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ARTICLE

A Policy-Based School Intervention to Prevent Overweight and Obesity

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What's Known on This Subject

The increasing prevalence and consequences of childhood obesity have prompted calls for broad public health solutions that reach beyond clinic settings. Schools are ideal settings for population-based interventions. Despite their intuitive appeal, the results for school-based interventions are mixed.

What This Study Adds

This study has several distinctive features: (1) it is a school-based intervention that is community originated, (2) the population is composed of fourth- to sixth-graders from a low socioeconomic status, and (3) the program is effective and particularly so for blacks.

ABSTRACT

BACKGROUND. The prevalence and seriousness of childhood obesity has prompted calls for broad public health solutions that reach beyond clinic settings. Schools are ideal settings for population-based interventions to address obesity.

OBJECTIVE. The purpose of this work was to examine the effects of a multicomponent, School Nutrition Policy Initiative on the prevention of overweight (85.0th to 94.9th percentile) and obesity (>95.0th percentile) among children in grades 4 through 6 over a 2-year period.

METHODS. Participants were 1349 students in grades 4 through 6 from 10 schools in a US city in the Mid-Atlantic region with ≥50% of students eligible for free or reduced-price meals. Schools were matched on school size and type of food service and randomly assigned to intervention or control. Students were assessed at baseline and again after 2 years. The School Nutrition Policy Initiative included the following components: school self-assessment, nutrition education, nutrition policy, social marketing, and parent outreach.

RESULTS. The incidences of overweight and obesity after 2 years were primary outcomes. The prevalence and remission of overweight and obesity, BMI *z* score, total energy and fat intake, fruit and vegetable consumption, body dissatisfaction, and hours of activity and inactivity were secondary outcomes. The intervention resulted in a 50% reduction in the incidence of overweight. Significantly fewer children in the intervention schools (7.5%) than in the control schools (14.9%) became overweight after 2 years. The prevalence of overweight was lower in the intervention schools. No differences were observed in the incidence or prevalence of obesity or in the remission of overweight or obesity at 2 years.

CONCLUSION. A multicomponent school-based intervention can be effective in preventing the development of overweight among children in grades 4 through 6 in urban public schools with a high proportion of children eligible for free and reduced-priced school meals.

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Key Words
children and adolescents, community pediatrics, obesity, population-based studies, school-based program

Abbreviations
SNPI—School Nutrition Policy Initiative
CDC—Centers for Disease Control and Prevention
GEE—generalized estimating equation
MI—multiple imputation
OR—odds ratio
CI—confidence interval

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THE INCREASING PREVALENCE and serious consequences of childhood obesity have prompted calls for broad public health solutions that reach beyond clinic settings.[1] Schools are ideal settings for population-based interventions to address obesity.[2,3] Children spend approximately half of their waking hours in school. Schools provide 1 to 2 meals daily and are a natural setting for education about healthy food choices. Despite their intuitive appeal, the results for school-based interventions have been mixed. Although some school-based programs have had favorable effects on BMI,[4–6] many have not.[7–9] The reason for this is unknown but may include an insufficient dose, barriers to effective implementation, the inability to effectively target children at highest risk, and that the behaviors targeted by interventions may not relate directly to body weight. Nearly all of the interventions tested have been developed and/or implemented by university-based teams. Few studies have examined the effects of school-based programs that have originated in the community. Also, as Doak et al[10] note, few studies have examined the possible adverse effects

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of obesity prevention programs, such as worsening body image or decreases in BMI *z* scores among those who are normal weight or underweight.

The purpose of this study was to examine the effects of a multicomponent School Nutrition Policy Initiative (SNPI) on the prevention of overweight and obesity among children in grades 4 through 6 over a 2-year period. Given the disproportionately high rates of obesity among children in lower socioeconomic status groups,[11] the study was implemented in schools that had ≥50% of children eligible for federally subsidized, free, or reduced-price meals.

METHODS

Study Design

The study was conducted in 10 schools in the School District of Philadelphia. Schools were the unit of randomization and intervention. Ten schools were selected from among 27 Kindergarten through eighth grade schools with ≥50% of students eligible for free or reduced-price meals. To obtain pairs of 2 schools per cluster, the 27 schools were first organized into 5 clusters of 4 to 7 schools each, based on school size and type of food service (eg, full service [2 clusters] or heat and serve [3 clusters]). Schools within each cluster were approached to participate in a predetermined, random order. When 2 schools in each cluster agreed to participate, the schools were randomly assigned as intervention or control schools. A total of 12 schools were approached; 2 declined and 10 were enrolled. Within schools, written parental consent and child assent were required for individual children to participate. The study was approved by the University of Pennsylvania Institutional Review Board.

Intervention

The SNPI was developed and delivered by The Food Trust, a community-based organization, and was funded by the US Department of Agriculture Food Stamp Nutrition Education Program. A task force was developed, which devoted a year to discerning how best to adapt the Centers for Disease Control and Prevention (CDC) Guidelines to Promote Lifelong Healthy Eating and Physical Activity[12] to meet the needs of the Philadelphia school district. Committees were established to make recommendations on the CDC guidelines and to work with the Food Services Division, which operates food services in all Philadelphia public schools, to remove all sodas, sweetened drinks, and snacks that did not meet the standards set by the committee (see below in nutrition policy) from the vending machines and the cafeteria line. All of the schools were under the direction of the district's Food Service Division, which agreed to make the necessary changes in the intervention schools, while making no changes to the control schools.

The SNPI included the following components: (1) school self-assessment; (2) nutrition education; (3) nutrition policy; (4) social marketing; and (5) parent outreach. Each component is described briefly below. A more detailed description of the intervention is available at www.thefoodtrust.org.

Self-Assessment

Schools assessed their environments by using the CDC School Health Index.[13] Each school formed a Nutrition Advisory Group to guide the assessment. Teams included administrators, teachers, nurses, coaches, and parents. After completing ratings on healthy eating and physical activity, schools developed an action plan for change. Schools proposed various strategies, such as limiting the use of food as reward, punishment, or for fundraising; promoting active recess; and serving breakfast in classrooms to increase the number of students eating a healthy breakfast.

Staff Training

All of the school staff in the intervention schools were offered ~10 hours per year of training in nutrition education. At these trainings, staff received curricula and supporting materials such as *Planet Health*[4] and *Know Your Body*,[14] as well as nutrition and physical activity theme packets designed to integrate classroom lessons, cafeteria promotions, and parent outreach. Staff attended trainings both across and in intervention schools, giving them a chance to work together as a team and to share ideas with their counterparts in other intervention schools.

Nutrition Education

The goal was to provide 50 hours of food and nutrition education per student per school year, which was based on the National Center for Education Statistics guidelines.[15] The educational component was designed to be integrative and interdisciplinary. Its purpose was to show how food choices and physical activity are tied to personal behavior, individual health, and the environment. Nutrition was integrated into various classroom subjects. For example, students used food labels to practice fractions and nutrition topics for writing assignments.

Nutrition Policy

In each of the intervention schools, all of the foods sold and served were changed to meet the following nutritional standards, which were based on the Dietary Guidelines for Americans and converted from the percentage of calories to grams per serving,[16] which is in alignment with information shown on nutrition labels: all of the beverages were limited to 100% juice (recommended 6-oz serving size), water (no portion limits), and low-fat milk (recommended 8-oz serving size). Snack standards allowed ≤7 g of total fat, 2 g of saturated fat, 360 mg of sodium, and 15 g of sugar per serving. Before these changes, soda, chips, and other drinks and snacks had been sold in vending machines and a la carte in the cafeteria of schools with full-service kitchens. Schools without full-service kitchens did not sell a la carte food items or have vending machines. Schools were matched

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by type of food service to control for differences in the sales of vending and a la carte items.

Social Marketing

The SNPI used several social marketing techniques. To increase meal participation and consumption of healthy snack and beverage items, students who purchased healthy snacks and beverages or who brought in snack items that met the nutritional standards from home or local stores received raffle tickets. Raffle winners received prizes for healthy eating, such as bicycles, indoor basketball hoops, jump ropes, and calculators. The message "Want Strength?. . .Eat Healthy Foods," paired with an easily recognizable character, reinforced healthy messages through incentives and frequent exposure. Both the slogan and the character were developed through focus groups with students who were not in the study schools but were of similar age, ethnicity, and socioeconomic status.

Family Outreach

Nutrition educators reached family members through home and school association meetings, report card nights, parent education meetings, and weekly nutrition workshops. They encouraged parents and students, on the way to and from school, to purchase healthy snacks. Students participated in the 2-1-5 challenge to be less sedentary (≤2 hours per day of television and video games), to be more physically active (≥1 hour per day), and to eat more fruits and vegetables (≥5 per day). Intervention schools reduced the amount of unhealthy foods sold at parent fundraisers and discouraged parents from sending sweets to teachers at holiday time. One school chose to have a weekly breakfast club with female athletes from a local university.

Outcomes

Measurements were collected at baseline in the spring semester and again at year 2 in the spring semester. Interim weight data were collected in the spring semester of year 1. Return visits were scheduled within 1 month to reach absent students. Race/ethnicity data were self-reported by each child and were collected to assess potential interaction effects with the intervention, as well as to examine the disproportionate prevalence of overweight and obesity.

Weight and Height

Heights and weights were measured annually on a digital scale and wall-mounted stadiometer by a trained research team with a standardized protocol. The team was not blinded to treatment condition, because social marketing materials were in the intervention schools. BMI *z* scores and percentiles based on age and gender were calculated for each student using CDC growth charts.[17] Each participant was classified into 1 of 4 weight categories as described by the Institute of Medicine[1]: underweight (BMI for age less than the fifth percentile; $n = 23$; 2.2%); normal weight (BMI for age from the fifth to 84.9th percentile; $n = 619$; 57.9%); overweight (BMI for age from the 85th to 94.9th percentile; $n = 182$; 17.1%); and obese (BMI for age >95th percentile; $n = 245$; 22.9%).

Dietary Intake, Physical Activity, and Sedentary Behavior

Dietary intake, specifically total energy consumed (kilojoules), fat consumption (grams), and the number of fruit and vegetable servings, was measured with the Youth/Adolescent Questionnaire, a self-administered 152-item food frequency questionnaire, which has been used to measure dietary intake in previous studies.[18,19] Physical activity and sedentary behavior, specifically television viewing, were measured by the Youth/Adolescent Activity Questionnaire, a self-administered 24-item questionnaire also used in past research. Total inactivity was calculated by combining all of the 8 sedentary behaviors that were assessed in the questionnaire. Finally, body image was assessed using the body dissatisfaction subscale of the Eating Disorder Inventory-2 (EDI-2).[20]

Statistical Analysis

Incidence of overweight and obesity after 2 years (percentage of subjects who were initially not overweight or obese but who became overweight or obese) was analyzed as a primary outcome, because the goal of the intervention was the prevention of overweight and obesity. Prevalence (percentage of subjects who were overweight or obese) and remission (percentage of subjects who were overweight or obese at baseline but were not overweight or obese at follow-up) were analyzed as secondary outcomes. Analyses of overweight and obesity were conducted separately. Analyses were also conducted after collapsing the overweight and obese categories (≥85th percentile). Additional secondary analyses included BMI *z* score, total energy and fat intake, fruit and vegetable consumption, body dissatisfaction, and hours of activity and inactivity, including weekday television viewing after 2 years.

The generalized estimating equations (GEE) method was used to account for the intraclass correlation of responses within a school (ie, students within a school are more similar than students between schools). In addition to individual-level covariates measured at baseline, an indicator variable for each randomization pair was included in these models as fixed effects to account for school matching.[21,22] To assess the primary outcome of incidence and the secondary outcomes of prevalence and remission, GEE was used to model a binary outcome. These models included race/ethnicity, gender, age, and an indicator of the randomization pair as covariates. The models predicting prevalence also controlled for prevalence at baseline.

For the remaining secondary outcomes, GEE was also used to model a Poisson distribution for count variables (eg, hours of inactivity and television watching). We note that, because GEE and random coefficients analyses

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TABLE 1 **Baseline Characteristics of Participants**

Variable	Control ($n = 600$)	Intervention ($n = 749$)	*P*
Female, *n* (%)	313 (52.17)	412 (55.01)	.30
Age, mean ± SD, y	11.20 ± 1.0	11.13 ± 1.0	.20
Race/ethnicity, *n* (%)			<.001
Black	281 (46.83)	332 (44.33)	
Asian	166 (27.67)	128 (17.09)	
Hispanic	35 (5.83)	168 (22.43)	
Other	33 (5.50)	41 (5.47)	
White	85 (14.17)	80 (10.68)	
Weight status, *n* (%)			.08
Underweight	18 (3.00)	10 (1.34)	
Normal weight	352 (58.67)	420 (56.07)	
Overweight	99 (16.50)	129 (17.22)	
Obese	131 (21.83)	190 (25.37)	
BMI, mean ± SD, kg/m^2	20.71 ± 5.0	20.98 ± 5.1	.33
BMI *z* score, mean ± SD	0.65 ± 1.1	0.71 ± 1.1	.35
Fruit and vegetable, mean ± SD, *n* per d	5.64 ± 4.2	5.32 ± 3.9	.16
Total energy, mean ± SD, kJ/d (kJ/d)	13979.41 ± 8170.68	14029.85 ± 8112.72	.91
Total Fat, mean ± SD, g/d	118.46 ± 72.2	119.18 ± 71.0	.86
Activity, mean ± SD, h/wk	26.18 ± 19.3	25.85 ± 19.8	.77
Inactivity, mean ± SD, h/wk	108.77 ± 44.5	113.91 ± 50.1	.14
Television, mean ± SD, h per weekday	2.80 ± 1.5	2.87 ± 1.6	.49
Television, mean ± SD, h per weekend	3.34 ± 1.57	3.31 ± 1.6	.75
Body dissatisfaction, mean ± SD, raw score	9.19 ± 7.8	9.04 ± 7.6	.74

$N = 1349$.

were demonstrated to yield comparable results,[23] GEE was used to model continuous outcomes (eg, BMI *z* score). These models included race/ethnicity, gender, age, randomization pair, weight status at baseline, and baseline measures of the dependent variable. We note also that, because the unit of randomization and intervention was the school, we also implemented the approach suggested by Donner and Klar[24] to compare proportions (eg, of subjects who become obese). This approach uses a paired *t* test to compare the mean of the binary (for proportions) or continuous variables. This approach can work well even for a sample size of 5 pairs.[24]

To account for attrition at the student level, we imputed missing data at year 2 using the multiple imputation (MI) procedure with the Markov chain Monte Carlo algorithm.[25] Although the more conventional intent-to-treat analyses fill in a single value for each missing value, the MI procedure uses information obtained from an individual (eg, demographics, baseline values, intervention condition, etc) to replace each missing value with a set of plausible values that incorporate uncertainty about the right value to impute. Plausible values are then integrated into a single data set using the MIANALYZE procedure in SAS (SAS Institute, Inc, Cary, NC). The MI procedure is superior to the more conventional intent-to-treat analyses, because it produces estimates that are consistent, asymptotically efficient, and asymptotically normal.[26] Convergence was assessed via time series and autocorrelation plots. In addition, to assess the consistency of our findings, data were analyzed using the more conventional baseline carried forward and last observation carried forward methods.

RESULTS

Student and Teacher Participation

The consent rate across the 10 schools was 69.5% ± 15.4%, with no significant difference between control (67.7% ± 18.5%) and intervention (71.4% ± 13.5%) schools. There was no attrition at the school level. Among the 1349 students assessed at baseline, 921 (68.3%) (510 intervention and 411 control) were reassessed at year 1 and 844 (62.6%; 479 intervention and 365 control) were reassessed at year 2. Attrition rates did not differ between intervention and control schools at 1 (31.9% vs 31.5%) or 2 years (36.0% vs 39.2%). The reasons for attrition at 2 years were transfer (95.4%), repeated absences (3.6%), and refusals (1.0%). The analyses that accounted for attrition (MI, baseline carried forward, and last observation carried forward) did not differ from the analyses using complete data. Thus, the results obtained from participants whose data we had at the relevant assessment points (ie, baseline and year 2) are reported here. In addition, the results obtained from the paired *t* tests and GEE analyses were similar, so the GEE results are reported here.

With respect to implementation of the intervention, teachers and support staff participated in an average of 10.4 ± 2.9 and 8.4 ± 2.2 hours of training, respectively, during the first and second years of the intervention. Teachers and support staff, respectively, provided an

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TABLE 2 **Prevalence, Incidence and Remission of Overweight and Obesity at 2 Years**

Measure	Sample, *n*	Baseline, *n* (%)[a]	Follow-up, *n* (%)[a]	Unadjusted Change	Adjusted Odds (95% CI)[b]	*P*
Overweight						
Prevalence						
Control	365	58 (15.89)	73 (20.00)	4.11	1.00	
Intervention	479	78 (16.28)	70 (14.61)	−1.67	0.65 (0.54–0.79)	<.001
Incidence						
Control	208	—	31 (14.90)	14.90	1.00	
Intervention	268	—	20 (7.46)	7.46	0.67 (0.47–0.96)	.03
Remission						
Control	144	—	11 (7.64)	−7.64	1.00	
Intervention	206	—	22 (10.68)	−10.68	1.34 (0.71–2.54)	.37
Obese						
Prevalence						
Control	365	86 (23.56)	91 (24.93)	1.37	1.00	
Intervention	479	128 (26.72)	134 (27.97)	1.25	1.09 (0.85–1.40)	.48
Incidence						
Control	266	—	17 (6.39)	6.39	1.00	
Intervention	346	—	20 (5.78)	5.78	1.00 (0.66–1.52)	.99
Remission						
Control	86	—	12 (13.95)	−13.95	1.00	
Intervention	128	—	14 (10.94)	−10.94	0.84 (0.48–1.46)	.54

$N = 844$ (individuals with data at baseline and year 2). Models predicting prevalence also controlled for baseline prevalence. Sample sizes for prevalence included all 844 of the participant, whereas sample sizes for incidence and remission were dependent on initial weight status (eg, incidence of overweight was based only on individuals who were normal weight at baseline, whereas remission of obesity was considered using only those individuals who were obese at baseline). — indicates no data available.

[a] Data are unadjusted percentages.

[b] Odds were adjusted for race/ethnicity, gender, age, and an indicator of the randomization pair.

average of 48.0 ± 27.1 and 44.0 ± 18.3 hours of nutrition education during each year of the intervention.

Student Characteristics at Baseline

Baseline characteristics of the students are shown in Table 1. Among the 1388 students who provided parental consent and child assent, 1349 were assessed at baseline. The sample consisted of 53.7% females. Participants had (mean ± SD) an age of 11.2 ± 1.0 years, BMI of 20.9 ± 5.1 kg/m^2, and BMI *z* score of 0.7 ± 1.0. More than 40% (40.7%) were overweight or obese (≥85th percentile), and nearly a quarter (23.8%) were obese (≥95th percentile). Black children composed nearly half of the sample. There were no significant differences between control and intervention groups on any variable at baseline except for race/ethnicity (see Table 1). There were more Hispanic/Latino students in the intervention group (22.4%) than there were in the control group (5.8%; $P < .001$). To account for these differences at baseline, race/ethnicity was controlled for in subsequent analyses.

Primary Outcome

Incidence of Overweight and Obesity

Significantly fewer children in the intervention schools (7.5%) than in the control schools (14.9%) became overweight after 2 years (unadjusted means). After controlling for gender, race/ethnicity, and age, the predicted odds of incidence of overweight were ~33% lower for the intervention group (odds ratio [OR]: 0.67; 95% confidence interval [CI]: 0.47–0.96; $P < .05$). By contrast, there were no differences between intervention and controls schools in the incidence of obesity (see Table 2). At 2 years, there were no interaction effects between the intervention and race/ethnicity, gender, or age on obesity incidence. After collapsing the overweight and obese weight categories (≥85th percentile), the predicted odds of incidence of overweight or obesity were ~15% lower for the intervention group (OR: 0.85; 95% CI: 0.74 to 0.99; $P < .05$).

Secondary Outcomes

Prevalence of Overweight and Obesity

After 2 years, the unadjusted prevalence of overweight had decreased by 10.3% in intervention schools and had increased by 25.9% in control schools. After controlling for gender, race/ethnicity, age, and baseline prevalence, the predicted odds of overweight prevalence were 35% lower for the intervention group (OR: 0.65; 95% CI: 0.54 to 0.79; $P < .0001$). In addition to the main effect of the intervention, the intervention's effect on the prevalence of overweight was particularly effective for black students (OR: 0.59; 95% CI: 0.38 to 0.92; $P < .05$). Thus, after controlling for gender, age, and baseline prevalence, treated black students in the intervention schools were 41% less likely to be overweight than those in the control schools after 2 years. By contrast, there were no interaction effects between the intervention and gender or age on the prevalence of overweight. After 2 years, there were no differences between intervention and control schools in the prevalence of obesity (see Table 2 and Fig 1). After collapsing the overweight and obese

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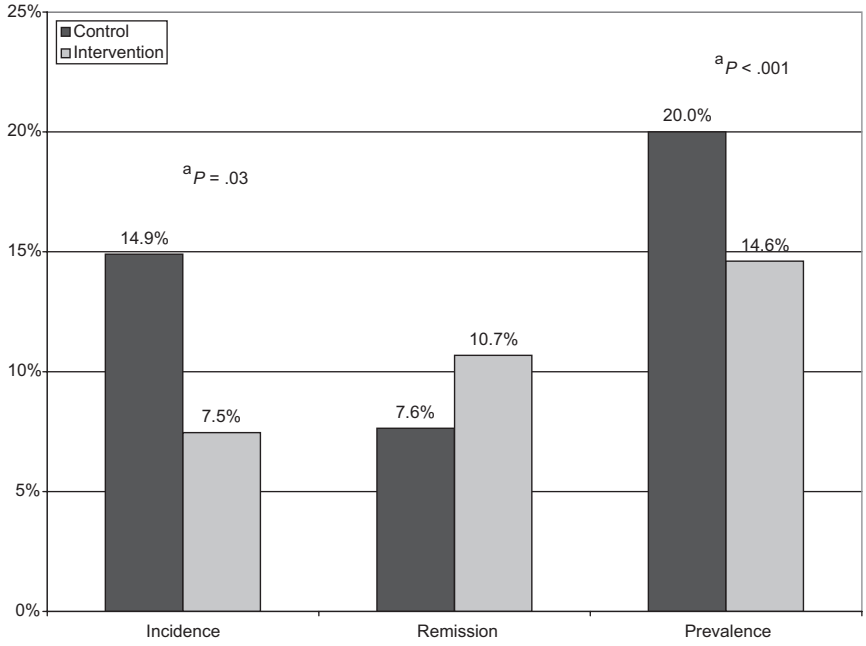

FIGURE 1
Unadjusted incidence, remission, and prevalence of overweight (85.0th–94.9th percentiles) at 2 years. [a] Statistically significant differences between the intervention and control schools after controlling for race/ethnicity, gender, age, and baseline prevalence for the prevalence outcome.

weight categories (≥85th percentile), there was no statistically significant difference between the intervention and control schools in the prevalence of overweight or obesity ($P = .07$).

Remission of Overweight and Obesity

After 2 years, there were no differences between intervention (10.7%) and control (7.6%) schools ($P = .40$) with respect to the remission of overweight. Similarly, there were no differences between intervention (10.9%) and control (14.0%) schools ($P = .50$) in the remission rates of obesity (see Table 2). After collapsing the overweight and obese weight categories (≥85th percentile), the predicted odds of remission of overweight or obesity were ~32% higher for the intervention group (OR: 1.32; 95% CI: 1.09 to 1.60; $P < .01$).

Independent of any intervention effect, there was a main effect of age for the prevalence (OR: 0.73; 95% CI: 0.56 to 0.94; $P < .05$), the incidence (OR: 0.73; 95% CI: 0.54 to 0.99; $P < .05$), and the remission (OR: 1.46; 95% CI: 1.07 to 1.99; $P < .05$) of obesity over 2 years. Thus, older children were less likely to be obese or become obese and more likely to remit after 2 years. There were no main effects for the prevalence, incidence, and remission of overweight. There were no differences between groups with respect to changes in BMI ($P = .71$) or BMI z score ($P = .80$).

Dietary Intake and Physical Activity

Students in both intervention and control schools showed similar decreases in self-reported consumption of energy, fat, and fruits and vegetable over 2 years (Table 3). Decreases in self-reported amounts of physical activity were reported by students at intervention and control schools, also with no differences between the 2 groups.

Sedentary Behavior

After 2 years, the unadjusted hours of total inactivity increased by ~3% in the control group and decreased by ~9% in the intervention group. After controlling for gender, race/ethnicity, age, and baseline inactivity, inactivity was 4% lower in the intervention group than in the control group (OR: 0.96; 95% CI: 0.94 to 0.99; $P < .01$) after 2 years. There were no interaction effects between the intervention and race/ethnicity, gender, or age on the level of inactivity.

Similarly, after 2 years, unadjusted weekday television watching increased by ~7.5% in the control group and decreased by ~1% in the intervention group. After controlling for gender, race/ethnicity, age, and baseline television viewing, weekday television watching was 5% lower in the intervention group than in the control group (OR: 0.95; 95% CI: 0.93 to 0.97; $P < .0001$) after 2 years. There were no interaction effects between the intervention and race/ethnicity, gender, or age on television watching.

Potential Adverse Effects

The intervention showed no evidence of an adverse impact with respect to a worsening body image or changes in the incidence, remission, and prevalence of underweight. Both groups showed comparable, minimal changes on the EDI-2 body dissatisfaction subscale (see Table 3). Similarly, at year 2, the same numbers of children were underweight (0.63%, 2.20%) and moved from normal weight to underweight (1.50%, 2.90%) between the intervention and control groups, respectively. Moreover, the same number of children moved from underweight to normal weight (40.00%, 38.50%) for the intervention and control schools, respectively.

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TABLE 3 **Secondary Outcomes at 2 Years**

Measure	Sample, *n*	Baseline[a]	Follow-up[a]	Unadjusted Change	Adjusted Difference (95% CI)[b]	*P*
BMI						
Control	364	20.76	22.86	2.10	−0.04 (−0.27–0.19)	.71
Intervention	479	21.07	23.06	1.99		
BMI *z* score						
Control	364	0.66	0.76	0.10	−0.01 (−0.08–0.06)	.80
Intervention	479	0.73	0.80	0.07		
Total energy, kJ/d						
Control	331	12900.59	10154.13	−2764.46	−104.27 (−234.28–25.73)	.12
Intervention	437	13764.37	10019.10	−3745.26		
Total fat, g/d						
Control	332	109.63	83.88	−25.75	−3.78 (−8.59–1.02)	.12
Intervention	437	116.68	82.63	−34.05		
Fruits and vegetables, *n* per day						
Control	333	5.33	4.28	−1.05	−0.04 (−0.37–0.30)	.82
Intervention	441	5.26	4.17	−1.09		
Total activity, h/wk						
Control	335	25.17	20.62	−4.55	0.30 (−0.40–1.00)	.40
Intervention	416	25.03	21.28	−3.75		
Body dissatisfaction (raw)						
Control	323	8.98	9.53	0.55	−0.14 (−0.73–0.45)	.64
Intervention	421	8.87	9.20	0.33		
Count variables[c]						
Total inactivity, h/wk						
Control	210	105.45	108.93	3.48	1.00	
Intervention	269	115.21	104.42	−10.79	0.96 (0.94–0.99)	.005
Total television, hours per weekday						
Control	315	2.81	3.02	0.21	1.00	
Intervention	390	2.92	2.89	−0.03	0.95 (0.93–0.98)	<.001
Total television, hours per weekend						
Control	300	3.41	3.32	−0.09	1.00	
Intervention	372	3.28	3.26	−0.02	0.97 (0.89–1.05)	.39

N = 844.

[a] Data are unadjusted means.

[b] Differences between the intervention and control groups were adjusted for race/ethnicity, gender, age, randomization pair, weight status at baseline, and baseline measures of the dependent variable.

[c] Count variables were modeled as Poisson distributions with adjusted change interpreted as ORs.

DISCUSSION

These data demonstrate that implementation of the multicomponent SNPI was associated with a substantial (~50%) and statistically significant decrease in the incidence of overweight. Compared with the 15% of children who became overweight in control schools, only 7.5% became overweight in intervention schools. Although a 50.0% reduction in incidence is impressive, the 7.5% increase over 2 years suggests that stronger or additional interventions are needed. These may include environments that are within schools (eg, physical education classes or more aggressive nutrition policies) or more proximal to schools (eg, local corner stores or after-school feeding programs). The intervention also had positive effects on the overall prevalence of overweight. Among intervention schools, prevalence decreased by 10.3% compared with a 25.9% increase in control schools. The intervention was even more effective for reducing the prevalence of overweight among black students. Treated black students were 41% less likely than nontreated black children to be overweight after 2 years compared with 35% less likely in the entire group. This is important to note given the increased prevalence of overweight among black children.[11] The intervention effect on overweight may have been mediated by changes in sedentary behavior. Other effective school-based interventions have found similar results,[4,5] suggesting that decreasing sedentary behavior may be a fruitful target. The self-reported nature of our activity data, however, makes this conclusion less certain.

In contrast to the effect on overweight, the intervention had no effect at the upper end of the BMI distribution, that is, on the incidence, prevalence, or remission of obesity. Progression to or remission from ≥95th percentile may be more likely to result from targeted and/or clinic-based programs than from untargeted approaches, such as the SNPI. The lack of an effect on BMI *z* score was not surprising. A reduction in BMI *z* score is not desired among those in the normal or underweight categories who composed ~60% of the sample at baseline. BMI *z* score is probably a more appropriate metric to use in clinic-based studies of those who are already overweight or obese.

There is some concern that school-wide obesity prevention programs may heighten body image concerns among youth and/or create more underweight children.

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Neither of these concerns was supported by our data. There were no differences between intervention and control groups in body image dissatisfaction or in the incidence, prevalence, or remission of underweight. Although the purpose of the intervention was the primary prevention of overweight and obesity, the emphasis was on eating well and moving more rather than weight control. This emphasis may have mitigated any potential adverse effects.

The use of self-reported measures of diet and physical activity makes any conclusions about mediators of the intervention effect tenuous. For example, it is unlikely that differences in energy intake had no role in mediating the intervention effects, but there were no group differences in self-reported energy intake. Children reported decreases of 2520 to 3780 kJ per day (600–900 kcal per day) raising questions about the validity of the self-reported intake data. Future studies would be improved by using accelerometry or doubly labeled water to more effectively look at mechanisms. Future studies would also be improved by a large number of schools and measures in addition to BMI (eg, waist circumference, glucose, and insulin).[27,28]

Despite the randomized nature of the study, our sample of 10 schools limited our ability to create identically equivalent groups. Although the groups only differed with respect to race/ethnicity, which was included in all of the statistical models, it is possible that the intervention and control schools differed on unmeasured characteristics that were related to our outcome. To ensure more complete randomization, future studies should consider either increasing the number of schools or matching schools on additional variables (eg, race/ethnicity).

CONCLUSIONS

In conclusion, our data suggest that a multicomponent school-based intervention can be effective in curbing the development of overweight among children in grades 4 through 6. It is of note that the intervention was implemented in urban public schools with a high proportion of children eligible for free and reduced-priced school meals. A troubling observation within these data are that, in the absence of any intervention (ie, control schools), 15% of the children who were not overweight in grades 4 to 6 became overweight over the next 2 years. Among those who were not obese, 6% became obese within 2 years. This secular trend has significant public health implications. According to the 2000 census, there are 20 528 072 children aged 10 to 14 years, which is the age range of this study. According to our incidence findings, ~3 million (0.149 * 20 528 072 = 3 058 683) children will become overweight, and ~1.3 million (.0639*20 528 072 = 1 311 744) will become obese over 2 years. Given that there was still a 7% incidence of new cases of overweight even in the intervention schools, there is much room for improvement in the effect, dose, and range of interventions. Future directions might include a focus on other aspects of the school environment (eg, physical education classes) or on environments beyond the school (eg, corner stores and homes). Finally, given the already high prevalence of children above the 85th percentile in grades 4 through 6 (41.7%), prevention programs should begin earlier than fourth grade.

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