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Special Series Review

Nutrition-Related Interventions Targeting Childhood Overweight and Obesity: A Narrative Review

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Abbreviations: BMI body mass index; HeLTI Healthy Life Trajectories Initiative; WHO World Health Organisation; RCT randomised controlled trial; AMSTAR A Measurement Tool to Assess Systematic Reviews; CI confidence interval; IOTF International Obesity Taskforce; CDC Center for Disease Control and Prevention

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ABSTRACT

Introduction: Systematic reviews of nutritional interventions indicate limited efficacy in reducing childhood obesity, but their blanket conclusions could obscure promising components. This narrative review sought more detail on effective components within nutrition-related interventions involving children aged 2-11 years.

Methods: In May 2016, the World Health Organisation (WHO) searched the Cochrane Library and PubMed for relevant reviews. From 36 reviews, we screened 182 nutrition-related randomised trials for inclusion. We then reviewed those that reported ≥1 statistically significant ($p<.05$) treatment benefit on body weight and/or composition outcomes at their longest follow up assessment.

Results: Fourteen trials met inclusion criteria (median n=554; mean intervention duration=10.8 months, follow up=4.4 months). ‘Effective’ approaches included environmental changes such as school water fountain installations and cafeteria menu changes, and possibly less sustainable strategies such as health education lessons. However, effect sizes even of these selected significant treatment benefits were modest - significant body mass index z-score effects range -0.1 to -0.2.

Conclusions: Each trial was associated with very small improvements in body composition. Because this is a ‘best-case’ scenario (reflecting our design), trialists should rigorously test these strategies alone and possibly together; be open to novel strategies; and ensure that each strategy is culturally-relevant and self-sustainable.

INTRODUCTION

Childhood obesity remains a major global health issue. Its prevalence in developed *and* developing countries(1) is causing worldwide burden on population-level health and healthcare budgets. Although very early prevention and intervention are paramount, current and historic efforts to curb obesity during childhood have met with short-lived and limited success.

Overconsumption is one of the main drivers of childhood obesity.(2) However, past reviews reveal that nutrition-related interventions lack long-term efficacy and are of mixed quality.(3-5) Moreover, a 2017 Cochrane review estimated that multicomponent interventions incorporating diet, physical activity and lifestyle behaviour change strategies have on average reduced children's body mass index (BMI) z-score by a trivial 0.06; most included trials were of low quality with insufficient follow-up periods.(6)

Thus, despite numerous systematic reviews and meta-analyses, there is little information on what individual strategies could most optimistically be selected for testing in the forthcoming complex Healthy Life Trajectories Initiative (HeLTI). Because reviews tend to draw blanket conclusions, specific and potentially important information about individual interventions can get "lost in translation". Detail is often missing on the specific context, settings and co-factors for individual components that, if tested in different combinations or settings, might prove effective. This reduction of detail does not benefit clinical knowledge translation or policy development,(5, 7) and provides little guidance to move this field forward(7) particularly as it relates to testing new approaches and their combinations.

Therefore, to inform the design of the HeLTI interventions, the World Health Organisation (WHO) commissioned this author group to critically appraise specific individual components of nutrition-related interventions that may be promising for childhood obesity. We aimed to detail the components of published *effective* nutrition-related interventions to prevent or treat overweight or obesity, focusing on children aged 2 years up to their 12th birthday.

METHOD

We conducted a narrative review of randomised control trials (RCT) with a nutrition-related component identified within systematic reviews with the aim of preventing overweight/obesity among 2- to 11-year-old children. Because the HeLTI trials have the opportunity to intervene across multiple environments using multiple strategies, our definition of "nutrition-related" was broad, pertaining to any strategy to reduce unhealthy and/or increase healthy food or drink consumption. We included non-clinical secondary prevention trials among children already experiencing overweight/obesity. Multi-component interventions were eligible only if the nutrition component was deemed substantial.

Identification of Systematic Reviews: WHO conducted the underlying search in May 2016 (Supplement 1). Of 51 potential reviews among children aged 24-59 months and 59 months to 12 years, very few reviews were in the younger age group, so the two groups were combined for this narrative review. To be included, reviews had to include at least one primary paper with an overweight or obesity-related RCT containing:

(i) a nutrition-related component;

(ii) a sample of children whose mean age was within the 2 to <12 years age range; and

(iii) at least one statistically significant ($p<.05$) desirable effect on an outcome measure related to body weight and/or composition.

We excluded reviews if they:

(i) were published in a language other than English (due to available resources);

(ii) focused on the clinical treatment of existing overweight/obesity;

(iii) focused on rare conditions, physical deformities, neurological defects, genetics or;

(iv) examined overweight/obesity as a side effect or outcome of another condition or as a contributing factor to other diseases.

Systematic Review Selection and Identification of Primary Trials: Either JAK, AL or AK screened each of the 51 reviews on title, abstract and full-text against the inclusion and exclusion criteria. Thirty-six eligible reviews were identified (Supplement 2). Then, to better understand the individual characteristics of effective interventions, we identified all relevant primary RCT papers included in the 36 systematic reviews. This resulted in 182 papers describing RCTs that either AL, AK or JAK screened on full-text for inclusion in this review. The inclusion/exclusion criteria for these primary trials were the same as for the systematic reviews (above), except that we included trials within these reviews that focused on preventive interventions in children already with established overweight or obesity. This reflects the decisions already taken by the reviews in light of the considerable overlap between nutrition-related strategies to prevent and treat obesity.

We only *included* primary RCTs:

(i) that reported at least one statistically significant treatment benefit, demonstrated by differences *between* a treatment and control group ($p<.05$) on a body weight and/or composition outcome at their longest follow-up assessment.

We further *excluded* primary RCTs:

(ii) if the mean age of the sample at baseline was ≥12 years (+/- 1 standard deviation);

(iii) if the control/comparison condition contained some attempt, other than usual care, to improve nutrition;

(iv) that assessed outcomes <6 months after the end of intervention, unless the intervention itself was >6 months, in which case any length of follow up was included (e.g. a 3-month intervention period would be excluded unless outcomes were reported ≥6 months after the intervention ended);

Fourteen RCTs were identified for inclusion (see PRISMA Flow Diagram, Figure 1); the 168 excluded papers are listed in Supplement 3.

Data Extraction from Primary Trials: AL or AK extracted relevant data from primary trials using a pre-piloted electronic tool adapted from the Cochrane data collection form for RCTs. We collected information on trial design, population, type of intervention, statistical methods, and any body weight/composition-related outcome data. A summary of these data and intervention characteristics is available in Table 1. We do not report on the quality of primary trials. However, an AMSTAR quality rating is available from the authors for the systematic reviews from which the primary trials were drawn.

To enable consistent estimates of effect to be drawn across the wide child age range, where possible we expressed change in terms of BMI z-score (recognising that there is disagreement on this), rather than raw BMI, body weight or body-weight z-score.(8) In children receiving tertiary level care for overweight or obesity, trials typically aim to reduce BMI z-score by at least 0.5 - equivalent to losing at least 5.8% body fat.(8-12) However, to a lesser extent a BMI z-score reduction of 0.25 to 0.5 among children with established overweight or obesity (equivalent to losing 2.9% to ≈5.8% body fat(8)) can still improve children's blood pressure, insulin resistance and lipid profiles.(9, 12) Agreement is wanting as to what constitutes success in preventing BMI z-score gain in a population prevention trial including children with normal weight, overweight or obesity. Therefore, we took this smallest difference between arms (0.25 BMI z-score) as evidence of effect. We report outcomes in raw BMI only when BMI z-score was not reported.

RESULTS

Fourteen RCTs met inclusion criteria (median sample size 554 children, median age 8.65 years), with summary details outlined in Table 1. All 14 used parallel group designs; 11 were multi-component interventions and nine trials involved parents. Eleven were school based, employing a cluster-randomisation at the level of school (n=10) or individual (n=1). The remaining three community-based trials randomised at the level of the individual child. One trial employed purely environmental change, two were purely educational, and the remainder employed a mixture of strategies. Thirteen trials were conducted in developed countries. Although two trials recruited only children already with overweight and/or obesity, a relatively high rate of baseline overweight and obesity was common in trials with 'healthy' populations, reflecting prevalence rates in the general population. The comparison group for 10 of the trials comprised true or usual-care controls. Interventions ranged in duration from 2-30 months (mean 10.8 months). Eight trials reported results directly after intervention, and the remaining six after post-intervention follow-up intervals ranging from 2-24 (median 9) months. Of the 10 trials that measured a nutritional outcome (not our focus), seven obtained some beneficial nutrition-related effect among intervention participants (see Table 1).

The following synthesis focusses on only the reported beneficial effects ($p<.05$ difference between treatment/control groups) on relevant body weight/composition outcomes, recognising that these could have come about by chance. Variability in both analysis and reporting standards precluded the examination of effect sizes or meta-analysis. Due to the heterogeneity of sampling and statistical procedures, the effects in Table 1 are taken directly from information reported in the papers by the trial authors. Post-intervention outcomes were adjusted for baseline values, demographics (age, gender, socioeconomic status) or age at follow up in 11 trials.

Nutrition Interventions (n=3): Here we review three nutrition-only RCTs.(13-15) Two focused on soft drinks, and the third on water consumption.

In de Ruyter et al.'s (n=641) double-blind trial, 8-10-year-old normal-weight children from elementary schools in urban Amsterdam who self-reported that they commonly consumed sugar-sweetened beverages (baseline mean: 1.0 to 1.5 per day) were assigned to consume a daily 250-millilitre can (104 kilocalories) of sugar-sweetened beverage (control group) *or* to a consume artificially-sweetened (0 kilocalories) beverage (nutrition-related intervention group) every day for 18 months. The beverages were identical in appearance and children were blinded to the condition. Parents in both conditions reported on adverse effects and were provided with trial newsletters and gifts for compliance. Teachers monitored the weekday adherence of children in both conditions and prompted weekend consumption. Adherence was also encouraged with tournaments and birthday cards. After 18 months of intervention, the school-based trial resulted in a small relative beneficial effect for BMI z-score (effect size -0.1, 95% confidence interval (CI) -0.2 to -0.1), body fat % (-1.1, 95% CI -2.0 to -0.2), fat mass in kilograms (-0.6, 95% CI -1.2 to -0.1), waist circumference in centimetre (-0.7, 95% CI -1.2 to -0.1) and skinfold thickness in centimetre (-2.2, 95% CI -4.0 to -0.4).

The other two trials in this category were also school-based, but ranged in duration from 10-11 months and did not involve parents.(14, 15) James et al (n=644) targeted children's consumption of carbonated drinks within southwestern English primary schools.(14) The intervention was education-based (i.e. carbonated drinks were not replaced) and mainly comprised lessons about the effects of sugar on dental health (i.e. educational nutrition-related component). A single one-hour lesson per term was delivered throughout the school year by their lead author, with teachers encouraged to reiterate messages subsequently. Lessons were accompanied by quizzes, art and music presentations delivered by the children. Children were urged to read additional information on the project's website. BMI and BMI z-score did not differ between groups 2 months after the end of the trial. However, the control cluster increased, while the intervention cluster decreased, consumption of soft drinks and their percentages overweight/obese (reference values: Child Growth Foundation, London), for mean group differences in soft drink consumption of 0.7 glasses per day (95% CI 0.1 to 1.3) and in percentage overweight/obesity of 7.7% (95% CI 2.2 to 13.1).

Muckelbauer et al.'s educational and environmental intervention (n=2950) targeted increased daily water consumption at socially-deprived schools in Germany.(15) Deprived (i.e. disadvantaged) areas were defined as those with unemployment rates ≥15%, proportion of social welfare recipient's ≥5%, and proportion of non-German resident's ≥5%. This controlled cluster trial was 11 months in duration, with school randomisation implemented at the city level. At baseline, control and intervention schools consumed an average of 3.0 to 3.4 glasses of water per day, around 1.6 to 2.0 glasses below recommendations for 8-year-old children.(16) Control schools did not receive any intervention. Water fountains were installed at intervention schools (1 fountain per 150 participants) to increase consumption (i.e. environmental nutrition-related component), but it is unclear if any schools already had fountains and/or whether these were replacement or entirely new fountains. The fountains delivered cooled plain or carbonated water and participants were also given a 500-millilitre water bottle that they were encouraged to fill every morning. This bottle was replaced with a new design after 5 months. The educational nutrition-related component consisted of four teacher-delivered 45-minute sessions that were based on the theory of planned behaviour and focused on the importance of drinking more water throughout the day and why the human body needs water. After 3 months, teachers provided booster educational sessions designed to increase children's water consumption goals. Water consumption increased significantly more among children within intervention compared to control schools (effect 1.1 glasses per day, 95% CI 0.7 to 1.4). The odds of intervention group children being overweight (International Obesity Task Force IOTF cut points) was 31% lower than control group children, but no mean group difference was seen in BMI z-score.

Summary: Each of these diverse strategies produced either small mean improvements in BMI z-score or reductions in overweight/obesity without mean BMI z-score differences (suggesting the impact was mainly at the high end of the BMI distribution).(8-12) Perhaps a combination of several of the reviewed strategies would produce larger clinically relevant results, but this awaits rigorous testing.

Multi-component Interventions: Due to the larger number of multicomponent trials, this category has been divided into school and community settings.

Elementary school-based interventions *(n=6)****:*** Six school-based cluster RCTs (unit of randomisation: schools) that reported beneficial effects.(17-22) Children ranged from 8-12 years old and were of varied ethnicity. Intervention duration ranged from 8-30 months, with sample sizes ranging from 201 to 2489.

In consultation with a community-based organisation, Foster et al. designed a multicomponent 2-year school policy initiative to implement the Center for Disease Control and Prevention (CDC) Guidelines in a low socio-economic area of Philadelphia (n=1349).(22). Control schools received no intervention, while intervention schools received changes to their nutrition policy (e.g. updates to cafeteria and vending machine options) and nutrition and physical activity education (i.e. nutrition-related environmental and educational components). The intervention also incorporated nutrition and physical activity challenges, social marketing and parent outreach. School staff were actively involved in the design and delivery, and were supported by 10 hours training per year. Nutrition education was incorporated into multiple school subjects and policies ensured that foods available within school met American nutritional guidelines. Students were rewarded for purchasing or bringing healthy foods to school with raffle tickets and prizes. In addition, a 2-1-5 challenge was set for students which encouraged ≤2h sedentary behaviour per day, ≥1h daily activity and ≥5 daily servings of fruit/vegetables. Meetings, workshops and report-card evenings were delivered to parents in the intervention group by nutrition educators. This trial used CDC growth charts to determine participants' BMI z-scores and percentiles, and classified BMI status according to the Institute of Medicine (overweight: 85-94.9th percentile, obesity: ≥95th percentile). At the conclusion of the trial the incidence and prevalence of overweight (but not obesity) decreased within intervention schools (prevalence odds ratio (OR) 0.7, 95% CI 0.5 to 0.8, incidence OR 0.7, CI 0.5 to 1.0), but the two groups remained similar on multiple measures of nutrition and BMI/z-score.

Jiang et al.(20) delivered a large 30-month intervention in Beijing (n=2489) which incorporated ten teacher-led nutrition education and physical activity sessions for intervention group children within school hours, coupled with nutritional education sessions and materials for parents. Parent sessions focused on the food pyramid, healthy lifestyles (e.g. consuming less Western fast food, decreasing screen time) and health consequences of childhood obesity. Children already with overweight/obesity attended extra lessons on health behaviours and participated in twice weekly running events after class. The parents of those children already with established overweight/obesity were also offered additional education sessions to encourage healthy habits at home (e.g. reduce overeating, implementation of a traffic light diet colour coding healthy/unhealthy foods, walking after dinner). The control group followed normal school curriculum. Directly following the trial, the prevalence of overweight and obesity (IOTF cut points) had decreased by around 40% within intervention, compared to control, schools (ORs 0.6, 95% CIs 0.4 to 0.8). The control (20.3 +/- 3.4) and intervention (18.2 +/- 2.6) schools' mean BMI differed by 2.1 units, representing a 0.6 unit rise within intervention schools and a 2.5 unit rise within control schools.

Three other interventions were activity based. Over a 9-month trial period (n=450), in consultation with the community, Greening et al. designed monthly family events for one intervention school in rural Mississippi. Nutrition-related components were both educational, activity-based and environmental. Events alternated between physical and nutritional activities such as preparing healthy foods for community events and sports competitions coinciding with community sports.(21) In addition, this intervention made environmental changes to school food services (e.g. deep fryer replacement). Children at the control school continued to receive their standard curriculum. At the conclusion of the trial, although no differences were obtained between control and interventions schools' BMI percentile (CDC reference values) and waist circumference, for children in the intervention school their percentage body fat reduced from 26.2% to 25.6%, while it remained stable among control school children.

Two other activity-based cluster RCTs conducted by Barbeau et al.(17) and Yin et al.(18) were developed by similar study teams in Georgia, USA. Both intervention groups received after-school programs delivered by trained school teachers assisted by research staff; they targeted daily physical activity and provision of healthy snack foods (i.e. nutrition-related component). The control schools did not receive any contact. Barbeau et al.'s intervention targeted African-American school girls and provided rewards for participation, attendance and effort, and both trials offered monetary incentive for completing postassessment measures. Neither intervention involved parents. Although both trials encouraged regular attendance by providing complementary transport home, overall attendance was only ≈50%. At the conclusion of the trial, Yin et al.'s 8-month intervention (n=601) did not result in between-group differences in BMI, waist circumference, fat mass or fat-free mass; however, the intervention group had significantly reduced percentage body fat (effect -0.8, 95% CI -1.4 to -0.1). In comparison, though no differences were obtained for children's waist circumference or fat-free soft tissue, Barbeau et al.'s 10-month intervention (n=201) did yield positive effects for BMI (effect -0.5, 95% CI -0.8 to -0.1), percentage body fat (-2.0, 95% CI -3.0 to -1.0), fat mass (-1.3, 95% CI -2.0 to -0.6) and visceral adipose tissue (-14.6, 95% CI 24.2 to -5.1).

The sixth trial compared the efficacy of five simultaneously-run 9-month interventions in Australian children aged 10-12 years (n=1147).(19) Control group children received their normal school curriculum. All interventions were delivered via the school setting with differing areas of focus: school-based fitness education/activities, school-based fitness education/activities and nutrition education, school-based nutrition education only, school-based nutrition education and home-based nutrition education and activities, home-based nutrition education and activities only. The nutrition interventions aimed to increase children's daily consumption of fibre to 25 grams and limit daily intake of fat to 33% of total energy consumption and sugar to 12%. The school-based nutrition education intervention was delivered by trained teachers and included ten lessons to improve eating habits, knowledge and attitudes. The home-based nutrition intervention included information for the children and their parents, who were encouraged to help children prepare healthy recipes and complete their related homework. Fitness sessions comprised six health-education lessons about the importance and physiology of physical activity and daily 15-minute exercise sessions delivered by trained teachers. Activities increased in intensity and duration throughout the intervention and children were encouraged to remain active outside school hours. Although some positive results emerged for nutrition-related measures and for tricep skin-fold thickness (-0.5 millimetre following the combined school-based fitness and nutrition intervention), no intervention effects were obtained for BMI, percentage body fat, or subscapular skin-fold thickness. Groups that received only nutritional interventions had similar outcomes to control children.

Preschool-based interventions *(n=2):* Our review yielded just two trials conducted in young children (2-5 years-old). Fitzgibbon and colleagues' short 3.5-month intervention was tested in 409 healthy African American pre-schoolers from low socioeconomic backgrounds.(23) Paediatricians, community health advocates, physiologists, nutritionists, early childhood educators, minority health experts and community members all contributed to the development of this intervention. The trial featured classroom activities promoting healthy nutrition and physical activity, parent lectures and take-home materials. The intervention group received three weekly 40-minute sessions, each divided equally into 20-minutes of physical activity and 20-minutes of physical health/nutrition education led by trained teachers and handheld puppets (i.e. nutrition-related component). Parents received newsletters matching the content of their child's lessons and completed homework each week, incentivised by a grocery coupon. Staff training was intensive, and regular checks ensured delivery integrity. Control group children received general health education sessions that did not focus on diet or physical activity (e.g. dental health) and parents received generic health-related newsletters. Significant between-group differences for nutritional measures at 1-year follow up dissipated by 2-year follow up. Nevertheless, control and intervention schools differed in BMI (effect -0.5, 95% CI -1.0, -0.1) and BMI z-score (effect -0.2, 95% CI -0.3, -0.0) at the 2-year follow up.

Nemet et al.'s health promotion trial recruited preschool aged Arab-Israeli children (mean age 5.4, n=203) in Israel.(24) Eleven kindergarten schools were recruited from communities with low-socioeconomic status in central Israel. This intervention was delivered over one school year and designed in consultation with dietitians, exercise coaches and physiologists, paediatricians and school staff; special effort was made to include Arab educators and dieticians. The study team trained teachers to deliver most aspects of the program, with teacher booster training delivered twice during the intervention. Control schools continued to receive their usual school curriculum, whereas children within the intervention schools received in-school nutrition-based education sessions and participated in a physical activity program. The nutrition intervention was based on a program developed by the Israeli Ministry of Education and included topics such as healthy choices, food preparation, contents of popular Israeli foods dietary considerations during holidays and excess food during celebrations, vacations and at restaurants. Sessions were tailored to suit the children's developmental level and delivered via short lectures, storytelling and games. Each month, children were also given nutritional information sheets to take home and discuss with their parents. The physical activity sessions were game-based (20% team sport: 80% running games) and totalled 45 minutes per day for 6 days a week; after-school activity was also encouraged. Once a week, sessions were directed by a youth coach, but were otherwise teacher-directed. Intervention adherence was monitored weekly. Children and parents also attended two health festivals, in which lectures and games focused on the major themes of the intervention. 12 months after the end of the intervention, a decrease in BMI percentile was greater among intervention (69.4 to 61.5) than control group children (61.1 to 58.5). However, it is not clear whether baseline percentile differences were accounted for in this analysis.

Summary: Of the many school-based obesity interventions in the literature, only a handful resulted in beneficial, yet very small, effects which are unlikely to be classed as clinically significant.(8-12) All eight trials followed a relatively similar structure and a qualitative assessment failed to reveal any clear reasons underlying their efficacy. The after-school programs without parental involvement and with relatively low attendance were somewhat effective, and simpler interventions seemed as effective as those targeting multiple systems (policy, education, environment, family, individual).(17, 18, 22) While intervention duration was not a clear predictor of outcome, the shorter interventions tended to be conducted more intensively with more frequent sessions. To some extent this suggests that trialists may trade duration for intensity. Finally, although school-based interventions dominate this literature, it is now known that children (particularly children with obesity) gain a substantial amount of their weight after school time and in the holidays.(25, 26) Therefore, any small changes that are produced by school-based interventions are unlikely to be cumulative and long-lasting unless intervention is continuous and sustained throughout school holiday breaks.

Community-based interventions (n=3): These three interventions were group-based in community settings, involved parents, were based in the USA, and had relatively small sample sizes (<100) and short duration (2 to 4 months).(27-29) They frequently involved multiple components such as educational and participatory activities for children, parents and families. Two of these three interventions targeted only children already with overweight/obesity.

Chen et al. conducted a 2-month trial based on social cognitive theory (n=67) with Chinese-American families in the San Francisco Bay Area (≈50% of the sample were overweight/obese).(27) Families of normal and overweight children (CDC) were randomly assigned to the intervention or waitlist control group. Separate group sessions for children and parents focused on building children's self-efficacy, led by bicultural/bilingual researchers and dietitians. Children's weekly sessions comprised 30 minutes of education regarding nutritional and physical activity and 15 minutes of non-competitive physical activity. Children also received a pedometer, activity diaries and books. Parents attended two 2-hour sessions aimed at supporting children's healthy behaviour. Attendance was encouraged with gift certificates. Participation targeted two adults per child. Six months following the trial end, intervention-group children had decreased their BMI (effect -0.2, 95% CI -0.2 to -0.1) and improved their nutrition, but no changes were evident for waist circumference.

Israel et al. conducted a 2-month education-based trial with 33 children at least 20% over their ideal weight (defined as the weight expected for the child's height, weight, sex).(28) The intervention group children and parents received a multicomponent intervention, with or without additional pre-treatment parent training on behavioural child management skills. Weekly group sessions were conducted by psychology students, separately for children and parents. Sessions focused on behavioural weight reduction strategies, with content (e.g. stimulus control cues, regulation of food intake) individualised for each family. Phone support was available for parents to encourage the completion of homework, increase motivation and to provide further individualisation to the treatment program. Although parents were responsible for monitoring children's behaviour, self-monitoring was encouraged among children who were deemed capable. Compared to waitlist controls 12 months after the trial ended, skinfold thicknesses were similar between groups. Children whose parents received pre-treatment training and the multicomponent intervention reduced from on average 45.8% to 38.7% being overweight (controls 56% to 55.1%).

Janicke et al. conducted a 4-month trial among 93 children already with overweight or obesity (>85th percentile for age and sex) and parents in a rural community of the USA.(29) Families were assigned to one of three conditions: waitlist control, parent-only intervention, or family (parent/child) intervention. All intervention children and parents were asked to monitor their food intake. Dietary intake was guided by a modified traffic-light diet (e.g. unhealthy foods are colour coded red = stop); they were also provided with pedometers and encouraged to follow a program to gradually increase their steps. They all received sixteen 90-minute health education sessions on nutrition, physical activity and behaviour management. Sessions were led by psychology graduates and nutrition specialists who received booster training midway through the trial. Self-monitoring and goal setting were individualised for each family, who worked with interventionists to achieve their own activity and nutrition targets. Depending on the intervention condition, the health and goal setting sessions were delivered to parents only (parent-only intervention) or separately to parents and their child (family intervention). Although there were no differences on nutrition-related outcomes 6 months after the intervention, children in both intervention groups had slightly lower BMI z-scores than did children in the waitlist control group (parent-only intervention effect -0.1, 95% CI -0.0 to -0.2; family intervention effect: -0.1, 95% CI -0.0 to -0.3).

Summary: Compared to the school-based interventions, these community-based interventions were shorter, smaller in sample size, and parent involvement appeared to be more concentrated in after school hours - often the parents were offered skill development as well as the children. Although the trials were short, they generally incorporated intensive and highly-individualised weekly or bi-weekly group sessions with a specialist (i.e. not a school teacher).

DISCUSSION

Statement of principal finding and recommendation: Overall, the 14 trials included in this review resulted in small, but beneficial treatment effects. ‘Effective’ approaches included environmental changes such as school water fountain installations and cafeteria menu changes, and strategies that are possibly less sustainable such as health education lessons and motivational activities. However, even these selected ‘effective’ trials had very modest effects (e.g. statistically significant BMI z-score effects range -0.1 to -0.2) that would seem unlikely to produce clinically meaningful health improvements, even at the population level.(8-12) The possible exceptions were the three interventions that reduced overweight and/or obesity prevalence by 30-40% - two of which included noteworthy environmental change.(15, 20, 22) Figures 2-4 visually compare the main results (extracted from Table 1) across all trials. Visual inspection of these figures makes it clear that the mean BMI/z-score changes are very small, yet the reduction of overweight and obesity rates are relatively large. This pattern implies that intervention (at least those within this review) are having their greatest effects amongst those children at the upper end of the BMI distribution with already established overweight or obesity. However, due to the nature of our methodology, it is possible that the identified strategies within this review are chance findings and we suggest that future trials consider simultaneously and rigorously testing the diverse strategies pinpointed by our investigation within different cultures and contexts (e.g. sustainable environmental changes, school policy changes).

Comparison with prior literature: Similar to systematic reviews and meta-analyses in this field,(3, 4, 6) we found that nutrition-related obesity interventions can report modest successes. Also in line with previous research,(30) the reviewed interventions were dominated by “common-sense” lifestyle strategies that targeted children’s nutrition and physical activity via education. This is unfortunate, given that previous research demonstrates that education-based interventions achieve short-lived success.(31-33) Nonetheless, within these 14 trials, such strategies were usually coupled with other activity-based or broader environmental changes. In fact, we only reviewed two purely education-based interventions,(14, 28) perhaps indicating that few such interventions produce long-term reductions in childhood overweight or obesity and thus did not meet our inclusion criterion of efficacy.

Cauchi et al.'s recent overview of systematic reviews of childhood obesity prevention interventions with environmental components summarised small, but positive effects for longer intervention duration, parental involvement and community involvement.(5) Their results were inconclusive when studying environmental intervention within schools – perhaps a result of children's weight gain out of school.(25, 26) The four trials in our review with environmental components(13, 15, 21, 22) do not closely align with Cauchi et al.'s findings. We cannot pinpoint greater effects to intervention duration, parental involvement or setting.

Strengths and weaknesses: The review was strengthened by our systematic approach to the literature and by our attempt to unpick the key elements of successful interventions. Consequently our evidence is restricted to trials that obtained at least one beneficial outcome effect. Thus, the positive findings on which this review selectively focused may represent the extreme positive end of a spectrum of efficacy for each strategy, with other trials that generated null findings for the same strategy excluded by our criteria. We acknowledge that similarly-designed trials in the literature have produced null findings. Taking this into account, the small effect sizes for each strategy - even for the most positive trials - are of concern. Nonetheless, endeavours such as the HeLTI trials need some positive starting point on which to build their future rigorous trials.

Lack of an agreed standard against which to measure 'success' for preventive interventions is a limitation that is broader than this review, particularly for preschool children. The criterion used in clinical trials (>0.5 difference in BMI z-score change) is based on weight loss among children already with overweight or obesity at an older age range than the children in our review.(8-12) However, even the much less ambitious yet still arbitrary ‘population’ criterion (>0.25 difference in BMI z-score change) was never met by the trials in this review. As mentioned, differences in rates of overweight and obesity were more marked, suggesting that effective interventions may tend to show differential benefit for those of higher BMI.

Future directions: Several areas of research seem to deserve greater attention: interventions for very young children; high-quality trials in developing countries; and economic evaluation. Similarly, relatively few trials were conducted outside of school hours and premises, and none during the school holidays – the very period during which new evidence suggests weight gain predominantly occurs.(26) We were also surprised by the lack of new and/or novel approaches (e.g. home-based, school-based or community-based nudges such as substituting children’s dishware (34)) that were tested to tackle childhood obesity.

Unfortunately, childhood obesity trialists and policy makers continue to repeat interventions that have already demonstrated weak and short-lived effects. If we hope to better serve our next generation of children, there is a great need to carefully examine the literature on null trials before beginning work on intervention design.(35) We also wish to highlight that impressive longitudinal datasets are now available to all researchers in many countries. These rich datasets make possible causal modelling approaches to obesity research that may approximate the impacts of interventions, using real data for children of different ages and circumstances. There are calls for future childhood obesity trials to draw on such data and conduct real-world testing of these causal models.(35)

Implications and recommendations: Unlike a systematic review or meta-analysis, we aimed to pinpoint specific strategies that might enhance the success of childhood obesity interventions. We do not consider any of the mean effects across the 14 trials large enough to produce clinically relevant metabolic benefit,(8-12) although this could have been the case for the interventions that resulted in 30-40% reductions in overweight and obesity.(15, 20, 22) Therefore, in isolation, the reviewed trials may mitigate the current epidemic, but would not solve it. In our view, employing any one of the reviewed interventions or strategies would most likely shift children's body weight only marginally and temporarily.

Nevertheless, the multitude of small incremental benefits obtained in this review should not be overlooked. In our view, the four environmental changes made to school environments (installing water fountains, replacing sugar-sweetened beverages, replacing the cafeteria's deep fryers, and changing the contents of vending machines and cafeteria menus (13, 15, 21, 22)) are sustainable and perhaps could produce larger long-term changes if employed in unison and extended to community and home environments. (For additional environmental strategies, see Cauchi et al.'s review of environmental components within childhood obesity interventions.(5)) However, it also important to consider culture and context. For example, water fountains are already commonplace within Australian schools, yet overweight and obesity are rife. Nonetheless, their adoption may benefit socially-disadvantaged schools in some other countries.(15) Strategies such as educational initiatives, one-time activity/cooking tournaments or festivals, phone support and booster sessions are resource-heavy and may not be sustainable.(30-33) We therefore recommend that any educational initiatives similar to those reviewed here be coupled with simultaneous environmental change across multiple systems within the community, school and home.(5)

Conclusion: Several different environmental and educational strategies were associated with small positive benefits in body composition. Because even this is likely a 'best-case' scenario (reflecting this narrative review's design), we recommend that HeLTI, and other, trialists work to ensure that each trial component is self-sustainable and culturally relevant for its own community, and reaches multiple settings. Finally, trialists should continue to be open to completely novel strategies.

Author contributions

MW and KJA oversaw this narrative review. JAK, AL, AK and JJK developed the data extraction form; JAK, AL and AK screened the systematic reviews and primary RCT papers for inclusion and extracted data. AK generated figures and tables. JAK wrote the first draft of the manuscript, which all authors read, contributed to and approved for submission.

Supporting information

Supplementary information may be found in the online version of this article.

1 Search conducted by the World Health Organisation

2 Included and Excluded Systematic Reviews

3 Primary Papers Excluded

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Table and Figure Legends

Figure 1: PRISMA flow diagram

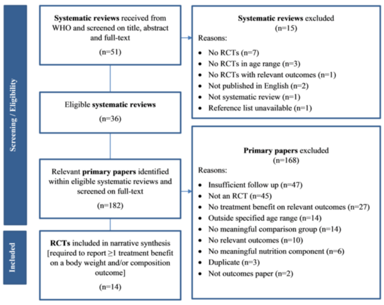
Table 1: Characteristics of eligible trials

Figure 2: BMI z-score change by trial (numbers in parentheses correspond to RCT reference)

Figure 3: Raw BMI change by trial (numbers in parentheses correspond to RCT reference)

Figure 4: Relative reduction in overweight/obesity prevalence by trial (numbers in parentheses correspond to RCT reference)

Figure 1: PRISMA flow diagram



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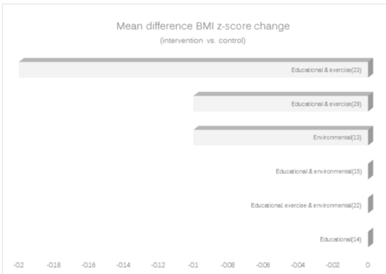

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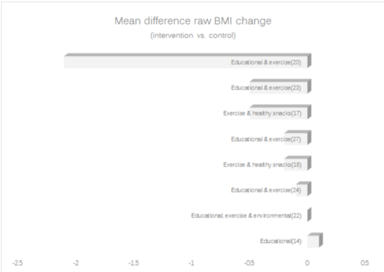

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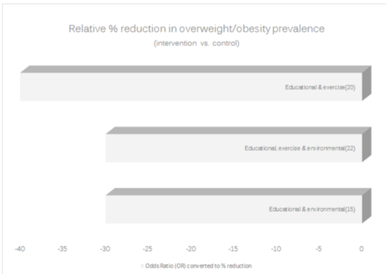

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