School-based Obesity Prevention Programs: An Evidence-based Review

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Objective: This review seeks to examine the effectiveness of school-based programs for reducing childhood overweight or obesity.
Methods and Procedures: A systematic review of the research literature published since 1990 was conducted to identify experimental or quasi-experimental school-based curricular or environmental preventive interventions, with evaluation ≥6 months after baseline, which reported outcomes in terms of a measure of overweight.
Results: Fourteen studies were identified, including one involving a nutrition-only program, two physical activity promotion interventions and eleven studies combining nutrition and physical activity components. Most studies (n = 10) offered weak (grade 2) quality evidence. One study offered strong (grade 4) evidence reducing the odds ratio for overweight in girls only, while four grade 2 studies reported significant improvements in BMI or at-risk-for overweight or overweight prevalence in boys, girls, or both. Twelve studies reported significant improvement in at least one measure of dietary intake, physical activity, and/or sedentary behavior.
Discussion: Our ability to draw strong conclusions as to the efficacy of school-based obesity prevention programs is limited by the small number of published studies and by methodological concerns. Qualitative analysis suggests programs grounded in social learning may be more appropriate for girls, while structural and environmental interventions enabling physical activity may be more effective for boys. High-quality evaluation protocols should be considered essential components of future programs.

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INTRODUCTION

Data from the 2003–2004 NHANES survey indicated 17.1% (95% confidence interval = 14.7–19.5) of US children were overweight while 33.6% (95% confidence interval = 30.1–37.1) were considered at-risk for overweight. Significant increases in the prevalence of at-risk-for overweight and overweight among children and adolescents aged 2–19 were reported from 1999–2000, 2001–2002, and 2003–2004 (1). Childhood BMI has been shown to correlate with adult BMI, and this relationship tends to strengthen with increasing child age (2–7). Increased BMI in youth has been associated with adverse risk factors for adult disease as well as morbidity and mortality in adulthood (2,8–14). There is evidence these incremental risks may be independent of adult BMI (2,15), thus preventing the development of overweight prior to adulthood may be an effective means of avoiding these undesirable health outcomes.

The role of schools

In 2005, 42 states introduced legislation designed to provide nutritional guidance to schools, and these statutes were enacted in 21 states. Bills offering guidance for physical education or activity levels in schools were introduced in 44 states and passed in 22. Nineteen states proposed some form of child BMI reporting to parents, and three states enacted such programs (16).

A recent nationwide survey found parents cited schools more frequently than health care providers and the government as having "a lot of responsibility" to reduce childhood obesity. Parents themselves, the media, and individual children were also commonly identified (17). Up to 65% of parents feel schools should play a major role in efforts to curb obesity (18). The vast majority of US children are schooled outside the home, thus the education system provides an established infrastructure for targeted implementation of childhood public health interventions. Schools offer access to children, the facilities requisite for classroom or physical education interventions, and the personnel capable of being involved in such efforts (19).

In light of this recent legislative trend of action and increase public awareness of childhood and adolescent obesity, there have been several recently published review articles (19–24) as well as a set of guidelines (25) addressing school-based

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obesity prevention programs within broader discussions of issues related to obesity. No conclusive evidence of benefit or lack thereof has been demonstrated for school-based approaches to obesity prevention, and there has been limited ability to identify intervention components offering more promising outcomes. This review seeks to provide a focused evaluation of the quality and results of long-term school-based obesity prevention programs and to offer guidance for future investigations into this intervention modality.

METHODS AND PROCEDURES

To examine the efficacy of school-based programs for improving weight status in children, a systematic review of the research literature was conducted. Studies were located through a search of items published from 1 January 1990 through 31 December 2005 of PubMed, Biological Abstracts, and Education Abstracts. Search terms included SCHOOL, OBESITY, OVERWEIGHT, WEIGHT, PREVENTION, NUTRITION, PHYSICAL ACTIVITY, TRIAL, BMI, BLOOD PRESSURE, CHOLESTEROL, ENVIRONMENT, CHILD, ADOLESCENT, FOOD CHOICES, METABOLIC SYNDROME, and combinations thereof. Other studies were sought and identified through references from previous review articles and primary publications as well as personal communication with researchers experienced in the field of obesity. Changing secular trends in overweight and obesity suggested data from the NHANES-3 and -4 periods were most representative of the current prevalence of overweight in children (26). To meet the inclusion criteria, studies were required to (i) be experimental or quasi-experimental design, (ii) report primary or secondary outcomes in terms of BMI, a measure of body fat or obesity/overweight prevalence, (iii) report outcomes at least 6 months post-baseline, (iv) be curricular and/or environmental (as opposed to extracurricular) in design, and (v) apply preventive interventions involving both overweight and normal-weight children. Frequent causes of exclusion included extracurricular delivery of the intervention program, specific targeting of overweight children for inclusion, and inadequate duration (final evaluation <6 months after baseline).

The principles of evidence-based medicine and use of evidence-based medicine criteria to analyze the strengths and weaknesses of studies have been thoroughly discussed elsewhere (27–29). This review adopts the criteria developed by the GRADE working group (27,30). Briefly, the design of a study, methodological strengths and weakness, and significance of the findings are used to characterize the evidence quality of a given study. A baseline grade of 1–4 was given to a study according to its design, and this grade was then adjusted based on features including confounders, sample size, power, directness, statistical techniques, and effect size (**Table 1**). Strong methodology and a large treatment effect not likely diminished by possible confounders increased the grade of studies, while concerns related to sources of bias, statistical techniques, and the validity of findings decreased the grade. Each study was assessed independently in the context of 15 criteria relating to these issues by two of the authors; any inconsistencies were settled by consensus discussion among these authors (**Table 2**). Specific concerns related to individual studies are indicated in **Table 4**. Consensus in assignment of overall grading score was uniform between the two raters.

Table 1 Grading the evidence

Quality of evidence	Base grade	Study design
High	4	Randomized controlled trial
Moderate	3	Quasi-experimental trial
Low	2	Observational study
Very low	1	All other evidence
	Grade modification	**Study characteristics**
Weaken evidence	−1	•Serious design limitation (i.e., significant baseline differences, failure to follow intention to treat protocol, high level of attrition)
		•Some uncertainty of directness (i.e., questionable validity of instruments/techniques)
		•Sparse data
		•High probability of reporting bias
		•Uncertainty of external validity
		•Internal inconsistency
	−2	•Very serious design limitations
		•Serious uncertainty of directness
Strengthen evidence	+1	•Strong association without plausible confounders, consistent, and direct evidence
		•All plausible confounders would have diminished effect size

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Table 2 Features assessed for scoring

Means of randomization
Randomization concealment
Study power
Cluster number and size
Differences in baseline covariates
Adjustment for baseline covariates
Blinding of data collectors to intervention status
Attrition
Subjective measures
Validity of measures
Intention to treat protocol
Unit of analysis
Subgroup analysis
Treatment effect
External validity

RESULTS

Fourteen studies were found to meet the inclusion criteria. One (31) reported an intervention with only a nutrition component. Two trials (32,33) evaluated interventions involving only physical activity components. The remaining 11 studies assessed programs with both nutritional and physical activity components. Study design and intervention characteristics are summarized in **Table 3**. One grade 4 study was identified (**Table 4**). Three studies offered grade 3 level evidence while the remaining 10 studies were considered weak evidence.

Nutrition vs. control

One small randomized controlled trial (RCT) set in the United Kingdom evaluated a program designed to reduce intake of carbonated beverages (31). Compared to

Table 3 Overweight and health behavior outcomes for school-based obesity prevention programs

Study	Design	Subjects	Ages	Duration	Program features	Evaluation	Attrition
Nutrition only							
James *et al.* (31)	RCT	644	7–11	1 Year	One hour lesson each term with focus on reducing carbonated beverages and benefits of a healthy diet	BMI; diet recall	26%
Physical activity only							
Sallis *et al.* (32)	RCT	740	8–12	3 Years	(i) Intervention (3 × 30 min classes with focus on stretching, muscular strength and cardiovascular endurance) led by PE specialist (ii) Intervention led by classroom teacher (iii) Usual curriculum control	BMI; mile run; sit-up test	26%
Mo-Suwan *et al.* (33)	RCT	292	4–5	30 Weeks	(i) 15 Min walk before class, 20 min dance/aerobic program in afternoon × 3 days/week (ii) Usual curriculum control	BMI; TSF	5.30%
Nutrition and physical activity							
Gortmaker *et al.* (34)	RCT	1,295	11–13	18 Months	Intervention 32 lessons with goals to (i) reduce TV viewing to <2 h/day, (ii) Increase MVPA, (iii) decrease consumption of high-fat foods, (iv) Increase fruit/vegetable consumption to 5 servings/day Usual curriculum control	BMI; TSF; FFQ; activity questionnaire; television and video measure	14–19%
Caballero *et al.* (35)	RCT	1,704	8–11	3 Years	Intervention (i) reduce energy from fat in school lunches to <30%, (ii) 64 × 45 min classroom lessons delivered twice weekly for certain portions of the year, (iii) 3 × 30 min PE sessions per week, (iv) family involvement Usual curriculum control	BMI; % body fat (%BF); activity questionnaire; accelerometry; diet recall; observation	17%
Luepker *et al.* (36), Nader *et al.* (37)	RCT	5,106	7–10	3 Years, 6 years	(i) Foodservice intervention to reduce energy from fat to <30% in school lunches, sodium to <600–1,000 mg/day, PE intervention to increase MVPA to >40% of class time, 55 × 30–40 min classroom lessons (ii) Foodservice, PE, classroom + family component with 19 activity packets and family fun nights (iii) Usual curriculum control	Serum cholesterol; SOFIT; health behavior questionnaire; diet recall; activity questionnaire; TSF; BMI; 9 min run	28%
Coleman *et al.* (38)	CCT	896	7–9	3 Years	CATCH program adapted at classroom level vs. usual curriculum control	BMI; 9 min run; SOFIT; observation	17%
Sallis *et al.* (39)	RCT	26,616	10–14	2 Years	Intervention (i) availability of harmful/protective products/services; (ii) physical structures; (iii) social structure and policies; (iv) media and culture messages; daily PE Usual curriculum control	SOFIT; observation; FFQ; activity questionnaire BMI	20% For survey
Sahota *et al.* (40)	RCT	634	7–11	10 Months	Intervention individual action plans developed by schools to promote physical activity and eating habits Usual curriculum control	BMI; diet recall; food diary; activity questionnaire	6% For BMI, 36% for diet recall

Table 3 continued on next page

Table 3 (continued)

Study	Design	Subjects	Ages	Duration	Program features	Evaluation	Attrition
Warren *et al.* (41)	RCT	218	5–7	14–16 Months	(i) Eat smart—nutrition education	BMI; TSF; parent activity questionnaire; diet recall; parent FFQ	21%
					(ii) Play smart—PE focus on increasing activity in daily living and reducing TV viewing		
					(iii) Eat smart/play smart—nutrition and PE		
					(iv) Be smart—control program with focus on food processing and traditions		
Donnelly *et al.* (42)	CCT	338	7–10	2 Years	Intervention with foodservice, nine education sessions delivered by classroom teachers, and PE 30–40 min × 3 days/week with focus on large muscle group use	BMI; %BF; 1 mile run; activity questionnaire; SOFIT; diet recall; serum lipids	Not reported
					Usual curriculum control		
Muller *et al.* (43), Danielzik *et al.* (44)	RCT	414	5–7	1 Year, 4 years	Intervention with focus on (i) daily fruit and vegetable consumption; (ii) reduce intake of high fat foods; (iii) keeping active each day; (iv) limiting TV time to <1 h/day	BMI; TSF; %BF; FFQ; activity questionnaire; calorimetry	Not reported
					Intervention + family counseling sessions		
					Usual curriculum control		
Kain *et al.* (45)	CCT	3,086	8–14	6 Months	Intervention with nutrition education, 90 min weekly PE, active recess and Canadian Active Life Challenge	BMI; TSF; waist circumference; sit-and-reach; 20 yard shuttle run; FFQ; activity questionnaire	13.70%
					Usual curriculum control		
VanDongen *et al.* (46)	RCT	1,147	10–12	1 Year	(i) Fitness—6 × 30 min lessons + 15 min daily exercise	BMI; BP; TSF; Leger run; food diary; serum cholesterol	17%
					(ii) Fitness + school nutrition with 10 × 1 h lessons with focus on food knowledge and influencing eating behaviors		
					(iii) School nutrition		
					(iv) School nutrition and home nutrition with comic materials for children and reading material for parents		
					(v) Home nutrition		
					(vi) Usual curriculum control		

CATCH, Child and Adolescent Trial for Cardiovascular Health; CCT, cohort concurrently controlled trial; FFQ, food frequency questionnaire; MVPA, moderate-to-vigorous physical activity (3–6 METS); PE, physical education; RCT, randomized controlled trial; SOFIT, System for Observing Fitness Instruction Time (ref. 52); TSF, triceps skinfold thickness.

baseline, there was a significant reduction in carbonated beverages of 0.7 drinks/3 days; however, BMI outcomes were not reported.

Physical activity vs. control

Two studies compared physical activity interventions to usual curriculum controls. The first, a grade 2 study set in California achieved a significant improvement in moderate-to-vigorous physical activity time of 13–16 min during physical education; however, there was no effect for measures of overweight (32). The second, a grade 3 study involving kindergarten children in Thailand found a significant reduction in girls odds ratio for increased BMI (33). No other measures of overweight achieved significance.

Combined nutrition and physical activity vs. control

Eleven studies compared various combinations of nutrition and physical activity interventions compared to controls. One grade 4 study (34) of middle-school students in Boston showed a significant reduction in girls overweight percentage with an adjusted odds ratio for overweight of 0.47. The authors reported this effect was mediated by a reduction in television viewing among intervention girls. A grade 3 (35) study involving

Table 4 Overweight and health behavior outcomes for school-based obesity prevention programs

Study	Effect for overweight	Effect for health behaviors	Limitations	Grade
Nutrition only				
James *et al.* (31)	Overweight prevalence decreased 7.7%, significance not reported	−0.7 Carbonated drinks/3 days (95% CI = 0.1–1.3)	Underpowered for BMI; possible intercluster outcome correlation due to spread of information within school; low response rate for food diaries (36% of subjects returned pre- and post-intervention)	3
Physical activity only				
Sallis *et al.* (32)	No effect	MVPA 16 min greater/week in specialist led group, 13 min greater in classroom teacher led group compared to controls—significance was not reported	Graphical data presentation without measures of error; no intention to treat analysis; inadequate cluster number; unit of analysis error	2
Mo-Suwan *et al.* (33)	Girls OR for increased BMI slope =0.32 (95% CI = 0.18–0.56). Other measures no effect. Boys no effect	No effect	Small sample size; baseline difference in physical activity; suboptimal number of clusters; (inconsistent results for girls overweight)	2
Nutrition and physical activity				
Gortmaker *et al.* (34)	Girls: OR for overweight =0.47 (95% CI = 0.24–0.93), boys no effect	TV viewing decreased for girls −0.58 h/day (95% CI = −0.85 to −0.31) and boys −0.40 h/day (95% CI = −0.56 to −0.24), fruit and vegetable servings increased 0.32 servings/day (95% CI = 0.14–0.50) in girls	School-level randomization increases likelihood of outcome clustering; change in measured variables did not completely explain BMI outcome	4
Caballero *et al.* (35)	No effect	Mean difference in self-reported PA was 0.04 units higher in intervention children than controls (95% CI = 0.01–0.06) percentage energy from fat decreased by 2.5% (95% CI = −3.9 to −1.1)	School-level randomization increases likelihood of outcome clustering; very high baseline obesity prevalence; ethnic homogeneity; inconsistent results for physical activity	3
Luepker *et al.* (36), Nader *et al.* (37)	No effect	MVPA/VPA was significantly greater in intervention students than controls, 58.6 min/day vs. 45.6 min/day, ($P < 0.03$)[a], energy from fat decreased 2.2% ($P < 0.001$)[a]	School-level randomization increases likelihood of outcome clustering; very small subsample used for diet intake assessment; anthropometric measures as secondary outcome	3
Coleman *et al.* (38)	Adjusted at-risk for overweight prevalence was reduced 11% in girls and 8% in boys, both significant[a]	MVPA was not significant. VPA increased an adjusted 3%, which was significant[a]	Nonrandomized design; very high overweight prevalence; ethnic homogeneity; very large increase in overweight prevalence in control schools during year 1; measures of error not reported; inconsistent results for overweight; concern of Type I error	2
Sallis 2003 (39)	Boys adjusted change in BMI decreased 0.64 kg/m^2 (effect size = 0.83, $P = 0.044$)[a]. Girls BMI did not differ from control	MVPA increased significantly for boys (effect size = 1.10, $P = 0.0011$), MVPA was No effect for girls	School-level randomization increases likelihood of outcome clustering; BMI self-reported and under-represented males; survey instruments were sent to different subsamples at baseline and follow-up	2
Sahota *et al.* (40)	No effect	Vegetable intake significantly increased 0.3 servings/3 day recall (95% CI = 0.2–0.4)	School-level randomization increases likelihood of clustering of outcomes; inadequate cluster number for appropriate study power; no intention to treat analysis; intervention not generalizable	2
Warren *et al.* (41)	No effect	“Eat smart” and control groups increased vegetable consumption 1.5 and 0.7 servings/day ($P < 0.05$ for each)	Small sample size; Inadequate power to detect treatment effect; concern of Type II error; no intention to treat analysis; concern of extracurricular information contamination between groups	2

Table 4 continued on next page

Table 4 (continued)

Study	Effect for overweight	Effect for health behaviors	Limitations	Grade
Donnelly *et al.* (42)	No effect	In class PA 6% greater in intervention group—this change was reported to be significant[a]	Nonrandomized design; small sample size; unit of analysis error; use of self-selected sample for several measures; attrition not reported; post-hoc analysis of overweight subjects; no intention-to-treat analysis	2
Muller *et al.* (43), Danielzik *et al.* (44)	Intervention TSF decreased 1.9 mm vs. control ($P < 0.01$), overweight children ($n = 25$) % body fat decreased 3.2% vs. control ($P < 0.05$)[a]; At 4 years girls overweight prevalence reduced 13.2% vs. control ($P < 0.05$)[a], boys no effect	Daily physical activity increased to 68% of intervention children vs. 50% of controls, television time decreased 0.3 h/day in intervention children vs. controls ($P < 0.05$ for each)[a]	All data not available; no intention-to-treat analysis; additional programming delivered to overweight children; high attrition from family component; unclear algorithm for targeting subjects; intervention cohort more overweight, higher SES than controls	2
Kain *et al.* (45)	Intervention boys BMI, *z*-BMI reduced 0.3 kg/m^2 and 0.1 units, respectively ($P < 0.001$ for each). Girls no effect		Nonrandomized design with selection based on overweight prevalence and interest in implementing new program; baseline differences between groups; suboptimal number of control subjects; unit of analysis error	2
VanDongen *et al.* (46)	TSF decreased relative to controls in boys and girls fitness + school nutrition groups[a]	Girls fat intake decreased significantly in home nutrition group, boys protein intake increased significantly in fitness + school nutrition, school nutrition and school nutrition + home nutrition groups[a]	Randomization at school level increases likelihood of clustering of outcomes; suboptimal cluster number; no intention-to-treat analysis; significant differences in noncompleters compared to completers; 95% CIs not reported	2

95% CI, 95% confidence interval; CCT, cohort concurrently controlled trial; MVPA, moderate-to-vigorous physical activity (3–6 METS); OR, odds ratio; PA, physical activity; RCT, randomized controlled trial; VPA, vigorous physical activity (>6 METS); SES, socioeconomic status; TSF, triceps skinfold thickness; *z*-BMI, BMI *z*-score = (BMI – mean BMI)/s.d.

[a]95% Confidence intervals were not reported.

Native American children found no difference in overweight between intervention and control students, although there was a small increase in self-reported physical activity among intervention students.

Two studies evaluated implementations of the Child and Adolescent Trial for Cardiovascular Health program. The first, a large grade 3 RCT (36) did not find a treatment effect for overweight outcomes. There was a significant increase in daily moderate-to-vigorous physical activity of 13 min and a decrease in school lunch energy from fat of 2.5%. Further follow-up of this cohort 3 years later showed persistently increased moderate-to-vigorous physical activity and decreased dietary fat in intervention schools compared to controls (37). The second, a grade 2 quasi-experimental effectiveness trial set in a predominantly Mexican-American community in Texas demonstrated a significant relative reduction in overweight prevalence of 11% in girls and 8% in boys (38). Vigorous physical activity also showed a small but statistically significant increase among intervention subjects.

A grade 3 RCT employed an environmental intervention in middle-school students (39). A significant relative reduction in BMI in boys of 0.64 kg/m^2 along with a significant increase in moderate-to-vigorous physical activity was reported. There was no significant effect for girls.

Two small grade 2 RCTs set in the United Kingdom (40,41) did not demonstrate significant effects for overweight but did report significant increased in fruit and/or vegetable intake. A small grade 2 quasi-experimental study set in Nebraska (42) did not show a significant effect for overweight. A significant 6% increase in physical activity was noted.

One year outcome data from a large grade 2 study set in Germany (43) showed a significant reduction in triceps skinfold thickness of 1.9 mm in intervention subjects compared to controls. Post-hoc analysis identified a significant 3.2% reduction in body fat among overweight subjects. Improvements in daily physical activity and television viewing time also achieved significance. More recently published 4-year outcome data showed a significant relative reduction in obesity prevalence of 13.2% among intervention girls only (44).

A nonrandomized grade 2 quasi-experimental study set in Chile found significant reductions of 0.3 kg/m^2 for BMI and 0.1 units for *z*-BMI in boys only (45). A fairly large grade 2 study set in Australia (46) reported significant differences in post-intervention triceps skinfold in the boys and girls physical

Table 5 Recommended features for future studies

Design	•Cluster randomization at the school-level
	•Stratification is preferred vs. matched-pair design
	•Follow-up for a minimum 2–3 years post-intervention
	•Include description of theoretical basis and stakeholders involved in program design
Power	•Minimum of three to four clusters per treatment condition
	•Minimum of several hundred students necessary to detect a 0.5 s.d. change in BMI or overweight prevalence at a 0.8 β level
Covariates	•Appropriate assessment of and multivariate logistic control for covariates including age, gender, grade level, weight, ethnicity, SES, baseline physical activity and medical comorbidities
Program design	•Multidisciplinary design including environmental, physical activity, and educational components appropriate for developmental level
	•Intervention duration at minimum 1 year
	•Consider targeting older children and adolescents who are establishing personal health behavior patterns
Statistical analysis	•Intention-to-treat analysis with valid imputation for missing data
	•Appropriate statistical control for cluster randomization and intracluster correlation of outcomes
	•Appropriate subgroup analyses assessing overweight subjects, gender differences, and pertinent covariates
Outcomes	•Include multiple measures of adiposity including BMI (CDC 2000 guidelines), TSF, waist circumference, % body fat, overweight prevalence, incidence and remissions where feasible
	•Appropriate reporting of attrition
	•Utilize validated instruments for physical activity and diet intake assessment outcomes
	•Include process-based measures of implementation and acceptance

SES, socioeconomic status; TSF, triceps skinfold thickness.

education plus school nutrition groups. There were also significant improvements in dietary measures in a number of groups.

DISCUSSION

Quality of evidence

There have been three recently published systematic reviews which included an analysis of school-based obesity prevention programs (20,21,25). A Cochrane systematic review (20) of long-term (>1 year) interventions designed to prevent obesity in children and adolescents found little evidence to support school-based initiatives. Major concerns included frequent unit of analysis errors, underpowered studies, inadequate focus on issues related to the sustainability of the health behavior climate, and failure to address "upstream factors". For future studies, the authors recommended including process-based outcome measures, longer and more intense interventions, broader outcome measures, strengthening methodology, and considering the sustainability and generalizability of interventions.

A Canadian group led by Flynn and colleagues conducted a broad systematic review of the evidence related to obesity and chronic disease prevention with regard to population health, program development, program effectiveness, and immigrant health (21). The authors reported favorable outcomes in terms of body composition in 27 of the 37 studies in the primary or secondary school setting, along with favorable changes in nutrition or physical activity in nearly all trials. Of note, a significant change in any body composition or obesity prevalence outcome led to categorization as a "successful" program. When changes in a single obesity-related outcome measure are not paralleled by changes in other highly correlated variables, there must be concern of Type I error.

The guidelines recently published by The National Institute for Health and Clinical Excellence in the United Kingdom addressed a wide range of issues relating to obesity (25). In an analysis of school-based programs, the authors indicated the evidence for weight outcomes was equivocal. There was limited evidence supporting the multidisciplinary "whole school" approach advocated by UK National Healthy Schools Program. The authors also suggested there may be gender differences in program response.

This review employed rigorous evidence-based criteria to conduct a *focused systematic review* of long-term (>6 months duration) school-based programs designed to prevent obesity in children and adolescents. One new study and more recently follow-up data from another study not included in previous reviews were analyzed. This review also employed a grading scheme not previously utilized to assess school-based obesity prevention programs. Because the GRADE rating score represents a composite of issues including study design, power, sources of bias, control for confounding variables, and also considers the effect size and validity of outcomes, a simple comparison of studies' global quality and impact is possible.

There has been discussion questioning the use of RCTs as the "gold standard" for evaluating public health promotion interventions. Frequently cited concerns are the randomization process, economic and feasibility barriers, inadequate cluster number to ensure similar distribution of possible confounders among groups (47) as well as the logistical implausibility of blinding, risk of contamination between treatment groups, and outcome clustering. While a complete discussion of the merits of RCTs in public health is beyond the scope of this review, one of the unique merits of the GRADE system is a methodologically strong quasi-experimental or observational study with a large and consistent effect can earn the highest evidence grade. Well-designed, methodologically sound RCTs remain the highest standard of evidence available; however, useful data can be gathered from similarly well-implemented quasi-experimental studies. Observational and quasi-experimental design offer reasonable alternatives when randomization is not feasible.

Other groups have advocated use of process-based outcome measures in the evaluation of public health promotion studies (20,21). Process-based outcomes are practically relevant to the implementation of programs in the community and likely warrant inclusion in study protocols; however, there are also concerns related to their use as independent study outcome measures. First, the evidence supporting these is often limited to consensus opinion of the authors; we did not consider this standard adequate to warrant application of these recommendations as outcome measures for other studies. There is also potential concern for bias in any interpretation of studies that employ self-derived recommendations as objective outcome measures.

Evidence quality in present review

Only 4 of 14 studies were of grade 3 or 4 quality, thus as has been suggested elsewhere by previous qualitative and broader systematic reviews (19–25), we found the quantity and strength of evidence for these interventions were insufficient to draw specific conclusions as to their effectiveness for weight outcomes. At present, the overall quality of evidence must be considered weak.

Several design issues were not consistently addressed. Concern of Type I or Type II error was a common reason for reducing the evidence grade of studies. Lower quality studies were frequently underpowered to detect clinically significant change in measures of overweight. Study power for overweight was discussed in 3 of the 14 studies (31,41,45), and one study (36) calculated power for a serum cholesterol endpoint. Applying appropriate statistical procedures, 13 of the 14 studies were underpowered to detect a reasonably achievable change in BMI, triceps skinfold, or overweight prevalence during the intervention period. This suggests that Type II error cannot be excluded from most studies.

Although most studies were cluster-randomized, three of the studies discussed here included three or fewer clusters per treatment (32,43,45) and are thus poorly designed to detect an intervention effect (48). There are advantages as well as disadvantages to cluster randomization vs. randomization at the individual level. Feasibility is clearly a concern in these interventions and with this in mind, cluster randomization (with appropriate power consideration and statistical control for intracluster correlation) provides a reasonable means of achieving the benefits of randomization in a logistically achievable manner.

Only three of the trials (34,36,39) included study cohorts that were demographically representative of the US population. Several studies (35,42,45) were implemented in populations found to have particularly high overweight prevalence. Targeting these groups shifts the design of these studies away from primary prevention and closer to secondary prevention than trials involving more representative samples. Concern of an unpredictable treatment response bias with regard to overweight status also limits the external validity of these studies.

Five of the fourteen trials reported an intention-to-treat analysis. Valid assessment of a preventive public health intervention is contingent upon evaluation of the entire study cohort regardless of adherence to program. Only one of the five studies (35) adequately described the methods employed to impute for missing data (49,50).

Efficacy

Owing to inconsistent reporting of specific outcome measures and measures of error, pooling of data for meta-analysis was not possible. The highest quality study reviewed here found a large and significant reduction in odds ratio for overweight in girls, and changes in BMI were consistent with this finding. There were also significant improvements in overweight measures reported in several grade 2 studies (**Table 4**), although enthusiasm must be tempered as there was considerable inconsistency of results within a number of these programs. Nonetheless, it appears school-based obesity prevention programs may be effective for certain populations.

What have we learned?

Although we were not able to offer rigorous data to support particular intervention characteristics, there are a number of qualitative trends warranting comment.

First, as suggested in the NICE guidelines (25), it appears girls and boys do not necessarily respond comparably to a given intervention. The Planet Health study (34) showed a significant effect for girls only, as did 4-year outcomes of the Kiel Obesity Prevention Study program in Germany (44), while weaker trials in the United States (39) and in Chile (45) reported positive outcomes for boys only. While intervention details are somewhat limited, this suggests girls may respond better to educational components grounded based upon social learning, while boys may be more influenced by structural and environmental changes facilitating increased physical activity and improved diet intake. Intervention components targeting both boys and girls through different techniques may be necessary for a single program to effectively have an impact on the study group as a whole.

The home environment has significant influence on a given child's weight status through food and physical activity access as well as behavior modeling. Despite this, interventions specifically including familial components have not been more effective in the primary or secondary prevention setting than those without specific targeting or inclusion of parents or families. Further research is required to determine whether novel or more aggressive approaches to address health behaviors at home through school-based programs will prove more effective than efforts to date.

Studies demonstrating significant findings frequently involved subjects more overweight than their peers nationwide. It does not appear changes in diet or physical activity reproducibly led to improvements in overweight outcomes, although the time required for small behavior changes to manifest in anthropometric measures may exceed the duration of studies reviewed here. A reduction in television viewing may have mediated the effect of one intervention (34), and other research has indicated reducing television viewing time can effect favorable change in overweight outcomes (51).

Both cognitive and physiological development likely influence the impact of specific interventions on a given child. Most studies discussed here targeted youths aged 7–10 years. Programs including younger children were generally not effective (33,41,43) in terms of reducing BMI or obesity prevalence. To the contrary, older children were included in three trials which did demonstrate positive outcomes (34,39,45), suggesting it may be desirable for future programs to target 10–14-year-old children. This somewhat surprising trend contrasts with that found by some other authors (25) and may be due to increased control over their food choices and leisure activities, greater concerns about weight and appearance, peer-group mediated changes in behavior, or some combination of these factors. Targeting of these slightly older children as they begin to establish long-term health behavior patterns may be indicated; however, further research is necessary to validate this hypothesis.

Policy decisions

Recently proposed nutritional legislation has been aimed at eliminating sales of or reducing consumption of soft drinks in schools (16). Legislative targeting of a single issue like soft drinks may be an appropriate high profile component of the acute management of childhood obesity in the United States, but may also distract public and financial attention away from other relevant health promotion efforts offering promise of lasting impact on health behaviors and outcomes. New legislation represents action by policymakers to address an issue of serious public concern, however as there is not sufficient evidence to conclusively identify particular program characteristics predictive of success, a well-designed evaluation protocol should be considered an essential component of any newly funded program.

Future goals

Greater experience with implementation and evaluation of school-based obesity prevention programs should further efforts to determine the effectiveness of this intervention modality. A crucial component of this process will be improved study design with a particular emphasis on powering studies appropriately to detect meaningful difference in outcome measures (**Table 5**).

A number of important questions remained unanswered. Can truly meaningful outcomes be reasonably achieved within a 1–3-year period of programmed intervention? Are BMI-based indices the most appropriate outcome measures for school-based obesity prevention programs? At what age are children developmentally most appropriate for targeting? What duration of intervention is optimal? What role should families and teachers play in these interventions? Can school-based obesity prevention programs achieve cost efficacy? Continued support of well-designed intervention trials should provide guidance as to the ultimate role of school-based preventive programs in combating obesity in the United States.

Limitations

This systematic review identified studies published in the peer-review research literature. It is possible, if not likely, that results of other school-based obesity prevention programs have been presented in other forums including trade journals, conferences, and committee meetings. A larger sample of programs to analyze would have improved our ability to derive recommendations. Had outcomes been presented in terms of consistent parameters, meta-analysis would have been possible and would have given a statistical backing to our qualitative assessment of programs and studies.

The diversity of populations, study protocols, interventions, aims, and outcomes represents a significant challenge to meaningful evaluation of school-based obesity preventions as a whole. This heterogeneity renders studies dependent on both content and implementation for success. Discussion of both variables was rare and not extensive, thus limiting our efforts to characterize successful vs. unsuccessful programs.

Conclusion

Overweight and obesity in children are serious public health concerns that warrant attention from health policymakers. Schools are one avenue through which childhood obesity might be addressed. An ideal school-based overweight prevention program would reduce the incidence and prevalence of overweight in both boys and girls by facilitating lasting changes in diet and physical activity without instigating inappropriate weight control behaviors. It would also demonstrate cost effectiveness. At present, there is insufficient evidence to provide strong guidance as to the benefits of these programs due to a limited number of published studies as well as methodological concerns that limit the validity of and comparability between those identified. Future studies should include a well-designed evaluation protocol that assesses short- and long-term efficacy for weight outcomes, valid analysis of diet and physical activity outcomes, discussion of process-based outcomes, and cost-effectiveness analysis. The authors believe schools will play an important role in stemming current trends in overweight and obesity in children. Health services researchers should pay increased attention on this important opportunity to identify practical interventions that work.

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