.,
259 were not used in prevention trials) were: Prompt review of behavioural goals, relapse
260 prevention/coping planning, shaping, provide information on where and when to perform the
261 behaviour, environmental restructuring, prompt self-talk and motivational interviewing.
262 BCTs that were unique to prevention trials were: Provide normative information about

263 others' behaviour, prompt rewards contingent on effort or progress towards behaviour, action
264 planning, provide feedback on performance, teach to use prompts/cues, and facilitate social
265 comparison.

266

267 *Effective BCTs in obesity management*

268 All but three out of the nine obesity management interventions selected for review
269 were effective according to our criteria (30-32, 40, 42, and 43). An average of 7.5 (range = 3-
270 15) BCTs from the CALO-RE taxonomy were identified at least once across these
271 interventions (effective and non-effective) and there was little difference in mean number of
272 BCTs coded in effective ($M = 8$) vs. non-effective ($M = 7$) interventions. Twenty-four out of
273 41 (59%) BCTs were identified in at least one of the interventions. Thirteen of these
274 techniques were unique to effective trials, two were unique to non-effective interventions and
275 nine appeared at least once in both effective and non-effective trials. Figure 2 presents the
276 ratio of effectiveness for BCTs appearing two or more times in trials. In order that the ratio
277 was meaningful and to be satisfied that there was 'evidence' of effectiveness for individual
278 BCTS, we required that a BCT must be a feature of two or more trials, therefore the five
279 unique BCTs appearing only once in effective trials were excluded. These criteria have been
280 used in previous studies assessing BCT effectiveness (60, 61). Six BCTs achieved 100%
281 effectiveness ratios (Provide information on consequences of behaviour to the individual,
282 Environmental restructuring, Prompt identification as role model/position advocate, Stress
283 management/Emotional control training, General communication skills training and Prompt
284 practice) and one BCT (Provide information on consequences of behaviour in general) had a
285 100% non-effective ratio.

286

287

288 *Effective BCTs in obesity prevention*

289 According to our effectiveness criteria, four trials reported in favour of the
290 intervention (33-35, 46) and four trials reported no difference between groups (36-39). An
291 average of 8 BCTs (range = 1-12) from the CALO-RE taxonomy were identified at least once
292 across these interventions and there was again little difference in the mean number of BCTs
293 coded between effective ($M = 8.5$) vs. non-effective ($M = 7.5$) trials. Twenty-four out of 41
294 (59%) BCTs were identified in at least one of the effective and non-effective interventions.
295 Only one of these BCTs (prompt generalization of a target behaviour) was unique to effective
296 trials, seven were unique to non-effective interventions and 16 appeared at least once in both
297 effective and non-effective trials. Again, an effectiveness ratio was calculated to illustrate the
298 relative weight of each BCT appearing in two or more trials (Figure 3). Only prompt
299 generalization of a target behaviour achieved a 100% effectiveness ratio. Three BCTs were
300 shown to be 100% non-effective (provide information on the consequences of behaviour in
301 general, provide rewards contingent on successful behaviour and facilitate social
302 comparison).

303

304

Discussion

305 This review is the first to utilise a behaviour specific taxonomy of BCTs to formally and
306 systematically identify the components of childhood obesity interventions. We linked
307 individual BCTs with positive health and behavioural outcomes, by assessing effectiveness
308 ratios, thus providing some evidence for the inclusion of particular BCTs as active agents of
309 change in interventions aiming to prevent and manage childhood obesity in the long term. We
310 reliably identified BCTs utilised in prevention and management trials and identified BCTs
311 that were unique features of each. Effectiveness ratios demonstrated an evidence base for the
312 inclusion of BCTs that were unique features of effective interventions. Six BCTs were

313 identified as uniquely effective (i.e., achieved 100% effectiveness ratios) in obesity
314 management interventions and one BCT for obesity prevention interventions. Effectiveness
315 ratios also demonstrated BCTs that were components of non-effective trials. One BCT was
316 identified as uniquely non-effective for obesity management interventions and three BCTs for
317 prevention interventions.

318 There is currently little evidence supporting the inclusion (or not) of BCTs in
319 childhood obesity programmes. It is unknown in particular, 1) whether individual BCTs are
320 more effective in the prevention or management of obesity, 2) whether (and how) the content
321 of programmes may differ to those applied to adults, and 3) if particular BCTs may be more
322 or less effective when applied to specific target groups (e.g., parents vs. children) or
323 intervention modes (e.g., delivered in school vs. hospital). The only general guidance of this
324 nature we have identified was included in the UK National Institute for Health and Clinical
325 Excellence (NICE) guidance on the prevention, identification, assessment and management
326 of overweight and obesity in adults and children (9). BCTs such as self-monitoring, goal
327 setting and providing rewards are recommended in this guidance and no further information
328 is offered in relation to the above issues. In our sample of papers, we found inconclusive
329 evidence that self-monitoring and goal setting were consistently effective techniques in both
330 prevention and management trials. Our findings suggest that providing rewards was actually
331 ineffective for obesity prevention. The potential difference in content between programmes
332 aimed at adults vs. children, and the effectiveness of BCTs applied to particular groups or
333 modes of intervention delivery are important topics of further research in this area. From our
334 work here however, we would recommend intervention designers in the field build into
335 interventions the BCTs shown here in relation to specific prevention and management
336 programmes for children and adolescents.

337 There are a number of issues we would like to highlight from this review. First,
338 formally defining the content of trials is inherently problematic due to reporting
339 inconsistencies and differences in terminology which may have resulted in providing an
340 incomplete picture of some interventions and potentially led to exclusion of eligible studies
341 in the selection stages of this review. We applied a stringent coding strategy where BCTs
342 were not coded as present if there was insufficient description, therefore it may be the case
343 that we coded as absent techniques that the authors of the intervention would argue were
344 present. This issue has been identified in previous attempts to categorise intervention content
345 (21). To advance and implement a science of behaviour change in the field of childhood
346 obesity, we would echo calls for improving the quality of reporting of trials (15-18).
347 Likewise, given that only a small pool of studies reached our stringent criteria, we would
348 acknowledge the need for more studies in this field that are conducted as RCTs, contain
349 control conditions, and report data at least 6 months after the intervention has ended.

350 Second, this is the first time to our knowledge that the CALO-RE taxonomy has been
351 applied to interventions for children, and we made a number of revisions to the descriptions
352 of BCTs. The authors of the original taxonomy themselves identify that the development of
353 behaviour-specific taxonomies is an iterative process and revisions are inevitable and indeed
354 welcome (1). However, we would stress that, even with our revisions, the CALO-RE
355 taxonomy may not characterise every strategy used in childhood obesity interventions. In a
356 larger sample, we would anticipate that the CALO-RE taxonomy may be revised further, and
357 new BCTs added. For this reason, we would not recommend discarding BCTs in the CALO-
358 RE taxonomy that we agreed were not present in any of the interventions in this review.

359 The third issue relates to the ability to isolate and assess the effect of individual BCTs
360 in interventions. Our findings are limited to the impact of individual BCTs and we did not
361 assess the effect of combinations of BCTs. We therefore cannot assess whether BCTs

362 demonstrated to be individually effective did not contribute to effective outcomes only as a
363 combination, or whether, when combined differently, their effectiveness would alter. It is
364 worth noting that the BCTs we have shown to be non-effective may well prove to be
365 effective in (alternative) specific combinations, or applied to specific populations or different
366 modes of intervention delivery. Dumbrowski et al. (62) assessed the effect of combining
367 theory-congruent clusters of BCTs on outcomes of behaviour change interventions with
368 obese adults and found that interventions that included BCTs congruent with Control Theory
369 were associated with an increase in weight loss. Exploring combinations of BCTs according
370 to other theories of behaviour change may also prove fruitful, for example, goal setting might
371 be more effectively paired with action planning to enable the initiation and enactment of
372 behavioural change according to the theory of implementation intentions (63). Our findings
373 demonstrate the BCTs we have the best available evidence possible for, but this should not be
374 at the expense of investigating other BCTs, individually or in combination. Evidence
375 demonstrates that the most successful interventions contain combinations of BCTs therefore
376 addressing these issues is of prime importance.

377 Finally, we would like to comment on the clinical value of using BCTs as components
378 of childhood obesity interventions, since the effects of our sample of studies reviewed here
379 were variable and there is currently little consensus on the clinical reductions that may
380 reasonably be expected from behavioural modification. Unfortunately, evidence suggests that
381 the effects of interventions to promote healthy eating are variable (18), and this variability
382 was reflected in our sample of trials, potentially limiting our findings in relation to effective
383 vs. non-effective BCTs. Smaller effect sizes may be explained by our measurement time
384 frame (i.e., at least 6 months after the intervention had ended) as we would anticipate that
385 differences between intervention and control groups would diminish over this time period,
386 after initial weight loss in intervention groups had stabilised. However, we would argue that

387 this pattern of weight loss (and subsequent gain or stabilising) represents an accurate picture
388 of weight loss maintenance and it is essential to be clear about the impact of behaviour
389 change interventions over time. Observed effect sizes for trials in this review were small, and
390 our method of classifying trials as effective vs. ineffective may have limitations compared to
391 other methods of assessing effectiveness. However, our findings clearly illustrate that the
392 effectiveness of interventions is currently being hampered by the inclusion of BCTs that are
393 ineffective in achieving clinically valuable reductions in BMI, and this may explain why such
394 interventions fare so poorly in achieving (and maintaining) larger reductions in BMI over
395 time. We have reflected on the clinical meaning of our observed effect sizes and concluded
396 that although small, such unit reductions in BMI can be related to reduced risks of adverse
397 health outcomes. A linear relationship between BMI in childhood and risk of CHD (64) and
398 diabetes (65) in adulthood has been demonstrated, for example, and reductions in BMI also
399 impact upon 'secondary' health outcomes such as cholesterol levels, blood pressure, and
400 psychological well-being that exist along with obesity (66).

401 There is currently no clear evidence upon which to include (or not include) BCTs in
402 successful childhood obesity prevention and management programmes. It is absolutely
403 essential to develop such knowledge so that intervention designers in the field can apply
404 these findings to practice. We outline here a novel approach for establishing the effectiveness
405 of BCTs in childhood obesity interventions: this is the first study of its kind (to our
406 knowledge) in this behavioural domain to relate BMI outcomes at 6 months to intervention
407 content.

408 We have outlined a number of issues remaining to be addressed; however, the
409 methods used in this review represent an important first step towards establishing a method
410 by which it is possible to distinguish between effective and non-effective components of
411 interventions. The results of this study offer the first evidence for the inclusion of effective

412 BCTs in childhood obesity prevention and management programmes, and may contribute to
413 our theoretical understanding of the mechanisms under-pinning obesity-related behaviour
414 change. Identifying and utilising effective BCTs for childhood obesity interventions will aid
415 the development of potentially more effective, replicable and targeted interventions, policies
416 and guidelines for health professionals in the field, thus building a strong evidence-base to
417 support obesity prevention and management in children.

418 Supplementary information is available at the journal's website

419 Conflict of interest statement: The authors have no conflicts of interest to declare

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615

616 *Table 1 Frequency of Behaviour Change Techniques coded in effective and non-effective*
 617 *obesity prevention and management trials*

Behaviour Change Techniques	Prevention		Management	
	Effective	Non-effective	Effective	Non-effective
Provide information on consequences of behaviour in general	0	2	0	1
Provide information on consequences of behaviour to the individual	3	2	5	0
Provide normative information about others' behaviour	0	1	0	0
Goal setting (behaviour)	2	3	4	3
Action planning	0	1	0	0
Barrier identification	1	1	2	3
Set graded tasks	1	0	1	0
Prompt review of behavioural goals	0	0	3	1
Prompt rewards contingent on effort or progress towards behaviour	1	1	0	0
Provide rewards contingent on successful behaviour	0	2	3	3
Shaping	0	0	1	0
Prompting generalization of a target behaviour	2	0	1	0
Prompt self-monitoring of behaviour	4	3	3	1
Provide feedback on performance	1	1	0	0
Provide information on where and when to perform the behaviour	0	0	1	0
Provide instruction on how to perform the behaviour	1	2	3	2
Model/Demonstrate the behaviour	2	1	1	0
Teach to use prompts/cues	0	1	0	0
Environmental restructuring	0	0	3	0
Agree behavioural contract	1	0	1	3
Prompt practice	3	1	2	0
Facilitate social comparison	0	2	0	0
Plan social support/social change	2	3	2	1
Prompt identification as role model/position advocate	1	0	3	0
Prompt Self talk	0	0	1	0
Relapse prevention/coping planning	0	0	3	1
Stress management/Emotional control training	1	0	2	0
Motivational interviewing	0	0	0	1
General communication skills training	2	2	2	0
Exposure to healthy choices	1	1	1	0

618 Figure captions

619 *Figure 1 Flow chart of trials selected for review*

620

621 *Figure 2 Percentage effectiveness of Behaviour Change Techniques in obesity*

622 *management trials*

623

624 *Figure 3 Percentage effectiveness of Behaviour Change Techniques in obesity*

625 *prevention trials*





