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Combinations of Obesity Prevention Strategies in U.S. Elementary Schools: A Critical Review

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Abstract

The prevalence of obesity among children has roughly tripled in the past thirty years. Given the numerous health risks associated with obesity, elementary schools have implemented a variety of prevention programs targeting this problem. This review examines recent studies of combinations of obesity prevention programs in U.S. elementary schools and offers recommendations about effective strategies. We found twelve studies that met selection criteria and reviewed their findings related to obesity-related outcomes. Among the single intervention strategies, neither physical activity nor education alone demonstrated efficacy in reducing objective measures of obesity. Most studies of programs with two or three components (i.e., physical activity plus nutrition, physical activity plus both education and nutrition) found statistically significant improvements in objective obesity-related outcomes. Studies evaluating programs with community and parental involvement suggest that these components may increase effectiveness. However, studies assessing outcomes following the cessation of the program showed a reversal of positive effects, suggesting that long-term implementation of programs is important for sustained gains. Results suggest that combinations of obesity prevention programs sustained over time are most likely to be effective.

Keywords

obesity prevention; school-based programs; elementary education; systematic review

Over the past 30 years, childhood obesity has become an epidemic in the U.S. As of 2008, more than one third of children under age 18 were overweight or obese. The prevalence of obesity in 6-11 year olds is now nearly 20%, almost triple the prevalence of 1980 (Ogden, Carroll, Lamb, & Flegal, 2010). This increased prevalence is linked to a rise in health problems previously underrepresented among youth, including diabetes, hypertension, and

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heart disease (Ogden et al., 2010). In addition, obese children are at risk for social and psychological problems, including stigmatization and poor self-esteem (Daniels et al., 2005). Obese children are also more likely to be obese adults, forecasting a lifetime of adverse health implications (Freedman, Khan, Dietz, Srinivasan, & Berenson, 2001).

One of the *Healthy People 2020* national health objectives is to decrease obesity among 6-11 year olds to under 16% (US Department of Health and Human Services, 2011). However, there is debate regarding effective methods for reaching this goal, largely because the "caloric imbalance" generally credited as the cause of obesity is affected by a large number of genetic, behavioral, and environmental factors (Daniels et al., 2005). The most commonly used interventions target known individual risk factors for obesity, including poor diet and low physical activity (Centers for Disease Control & Prevention [CDC], 2011). However, since obesity is a multi-factorial problem, approaches must target not only individual behaviors but also environmental (e.g., home, school, community) factors that promote either obesity-related or healthy behaviors. For example, the home environment, including family meal patterns, parental lifestyles, and food availability, is a strong correlate of fruit, vegetable, and dairy intake (Neumark-Szainter, Wall, Perry, & Story, 2003). The community environment is equally important, contributing to the availability of unhealthy foods in schools, absence of local grocery stores, and density of fast-food restaurants (CDC, 2011). Physical environments are of particular interest because they are often easier to modify than individual factors, and such changes can reach a broad audience.

School-Based Programs

Schools are important physical environments that reach a large captive audience and are responsible for both educating and feeding children (Benjamins & Whitman, 2010). Over 95% of youth ages 5-17 attend school, spending an average of six hours in school daily for 13 developmentally crucial years (National Center for Education Statistics, 2013). Most U.S. children eat lunch at school, which constitutes their most frequent exposure to fruits and vegetables. Therefore, schools can play a vital role in obesity prevention and development of healthy habits (Hendy, Williams, & Camise, 2011). Elementary schools are especially important, as prevention is most effective when targeting younger children still developing lifestyle habits. Lastly, schools reach various regional, demographic, and income categories and may provide support for behavior changes for children who lack such support at home (CDC, 2011).

The CDC developed nine guidelines for developing, implementing, and evaluating school-based anti-obesity programs (CDC, 2011). In addition to defining quality meal and physical activity programs, these guidelines suggest the implementation of additional services, including health education; health, mental health, and social services; and wellness programs. They recommend that programs take a coordinated approach between schools, parents, students, and the community. Notably, many of the guidelines are open for interpretation, so there is no concrete outline for the ideal obesity prevention program.

Obesity prevention programs adopted by schools differ in strategies utilized, target age, program length, and program evaluation outcomes. Although several themes in childhood

obesity prevention have emerged, no single approach stands out as the most effective (Hadley, Hair, & Dreisbach, 2010). Existing programs utilize various combinations of community involvement, parental involvement, health education, physical exercise, and nutrition components. Because of time and budget constraints, many schools implement only one or two components. However, there is limited guidance about whether combination strategies are more effective than single strategies, and if so, which combinations are the most effective. One exception is a recent review by the Agency for Healthcare Research & Quality (AHRQ), which summarized the literature on obesity prevention programs for children and adolescents in both the U.S. and internationally (Wang et al., 2013). They reported moderate evidence supporting the efficacy of school-based nutrition or physical activity interventions on obesity-related outcomes but insufficient evidence for combinations of physical activity and nutrition interventions. The aim of the current review is to build on these findings by more closely examining these trends in a more homogenous group of studies. To this end, we focus on elementary school students as opposed to students of all ages, U.S. rather than international samples, and rigorously designed, experimental or quasi-experimental studies that included objective measures of obesity-related outcomes such as body mass index (BMI). A secondary aim is to examine the importance of parental and community involvement in the success of school-based obesity prevention programs. These findings will inform recommendations regarding optimal school-based obesity prevention programming in U.S. elementary schools. Selecting interventions based on existing research will allow school personnel to make the greatest difference in obesity rates when resources are scarce, thus progressing toward a leaner and healthier youth population.

Method

Search Strategy

The target of the search was school-based obesity prevention programs in U.S. elementary schools. We conducted searches using PubMed and the Cumulative Index to Nursing and Allied Health Literature (CINAHL) databases. Using PubMed, we performed searches with the following Medical Subject Heading (MeSH; the National Library of Medicine's vocabulary thesaurus) terms: (1) obesity/prevention and control AND schools, and (2) obesity AND obesity/prevention and control AND program evaluation. Using CINAHL, we performed the search: (1) prevention and control AND schools AND obesity. Finally, we hand-searched the recent review published by AHRQ for relevant articles.

Screening Abstracts

We first reviewed titles and abstracts from the PubMed and CINAHL searches for relevancy. Study team members screened records individually to remove clearly non-relevant records. Second, two study team members screened remaining records independently and compared results. We obtained full-text articles for all selected records, and two independent reviewers again assessed these articles for eligibility. Differences at each stage were resolved through consultation with a senior team member.

Programs that met inclusion criteria: (a) were published in English; (b) targeted children ages 6-12; (c) were school-based and aimed to prevent obesity through school-based

physical activity, education, and/or nutrition modification; (d) were implemented in the U.S.; (e) were published between January 1, 2007 and December 31, 2012; and (f) utilized an experimental or quasi-experimental study design with a control group. We excluded studies of programs organized primarily through churches or other community groups as well as those primarily aimed at preventing diabetes or other metabolic syndromes.

Data Extraction

We extracted data independently from each study regarding sample population, sample size, duration, description of the intervention (physical activity, education, or nutrition components), explanation of community and parental involvement, type of control group, outcome measures, cost, and study findings (see Table 1). Two team members extracted data initially, and a third member provided consultation to resolve discrepancies.

Interventions

Types of interventions examined were physical activity, education, and nutrition. The definition of physical activity interventions included activities designed to expend more energy than a typical school day (e.g., increasing Physical Education hours). The definition of educational interventions included additions or alterations to the health curriculum to improve understanding of obesity-related topics, including nutrition. Finally, we defined nutrition interventions as changes or additions that promoted healthy food options (e.g., changes in cafeteria menus).

Community and Parental Involvement

Because of CDC recommendations, we chose to examine community and parental involvement in school-based programs. We defined community involvement as community participation to aid in the development of healthy habits through volunteering, organizing, or contributing to events. We considered any role that parents played to supplement children's healthy choices as parental involvement (e.g., parents signed contracts to have healthy foods at home).

Data Analysis

We analyzed data according to coding categories and outcomes. We did not conduct a meta-analysis, as there was a high degree of heterogeneity among intervention modalities and outcomes measured.

Results

The initial database search yielded 379 records. Based on the review of abstracts, we selected twenty studies and obtained full-text versions of the articles. Upon review, we excluded three publications because their respective programs were not confined to elementary schools, six because they did not use experimental or quasi-experimental designs, and three that were implemented outside of the U.S. Eight of these studies met our inclusion criteria. We included an additional four studies based on the result of hand searching the AHRQ review paper (Wang et al., 2013). Thus, a total of twelve publications met the inclusion criteria.

Sample Descriptions

Studies recruited samples that included kindergarten through 6th grade. Ten of the twelve studies recruited both male and female students without a focus on specific ethnic/racial backgrounds, whereas one study recruited only African American females (Barbeau et al., 2007), and another recruited only African American males (Howe et al., 2011). Sample sizes ranged from 27 to 2,494. Only one study reported detailed cost information (Hendy et al., 2011), which precluded cost comparisons across studies. The type of staff implementing the programs varied considerably; four programs were implemented by teachers, two required a specialized multidisciplinary staff, two were administered by college students (though one of these was also tested with parents), one by a combination of teachers and research staff, one by nursing students, and one by research staff.

Duration of Intervention and Study Follow-up

Interventions varied from nine weeks to three years. Longer interventions were not always associated with better outcomes. For example, the 3-year Physical Activity Across the Curriculum (PAAC) produced no significant reduction in BMI (Donnelly et al., 2009), whereas a 10-month afterschool program led to significant decreases in BMI (Barbeau et al., 2007). There was no clear trend for program length based on a review of the other studies. Ten of the twelve studies assessed students at baseline and again at post-intervention, though several studies employed multiple assessments between baseline and the end of the intervention. Only two studies examined the longer-term effects of the intervention, one with a 6-month follow-up (Hendy et al., 2011) and one at 12 weeks post-intervention (Speroni, Early, & Atherton, 2007).

Control Group Type

Eight studies used non-intervention control groups. Two used alternative intervention control groups (e.g., 30 minutes of free play). Two studies used an active obesity prevention program, one to determine the effectiveness of adding intensive one-on-one coaching (Tucker et al., 2011) and the other to determine the effectiveness of adding a community involvement component (Hoelscher et al., 2010).

Outcomes

All twelve studies measured BMI, percent body fat, and/or weight as a primary outcome. Nine examined children's level of physical activity through either observation or self-report. Five reported some indicator of healthy eating or nutrition. Other outcomes included heart rate, blood pressure, cardiovascular fitness, performance on fitness tests, and waist circumference.

Intervention Types

Three interventions were limited to physical activity. One had only an education component, three had both physical activity and nutrition components, and the remaining six had a combination of physical activity, nutritional, and educational components. None were solely comprised of a nutrition component, combinations of physical activity and educational components, or combinations of nutritional and educational components. Physical activity

interventions involved the addition of physical activity during classes (Donnelly et al., 2009; Hoelscher et al., 2010; Hollar et al., 2010), after school (Barbeau et al., 2007; Howe et al., 2011; Speroni et al., 2007), during recess (Howe et al., 2012), or on the way to and from school (Heelan et al., 2009). Other physical activity interventions gave students activity targets to reach throughout the day (Foster et al., 2008; Hendy et al., 2011) or set up physical activity contests (Greening et al., 2011). Several interventions involved additional hours of educational materials presented in the classroom (Foster et al., 2008; Speroni et al., 2007; Tucker et al., 2011) and during program events (Greening, Harrell, Low, & Fielder, 2011). Other programs used multimedia with education in both classrooms and through other promotional materials (Hollar et al., 2010; Hoelscher et al., 2010). Nutrition interventions were diverse, including cafeteria menu changes (Foster et al., 2008; Greening et al., 2011; Hollar et al., 2010; Hoelscher et al., 2010), providing healthy snacks at after school programs (Barbeau et al., 2007; Howe et al., 2011), rewarding healthy lunch choices (Hendy et al., 2011), nutritional activities or contests (Foster et al, 2008; Greening et al., 2011), and the use of food logs (Speroni et al., 2007).

Community or Parental Involvement

Three interventions incorporated parental but not community involvement, four incorporated both parental and community involvement, and five had no external involvement. The degree of parental involvement varied substantially. For example, the Kid's Choice Program was designed to be delivered by parents, although it was first tested with college students implementing the program (Hendy et al., 2011). The School Nutrition Policy Initiative (SNPI) encouraged parental involvement by holding meetings, report card nights, and weekly nutrition workshops (Foster et al., 2008). The Kid Living Fit (KLF) program encouraged and tracked parental attendance at dietary sessions (Speroni et al., 2007).

Community involvement included programs implemented or informed by community groups. The Coordinated Approach to Child Health (CATCH) trial evaluated the addition of a "CATCH Community Action" Team to an established program (Hoelscher et al., 2010). This team implemented a self-assessment to identify priority areas of action based on the CDC School Health Index, attended "Best Practices" workshops, and selected "evidence-based" activities to promote physical activity and healthy eating.

Outcomes by Intervention Type

Physical activity alone—Three studies evaluated a physical activity only intervention. The Physical Activity Across the Curriculum (PAAC) program added 90 minutes of physical activity administered in 10-minute segments throughout the week for three years (Donnelly et al., 2009). Howe et al. (2012) implemented a 9-week recess intervention, comparing 30 minutes of structured recess using "moderate-to-vigorous" energy expenditure to a control group participating in 30 minutes of free-play recess. Heelan et al. (2009) evaluated a 2-year Walking School Bus Program that involved children walking to and from school. None of these studies found significant effects on BMI or other physiological indicators, although all three reported significantly greater increases in physical activity among children participating in the programs compared to controls.

Education alone—One study evaluated the additive effects of including one-on-one coaching when added to an education-only intervention, the Let's Go 5-2-1-0 program (Tucker et al., 2011). Program length varied from 4 to 8 months depending on school. Investigators found no differences between the control group, which received just the Let's Go 5-2-1-0 program and the experimental group, which received the program plus mentoring on BMI, physical activity, or nutrition outcomes.

Combined physical activity and nutrition—Three programs combined physical activity and nutrition. Two were10-month afterschool physical activity programs – one for African American girls (Barbeau et al., 2007) and one for African American boys (Howe et al., 2011). Both provided 80 minutes of physical activity and a healthy snack. Both found a significant effect on BMI, though the Howe et al. (2011) excluded boys who did not participate in at least 60% of the sessions from the analyses. Barbeau et al. (2007) also found significant improvements in body fat and cardiovascular fitness. The third evaluated the Kid's Choice Program (KCP), which recommended 5,000 steps per day and provided pedometers to document students' daily steps for 3 months (Hendy et al., 2011). The KCP also targeted diet by giving token rewards when children ate fruits and vegetables before other lunch items and chose healthy drinks during lunch. An optional parent component allowed children to earn extra tokens if their parents completed logs of their weight management behaviors at home, although only 20% completed these logs. The KCP intervention had a significant effect on BMI, but this effect was diminished by the 6 month follow-up for children who had been average weight (but not obese) at baseline. There were also significant effects on physical activity and healthy eating.

Combined physical activity, education, and nutrition—Six studies included all three interventions. The 8-month TEAM Mississippi program consisted of monthly physical activity or nutritional activities or contests, education during monthly events, and changes to the school's food service (Greening et al., 2011). The evaluation found no effects on BMI, waist circumference, or nutrition knowledge but significant effects on percent body fat, physical activity, dietary fat intake, and performance on fitness tests. The Healthier Options for Public Schoolchildren (HOPS) added 10-15 minutes of extra daily physical activity, an educational curriculum, and remodeling of the school menu for two school years (Hollar et al., 2010). HOPS produced a significant decrease in BMI and blood pressure relative to the control group, but only for girls. Hoelscher et al. (2010) added a community partnership program to determine whether it was superior to an existing obesity prevention program (CATCH BasicPlus [BP]). The CATCH BP program included increased moderate to vigorous exercise in physical education classes, a peer-based curriculum to teach healthy eating and activity levels, and an improvement in the healthfulness of school meals. After one year, investigators found the version of the program with the community partnership (CATCH BPC) to be superior to CATCH BP in reducing obesity, improving diet outcomes, and reducing sedentary activities, but not for increasing physical activity. Kids Living Fit (KLF) consists of a 12-week afterschool program led by trainers, education from dieticians, and weekly food and activity logs (Speroni et al., 2007). Program evaluators found a significant decrease in BMI and waist circumference in the KLF group and non-significant increases in the control group, though the results of significance tests of between-group

differences were not presented. Finally, the School Nutrition Policy Initiative (SNPI) consisted of fifty hours of food and nutrition education per student annually, removal of all sodas, sweetened drinks, and snacks from vending machines and cafeterias, and a student challenge to reduce sedentary behaviors and increase physical activities (Foster et al., 2008). After two years, the intervention group showed a lower obesity incidence and fewer sedentary behaviors compared to controls, but there was no effect on physical activity.

Outcome by Parental or Community Involvement

Three of the five interventions that lacked parental or community involvement included only physical activity components, and these types of interventions did not have significant effects on BMI (Dennelly et al., 2009; Howe et al., 2012; Heelan et al., 2009). The other two studies of interventions without external involvement evaluated afterschool programs incorporating physical activity and a healthy snack; both found significant effects on BMI (Barbeau et al., 2007).

Three programs had a parental, but not community, component. As noted above, children participating in the Kid's Choice Program could earn additional rewards for healthy behaviors reported by parents. Children participating in this program showed statistically significant decreases in BMI, although the control group showed similar improvements and neither group maintained these gains at follow-up (Hendy et al., 2011). The program encouraged but did not require parents to attend the Kids Living Fit afterschool program (Speroni et al. 2007). Investigators found improvements in BMI, but did not compare the control and intervention groups statistically. Finally, the Healthier Options for Public Schoolchildren (HOPs) program provided parental education but the nature of this involvement was unclear. The researchers found that HOPs affected BMI but only for girls (Hollar et al., 2010).

Four programs incorporated both parental and community involvement. The Let's Go 5-2-1-0 program was created out of a partnership with a local nursing school, using nursing students to deliver the intervention, and offered two parent education seminars (Tucker et al., 2011). This study found no significant effects on BMI. The TEAM Mississippi intervention invited families to participate in monthly events and used focus groups of community members to develop obesity prevention activities (Greening et al., 2011). The evaluation found a significant effect on percent body fat but not BMI. The School Nutrition Policy Initiative, developed and delivered by a community organization, included school association meetings, report card nights, parent education, and nutrition workshops (Foster et al., 2008). This study reported statistically significant decreases in overweight, but not obesity, incidence. Finally, one study had the explicit aim of determining whether adding community involvement would increase the effectiveness of an established obesity prevention program (Hoelscher et al., 2010). Their community involvement included setting up "CATCH Community Action" teams to perform self-assessments to inform and implement interventions. Compared to the CATCH BP control program, which did not include community involvement, the CATCH BPC resulted in a significantly greater decrease in the percentage of obese students compared to the control group.

Discussion

The twelve studies reviewed evaluated programs implementing various combinations of physical activity, education, and nutrition components. Programs produced either positive or neutral effects on BMI, health knowledge, or physical fitness in elementary school children. Although the CDC proposed nine guidelines for school-based anti-obesity programs, results of this review do not suggest any single approach as best. This is similar to the results from the AHRQ review (Wang et al., 2013). However, our results differed from their finding that school-based nutrition interventions or physical interventions alone were effective at reducing obesity. None of the four programs reviewed here that used a single approach (physical activity or education alone) effectively reduced BMI. These differential findings may be due to differences in study inclusion criteria, as many of the studies that the AHRQ review used to draw these conclusions were conducted outside of the U.S. Another primary finding of the current review is that the majority of multi-component programs showed positive results, supporting the idea that childhood obesity is a multi-factorial problem and best addressed using multiple approaches. However, several different combinations were effective.

Increasing physical activity alone did not affect BMI. Specifically, the two programs in which physical activity was extended by 90 minutes per week or was made more vigorous (Donnelly et al., 2009; Howe et al., 2012, respectively) and the one intervention involving daily physical activity by means of a Walking School Bus program (Heelan et al., 2009) did not demonstrate positive effects. However, according to the “caloric imbalance” theory of intake and expenditure, physical activity should be an important obesity prevention component. No federal legislation mandates minimum physical activity requirements in schools, but many states jurisdictions have passed such laws (CDC, 2012a). Unfortunately, these laws range from no physical activity requirements in Alaska to 150 minutes per week in South Carolina (National Association of State Boards of Education, 2013). This may explain why a study using a “no physical activity” control group is difficult to conduct, although it would constitute a more accurate test of physical activity interventions. Further, it is important to note that physical activity differs from physical education. The CDC defines physical activity as simply bodily movement, while physical education includes instruction, which would theoretically provide better long-term outcomes (CDC, 2012a). An evaluation of physical education specifically would provide more information on this topic.

The only other single component intervention reviewed here was Let’s Go 5-2-1-0, a primarily education-based program (Tucker et al., 2011). Unfortunately, this study was not a true test of the program’s effectiveness, as it compared Let’s Go 5-2-1-0 alone to an enhanced version that included one-on-one coaching using motivational interviewing techniques. Not surprising, there were no significant differences between these two groups on obesity related outcomes. Although we cannot draw firm conclusions about education only programs based on these results, there is limited empirical support for the notion that non-interactive education-only interventions prevent other types of problematic health behaviors in children, such as substance use (e.g., Tobler et al., 2000). Nevertheless, education may be an important aspect of multi-component anti-obesity interventions. This may be why activity-based physical education is superior to physical activity alone and

supports curriculum requirements specified by legislation in many states. The content of the educational program may also be important. Average waist circumference increased 12 weeks following the Kids Living Fit program despite implementation of an educational component. However, whereas the educational materials focused on dietary modification, no diet modifications were actually made in the school (children only recorded food choices in logs; Speroni et al., 2007). Thus, it may be important for education to be relevant and reflected in school policy to be effective. Future studies of obesity prevention should include education relevant to the behavioral changes promoted by other program components.

No nutrition-only programs met inclusion criteria, making it difficult to determine the effect of this component. All of the multi-component programs included a nutrition component, though nutritional interventions ranged from the provision of a healthy snack during afterschool programs to complete remodeling of cafeteria offerings. Programs with nutrition interventions that made substantial changes to the school's food offerings or rewarded healthy food choices resulted in positive effects (Greening et al., 2011; Hendy et al., 2011; Hollar et al., 2010; Hoelscher et at., 2010). Further, though increasing physical activity alone was not effective, the combination of physical activity and nutrition changes resulted in significant improvements in BMI and cardiovascular fitness (Barbeau et al., 2007; Hendy et al., 2011; Howe et al., 2011). Taken as a whole, these results suggest that nutritional interventions are a promising area of focus.

The addition of parental and/or community involvement appeared to increase the effectiveness of school-based programs but may not be essential. Two programs resulted in decreased BMI despite the absence of community or parental involvement (Barbeau et al., 2007; Howe et al., 2011). However, one study, the CATCH trial, explicitly tested the effectiveness of adding a community involvement component to an existing obesity prevention program. The evaluation found that the addition of community involvement had a positive impact on BMI and knowledge over and above the other components (Hoelscher et al., 2010). Though it is not possible to make a similarly firm conclusion about the importance of parental involvement based on the studies reviewed, many of the effective prevention programs did include a parental component. It is likely that both parental and community involvement help children to generalize skills and habits learned at school to home and community settings.

There was significant variability in program length, ranging from nine weeks to three years, and longer interventions did not always produce better outcomes. However, results highlight the need for ongoing intervention to maintain improvements. Only two studies included long-term follow up. The Kids Living Fit study measured the results of a twelve-week intervention at twenty-four weeks and found that waist circumference had increased in the intervention group, but not as significantly as in the control group (Speroni et al., 2007). At follow up, the Kids Choice Program showed a reversal of positive effects (1.5% BMI increase in the intervention group; Hendy et al., 2011). This may indicate that interventions of finite duration, with subsequent restoration of pre-intervention conditions, are not sufficient to promote long-term change. This is consistent with the large literature on the importance of continued intervention to maintain improvements in obesity-related outcomes (e.g., Perri, Sears, & Clark, 1993; Turk et al., 2009). Thus, given the lack of evidence for

lasting effects following program termination, schools will likely need to commit to long-term implementation of obesity prevention programs to sustain positive results.

We also attempted to examine two factors that affect the adoption of school-based prevention programs: the costs of the program and who can implement it. Unfortunately, only one study reported cost data, estimating a monthly cost of $2/child with an additional $5/child per month if pedometers were used (Hendy et al., 2011). Future studies should evaluate program cost to aid school personnel in making decisions about the feasibility of adopting such programs. Programs were implemented by a wide range of professionals; some primarily by teachers and school staff and others by multidisciplinary teams. However, many school districts do not have the budget for specialized teams. Thus, the adoption of these more intensive programs will likely need to be justified by favorable cost-effectiveness studies.

There are several limitations to the current study. First, differences between studies make them difficult to compare. This limitation precluded the use of meta-analyses, which would have provided more definitive conclusions regarding effect sizes. Further, many extraneous factors can influence program success. For example, communities may differ on average family income, availability of safe locations for physical activity, or density of fast food restaurants and grocery stores. While the studies used intervention and control groups with similar demographics, this review does not account for differences in demographics between studies. For example, the TEAM Mississippi participants were largely African American, and the program was implemented in Mississippi, a state where the median household income is $38,000 (US Census Bureau, 2012) and obesity prevalence is 34% (the #1 most obese state; CDC, 2012b). In comparison, the Kids Choice Program participants were primarily White, and the program was implemented in Pennsylvania, a state where the median household income is $51,000 (US Census Bureau, 2012) and obesity prevalence is 28.6% (the #20 most obese state; CDC, 2012b). Thus, there are differences between settings that may influence obesity and make a true comparison difficult.

Implications

Although there is no perfect school-based anti-obesity program, this review suggests that several strategies can be effective. Although we believe that programs should address all nine CDC guidelines, this review can inform decision-making when budgets are restricted. Strategies involving a combination of physical activity, nutritional, and educational interventions are likely to yield better outcomes than single component strategies, although no nutrition-only studies was reviewed. When the use of all three interventions is not possible, schools should invest in nutritional interventions accompanied by some increase in physical activity. Research does not support the effectiveness of physical activity beyond mandated state physical education requirements as a single-component strategy. Because of the psychosocial influence on childhood behavioral development, parental involvement may be a beneficial program addition. Since this review highlights the potential for community involvement to increase the effectiveness of obesity prevention strategies, schools should involve community stakeholders when feasible. The ideal length of obesity prevention programs remains undetermined. We recommend that schools regularly monitor outcomes

of interest (e.g., student BMI) when implementing an intervention to ensure effectiveness and inform modifications. However, there is some evidence that gains attenuate after interventions cease, so the systematic and continuous implementation of programs throughout the elementary school years is likely necessary to sustain effects. These principles should form the basis for school-based anti-obesity programs as effective strategies to address the growing obesity epidemic.

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Table 1

Summary of included studies of school-based obesity prevention programs

Study/ Program/ Administration	Sample	Intervention Duration/Cost	School-Based Intervention			Community Involvement	Parental Involvement	Control Condition	Measurement Time Frames & Outcome
			Physical Activity (PA)	Education	Nutrition				
Physical Activity Only Interventions									
Donnelly et al. (2009) Physical Activity Across the Curriculum (PAAC) Implemented by teachers	24 schools; grades 2-3 followed to grades 4-5, longitudinal study N = 454	3 years Detailed cost information was not provided. Authors describe PAAC as "low burden" and "minimal cost."	90 additional minutes of PA administered in 10 minute segments throughout the week during class time (in addition to 60 min of PA/week that is already part of the curriculum)	No	No	No	No	No intervention. Children received 60 min of PA/week, the same as they received prior to the start of the program	Analyses examined change between baseline and post-intervention (3 years) **i.** BMI: No significant reduction in BMI versus control. However, there was a significantly smaller increase in BMI among schools with ≥75 minutes of PAAC/ week at the three year mark compared to schools with <75 minutes of PAAC/ week (p=0.02) **ii.** PA: Children in the PAAC group engaged in significantly more PA compared to children in the control group.
Howe et al. (2012) A recess intervention to promote moderate-to-vigorous PA Implemented by trained research staff	2 schools; grade 3 N = 27	9 weeks No cost data reported	30 minute structured recess using 22 games of known energy expenditure resulting in "moderate-to-vigorous" PA	No	No	No	No	30 min free play recess	Analyses examined change between baseline and post-intervention (9 weeks) **i.** BMI: No significant reduction in BMI for the intervention or control group. **ii.** Physiological indicators: No significant effects

Study/ Program/ Administration	Sample	Intervention Duration/Cost	School-Based Intervention			Community Involvement	Parental Involvement	Control Condition	Measurement Time Frames & Outcome
			Physical Activity (PA)	Education	Nutrition				
									on waist circumference, blood pressure, on waist circumference, blood pressure, on waist circumference, blood pressure, on waist circumference, blood pressure, on waist circumference, blood pressure, **iii.** Physical activity: Rates of moderate to vigorous PA increased more in the intervention group than in the control group, $p<.05$
Heelan et al. (2009) Walking School Bus (WSB) Program Administered by paid college students	3 schools, grades 1-5 N = 324	2 years – daily, only cancelled for temperatures below 25 degrees, rain, or snow No cost data reported	Neighborhood walk stops were designated in a 1-mile radius of the school. The WSB leader met children at stops and walked them to their school in the morning and back to the stop in the afternoon. Routes resulted in an average of .65 miles of walking each way.	No	No	No	No	No intervention	Analyses examined change between baseline and post-intervention (2 years) **i.** BMI: No significant difference between groups on BMI or percent body fat. However, children who participated more frequently in the program had significantly greater decreases in BMI, $p<.05$. **ii.** Physical activity: Children in the WSB program had significantly more PA than children in the control school, $p<.05$.
Education Only Interventions									
Tucker et al. (2011) Let's Go 5-2-1-0 Program Delivered by nursing students	4th and 5th grade students from two schools N = 99	Information on the overall length of Let's Go 5-2-1-0 was not provided. One school provided 1:1	No	Same 5-2-1-0 curriculum as control condition plus 1:1 student nurse coaching using motivational	No	Delivery by nursing students was meant to help create a community partnership between the	Two parent evening offerings were provided.	5-2-1-0 curriculum delivered by nursing students in the classroom. Based on these principles: Eat	Analyses examined change between baseline and post-intervention. This time period appeared to vary across schools (i.e., 4 months or 8 months).

Study/ Program/ Administration	Sample	Intervention Duration/Cost	School-Based Intervention			Community Involvement	Parental Involvement	Control Condition	Measurement Time Frames & Outcome
			Physical Activity (PA)	Education	Nutrition				
		coaches for 8 months (1 to 12 sessions) and one for 4 months (10-14 sessions). No cost data provided		interviewing techniques occurring after school. Reinforcement incentives were provided but it is not clear which behaviors were reinforced.		school of nursing and the public schools		fruits and vegetables ≥5 times/day, Cut screen time to ≤2 hours/day, Participate in ≥1 hour of moderate PA daily, 0 sodas or sweetened drinks Note that this was an active control group	**i.** BMI: No significant differences between groups. **ii.** Physical activity (objectively measured): No significant differences between groups. **iii.** Nutrition: No significant differences between groups.
Combined Physical Activity and Nutrition Interventions									
Barbeau et al. (2007) Afterschool Physical Activity Program Administered by teachers and teaching assistants	8 to 12 year olds (mean age=9.5), all African American females; Grades 3-4 N = 201	Daily after school intervention for 10 months No cost data provided.	80 minutes of PA consisting of 25 minutes of skill development, 35 minutes of moderate to vigorous PA, and 20 minutes of stretching/toning. Children were taught how to maintain their heart rate during exercise using a heart rate monitor. Children received small weekly prizes for participation.	No	Children were provided with a healthy after school snack	No	No	No intervention	Analyses examined change between baseline and post-intervention (10 months) **i.** BMI: Children in the intervention group had a greater decrease in BMI than children in the control group, $p<.01$ **ii.** Other physical indicators: Children in the intervention group showed greater improvements in % body fat ($p<.001$) and cardiovascular fitness ($p<.05$)
Hendy et al. (2011) Kid's Choice Program (KCP) KCP was delivered first by undergrad college students	1 school; grades 1-4 N = 382	3 months Cost estimate: ~$2/child per month with an additional $5/child per month if pedometers	Children were provided with rewards for having 5000 exercise steps recorded on their pedometers each day. Rewards were stars that	No	Children were provided with rewards for eating fruits and vegetables first during their meal	No	Children received extra rewards if parents reported their behaviors	Children received rewards for good citizenship behaviors during lunch, including respecting	Analyses examined change between baseline, post-intervention (3 months), and 6-month follow-up **i.** Healthy eating: Children in the KCP group

Study/ Program/ Administration	Sample	Intervention Duration/Cost	School-Based Intervention			Community Involvement	Parental Involvement	Control Condition	Measurement Time Frames & Outcome
			Physical Activity (PA)	Education	Nutrition				
and then by parents in this study. Analyses indicated that parents could effectively implement the intervention.		are used.	could be cashed in for small prizes (e.g., pens, puzzles, balls, jump ropes).		and choosing low-fat and low-sugar healthy drinks during lunch. Children with both school-provided and home packed lunches were allowed to participate. Rewards were stars that could be cashed in for small prizes (e.g., pens, puzzles, balls, jump ropes).		during dinner at home. Only 20% of parents returned these forms. Parents also served as volunteers to implement KCP in school cafeterias during the second part of this study.	others and talking quietly. PA and nutrition behaviors were not rewarded. Control children were in the same school as those receiving KCP.	showed significantly larger increases in eating fruits and vegetables first during lunch and consuming healthy drinks compared to children in the control group. Parents of children in the KCP group showed greater increases in packing fruits and vegetables in home packed lunches compared to controls. **ii.** PA: The KCP group showed greater increases in daily steps recorded on pedometers compared to the controls. **iii.** BMI: Both overweight and average weight children in the KCP group showed a significant decrease in BMI immediately following the intervention. At 6 month follow-up, average weight children but not overweight children maintained these improvements. Similar improvements were seen in the control group,

Study/ Program/ Administration	Sample	Intervention Duration/Cost	School-Based Intervention			Community Involvement	Parental Involvement	Control Condition	Measurement Time Frames & Outcome
			Physical Activity (PA)	Education	Nutrition				
									presumably due to contamination from th presumably due to contamination from th presumably due to contamination from th presumably due to contamination from th presumably due to contamination from th
Howe et al. (2011) After school PA program Delivered by study personnel and school teachers	5 schools, grades 3-5, ages 8-12 all African American boys N = 106	10 months	80 minutes of PA after school every day, consisting of 25 minutes of skill development, 35 minutes of moderate to vigorous PA, and 20 minutes of stretching/toning. Boys wore heart rate monitors to record PA intensity and asked to maintain a heart rate of at least 150 bpm	No	Healthy snack provided after school.	No	No	No intervention	Analyses examined change between baseline and post-intervention (10 months) For the analyses, there was a distinction made between those boys who attended at least 60% of the after school sessions (attenders) and those who did not (non-attenders) **i.** BMI: Attenders showed a significantly greater decrease in % body fat compared to the control group, $p<.05$ and a significantly greater decrease in BMI compared to the non-attenders, $p<.05$ and the control group, $p<.01$. **ii.** Physical activity: Attenders showed a significant increase in PA, $p<.05$, whereas the non-attenders and control group did not. Significant tests for differences between groups were not reported.
Combined Physical Activity/Education/Nutrition Interventions									

Study/ Program/ Administration	Sample	Intervention Duration/Cost	School-Based Intervention			Community Involvement	Parental Involvement	Control Condition	Measurement Time Frames & Outcome
			Physical Activity (PA)	Education	Nutrition				
Greening et al. (2011) TEAM Mississippi Authors suggest that the program can be implemented by school health champions (e.g., school nurses, counselors)	6-10 year olds (M = 8.34) N = 450	8 months Detailed cost information was not provided. Authors indicated that expenses were offset by donations of services and products by local vendors and organizations.	PA contests every other month (e.g. parent-child Softball throw contest at the beginning of baseball season)	Education on the nutritional content of foods, eating in moderation, and benefit of exercise was provided during monthly nutritional events.	Nutritional activities/ contests every other month (e.g., school-children and parents prepared healthy recipes for "healthy-tailgating party" at the high school football game) Changes to school's food service (e.g., replacing deep fryers with baking ovens)	Community resident focus groups developed PA/ nutritional activities to complement the community's existing activity schedule	Families participated in monthly events (either nutritional or PE)	The state's standard health curriculum: One 45 minute nutritional presentation, two 45 minute weekly PE classes. Teachers were instructed to include nutritional information in lessons.	Analyses examined change between baseline and post-intervention (8 months) **i.** Percentage body fat: Statistically significant decline in percentage body fat ($p = 0.02$) for intervention group. No change for the control group. **ii.** Physical activity: Intervention group reported an increase in PA ($p = 0.04$), while the control group reported a decline in PA. **iii.** Nutrition: Intervention group reported a greater reduction in dietary fat intake than the control group ($p < 0.0005$). **iv.** Performance on 3 fitness tests: improvement in performance on 2 of 3 fitness tests, including curl-ups and the shuttle run ($p's < 0.0001$) compared to control schools **v.** No differences were found between groups on nutrition knowledge, BMI, or waist circumference.

Study/ Program/ Administration	Sample	Intervention Duration/Cost	School-Based Intervention			Community Involvement	Parental Involvement	Control Condition	Measurement Time Frames & Outcome
			Physical Activity (PA)	Education	Nutrition				
Hollar et al. (2010) Healthier Options for Public School-children (HOPS) Administered by a registered dietician, cafeteria staff, Master Gardeners, and teachers.	5 schools; 6-13 year olds, K – 6 grades N = 2,494	2 school years No cost information reported.	10-15 min/day was added to mandated PA requirements using a desk-side activity program led by teachers. Structured PA was encouraged during recess. Students were provided with pedometers but many broke or lost them so this was discontinued. Adults and students encouraged to walk laps around the track before school began.	Educational curriculum and other school-based wellness programs focused on good nutrition and the benefits of PA. Program used multimedia including posters, parent newsletters, handouts, activities, school assemblies, videos, online activities, and books. Also had gardens and related education at each school.	School menu (breakfast, lunch, snacks) remodeled by a registered dietician based on USDA dietary guidelines, including lower amounts of fat and sugar and more whole grains and fruit. School menu also coincided with what was being taught in the classroom.	No	Authors indicate that education was provided to parents but the nature of their involvement is unclear. Parents were sent newsletter inserts about nutrition and health lifestyle.	No intervention	Analyses examined change between baseline and post-intervention (end of the second school year) **i.** BMI and weight: Significantly greater decreases in BMI ($p<.05$) and weight ($p<.01$) among girls in the intervention group compared to the control group. No significant effect on BMI or weight for boys. **ii.** Blood pressure: Girls in the intervention group showed a significant decrease in systolic blood pressure over the 2 year period. Girls in the control group showed a slight increase. There was a greater decrease in diastolic girls in the intervention group compared to controls ($p < .05$). There was no effect on systolic or diastolic blood pressure for boys
Hoelscher et al. (2010) Compared Coordinated Approach to Child Health BasicPlus (CATCH BP)	97 schools; grade 4 N = 1107	1 year No cost data provided	Increase in moderate-to-vigorous PA in school PE and teacher-led activity breaks as well as encouragement of	CATCH BP materials consisted of a cartoon and peer-based curriculum that teaches	School Food Service personnel prepare healthier meals and help coordinate	Community partner was added to the CATCH program committee. CATCH Community	Family fun night activities	CATCH BP program without the "CATCH Community Action" Team (i.e., did not have any of	Analyses examined change between baseline and post-intervention (1 year) – serial cross-sectional design. **i.** Obesity: the percentage of

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			Physical Activity (PA)	Education	Nutrition				
to CATCH BP and Community (BPC) Implemented by teachers and school administrators; oversight by a program committee; CATCH facilitators trained school staff and coordinated the program.			PA at home.	healthy eating, tobacco avoidance, and the connection between sedentary lifestyle and obesity; messages on school menus, morning announcements, and other "social marketing" efforts. Health-related education provided in the classroom.	healthy messages with the rest of the school	Action Teams were asked to (i) conduct a self-assessment using the CDC School Health Index to identify priority areas of action, (ii) attend 3 "Best Practices" workshops per year, and (iii) select an activity each semester from a "CATCH Community Café" menu of evidence based strategies for promoting PA and healthy eating (e.g., a school gardening program, an after-school PA program)		the community involvement components) Note that this was an active control group and there were pre-post improvements in obesity-related outcomes for both groups.	students classified as overweight/ obese decreased significantly more in CATCH BPC schools (8.2%) compared to CATCH BP schools (3.1%), p<.05. **ii.** Diet outcomes: Students at CATCH BPC schools reported healthier diet outcomes than students in CATCH BP schools, including higher percentage of students eating breakfast and consumption of fewer unhealthy foods. No significant differences in increase in consumption of healthy foods. **iii.** Physical activity: No significant between group differences in PA. Students in the CATCH BPC schools reported a greater decrease in sedentary activities compared to CATCH BP students.
Speroni et al. (2007) Kids Living Fit (KLF) Program, a weekly	4 schools; grades 2-5 N = 185	12 week intervention Detailed cost information not provided. Children were	Weekly after school PA programs led by physical trainers (e.g., aerobic dance, light	4 30-minute dietary education sessions led by dieticians i) Week 1—best	Periodic weekly food logs; dietician helped students to make the	None	Parental attendance encouraged and recorded at dietary sessions	No intervention	Analyses examined change between baseline and post-intervention (12 weeks)

Study/ Program/ Administration	Sample	Intervention Duration/Cost	School-Based Intervention			Community Involvement	Parental Involvement	Control Condition	Measurement Time Frames & Outcome
			Physical Activity (PA)	Education	Nutrition				
afterschool program Implemented by a physical fitness trainer and registered dieticians. Authors note that KLF was designed for delivery by school nurses.		charged $100 to participate in the program.	strength training, yoga); periodic weekly activity logs; participants wore pedometers	choice lunch selections ii) Week 2—U.S. Department of Agriculture food pyramid and serving sizes iii) Week 3—age-appropriate interactive portion distortion presentation iv) Week 4—best choice at fast food restaurants and summary of past sessions	best choices from the school menu and for those students bringing lunch from home				i. BMI: mean percentile scores decreased 2.3 points in KLF group vs. increased 1.5 points in control group. There was 5% increase in students with normal BMI and decreased percentage in at-risk and overweight categories in the KLF group, but no shift in the control group. No significant testing was presented for these differences. ii. Waist circumference: 0.42” increase in KLF group vs. 0.98” increase in control group. No significance testing was presented for this difference.
Foster et al. (2008) School Nutrition Policy Initiative (SNPI) Delivered by teachers and school staff	10 schools; grades 4-6 N = 1349	2 years No cost data provided	Students participated in the 2-1-5 challenge - ≤2 hours of TV or video games/day; ≥1 hour of physical activity/day; ≥5 fruits and vegetables/day. Some PA education, though education component seemed more heavily oriented to nutrition.	~10 hours/year of training in nutrition education offered to all school staff; 50 hours of food and nutrition education per student per year integrated into regular classroom subjects.	Sodas, sweetened drinks, and snacks that did not meet predetermined standards removed from vending machines & cafeteria lines; raffle prizes given to students who purchased healthy	Program developed and delivered by The Food Trust, a community-based organization; no direct community involvement during the intervention	Nutrition education was provided at home and school association meetings, report card night, parent education meetings, and weekly nutrition workshops. Parents were encouraged to	No intervention	Analyses examined change between baseline and post-intervention (2 years) i. Incidence of overweight and obesity: Significantly lower incidence of children becoming overweight in SNPI schools (7.5%) compared to control schools (14.9%), $p<.05$. There was no significant

Study/ Program/ Administration	Sample	Intervention Duration/Cost	School-Based Intervention			Community Involvement	Parental Involvement	Control Condition	Measurement Time Frames & Outcome
			Physical Activity (PA)	Education	Nutrition				
					snacks/drink or brought items from home that met the standards. Nutritional standards were based on the Dietary Guidelines for Americans.		purchase healthy snacks and discouraged from sending sweets to teachers for holidays.		difference between schools in the incidence of becoming obese. **ii.** Nutrition: No significant differences between groups in nutrition outcomes. **iii.** Physical activity: No significant differences between groups in amount of self-reported PA. However, children in the SNPI schools reported significantly lower rates of sedentary behaviors ($p<.01$).