Obesity Prevention/Treatment

The effectiveness and promising strategies of obesity prevention and treatment programmes among adolescents from disadvantaged backgrounds: a systematic review

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Summary

This review aimed to summarize the evidence on the effectiveness of obesity prevention and treatment programmes for adolescents from socioeconomically disadvantaged backgrounds. A secondary aim was to identify potential successful intervention strategies for this target group. PubMed, EMBASE, PsycINFO and Cochrane Library were searched from January 2000 up to February 2016. Intervention studies targeting adolescents from disadvantaged backgrounds were included, with body mass index as outcome. Secondary outcomes were other adiposity measures, physical activity, diet, sedentary behaviour and screen time. Two independent reviewers extracted data, coded intervention strategies and conducted quality assessments. Fourteen studies were included: nine obesity prevention and five obesity treatment studies. Two preventive and four treatment studies showed significant beneficial effects on body mass index. Five of six studies (four preventive, one treatment studies) measuring dietary behaviour reported significant intervention effects. Evidence on other secondary outcomes was inconclusive. We found no conclusive evidence for which specific intervention strategies were particularly successful in preventing or treating obesity among disadvantaged adolescents. However, the current evidence suggests that involving adolescents in the development and delivering of interventions, the use of experiential activities and involvement of parents seem to be promising strategies. More high quality studies are needed. PROSPERO registration number: CRD42016041612

Keywords: intervention, low SES, overweight, youth.

Introduction

The prevalence of childhood and adolescent overweight and obesity remains a worldwide public health concern. Around 30% of American adolescents and 22–25% of European adolescents are overweight or obese (1). Socioeconomic status (SES) is inversely related to obesity in most Western countries (2–4), that is, greater socioeconomic disadvantage tends to be associated with a higher prevalence of overweight and obesity in adolescents. Moreover, low SES is associated with less physical activity, more sedentary behaviour and poorer dietary habits (3,5,6). These inequalities in obesity and health-related behaviours stem from the unequal distribution of social and economic resources (7). For instance, low-SES families have less access to recreation facilities and can afford to spend less money on healthier food options (7,11). Additionally, research shows that supermarkets in disadvantaged neighbourhoods expose consumers to considerably greater shelf space of energy-dense, nutrient-poor foods and soft drinks than supermarkets in more advantaged neighbourhoods (8). Despite the fact that adolescents from low SES are in most need of preventive

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interventions, there is evidence that the socioeconomic advantaged children and adolescents tend to profit more from such interventions, meaning intervention effects are moderated by SES. Therefore, these interventions may cause an even steeper SES gradient in overweight and obesity (9). If adolescents from low SES are not reached, the global obesity epidemic will persist and possibly increase. Interventions for this target group are urgently needed. Preventive efforts should therefore be better adapted and directed towards those from socio-economically disadvantaged backgrounds. As adolescence is a key period of biological, social and behavioural change (10), laying the foundations for future adult health, this is a particularly important age period for adopting a healthy lifestyle. Moreover, adolescent health affects adult health. Therefore, adolescence is an especially important period to start preventive efforts. Physical activity levels tend to decline during adolescence (11); therefore, it is important to prevent such a decline and stimulate a physically active lifestyle. In order to offer adolescents from disadvantaged backgrounds effective and attractive interventions, it is necessary to know which intervention strategies work for them and how these adolescents can best be addressed. As the environment in which adolescents nowadays grow up has undergone major changes and has become more obesogenic in recent years, the focus of the current review was on recent evidence. Therefore, the aim of this review was to summarize the recent evidence on the effectiveness of obesity prevention and treatment interventions targeting adolescents from disadvantaged backgrounds. A secondary aim was to identify potential successful intervention strategies for this target group.

Methods

The protocol for this review was registered in PROSPERO (registration number: CRD42016041612).

Literature search

A systematic literature search was conducted in collaboration with a medical information specialist in the electronic databases PubMed, EMBASE, PsycINFO and Cochrane Library from January 2000 up to February 2016. Search terms were related to body mass index (BMI), intervention, adolescents and SES. Search terms included controlled terms (MeSH) as well as free text terms. For the full search strategy in PubMed, see appendix A. In addition, the reference lists of all included studies were hand searched.

Inclusion and exclusion criteria

Studies were selected when they met the following inclusion criteria: (i) targeting adolescents (mean age ≥ 12 years, maximum age 18 years); (ii) from socio-economically disadvantaged backgrounds (i.e. living in low-income communities or attending schools situated in low-income areas), or when a stratified analysis for SES was performed; (iii) an obesity intervention study (prevention or treatment, randomized or nonrandomized controlled trial or studies with a pre-post design without control group) and (iv) BMI or BMI z-score as an outcome measure. In addition to our primary outcome measure of BMI, relevant secondary outcomes (adiposity measures, physical activity, diet, sedentary behaviour and screen time) were also extracted if measured. Only papers published in the English language and in peer-reviewed journals were included. No restrictions regarding intervention duration were applied.

Interpretation of results

This review included two study types: obesity prevention and treatment studies. As prevention and treatment studies have different aims, results were interpreted differently. Obesity prevention studies aim to prevent obesity, i.e. prevent an increase in BMI (z-score) in the intervention group. Therefore, in prevention studies, we classified intervention effects on BMI (z-score) as beneficial when BMI (z-score) in the intervention group remained stable or reduced as opposed to the control group or baseline in pre-post studies. Obesity treatment studies aim to reduce obesity. Therefore, in treatment studies, we classified intervention effects as beneficial when BMI (z-score) reduced as opposed to the control group or baseline in pre-post studies.

Selection process and data extraction

All titles and abstracts were screened independently by two reviewers (DKA, CRZ or DKA, TA). If necessary, full-text studies were screened and a fourth reviewer (MC) checked studies in case of doubt. Discrepancies for selected studies were discussed between the reviewers until consensus was reached.

Information on participants, setting, duration of the intervention, follow-up period, control group, outcome measures, quality of the study and results were extracted independently by two reviewers (DKA, CRZ or DKA, TA) using a standard data extraction form. Two reviewers (DKA, TA) independently coded the intervention strategies using the behaviour change technique taxonomy (BCTT v1), which contains 93 techniques, grouped into 16 clusters (12). Using this taxonomy, the various behaviour change techniques of interventions were coded. Both reviewers used a list of definitions of the 93 techniques and identified which techniques were included in the interventions. Inconsistencies were resolved through discussion.
Quality assessment

Two reviewers (DKA, TA) assessed the methodological quality of all included studies, using the quality assessment tool for quantitative studies of the Effective Public Health Practice Project (13). Eight quality components were scored: selection bias, study design, confounders, blinding, reliability and validity of data collection methods, withdrawals and dropouts (based on our outcome measures), intervention integrity and analyses. For all included studies, each component was rated as strong, moderate or weak, according to standardized instructions. Any discrepancies between the two researchers were resolved through discussion. The overall quality of each study was considered strong when at least five ratings were strong and no ratings were weak. When less than five ratings were strong and one rating was weak, the study was considered moderate. Studies with two or more weak ratings were considered weak. The quality assessment was conducted to better value the results, not to exclude any studies from this review.

Results

The search identified 3,605 potentially relevant studies (1,519 in PubMed, 1,365 in EMBASE, 550 in PsycINFO and 171 in Cochrane). After removing duplicates and further screening, 15 studies were included in this review (14–28) (Fig. 1). Two included studies described the same intervention, reporting results of a 12-month follow-up (24) and a 24-month follow-up (17) of the same intervention group. We decided to include the study with the longest follow up duration (17) in this review. This resulted in a total of 14 included studies.

Study characteristics and quality assessment of obesity prevention studies \( (n = 9) \)

Of the 14 included studies, nine were preventive intervention studies (14,16–20,25,26,28). All preventive intervention studies were randomized controlled trials, except for one study, which was an uncontrolled study with a pre-post design (28). Six interventions were school based (14,16,17,19,20,28) and three were community-based (18,25,26). All interventions were multi-component, combining behavioural, educational and/or environmental components, except for one intervention (20).

Four studies were conducted in the United States (18,20,26,28), three in Australia (14,16,17), one in...
Sweden (25) and one in India (19). The mean age of the adolescents ranged from 12.5 to 16.0 years at baseline. Sample sizes varied from 100 to 459 participants. Intervention duration ranged from 1 week to 12 months. Follow-up duration ranged from 3 months to 5 years. Three interventions targeted girls only (16,20,25), two interventions targeted boys only (14,17) and four interventions targeted both genders (18,19,26,28). Study details are summarized in Table 1.

Two studies were rated as strong quality (19,20), five studies as moderate (14,16–18,28) and two studies as weak quality (25,26) (Table 2). The limitations of the studies classified as being of weak quality included the following: the percentage of participants receiving the intended intervention was unknown, high dropout rates and/or analyses were not appropriate.

Study characteristics and quality assessment of obesity treatment studies (n = 5)

Of the 14 included studies, five were treatment studies (15,21–23,27). All treatment studies were uncontrolled studies with a pre-post design. Four interventions were community based (15,21–23) and one was camp based (27). All interventions were multi-component, combining behavioural, educational and/or environmental activities. Three studies were conducted in the United States (21,23,27), one in Australia (15) and one in the United Kingdom (22). The mean age of the adolescents ranged from 12.2 to 14.0 years at the start of the intervention. Sample sizes varied from 52 to 94 participants. Intervention duration ranged from 19 days to 12 months. Follow-up duration ranged from 12 weeks to 23 months.

One intervention targeted girls only (23) and four interventions targeted both genders (15,21,22,27). Study details are summarized in Table 1.

Two studies were rated as moderate (15,27) and three studies as weak quality (21–23) (Table 2). The limitations of the studies classified as being of weak quality included the following: the percentage of selected participants who agreed to participate (before assignment to intervention or control group) was low, the percentage of participants completing the study was low, assessors were not blinded to group assignment, adjustment for confounders was unknown, the percentage of participants receiving the intended intervention was low and/or high dropout rates.

Interventions strategies

Table 2 shows all intervention strategies. All studies combined a range of intervention strategies. A total of 26 behaviour change techniques (BCTs) were identified from the included studies, with a median of eight BCTs per intervention (range 2–10). The strategy behavioural rehearsal/practice was identified in 13 studies (eight prevention, five treatment studies). Demonstration of the behaviour and instruction on how to perform a behaviour were used in 12 studies (seven prevention, five treatment studies). Eight studies used goal setting (five prevention, three treatment studies). Seven studies used problem solving (three prevention, four treatment studies) and self-monitoring of behaviour (four prevention, three treatment studies). Social support was used in six (prevention) studies. The remaining BCTs were used in five or less studies. Additionally, we added three commonly used intervention strategies that were not present in the BCTT: knowledge transfer (eight prevention, four treatment studies), parental involvement (six prevention, four treatment studies) and student involvement to become peer-leaders (eight prevention studies). No apparent difference emerged in type or number of intervention strategies between effective and ineffective interventions. When considering preventive and treatment studies separately, it was discernible that all effective treatment studies used parental involvement, problem solving and social support as opposed to the only treatment study that was not effective, which did not use these strategies. Two strategies were used by all preventive studies (effective and non-effective): behavioural rehearsal/practice and student involvement to become peer leaders.

Effectiveness of obesity prevention studies (n = 9)

Two out of nine prevention studies reported significant beneficial intervention effects on BMI or BMI z-score (17,28). In one study (weak quality) (25), there was no difference in change of BMI between intervention and control group, but a within-group analysis showed an increase in BMI in the control group. In another study (weak quality) (26), significant beneficial intervention effects on BMI were observed in a subgroup of girls with a BMI > 85th percentile. In one study (moderate quality) (18), the percentage of overweight and obese participants decreased in the intervention group, compared with the control group. Six preventive studies measured body fat, of which two moderate-quality studies reported significant beneficial intervention effects (16,17). In one study (18), body fat decreased significantly in a subgroup of overweight/obese participants. Three studies (two moderate, one strong quality) measured waist circumference (14,17,19), one of which found a significant beneficial intervention effect (19).

Physical activity was included as an outcome in five studies (four moderate, one strong quality) (14,16–18,20), none of which reported significant effects. Screen time was measured in two moderate-quality studies (14,16) and was significantly reduced in one of these studies (14). Five studies (four moderate, one strong quality) included dietary behaviour measures (14,16–19), of which four reported significant beneficial effects on dietary...
Table 1  Characteristics of the intervention studies targeting adolescents from disadvantaged backgrounds

| Study, design  | Participants | Setting | Duration intervention | Follow-up | Description control group |
|---------------|--------------|---------|-----------------------|-----------|----------------------------|
| **Preventive studies:** | | | | | |
| Singhal et al. (19), RCT  | n = 201, 60% boys, mean age 16.04 ± 0.41 years in IG, mean age 16.0 ± 0.5 years in CG, Asian Indian adolescents  | Schools, metropolitan city of North India | 8 months | 6 months | Did not receive any intervention |
| Spruijt-Metz et al. (20), RCT  | n = 459, 100% girls, mean age 12.5 ± 0.6 years, 73% Latin, 16% Asian/Asian American, 8% white, 4% other, 20% overweight or obese, 17% at risk for overweight  | Public and private schools, United States | 5 to 7 consecutive days | 3 months | Did not receive any intervention |
| Black et al. (18), RCT  | n = 235, 51% boys, mean age 13.3 ± 1.0 years, 97% non-hispanic black, low-income, urban adolescents; 12% overweight and 26% obese  | Urban university medical center, United States | 12 sessions | Post-intervention (11 months) and delayed follow-up (24 months) | Did not receive any intervention |
| Dewar et al. (16), RCT  | n = 357, 100% girls, mean age 13.2 ± 0.5 years, 27.9% overweight and 16.2% obese  | Schools, New South Wales, Australia | 12 months | 24 months | Did not receive any intervention |
| Lazorick et al. (28), Pre-post design  | n = 106, 57% girls, mean age 12.8 ± 0.5 years, 60% black, 37% nonblack/non-Hispanic, 3% other, 51% overweight or obese  | School, North Carolina, United States | 14–16 weeks | 48–60 months | No control group | Alternatively, a nationally representative sample was used as a comparison group |
| Lubans et al. (17), RCT  | n = 100, 100% boys, mean age 14.3 ± 0.6 years, 22% overweight and 13% obese  | Schools, Hunter Region, New South Wales, Australia | 6 months | 6 months | Waitlist control group, programme was delivered at completion of the study |
| Smith et al. (14), RCT  | n = 361, 100% boys, mean age 12.7 ± 0.5 years, 21.3% overweight and 14.4% obese  | Schools, New South Wales, Australia | 20 weeks | 8 months (immediate post-intervention) and 18 months (long-term follow-up) | Usual practice, but will receive an equipment pack and a condensed version of the programme after the 18-month assessments |
| Lindgren et al. (25), RCT  | n = 110, 100% girls, mean age 15.3 ± 1.9 years in IG, mean age 15.5 ± 1.1 years in CG  | Two municipalities, Sweden | 6 months | 6 months | Waitlist control group, opportunity to take part in the programme at completion of the study |
| Shin et al. (26), RCT  | n = 242 African American youth–caregiver dyads, mean age 13.1 ± 1.4 years in IG, mean age 13.0 ± 1.6 years in CG, 36% boys and 53% girls overweight/obese in IG, 15% boys and 49% girls overweight/obese in CG  | Recreation centers and local stores, Baltimore, United States | 8 months | 8 months | Did not receive any intervention |
| **Treatment studies:** | | | | | |
| Baxter et al. (15), Pre-post design  | n = 88, 69% girls, mean age 13.1 ± 1.9 years, 91% Caucasian, 2% Asian and 7% Indigenous or Pacific Island, all participants were overweight/obese (BMI > 90th percentile)  | Tertiary paediatric hospital, Queensland, Australia | 12 weeks | 12 weeks | No control group |
|  | n = 52, 71% girls, mean age 14.0 ± 1.5 years, 29% white,  | | 19 days | 10 months** | A subgroup of 33 | No control group |**Continues** |
intake and/or consumption of sugar-containing beverages (14,17–19). Sedentary behaviour was measured in one strong-quality study (20) which found a significant beneficial effect.

**Effectiveness of obesity treatment studies (n = 5)**

Four out of five treatment studies (two weak, two moderate quality) reported significant beneficial effects on BMI (15,21,22,27). One weak-quality study (23) also included a measure of body fat, on which they found no significant intervention effect. Additionally, they included a measure of dietary behaviour, on which they found a significant beneficial intervention effect (23). One moderate-quality study (27) measured waist circumference and physical activity; on both measures, significant beneficial intervention effects were found.

**Discussion**

This review summarized the evidence on effectiveness of obesity prevention and treatment interventions targeting adolescents from disadvantaged backgrounds. Two out of nine prevention studies and four out of five treatment studies showed beneficial intervention effects on BMI. As expected, participants in treatment studies had a higher initial BMI than participants in preventive studies and were therefore more likely to gain from the intervention in terms of a reduction in BMI. This is in accordance with a review of Spruitt-Metz (29) who found that 23% of interventions aiming for treatment of childhood and adolescent obesity significantly reduced BMI, whereas in preventive interventions 18% prevented a rise in BMI percentile.

Intervention strategies applied in interventions that showed beneficial intervention effects on BMI did not clearly differ in the applied strategies of non-effective interventions. Furthermore, studies varied largely in study design, intervention duration and study quality. Therefore, it is not possible to conclude which specific strategies are most effective in preventing or treating obesity in disadvantaged adolescents. However, when considering preventive and treatment studies separately, some intervention components seem promising. For instance, peer-leadership, in which participants are involved to deliver parts of the intervention to their peers, seems a promising strategy. Lubans et al. (17) used an intervention that was designed to encourage participants to become promoters in physical activity and healthy eating, both at school and at home. Physical activity sessions were run and organized by students (under the supervision of teachers) and students promoted a healthy lifestyle at home. This approach empowers students to positively change their lifestyle. Retention and attendance levels were
Table 2  Outcomes and applied behavioural change strategies of intervention studies targeting adolescents from disadvantaged backgrounds, sorted by quality rating and study type

| Study and methodological quality | Applied intervention strategies (BCTs) | Summary of results\(^a\) |
|----------------------------------|---------------------------------------|--------------------------|
| Preventive studies:              |                                       | (95% CI) (intervention-control) |
| Singhal et al. (19)              | A school-based low-cost nutrition and lifestyle education intervention on behaviour modification and risk profile. It comprised seven components: (i) lectures and focus group discussions; (ii) promotion of physical activity; (iii) activities to promote healthy lifestyle; (iv) individual counselling; (v) policy-level changes in the school; (vi) involvement of teachers and parents and (vii) training of student volunteers to sustain the programme. | BMI: 0 (–0.18 to 0.34) |
| Moderate quality rating         |                                       | Waist circumference: + (–2.43 to –0.17) |
| Spruijt-Metz et al. (20)         | Classroom media-based intervention designed to increase physical activity and decrease sedentary behaviours. Students received information about physical activity and sedentary behaviour, participated in learning activities that supported engagement in physical activity and reduction of sedentary behaviour (e.g. creating a team message). | Sagittal abdominal diameter: + (–0.82 to –0.09) |
| Strong quality rating           |                                       | Waist-to-hip ratio: + (–0.03 to –0.004) |
| Black et al. (18)                | A 1-to-1 health promotion, obesity prevention programme, delivered by trained mentors. Mentors promoted healthy eating and physical activity. Intervention components comprised field trips to community sites, goal setting, preparation and tasting of healthy snacks, discussion and engaging in physical activity with mentor. | Difference (%) (intervention, control) |
| Moderate quality rating         |                                       | Consumption aerated drinks: + (–15.1, –7.7) |
| Dewar et al. (16)                | Multicomponent intervention with strategies to promote physical activity, reduce sedentary behaviours and improve dietary outcomes. Intervention components included enhanced school sport sessions, lunchtime | Energy-dense unhealthy foods: + (–6, –0.8) |
| Moderate quality rating         |                                       | Fruit consumption: + (9.9, –6.5) |
| (Continues)                      |                                       |                                        |

\(^a\) Adjusted mean difference (95% CI) (intervention-control)

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Table 2 (Continued)

| Study and methodological quality | Applied intervention strategies (BCTs) | Summary of resultsa |
|----------------------------------|---------------------------------------|---------------------|
|                                  | physical activity sessions, nutrition workshops, interactive educational seminars, pedometers, student handbooks, parent newsletters and text messages to reinforce and encourage targeted health behaviours. | BMI: 0  
−0.33 (−0.97 to 0.28)  
BMI z-score: 0  
−0.12 (−0.27 to 0.04)  
Body fat %: +  
−1.96 (−3.02 to −0.89)  
Screen time (min/d): 0  
−28.3 (−67 to 11)  
Moderate to vigorous physical activity: 0  
−0.77 (−1.84 to 0.29)  
Energy intake (kcal/kg/d): 0  
−86.4 (−368.3 to 196.7) |
| Lazorick et al. (28) Moderate quality rating | Multicomponent school-based intervention integrating health, nutrition, physical activity and technology curriculum. Key components were (i) conceptual knowledge (learn ‘why’); (ii) health skills (learn 'how'); (iii) individualized tasks (apply the skill) and (iv) motivational strategies (reinforce the skill).  
• Social reward – ‘rewards day’ for special achievements, recognition bulletin board  
• Material reward – wrist bands, T-shirt  
• Behavioural rehearsal/practice – daily 20 min physical activity  
• Self-monitoring of outcome of behaviour – students calculated their own BMIs and used physical activity data en pedometer steps to compute caloric expenditure  
• Self-monitoring of behaviour – pedometers, dietary recall, physical behaviour  
• Action planning – individual goal setting with action plans  
• Goal setting (behaviour) – step count goals  
• Knowledge transferb – interdisciplinary wellness and nutrition lessons and activities  
• Peer leadersb – peer accountability contracts | Mean difference per month (SD)  
(intervention, comparison group)  
BMI: 0  
0.05 (0.05), 0.05 (0.08)  
BMI z-score: +  
−0.004 (0.011), 0.0 (0.023) |
| Lubans et al. (17) Moderate quality rating | Multicomponent school-based obesity prevention programme, focused on promoting physical activity, reducing sedentary behaviours and encouraging healthy eating. It included six components: (i) school sport sessions; (ii) interactive seminars; (iii) lunch-time physical activity sessions; (iv) physical activity and nutrition handbooks; (v) leadership sessions and (vi) pedometers.  
• Non-specific reward – leadership certificate  
• Behavioural rehearsal/practice – physical activity session  
• Health consequences – benefits  
• Feedback on behaviour – physical activity and fitness results  
• Self-monitoring of behaviour – pedometers  
• Goal setting (behaviour) – individualized daily step goals  
• Review behaviour goals(s) – feedback physical activity results  
• Demonstration of the behaviour – physical activity session  
• Instruction on how to perform a behaviour – physical activity session  
• Knowledge transferb – seminars, handbooks, sport sessions involved an information component  
• Parental involvementb – adolescents promoted physical activity and healthy eating for parents  
• Peer leadersb – participants recruited and instructed Grade 7 students on physical activity  
Mean difference (95% CI), d  
(intervention-control)  
BMI: +  
−0.8 (−1.2 to −0.3), 0.7  
BMI z-score: +  
−0.2 (−0.3 to −0.1), 0.7  
Body weight: +  
−2.4 (−3.6 to 2.3), 0.8  
Body fat: +  
−1.8 (−3.5 to −0.2), 0.5  
Waist circumference: 0  
0.8 (−0.6 to 2.3),0.2  
Physical activity (counts/d): 0  
−871 (−2896 to 1155), 0.2  
Consumption sugar-containing beverages: +  
β = −1.17, Wald chi square = 5.67 |

(Continues)
### Table 2 (Continued)

| Study and methodological quality | Applied intervention strategies (BCTs) | Summary of results $a$ |
|---------------------------------|---------------------------------------|------------------------|
| **Smith et al. (14)**           | Multicomponent obesity prevention intervention, using smartphone technology, increasing physical activity, reducing screen-time and lowering sugar-sweetened beverages consumption. It involved: teacher professional development, provision of fitness equipment to schools, face-to-face physical activity sessions, lunchtime student mentoring sessions, researcher-led seminars, a smartphone application and website, and parental strategies for reducing screen-time.  
  - Behavioural rehearsal/practice – sport sessions  
  - Prompts/cues – app message reminder  
  - Health consequences – in parent newsletter: consequences of excessive screen use  
  - Feedback on behaviour – app  
  - Self-monitoring of behaviour – pedometers, app  
  - Goal setting (behaviour) – daily step counts, goal-setting function app  
  - Review behaviour goals(s) – review of fitness challenge results on app  
  - Social support (general) – motivational messages  
  - Demonstration of the behaviour – sport sessions  
  - Instruction on how to perform a behaviour – sport sessions  
  - Knowledge transfer – seminars, workshops  
  - Parental involvement – newsletters  
  - Peer leaders – participants recruited and instructed  
  | Grade 7 boys in physical activity | Mean difference (SE) (intervention-control) BMI: 0  
  |                             | Waist circumference: 0  
  |                             | Body fat %: 0  
  |                             | Physical activity (counts/min): 0 weekday – 19 (23.30), weekend – 8 (53.94)  
  |                             | Screen-time (min/d): + – 30 (10.08)  
  |                             | Consumption sugar-sweetened beverages (glasses/d): + – 0.6 (0.26)  
| **Lindgren et al. (25)**        | Exercise intervention programme based on empowerment of participants and strengthening their perceived self-efficacy. Participants played an active part in the programme development. The intervention included exercise and discussion on healthy lifestyles.  
  - Behavioural rehearsal/practice – sports and exercise activities  
  - Social support (general) – leaders provided encouragement  
  - Demonstration of the behaviour – sports and exercise activities  
  - Social comparison – comparing performance with other girls  
  - Verbal persuasion to boost self-efficacy – leaders providing positive persuasion  
  - Instruction on how to perform a behaviour – sports and exercise activities  
  - Knowledge transfer – discussion sessions with exercise leaders  
  - Peer leaders – participants played an active role in programme development (participatory planning approach)  
  | Grade 7 boys in physical activity | Median (IQR) (intervention, control) BMI: 0 (within-group analysis: BMI increased in the control group) 21.9 (14.3–37.2), 23.2 (16.1–32.0)  
| **Shin et al. (26)**            | Multilevel nutrition and environmental intervention in which recreation centers and food stores were involved. Stores were encouraged to stock healthier, affordable foods. Intervention introduced materials and activities, such as taste tests, cooking demonstrations, giveaways, shelf labels, posters and flyers. Nutrition education was offered at recreation centers. Youth peer educators assisted in health promotions. The intervention comprised five phases, focusing on aspects of healthy eating: beverages, breakfast, cooking at home/lunch, healthy snacks and selecting healthier options at carryout restaurants.  
  - Behaviour substitution – healthier food options  
  - Habit reversal – healthier food options  
  - Behavioural rehearsal/practice – cooking demonstrations  
  - Restructuring the physical environment – stores stocked healthier foods  
  - Prompts/cues – shelf labels, posters and flyers  
  - Social support (general) – peer mentoring  
  - Demonstration of the behaviour – cooking demonstrations  
  - Instruction on how to perform a behaviour – cooking demonstrations  
  - Knowledge transfer – nutrition education, posters and flyers  
  - Parental involvement – youth–caregiver dyads took part in the intervention  
  - Peer leaders – youth peer educators assisted in health promotions  
  | Grade 7 boys in physical activity | Mean difference in BMI percentile (intervention, control) BMI: 0 (BMI decreased significantly in a subgroup of girls with baseline BMI > 85) – 1.88, 0.22  

(Continues)
### Table 2  (Continued)

| Study and methodological quality | Applied intervention strategies (BCTs)                                                                 | Summary of resultsa |
|----------------------------------|--------------------------------------------------------------------------------------------------------|---------------------|
| **Treatment studies:**           |                                                                                                        |                     |
| Baxter et al. (15)               | Dietary intervention. In a preparatory phase, adolescents received a psychological skills programme. Families were offered face to face tailored dietary advice and dietary counselling by telephone. Families were given meal and snack plans and were given advice to assist with compliance to the allocated diet. | Mean difference (SD) (pre-post) BMI z-score: + |
| Moderate quality rating         |                                                                                                        | −0.13 (0.11)        |
| Carraway et al. (27)             | A camp-based immersion treatment program. It comprised (i) a nutrition education curriculum and nutritious diet; (ii) daily physical activity (for instance swimming, kayaking, basketball); (iii) group therapy and (iv) cognitive-behavioural therapy. | Mean difference (SD) (pre-post) BMI z-score: + |
| Moderate quality rating         |                                                                                                        | −1.3 (0.9) (−1.0 to −1.6) |
| Germann et al. (21)              | A multidisciplinary obesity treatment programme for adolescents and their families, involving cognitive-behavioural therapy, nutritional counselling, exercise therapy and medical management. | Mean difference (SD) (pre-post) BMI z-score: + |
| Weak quality rating             |                                                                                                        | −0.07 (0.09) (−0.04 to −0.10) |
| Resnicow et al. (23)             | An intervention comprising components on healthy eating, physical activity and television viewing. Additionally, it comprised an educational component, field trips, preparation and tasting of low-fat meals and training of communication skills. | Adjusted mean (SD) (high attenders, low attenders) BMI: 0 |
| Weak quality rating             |                                                                                                        | 35.3 (7.9) raw change +0.7; 35.5 (6.8) raw change +0.9 |
|                                 |                                                                                                        | Body fat %: 0       |
|                                 |                                                                                                        | 44.7 (7.9) raw change −0.8; 46.4 (10.3) raw change +0.4 |

- **BCTs**: Applied intervention strategies (BCTs).  
  - **Knowledge transfer**: - instruction on how to perform a behaviour - demonstration of the behaviour - review behaviour goal(s) - goal setting (behaviour) - problem solving/coping planning - self-monitoring of behaviour - parent involvement - family day, workshop  
  - **Behavioural rehearsal/practice**: - relaxation techniques, self-awareness and mindfulness exercises - self-monitoring - problem solving – problem solving and step planning - goal setting (behaviour) – SMART goals - social support (emotional) – motivational interviewing - demonstration of the behaviour – relaxation techniques, self-awareness and mindfulness exercises - instruction on how to perform a behaviour – relaxation techniques, self-awareness and mindfulness exercises - knowledge transfer – workshops - parental involvement – advice, meal and snack plans for family  
  - **Self-monitoring**: - problem solving – problem solving and step planning - goal setting (behaviour) – SMART goals - social support (emotional) – motivational interviewing - demonstration of the behaviour – relaxation techniques, self-awareness and mindfulness exercises - instruction on how to perform a behaviour – relaxation techniques, self-awareness and mindfulness exercises - knowledge transfer – workshops - parental involvement – advice, meal and snack plans for family  
  - **Instruction on how to perform a behaviour**: - demonstration of the behaviour - problem solving/coping planning – assistance in overcoming challenges and obstacles  
  - **Demonstration of the behaviour**: - demonstration of the behaviour - problem solving/coping planning – assistance in overcoming challenges and obstacles  
  - **Goal setting (behaviour)**: - goal setting (behaviour) – weekly behavioural goals - review behaviour goal (a) – monitoring progress - social support (emotional) – (group) therapy sessions - demonstration of the behaviour – physical activities - instruction on how to perform a behaviour – physical activities - knowledge transfer – nutrition lessons - parental involvement – family day, workshop  
  - **Problem solving/coping planning**: - problem solving/coping planning – coping and relapse prevention training - goal setting (behaviour) – lifestyle exercise goals (e.g. 10,000 steps per day) - social support (emotional) – demonstration of the behaviour – exercise programme - instruction on how to perform a behaviour – exercise programme - regulate negative emotions – anxiety management, coping - knowledge transfer – education about cognitive-behavioural techniques and principles - parent involvement – counselling sessions for parents  
  - **Parental involvement**: - parent involvement – family day, workshop - parental involvement – advice, meal and snack plans for family - parental involvement – advice, meal and snack plans for family - knowledge transfer – nutrition lessons - self-monitoring - problem solving/coping planning – coping and relapse prevention training - goal setting (behaviour) – lifestyle exercise goals (e.g. 10,000 steps per day) - social support (emotional) – demonstration of the behaviour – exercise programme - instruction on how to perform a behaviour – exercise programme - regulate negative emotions – anxiety management, coping - knowledge transfer – education about cognitive-behavioural techniques and principles - parent involvement – counselling sessions for parents  
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Continues...
interventions, they may come up with new strategies that
Moreover, when involving students in the development of
and a sense of ownership within the target group (32).
this leads to higher acceptability, increased empowerment
targed groups, as they are trusted by the target group, and
and implementation of interventions for socially disadvan-
tioned neighbourhoods. The World Health Organiza-
t specificity is important when targeting adolescents from dis-
agement strongly suggests involving peers in the development
in this study, with rates of 80% and 70%, respectively. In
some of the included studies that found no beneficial effect
BMI, retention and attendance rates were low, for in-
stance Resnicow et al. reported an attendance level of
43% (23). Lubans posed that actively involving students
to deliver intervention components may enhance their sense
of responsibility and promote a deeper understanding of the
programme content. Consequently, their peers may also be
more motivated to participate in the intervention. Hence,
this may improve retention and attendance, in turn improving
intervention effectiveness.

In addition to involving the target population in delivering
intervention components, involving them in the develop-
ment of interventions also is a promising strategy to
improve intervention outcomes (30). Lindgren (25) used a
participatory planning approach, in which participants’
interests and needs were central to the development of the
programme, enabling them to play an active part in pro-
gramme development. Engaging students’ voice and encour-
aging adolescents to act as role models can have an
aspirational impact (31). It may also benefit the attractiveness
of the intervention and ensure that the intervention fits
the preferences of the target group. This strategy may be
specifically important when targeting adolescents from dis-
advantaged neighbourhoods. The World Health Organiza-
tion strongly suggests involving peers in the development and implementation of interventions for socially disadvantaged
groups, as they are trusted by the target group, and
this leads to higher acceptability, increased empowerment
and a sense of ownership within the target group (32).
Moreover, when involving students in the development of interventions, they may come up with new strategies that
are more successful than the intervention strategies
reviewed here. Except for BMI, most studies also measured
other outcomes of adiposity and behavioural determinants.
Based on outcomes other than BMI, most interventions
were effective at some level. For instance, five out of six
studies with a focus on dietary behaviour positively changed
the eating habits of adolescents (consumption of healthy
foods and/or sugar containing beverages). Although this
failed to result in beneficial intervention effects on BMI,
except for one study (17), this does not mean it has no positive impact on health. Possibly, it takes more time before a
healthier diet has measurable impact on BMI. Another
explanation may be that diet quality is not as tightly linked
to weight as is commonly promoted.

Six interventions included physical activity as an outcome
(14,16–18,20,27), but only one of these interventions was
successful in improving physical activity levels. The inter-
vention that was successful (27) comprised outdoor activities
such as swimming, kayaking and rock wall climbing. In
another study (23), adolescents from low-income communities indicated that they highly enjoyed physically active
field trips such as hiking, ice skating and swimming at state
parks. They reported enjoying ‘getting away’ and preferred experiential activities over more didactic lessons. Enjoyment
and participation in these types of activities may be responsible for substantially increasing physical activity. Moreover,
most of these activities cost little money and therefore are of particular interest for adolescents living in
low-income communities. Particularly in low-income communities, the cost of many school sport activities can be a
considerable barrier to participation (16,17). Involving par-
ents in facilitating a healthier lifestyle for their children is

Table 2 (Continued)

| Study and methodological quality | Applied intervention strategies (BCTs) | Summary of resultsa |
|----------------------------------|---------------------------------------|---------------------|
| Rudolf et al. (22)               | • Behaviour substitution – healthier versions of similar foods or noneating behaviours
• Behavioural rehearsal/practice – cooking and exercise
• Instruction on how to perform a behaviour – cooking and exercise
• Knowledge transferb – educational sessions
A community-based intervention, aimed at encouraging lifestyle changes, focusing on physical activity and regulating eating behaviour. It included three components: frequent individual appointments, weekly group activity sessions and group parenting sessions.
• Behavioural rehearsal/practice – physical activity sessions
• Problem solving/coping planning – solution focused approach
• Demonstration of the behaviour – physical activity sessions
• Social support (emotional) – encouragement, motivational counselling
• Instruction on how to perform a behaviour – physical activity sessions
• Parental involvementb – group parenting sessions |
| Weak quality rating             | Low-fat practices: + 40.5 (6.4), 36.9 (6.5)
Perceived changes in low-fat practices: + 6.4 (5.3), 3.9 (4.1) |
|                                 | Mean difference (SD) (pre-post)
BMI: + ~0.07 (0.16)              |

a+ = significant beneficial effect, 0 = no effect.
bNot included in BCTT v1.
important, because parents play an important role in the dietary and physical activity behaviours of their children (33). The involvement of parents appears to contribute to the success of weight-related health interventions (34). Most studies included in our review also targeted parents. Parents were involved through nutritional counselling, meal and snack plans for the family and group parenting sessions. Parental involvement that consists of only receiving newsletters seems less effective, as most interventions that used this type of parental involvement were unsuccessful. In one study (14) though, where parents received newsletters containing information on the potential consequences of excessive screen use and strategies for reducing screen time, the intervention group reported less screen time. This may be due to the type of information in the newsletters, but other strategies used in this intervention can also have caused adolescents to watch less television and spend more time on other activities. In the only treatment study that did not significantly reduce BMI (23), parental involvement was not used as an intervention strategy. The most common obstacle reported by adolescents in this study was lack of parental assistance with shopping and cooking. Apparently, these adolescents needed their parents’ support. This is in line with a study in which adolescents suggested needing parental and peer support to eat healthy (35). In the review of Golley et al. (36), the importance of engaging and supporting parents in promoting healthy weight and lifestyle behaviours in children is also stressed. Moreover, modelling of healthy behaviour by parents may also induce healthy behaviour in their children. A recent study showed that adolescents who perceived their parents to engage in healthy behaviours (diet and physical activity) were themselves more likely to eat healthier and be physically active (37).

A strength of this review is that it focused not only on intervention effectiveness, but also on its content through systematically identifying intervention strategies using a behaviour change taxonomy. Another strength is that two independent reviewers conducted data extraction, quality assessment and scoring of intervention strategies. A limitation is that no firm conclusions can be drawn based on the outcomes of the treatment studies as they all had a pre-post design. Because intervention studies on this subgroup are scarce, we decided to include studies without a control group to gather as much evidence as possible about potentially effective intervention strategies. The absence of a control group makes it impossible to infer if effects were indeed due to the intervention. Additionally, the quality of most of the included studies was moderate to weak, further preventing firm conclusions. Another limitation is that a quantitative analysis (meta-analysis) was not conducted, as included studies varied largely in intervention characteristics and follow-up duration.

In conclusion, two out of nine prevention studies and four out of five treatment studies showed beneficial intervention effects on the BMI of adolescents from disadvantaged backgrounds. Our review found no clear evidence for which strategies are particularly successful in this target group. More high quality studies are needed to enable firm conclusions regarding intervention strategies that are effective for adolescents from disadvantaged backgrounds. However, the current evidence suggests that involving adolescents in the development and delivering of interventions seems promising. Parents also appear to play an important role in facilitating a healthier lifestyle for their children. For adolescents from disadvantaged backgrounds, we also recommend to use experiential activities as opposed to didactic lessons and to deliver interventions at no or low costs to schools and students.

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Conflict of interest statement

No conflict of interest was declared.

Supporting information

Additional Supporting Information may be found in the online version of this article, http://dx.doi.org/10.1111/obr.12519

Appendix A Search strategy and results in PubMed

References

1. Bibiloni MM, Pons A, Tur JA. Prevalence of overweight and obesity in adolescents: a systematic review. ISRN Obes 2013; 27: 392747.
2. O’Dea JA. Differences in overweight and obesity among Australian schoolchildren of low and middle/high socioeconomic status. Med J Aust 2003; 179(1): 63.
3. Brug J, van Stralen MM, Te Velde SJ et al. Differences in weight status and energy-balance related behaviors among schoolchildren across Europe: the ENERGY-project. PLoS One 2012; 7(4): e34742.
4. Due P, Damsgaard MT, Rasmussen M et al. Socioeconomic position, macroeconomic environment and overweight among adolescents in 35 countries. Int J Obes (Lond) 2009; 33(10): 1084–1093.
5. Hanson MD, Chen E. Socioeconomic status and health behaviors in adolescence: a review of the literature. J Behav Med 2007; 30(3): 263–285.
6. Currie C, Molcho M, Boyce W, Holstein B, Torsheim T, Richter M. Researching health inequalities in adolescents: the development of the Health Behaviour in School-Aged Children (HBSC) family affluence scale. Soc Sci Med 2008; 66(6): 1429–1436.
7. Ball K. Traversing myths and mountains: addressing socio-economic inequities in the promotion of nutrition and physical activity behaviours. *Int J Behav Nutr Phys Act* 2015; 12: 142.
8. Cameron AJ, Thornton LE, McNaughton SA, Crawford D. Variation in supermarket exposure to energy-dense snack foods by socio-economic position. *Public Health Nutr* 2013 Jul; 16(7): 1178–1185.
9. Plachta-Danielzik S, Pust S, Asbeck I et al. Four-year follow-up of school-based intervention on overweight children: the KOPS study. *Obesity (Springer)* 2007; 15(12): 3159–3169.
10. Steinberg L, Morris AS. Adolescent development. *Ann Rev Psychol* 2001; 52: 83–110.
11. WHO regional office for Europe. 10 key facts on physical activity in the WHO European Region. In: Health topics, disease prevention, physical activity, data and statistics [WWW document]. URL http://www.euro.who.int/en/health-topics/disease-prevention/physical-activity/data-and-statistics/10-key-facts-on-physical-activity-in-the-who-european-region (accessed January 2016).
12. Michie S, Richardson M, Johnston M et al. The behavior change technique taxonomy (v1) of 93 hierarchical clustered techniques: building an international consensus for the reporting of behavior change interventions. *Ann Behav Med* 2013; 46(1): 81–95.
13. Effective public health practice project. Quality assessment tool for quantitative studies [WWW document]. 2016. URL http://www.ephspp.ca/tools.html (accessed October 2015).
14. Smith JJ, Morgan PJ, Plotnikoff RC et al. Smart-phone obesity prevention trial for adolescent boys in low-income communities: the ATLAS RCT. *Pediatrics* 2014; 134(3): e723–e731.
15. Baxter KA, Ware RS, Batch JA, Truby H. Predicting success: factors associated with weight change in obese youth undertaking a weight management program. *Obes Res Clin Pract* 2013; 7(2): e147–e154.
16. Dewar DL, Morgan PJ, Plotnikoff RC et al. The nutrition and enjoyable activity for teen girls study: a cluster randomized controlled trial. *Am J Prev Med* 2013; 45(3): 313–317.
17. Lubans DR, Morgan PJ, Aguiar EJ, Callister R. Randomized controlled trial of the Physical Activity Leaders (PALs) program for adolescent boys from disadvantaged secondary schools. *Prev Med* 2011; 52(3–4): 239–246.
18. Black MM, Hager EB, Le K et al. Challenge! Health promotion/obesity prevention mentorship model among urban, black adolescents. *Pediatrics* 2010; 126(2): 280–288.
19. Singhal N, Misra A, Shah P, Gulati S. Effects of controlled school-based multi-component model of nutrition and lifestyle interventions on behavior modification, anthropometry and metabolic risk profile of urban Asian adolescents in North India. *Eur J Clin Nutr* 2010 Apr; 64(4): 364–373.
20. Spruijt-Metz D, Nguyen-Michel ST, Goran MI, Chou CP, Huang TT. Reducing sedentary behavior in minority girls via a theory-based, tailored classroom media intervention. *Int J Pediatr Obes* 2008; 3(4): 240–248.
21. Germann JN, Kirschenbaum DS, Rich BH, O’Koon JC. Long-term evaluation of multi-disciplinary treatment of morbid obesity in low-income minority adolescents: La Rabida Children’s Hospital’s FitMatters program. *J Adolesc Health* 2006; 39(4): 553–561.
22. Rudolf M, Christie D, McElhone S et al. WATCH IT: a community-based programme for obese children and adolescents. *Arch Dis Child* 2006; 91(9): 736–739.
23. Resnicow K, Yaroch AL, Davis A et al. GO GIRLS!: results from a nutrition and physical activity program for low-income, overweight African American adolescent females. *Health Educ Behav* 2000; 27(5): 616–631.
24. Lubans DR, Morgan PJ, Okely AD et al. Preventing obesity among adolescent girls: one-year outcomes of the Nutrition and Enjoyable Activity for Teen Girls (NEAT Girls) cluster randomized controlled trial. *Arch Pediatr Adolesc Med* 2012 Sep 1; 166(9): 821–827.
25. Lindgren E-C, Baigi A, Apitzsch E, Bergh H. Impact of a six-month empowerment-based exercise intervention programme in non-physically active adolescent Swedish girls. *Health Education Journal* 2011; 70(1): 9–20.
26. Shin A, Surkan PJ, Coutinho AJ et al. Impact of Baltimore Healthy Eating Zones: an environmental intervention to improve diet among African American youth. *Health Educ Behav* 2015; 42(1 Suppl): 97S–105S.
27. Carraway ME, Lutes LD, Crawford Y et al. Camp-based immersion treatment for obese, low socioeconomic status, multi-ethnic adolescents. *Child Obes* 2014; 10(2): 122–131.
28. Lazorick S, Crawford Y, Gilbird A et al. Long-term obesity prevention and the Motivating Adolescents with Technology to CHOOSE Health program. *Child Obes* 2014; 10(1): 25–33.
29. Spruijt-Metz D. Etiology, treatment and prevention of obesity in childhood and adolescence: a decade in review. *J Res Adolesc* 2011; 21(1): 129–152.
30. Kim S, Flaskerud JH, Koniaik-Griffin D, Dixon EL. Using community-partnered participatory research to address health disparities in a Latino community. *J Prof Nurs* 2005; 21(4): 199–209.
31. What works in schools and colleges to increase physical activity? A briefing for head teachers, college principals, staff working in education settings, directors of public health and wider partners. Public Health England. 2015.
32. WHO physical activity promotion in socially disadvantaged groups: principles for action. WHO Europe. 2013.
33. Ventura AK, Birch LL. Does parenting affect children’s eating and weight status? *Int J Behav Nutr Phys Act* 2008; 5: 15.
34. Niemeier BS, Hektner JM, Enger KB. Parent participation in weight-related health interventions for children and adolescents: a systematic review and meta-analysis. *Prev Med* 2012; 55(1): 3–13.
35. Stephens LD, McNaughton SA, Crawford D, Ball K. Nutrition promotion approaches preferred by Australian adolescents attending schools in disadvantaged neighbourhoods: a qualitative study. *BMC Pediatr* 2011; 15: 61.
36. Golley RK, Hendrie GA, Slater A, Corsini N. Interventions that involve parents to improve children’s weight-related nutrition intake and activity patterns—what nutrition and activity targets and behaviour change techniques are associated with intervention effectiveness? *Obes Rev* 2011; 12(2): 114–130.
37. Zarychta K, Mullan B, Luszczynska A. It doesn’t matter what they say, it matters how they behave: parental influences and changes in body mass among overweight and obese adolescents. *Appetite* 2015; 96: 47–55.