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# SCIENTIFIC REPORT ON LEVERS TO REDUCE HEALTH INEQUALITIES



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1 **Focusing on low income/ low social class families for the prevention of obesity in children. A**  
2 **systematic review of energy-balance related behaviours interventions.**

3

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24 **Abstract**

25 Effective intervention programs are needed for primary prevention of obesity, especially in children  
26 and adolescents from low socioeconomic status families. Therefore, the aim of this systematic  
27 review was to compile available intervention studies conducted in low income children and  
28 adolescents that focused on energy balance-related behaviours, and to describe their effectiveness to  
29 prevent childhood obesity. MEDLINE was searched from inception to February 2014 for  
30 intervention studies focusing on diet, physical activity, sedentary behaviours and sleep time, of six  
31 months minimum duration, reporting obesity-related outcome (s). A total number of fifteen studies  
32 were included; two was a dietary intervention study, one focused on physical activity, seven  
33 combined diet and physical activity, one combined physical activity and sedentary behaviours, one  
34 study combined diet, PA and sedentary behaviours interventions, and three studies combined diet,  
35 physical activity, sedentary behaviours and sleep interventions. Nine out of fifteen studies showed  
36 significant and positive results in reducing obesity-related outcomes, i.e. weight or body mass  
37 index, in low income children or adolescents. There were only a few intervention studies  
38 exclusively focused on low SES groups or comparing high vs. low income young populations.  
39 Interventions were mainly conducted through schools. A combination of diet and physical activity  
40 was the most common approach to design obesity prevention interventions. Studies were  
41 heterogeneous in terms of sample size, participants, design, intervention, duration of the  
42 intervention and follow-up, and outcomes which hindered the generalization of the conclusions and  
43 the evaluation of the interventions in terms of effectiveness to prevent obesity in children and  
44 adolescents from minority groups. The findings were inconsistent, but overall suggested that  
45 combined diet and physical activity interventions may help to prevent low income young  
46 populations becoming overweight in the long term.

47 **Keywords:**

48 Diet, physical activity, sedentary behaviour, obesity, low income population, community-based  
49 interventions, ecode.

50 **Introduction**

51 The prevalence of obesity has increased in the last few decades (1), but recent evidence show that  
52 this trend may be levelling off in some developed countries (2-6). Early childhood body mass index  
53 (BMI) is moderately correlated with adult adiposity and overweight 2 to 5 years old children are  
54 more than 4 times as likely to become overweight as adults than their normal weight peers (7). In  
55 addition, overweight children are likely to exhibit risk factors for chronic diseases such as  
56 hyperlipidemia, hypertension, and hyperinsulinemia, and these risk factors may track from  
57 childhood into adulthood (8-10). Effective intervention programs should be developed for primary  
58 prevention of obesity, especially focusing in children.

59 The relationship between the environment and obesity is extremely complex. These can range from  
60 local factors to global determinants (11). Effective multilevel interventions should be developed to  
61 address the obesity epidemic During the past 20-30 years, multiple controlled intervention studies  
62 have been conducted, particularly among children and adolescents.. Comprehensive obesity-  
63 prevention programs that target multiple behaviours have been shown to promote positive dietary  
64 and physical activity behaviours, although single-strategy interventions generally report limited  
65 success.

66 Several systematic reviews have focused on energy-balanced related behaviours in young  
67 population groups with the aim of obesity prevention from all socioeconomic status (SES) (12, 13)  
68 For instance, Bleish et al. found in community-based childhood obesity prevention studies, that a  
69 combined strategy of diet and physical activity intervention(s) including a school component, is  
70 more effective for preventing obesity or overweight (12). A recent meta-analysis showed that  
71 school-based interventions for childhood obesity prevention, combining diet and physical activity  
72 were mildly effective in reducing BMI in children (13). Taking into consideration the  
73 socioeconomic position, Beauchamp et al. (14) recently published a systematic review on public  
74 health interventions conducted in all age-groups, i.e. young and adult populations, including also  
75 overweight/obese people. The review mainly focused on primary prevention of weight gain and  
76 concluded that those targeting the modification of individual behaviours may be less successful in  
77 lower SES individuals. The present systematic review aims 1) to include available interventions  
78 focusing in children and adolescents aged from 1 to 18 years old from low income, low SES or  
79 minority populations, that combined energy balance related behaviours (diet, physical activity,  
80 sedentary behaviours or sleep duration) and that have been developed to prevent obesity-related  
81 outcomes, and 2) to determine the effectiveness of these interventions.

82

83 **Material and Methods**

84 ***Inclusion criteria***

85 Studies included in our review had to met the following criteria: 1) to be an intervention study  
86 focused on energy balance-related behaviours such as diet, physical activity, sedentary behaviours  
87 and/or sleep aiming to prevent obesity in humans; 2) to involve children and/or adolescents (1-18  
88 years old); 3) to report on obesity outcomes (body mass index (BMI), fat mass, lean mass, skinfolds  
89 thickness, body circumferences, weight, height) at baseline and after intervention; 4) to have a  
90 minimum intervention duration of 6 months; and 5) to realize the intervention in different SES  
91 groups.

92 ***Search strategy***

93 An electronic search to identify intervention studies reporting data on energy balance-related  
94 behaviours to prevent obesity in children and adolescents was conducted in Medline (PUBMED)  
95 databases, from inception to February 2014. Appropriate text terms with truncation and relevant  
96 indexing terms were used. The form of the search was as follows: [body weight terms] and  
97 [intervention terms] and [population group terms] and [human studies]. The search terms used were:  
98 body mass index, body weight, obesity, overweight, obese, weight gain, weight loss, body fat,  
99 weight control, weight maintain, adiposity, adipose tissue, skinfolds thickness, waist circumference,  
100 waist-to-hip ratio, health promotion, intervention studies, children, adolescents, and kids.  
101 Additional publications were identified from the reference lists of reviews retrieved within the  
102 electronic search. The search was not limited to any language or country of publication. All studies  
103 were compiled into an EndNote XII library and were screened for potential relevance according to  
104 title and abstract based on exclusion criteria (**Table 1**) by two independent reviewers (AMPS and  
105 SBS). The full text of the studies fulfilling the inclusion criteria were collected and evaluated for  
106 relevance according to the aim of the systematic review. In doubtful cases, studies were discussed  
107 with the review team. Details regarding study design, setting, participants, intervention, duration,  
108 sample size, and results of obesity-related outcomes were extracted.

109 Experts were asked to suggest additional intervention studies for the review. The suggested studies  
110 were evaluated for potential inclusion, following the same steps and criteria mentioned above.

111

112 **Results**

113 ***Literature search***

114 The flow diagram for this review is displayed in **Figure 1**. The initial search yielded 6073  
115 references after exclusion of duplicates. A total of 6033 titles and abstracts were evaluated after the  
116 electronic and bibliographic searches or recommended by experts. Out of 128 studies potentially  
117 relevant and collected as full text articles, a total of 15 were selected for inclusion. The included  
118 studies are summarised in **Table 2**, ordered by year of publication.

119 Selected studies were classified according to the types of intervention conducted. Two studies (15,  
120 16) were dietary interventions, one study (17) referred a PA intervention, seven studies (18-24)  
121 were combined diet and PA interventions, one study (25) combined PA and sedentary behaviours,  
122 two studies (26, 27) combined diet, PA and sedentary behaviours interventions, and three studies  
123 (28-30) combined diet, PA, sedentary behaviours and sleep interventions.

124 Six out of the fifteen studies were conducted in the USA, two in Germany, two in Switzerland, and  
125 one in Australia, New Zealand, Sweden, Israel and Brazil. Eight studies were randomized  
126 controlled trials (RCT), five studies followed a quasi-experimental design, and one was a controlled  
127 trial.

128 Duration of the intervention ranged from 6 to 36 months. Thirteen studies were conducted in  
129 children, and two in adolescents. Age of the participants ranged from 3 to 14 years.

130 SES characterization varied across studies. Six out fifteen studies based on the migrational  
131 background of the participants; four of them on the family income; one combined the migrational  
132 background and family income; three were based on several specific characteristics of the country  
133 to define the SES; and one used an index which combined educational level, income and  
134 employment,

135

## 136 ***Study results***

### 137 *Dietary interventions*

138 Two analyses from the same study (15, 16) aimed to improve obesity-related outcomes through  
139 dietary intervention. These studies were carried out in the same population group. The duration of  
140 the intervention comprised 1 follow-up year and was realized in German children (mean age  
141  $8.3\pm 0.7$  years old). Assessed outcomes included BMI. The one-year-intervention comprised diet  
142 structured lessons, focussed on improving beverage consumption by increasing water intake via a  
143 combination of environmental and educational measures. Additionally, water fountains were  
144 installed in the schools of the intervention group. The risk of overweight was reduced by 31% in the  
145 intervention group, but changes in BMI SD scores did not differ between them (15). Analysing the  
146 differences between different immigration background the intervention effect on the remission of  
147 overweight was significantly modified by it ( $p=0.02$ ). Overweight incidence, during the follow-up  
148 period, was reduced significantly in the intervention group among the non-immigrant, but not  
149 among the immigrant background.(16)

### 150 *Physical activity interventions*

151 One intervention study including a physical activity intervention was carried out during a 6-month  
152 period (17). The study included 100 Australian adolescents from disadvantaged neighbourhoods  
153 (mean age  $14.3\pm 0.6$  years old) (17). The outcomes measured included BMI, percent of body fat and

154 waist circumference. The intervention integrated a multi-component school-based intervention and  
155 included sport sessions, interactive seminars, lunch-time activities, leadership sessions and  
156 pedometers monitoring of PA. The intervention group showed a beneficial reduction effect in BMI  
157 and z-BMI compared with the control group.

#### 158 *Dietary & physical activity interventions*

159 Seven studies (18-24) aimed to improve obesity-related outcomes through combined diet and PA  
160 interventions. These studies involved various types, intensities and durations of the interventions.  
161 One out of nine studies had a follow-up of less than one year, three of one year, three studies of two  
162 years and two studies had follow-up of 3 years. Assessed outcomes varied across studies: weight, z-  
163 weight, BMI, z-BMI, BMI percentiles, body fat percentage, and skinfolds thickness. Three of the  
164 seven studies showed statistically significant improvements in obesity-related outcomes (20, 21,  
165 23). All the effective studies were targeting children.

166 A two-year intervention, consisting of modifications of school-provided meals and of increased  
167 opportunities for PA during the school day, focused in low income elementary school children. The  
168 survey showed that significantly more children stayed within the normal BMI percentile range in  
169 the intervention schools than in the control school, during the two years of the study (21).  
170 Additionally, the intervention schools were significantly more likely to reduce their BMI z-score  
171 ( $p < 0.01$ ) and their weight z-score ( $p < 0.05$ ), in comparison with those children in the control schools  
172 (20).

173  
174 In a two-year intervention aimed to promote healthy lifestyle, included advice about nutritious  
175 eating habits, scheduled meals and daily physical activity among children and their parents. The  
176 results showed a significantly higher BMI in the control group (adjusted mean =  $28.94 \text{ kg/m}^2$ )  
177 compared to the intervention group (adjusted mean =  $28.09 \text{ kg/m}^2$ ) (23). BMI-SDS at follow-up  
178 was also significantly higher in the control group compared with the intervention group. The study  
179 was set in the school health services in the city of Göteborg (Sweden) among 176 children (mean  
180 age =  $10.6 \pm 0.4$  years).

181 Five studies did not found significant differences in terms of obesity-related outcomes, after  
182 conducting an intervention. Three of these studies were performed in school children and included a  
183 three-year intervention, focused on four components: classroom curriculum, food service, PA and  
184 family involvement (18). A three-year community-based intervention included physical education  
185 enhancements, food service reforms and farm-to-school-to-home programs; city policies and  
186 community awareness were also included (19). An academic-year intervention aimed to improve  
187 nutritional knowledge and increase PA by means of 45 minutes per day of exercise training during 6  
188 days per week (24).

189 . Only one study was conducted among female adolescents in secondary schools, located in low-  
190 income communities from Australia (22). The intervention lasted 12 months and included teacher  
191 professional development, enhanced school sport sessions, interactive seminars, nutrition  
192 workshops, lunch-time PA sessions, handbooks and pedometers for self-monitoring, parents  
193 newsletter, and text messaging for social support.

194 *Physical activity & sedentary behaviour interventions*

195 Only one study, which aimed improving obesity related outcomes through physical activity and  
196 sedentary behaviour interventions, was included (25). A tailored after-school dance and screen time  
197 intervention was implemented in low-income preadolescent African American children (age range:  
198 8-10 years old). One-year intervention duration was realized, including dance sessions 5 days per  
199 week and lessons about how to reduce screen time at the home environment. Assessed outcomes  
200 included BMI, waist circumference and triceps skinfolds. No changes in body composition  
201 indicators were observed between intervention group and control group, but the incidence of being  
202 overweight during the follow up period was reduced significantly in the intervention group among  
203 the non-immigration background.

204 *Dietary, physical activity & sedentary interventions*

205 One study aiming to improve obesity related outcomes through the combination of diet, physical  
206 activity and sedentary intervention was included (27). One-year intervention was performed in 2950  
207 American children via a combination of multiple aspects of the school environment, including the  
208 classroom, nutrition services, physical education activities, family and home environment and  
209 school health promotion messages and events (27). Two-intervention groups were created; one  
210 including activities to increase moderate-to-vigorous PA, PE and activity breaks, fruit and vegetable  
211 consumption, and to decrease TV viewing and sugar-sweetened beverage consumption. The other  
212 one included all the previous activities and the formation of the “community action” team, which  
213 identify priority areas of action and implemented workshops and activities each semester. Assessed  
214 outcomes included BMI. The percentage of students classified as overweight or obese decreased by  
215 3.1% in students from the first group compared to a decrease of 8.2% to the second group  
216 ( $p<0.005$ ).

217 *Dietary, physical activity, sedentary & sleep interventions*

218 Finally, three studies aimed to improve obesity related outcomes including dietary, physical  
219 activity, sedentary behaviours and sleep habits interventions were included (28-30), while two of  
220 them were part from the same study. The common study was carried out in preschool children from  
221 Switzerland. The follow-up period comprised ten and twelve month respectively. A cultural tailored  
222 intervention consisted of a physical activity program and lessons on nutrition, media use and sleep.  
223 Fixed and mobile equipment were installed around classrooms. Assessed outcomes included BMI,



224 percent body fat, waist circumference and skinfolds (triceps, biceps, subscapular and suprailiac).  
225 Intervention effect of percent body fat and waist circumference differed between non-migrant and  
226 migrant children ( $p < 0.005$ ), whereas no intervention effect was observed with regard to the BMI.  
227 However, the intervention group showed reductions in percentage of body fat and the sum of four  
228 skinfold measurements. Furthermore, the same group showed lower increase in waist circumference  
229 compared to the control group (28). No significant differences were found when controlling for the  
230 migrant background of the parent (29). The other study was carried out in preschool children from  
231 USA (30). The intervention promoted household routines, family meals, adequate sleep, limiting  
232 TV time, and removing the TV from the child's bedroom, using motivational coaching at home and  
233 by phone. After 6-month intervention, the IG decreased their BMI compared with the CG ( $p = 0.05$ ).

234

### 235 **Discussion**

236 Several systematic reviews have already summarized the available evidence on lifestyle  
237 interventions aimed to prevent obesity in children and adolescents (12, 13). To the best of our  
238 knowledge, this is the first that has exclusively focused on children and adolescents from low  
239 income, SES or minority populations, i.e. low income groups and migrants. The present systematic  
240 review is part of the EPODE for the Promotion of Health Equity (EPHE) evaluation project, which  
241 aims to reduce inequalities related to childhood obesity prevention, among high and low SES  
242 groups, with a special focus to the child and the family environment (31). Reducing health  
243 inequalities taking into consideration those related with overweight, obesity and related  
244 determinants are a priority for European researches, and the EPHE intervention will focus on four  
245 determinants: promotion of fruit and vegetables intake, tap water intake, active lifestyle and  
246 adequate sleep duration. Additionally, segmentation approaches are important to determine the  
247 intervention effectiveness in community based obesity prevention programmes (32). The present  
248 systematic review has been related to the energy balance related behaviours and the key-messages  
249 and actions that will be developed by the community-based programmes that will be involved in the  
250 EPHE study across Europe.

251 According to Brown & Summerbell (33), the number of interventions to prevent obesity during  
252 childhood, and even adolescence, has been increasing during the last decades. This tendency is also  
253 observed when referring to studies focused on low income population groups as all the studies  
254 included in the present systematic review were conducted between 2003 and 2012; nine of the  
255 twenty-one studies identified, were carried out in 2010. Interventions are mainly conducted  
256 through/in schools, i.e. kindergartens, primary schools and secondary schools, maybe because the  
257 school setting increases its ability to be implemented.

258 Four of the diet and PA studies, the PA study, one of two diet interventions, the diet, PA and  
259 sedentary behaviour intervention, and two of three of diet, PA, sedentary behaviours and sleep  
260 interventions showed significant changes in obesity indicators after the implementation of the  
261 intervention. The most common approach when designing obesity prevention interventions is a  
262 combination of diet and PA, as it allows researchers to cover two major lifestyle factors influencing  
263 obesity development. In spite of that, it seems that the combination or not of several energy  
264 balance-related behaviours- i.e. diet, PA, sedentary behaviours and sleep, within the same  
265 intervention does not determine its effectiveness. Based on our findings, the intervention that was  
266 exclusively focused on PA and the intervention that combined diet, PA and sedentary behaviours,  
267 both were effective and reduced significantly the obesity outcomes (22, 27). On the other hand,  
268 focusing on a single behaviour does not ensure the success of the intervention. According to our  
269 results, only one of two studies, that used a diet intervention approach, was effective to decrease the  
270 incidence of overweight at follow-up in children; but no changes were found in body composition  
271 indicators (15). Nevertheless, the use of PA interventions was effective in decreasing the obesity  
272 outcomes, both in children and adolescents. With reference to the only included study that  
273 combined PA and sedentary interventions, we conclude that this approach does not seem to be  
274 effective, given the lack of effectiveness in the specific study (25).

275 Regarding the effectiveness taking into consideration the classification of SES, one out of six of the  
276 interventions which were based on the migrant background (16), three out of four of those which  
277 classified the intervention group using family income (20, 21, 27); the one that combined migrant  
278 background and income (30); and the three interventions which considered their own country-  
279 specific characteristics(17, 22, 23) were effective in terms of obesity composition indicators (BMI  
280 and zBMI). Having real insights on the needs and reality of the disadvantaged communities to build  
281 tailored interventions seems to bridge the gap of a deficit view and improve the impact of the  
282 programme. The EPHE project by assessing the baseline on the four intervention themes and build a  
283 tailored action plan per country based on their results should lead to a better impact on the deprived  
284 population.

285 In agreement with Brown & Summerbell (33), the effectiveness of the interventions to prevent  
286 obesity with a combined diet and PA approach is equivocal, and this is also the case in interventions  
287 focusing on low SES. At the same time, a consistent pattern between the effectiveness of the  
288 intervention and the size and duration of the study was not observed either. In fact, those studies  
289 with the longest duration of intervention -i.e. three years, were not effective in reducing obesity  
290 (18). From a total of 18 studies, six were successful in reducing body fat (28) or BMI (17, 20, 23,  
291 27, 34), or maintaining BMI (16, 21, 25) in low income children and adolescents, whereas in ten  
292 studies no significant improvements were seen in terms of obesity outcomes.

293 Outcome measurements differed among the studies, but the most common was the BMI. Most of  
294 the studies included BMI, BMI percentile or z-BMI as their main outcome, followed by percent of  
295 body fat, which were measured in six out of eighteen studies. The majority of the studies used  
296 simple measurements to assess body composition, in order to ease and simplify the evaluation and  
297 the follow-up period.

298 The ability of the intervention to reach low income children and adolescents is crucial as will  
299 probably determine its success. Programmes adaptation according to the population of interest  
300 through previously conducted pilot studies and focus groups to address racial/ethnic population-  
301 associated disparities, seems to be one factor that positively influences the effectiveness of the  
302 intervention within low income population groups (35, 36). Offering free activities for free and even  
303 incentives during the interventions, could also improve –the intervention’s adherence, given that  
304 low income population groups often cannot afford these types of activities. Furthermore, children  
305 from low SES families had higher likelihood of being qualified from free and/or reduced prize at  
306 school canteen, which increased the proportion of children taking advantage of such school service  
307 and, consequently, the rate of exposure to interventions developed at the school canteen. Likewise,  
308 support from school-staff, long-term commitment of school, community resources and innovations  
309 are important for influencing child’s physiological changes. In fact, implementing interventions  
310 through the school settings with teachers acting as interventionists, could enhance the adherence to  
311 the intervention. This may be explained by the fact that teachers may be seen as role models, which  
312 would result to higher excitement to participate in activities. This provides children with consistent  
313 positive feedback to modify their behaviours. For those reasons, schools may be effective  
314 environments to implement strategies to prevent obesity (20). At the opposite, low levels of  
315 teachers’ compliance together with low likelihood of implementation of classroom curriculum-  
316 based interventions, can negatively affect the effectiveness of interventions. For that reason, it is  
317 recommended for the EPHE project as well as other programmes to support and encourage teachers,  
318 in order to guarantee the success of the program. Additionally, family involvement is a key factor  
319 for making healthy lifestyle changes and maintaining these changes within the home environment.  
320 Indeed, the lack of parental participation together with a poor willingness of parents to lobby for a  
321 change in lifestyle, were considered as crucial factors determining the success of the intervention  
322 therefore the EPODE methodology,(37) a coordinated multi-stakeholders approach, used by the  
323 EPHE programmes is a strong asset to achieve such objectives.

324 On the other hand, some studies observed that extended periods of out-of-school time, i.e. holidays  
325 and summer vacations, decreased the effect of treatment over the time. As proposed by Hollar et al.  
326 (20, 21), this could be ameliorated by the inclusion of additional programming during such periods.  
327 Additionally, the lack of control of habits within the home environment may be another key factor

328 influencing the absence of significant results in the improvement of obesity outcomes. The degree  
329 of heterogeneity in migrant background could also be decisive, as it may hinder the development of  
330 tailored intervention programmes to each specific population.

331

### 332 **Strengths and limitations**

333 A considerable strength of this review is the comprehensive search performed by two-independent  
334 reviewers on several obesity interventions conducted in normal-weight young population groups.  
335 The interventions included all types of energy balance related behaviours that had been related  
336 previously to obesity development in children and adolescents. On the other hand, the evaluation of  
337 different SES groups is a key-factor to develop further strategies for obesity prevention.  
338 Additionally, the fact that interventions directed at particular minority groups were also included  
339 contributed to the identification of specific factors that may determine the effectiveness of the  
340 intervention among these individuals and that will allow the development of tailored obesity  
341 prevention programmes for these specific disadvantaged groups. Included papers were in English,  
342 Spanish and Portuguese, although this fact did not prevent the exclusion of other relevant studies.  
343 There are, however, some limitations to consider. As with any systematic review, there is potential  
344 of publication bias, only MEDLINE database has been used to search potential included studies,  
345 nevertheless experts in the area from the EPHE project were asked to suggest additional  
346 intervention studies for the review. As well as, the SES evaluation is another limitation due to the  
347 different methodological approaches between studies.

348

### 349 **Conclusion**

350 There are only a few intervention studies exclusively directed at minority groups or comparing high  
351 vs. low SES populations. Furthermore, the studies were heterogeneous in terms of sample size,  
352 participants, design, intervention, duration of the intervention, outcomes and follow-up. That  
353 hindered the generalizability of the conclusions and the evaluation of the effectiveness of the  
354 interventions, and therefore, prevented us from drawing any straight conclusion on the interventions  
355 that may result effective in preventing obesity in children and adolescents from a low SES  
356 background. Despite results inconsistency, however, the overall findings suggest that combined diet  
357 and PA interventions may help to prevent children becoming overweight in the long term in low  
358 income/ low social class families for the prevention of obesity in children. The construction of a  
359 logic model based on the EPODE guidelines is an important element in the implementation and  
360 evaluation of comprehensive, community-wide health programmes. Furthermore, the flexibility and  
361 adaptability of this model complying to specificities at local level is key in the implementation of an

362 effective intervention, particularly when this intervention seeks to target disadvantaged  
363 populations.  
364

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**Table 1.** Inclusion and exclusion criteria.

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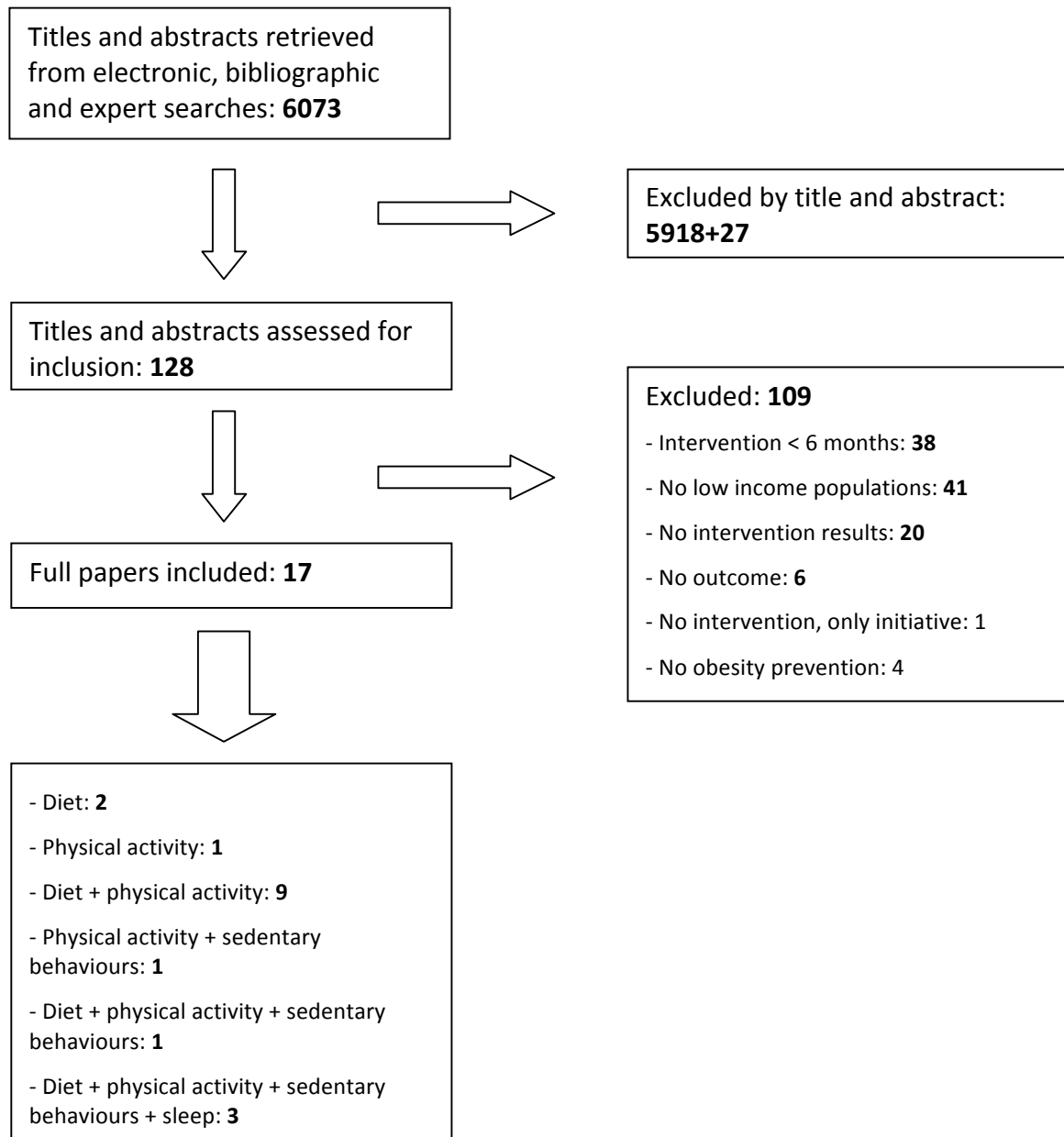
**Inclusion criteria**

1. Intervention studies on energy balance related behaviours focused (diet, physical activity and/or sedentary behaviours) aimed to prevent obesity conducted in humans.
2. Intervention studies carried out in children and/or adolescents (1-18 years old).
3. Intervention studies reporting obesity outcomes (body mass index (BMI), fat mass, lean mass, skinfolds thickness, body circumferences, weight, height) at baseline and after intervention.
4. Intervention duration  $\geq$  6 months.

**Exclusion criteria**

1. Intervention studies not focused on at least one energy balance related behaviour such as diet, physical activity or sedentary behaviours.
  2. Intervention studies not reporting obesity outcomes.
  3. Intervention studies reporting obesity outcomes without baseline information or data after the intervention.
  4. Intervention duration < 6 months.
  5. Intervention studies conducted in infants (< 1 year old) or adults (> 18 years old).
  6. Intervention studies not involving healthy participants.
  7. Studies in animals.
-

**Figure 1.** Flow diagram of the systematic review process.



**Table 2. Main characteristics of included studies.**

<b>Author Year</b>	<b>Study design</b>	<b>Participants Age Country</b>	<b>Intervention Intervention duration</b>	<b>Description of the intervention</b>	<b>Outcome(s)</b>	<b>Results</b>
Bürgi et al., 2012	Cluster-RCT	645 socially disadvantaged preschoolers 5.2 ± 0.6 yo Switzerland	Diet + PA + SB + sleep 10.5 months Individual + family + school level	- Diet + SB: 22 lessons on healthy nutrition and media use. - PA: four 45 min sessions of PA per week. - Parents participated in three information and discussion evenings about promotion of PA, healthy food and limitation of TV use.	BMI, percent body fat, WC	The intervention was similarly effective in preschoolers of migrant parents compared to their counterpart.
Caballero et al., 2003	School-based RCT	1704 American Indian children 7-10 yo USA	Diet + PA 36 months Individual + school level	- PA: three 30-minute sessions per week of moderate-to-vigorous PA. - Diet + PA: two 45-minutes lessons per week focused on the promotion of healthful eating behaviours and the increase of PA. - School: provision of nutrient guidelines and practical tools to reduce fat content of school meals.	Weight, BMI, percent body fat, triceps and subscapular skinfold thicknesses.	No significant differences between the IG and CG in any of the anthropometric variables at the end of follow-up.
Carrel et al., 2005	Quasi-experimental design	38 native and non-native obese American children and adolescents 6-18 yo (9 ± 3 yo) USA	Diet + PA 6 months Individual level	- Diet + PA: twice weekly classes (fitness and nutrition education + 45 minutes PA + 30 minutes healthy snack).	Percent body fat	No significant difference between IG and CG in body fat percent.
Chomitz et al., 2010	Quasi-experimental design	1858 pre-school children 7.7 ± 1.8 yo USA	Diet + PA 36 months Individual + school + family + community level	- Individual: health and fitness progress report. - Family: outreach events as “Fit Together” family nights, fitness expo, nutrition counselling to families of obese children. - School: PE and food service policies to improve access to appropriate PA opportunities and healthy food choices for children, school gardens and nutrition education. - Community: strategies to provide	Weight, BMI	Higher income children significantly decreased BMI z-score, but not low income children.

				policy support for healthy living choices, opportunities for community advocacy, after-school providers training on implementing the policies, and to raise community awareness of the resources available in the city to promote healthy eating and active living.		
Haines et al., 2013	RT	166 children 4.0 ± 1.1 yo USA	Diet+ PA+ SB+ Sleep Home-based intervention	Component of the intervention included: (1) motivational coaching by a health educator during 4 home visits and 4 health coaching telephone calls, (2) mailed educational materials and incentives, and (3) weekly text messages on adoption of household routines.	Weight, BMI	Children from the IG decreased BMI (-0.40[-0.79 to 0.00; p=0.05]).
Hoelscher et al., 2010	Quasi-experimental design	1107 (BasicPlus intervention (BP): 554; BasicPlus + community (BPC): 553) children 9.9 ± 0.51 yo USA	Diet + PA + SB 12 months High income children: individual + family+ school level Low income children: individual + family+ school + community level	- BP intervention: increase of moderate-to-vigorous PA in students, in school PE and activity breaks, and at home; to decrease TV viewing; to increase fruit and vegetables consumption, to decrease sugar-sweetened beverage consumption, to encourage healthy meal patterns such as breakfast consumption. - BPC intervention: BP intervention strategies + formation of the “Community Action” team to identify priority areas of action, to attend three “Best Practices” workshops per year with all BPC schools, and to select and activity each semester from a menu of evidence-based strategies for promoting PA and healthy eating in the school setting such as after school programs or school gardening programs.	Weight, BMI	- Percentage of students classified as overweight or obese decreased by 1.3 points in BP schools and 8.3 points in BPC schools. - Those in BPC schools showed a significant decrease over time in overweight and obesity.
Hollar et al., 2010	Quasi-experimental design	1197 low income school children 7.8 ± 1.7 yo	Diet + PA 24 months Family + school	- Diet: modifications of school-provided breakfasts, lunches and snacks in order to include more high-	BMI percentiles	Significantly more children in the IG than in the CG maintained the normal BMI percentile range.

		USA	level	<p>fiber items, fewer high-glycemic items, and lower amounts of total, saturated and trans fats.</p> <p>- PA: increase of the opportunities for PA during the school day.</p> <p>- Curricula component: nutrition and healthy lifestyle management program to teach children, parents and school staff about good nutrition and the benefits of daily PA.</p>		8.1% of intervention children with normal weight and 4.1% of overweight gained weight versus the same two groups in the control school (11.9% and 6.8%, respectively).
Hollar et al., 2010	Quasi-experimental controlled pilot study	1172 low income minority children 6-12 yo USA	Diet + PA 24 months Family + school level	<p>- Diet: modifications of school-provided breakfasts, lunches and snacks in order to include more high-fiber items, fewer high-glycemic items, and lower amounts of total, saturated and trans fats.</p> <p>- PA: increase of the opportunities for PA during the school day.</p> <p>- Curricula component: nutrition and healthy lifestyle management program to teach children, parents and school staff about good nutrition and the benefits of daily PA.</p>	Weight z-score, BMI z-score	Children from the IG were significantly more likely to reduce their BMI z-score and their weight z-score in comparison with the CG children.
Johnston et al., 2010	RCT	54 overweight or obese Mexican American children 10-14 yo (12.3 ± 0.7 yo) USA	Diet + PA 6 months Individual + school level	<p>- Instructor led intervention (ILI, n=37): instructor/trainer-led intervention for 24-weeks of daily sessions.</p> <p>- Self-help intervention (SH, n=17): 12-week parent-guided manual to promote child weight loss and long-term maintenance of changes.</p> <p>- Schools: educated on how to provide an environment to support healthy eating and physical activity habits.</p>	Weight, BMI, z-BMI, triceps skinfold	Children in ILI significantly reduced their z-BMI when compared to the SH children. Similar results were observed for BMI, weight and percent overweight.
Lubans et al., 2011	RCT	100 Adolescent boys from disadvantaged secondary schools. 14.3 ± 0.6 yo Australia	PA 6 months Individual + school level	- School: sport sessions, interactive seminars, lunch-time physical activities, PA and nutrition handbooks, leadership sessions and pedometers for self-monitoring.	BMI, percent body fat, WC	The IG present a beneficial and significant reduction effect in BMI and zBMI compared with the CG. Not differences were found in WC and %BF.
Lubans et al.,	RCT	357 adolescents	Diet + PA	- School: sport sessions, interactive	BMI, BMI z score,	The IG presents a reduction in BMI,

2012		from disadvantaged schools 12 to 14 yo New Zealand	12 Months Individual + school level	seminars, nutrition workshops, lunch-time physical activities, PA and nutrition handbooks, pedometers for self-monitoring and text messaging (weekly and bi-weekly) for social support. - Parents: newsletters (4 time periods).	percent body fat	zBMI and %BF, but not statistically different from those in the CG.
Meriaux et al., 2008	Quasi-experimental design	176 children from low/ high SES regions. 9.75-11.25 yo Sweden	Diet + PA IG: 1.3±0.42 years CG: 2.1±0.48 years Individual + school + family level	The school health services provided to children meant promotion of healthy lifestyle targeted at both children and parents. -Diet+ PA: Individual advice about nutritious eating habits, scheduled meals and daily PA, and regularly assessment of weight and height.	BMI	Weight, height, BMI and BMI SDS at follow-up were significant different between the IG and CG.
Muckelbauer et al., 2009  Muckelbauer et al., 2010	RCT	2950 children from deprived neighbourhoods. 8.3±0.7 yo Germany	Diet 12 months Individual+ school level	- Diet: structured classroom lessons for children focused on improving beverage consumption by increasing the water intake. - School: Teachers conducted four 45-min lessons focused on water losses and needs of the body and on the water circuit in the nature. - Environment: Installation of water fountain.	BMI	The BMI SDS of the IG did not differ from the CG.  Incidence of being overweight during the follow-up period was reduced significantly in the IG among the non-immigrational background.
Nemet et al., 2011	Quasi-experimental design	795 low socioeconomic kindergarten children 3.8 - 6.8 yo Israel	Diet + PA 12 Months Individual + school level	Intervention to improve nutritional knowledge and encourage children to increase their habitual afternoon PA and to reduce SB. -Diet: Teaching topics such as food groups, vitamins, healthy food choices, food preparation and cooking methods, and information on fast-food versus home cooking. - PA: 45 minutes/ day of exercise training (6 days per week) coordinated one by a professional youth coach, and the rest by the teacher. - School: Short lectures, talks, games and story readings were given to the children.	BMI, BMI percentile	No significant change in BMI, but a significant decrease in BMI percentile was found in the IG and CG. Reduction of the 32% in the IG and 18% in the CG the prevalence of overweight children (p<0.05).

Puder et al., 2011	RCT	652 migrant preschool children. 4-6 yo Switzerland	Diet + PA + SB +Sleep 12 months Individual + school + family + community level	<ul style="list-style-type: none"> <li>- Diet + SB: 22 lessons on healthy nutrition, media use and sleep. Healthy snacks during recess and healthy treats for anniversaries were promoted.</li> <li>- PA: four 45 min sessions of PA per week.</li> <li>Funny physical activity or nutrition activity card to take home.</li> <li>- School: Workshops, lessons, home activities, extracurricular activities, adaptation of the built environment. Workshops for teachers before intervention.</li> <li>- Family: Parents participant in interactive information and discussion evenings about promotion of PA, healthy food, limitation of TV use, and importance of sufficient sleep.</li> <li>- Environment: fixed and mobile equipment such as climbing walls, hammocks, balls, cords were installed or provided around classrooms</li> </ul>	BMI, percent body fat, WC, skinfolds (triceps, biceps, subscapular and suprailiac)	BMI did not differ between CG and IG, but children in the IG showed reductions in %BF (adjusted mean difference: -1.1 stages [95%CI -2.02 to -0.20; p=0.02]) and the sum of four skinfolds (-2.78[-4.35 to -1.2; p=0.001]), and lower increases in WC (-1.0[-1.6 to -0.42; p=0.001]).
Robinson et al., 2010	RCT	261 low-income African Girls. 8 - 10 yo USA	PA + SB 12 months Individual + family + community level	<ul style="list-style-type: none"> <li>- PA: Afternoon-school dance sessions (hip-hop, African and step dance classes) 5 days per week.</li> <li>- SB: 24 lessons about how to reduce screen time at home environment.</li> </ul>	BMI, WC, triceps skinfold	Changes in BMI, WC and triceps skinfold did not differ between IG and CG.

CI, confidence interval; RCT, randomized controlled trial; RT, randomized trial; IG, intervention group; CG, control group; yo, years old; SB, sedentary behaviours; TV, television; BMI, body mass index; zBMI, z-score BMI; WC, waist circumference; WHR, waist-to-hip ratio; PA, physical activity; PE, physical education; min, minutes; BF, body fat; %BF, percentage body fat; FM, fat mass; FFM, fat free mass; SES, socioeconomic study