Effect of a Two-Year Obesity Prevention Intervention on Percentile Changes in Body Mass Index and Academic Performance in Low-Income Elementary School Children

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Objectives. We assessed the effects of a school-based obesity prevention intervention that included dietary, curricula, and physical activity components on body mass index (BMI) percentiles and academic performance among low-income elementary school children.

Methods. The study had a quasi-experimental design (4 intervention schools and 1 control school; 4588 schoolchildren; 48% Hispanic) and was conducted over a 2-year period. Data are presented for the subset of the cohort who qualified for free or reduced-price school lunches (68% Hispanic; n = 1197). Demographic and anthropometric data were collected in the fall and spring of each year, and academic data were collected at the end of each year.

Results. Significantly more intervention than control children stayed within normal BMI percentile ranges both years ($P = .02$). Although not significantly so, more obese children in the intervention (4.4%) than in the control (2.5%) decreased their BMI percentiles. Overall, intervention schoolchildren had significantly higher math scores both years ($P < .001$). Hispanic and White intervention schoolchildren were significantly more likely to have higher math scores ($P < .001$). Although not significantly so, intervention schoolchildren had higher reading scores both years.

Conclusions. School-based interventions can improve health and academic performance among low-income schoolchildren. (*Am J Public Health.* 2010;100: 646–653. doi:10.2105/AJPH.2009.165746)

The prevalence of obesity remains high among all age and racial groups in the United States, particularly among African Americans, Hispanic and Mexican Americans, and low-income children.[1,2] Childhood-onset obesity is related to numerous risk factors for cardiometabolic disease that track from childhood into adulthood, including elevated blood pressure and lipids.[3–8] Additionally, studies have documented the mental health consequences of childhood obesity, including low self-esteem and higher rates of anxiety disorders, depression, and other psychopathologies among overweight and obese children.[9–12] How childhood overweight affects academic performance, however, is less well understood.

Studies show that in addition to socioeconomic status, obesity, poor nutrition, and food insufficiency affect a child's school achievement.[13–18] Specifically, students who experience food insufficiency may have lower math scores, social difficulties, and psychological difficulties.[15,16] Children described as normal-weight or overweight (versus obese) who are at nutritional risk have lower math scores, poorer attendance, and more behavior problems.[13,14] Moreover, young children who become overweight between kindergarten and the end of third grade experience reductions in test scores.[17,18] Additionally, severely obese children have been shown to have lower IQs, poorer school performance, and lower test scores than their less-overweight classmates, even after control for behavioral and socioeconomic variables.[19–21]

Schools play a crucial role in improving the health, and in turn the academic performance, of students. Children generally attend school 5 days per week throughout most of the year, and schools in the United States are located in communities of every socioeconomic and racial/ethnic group. The school environment provides many opportunities to teach children about important health and nutrition practices. The influence of schools on the health of children is strong, especially in low-income communities, where children often receive a significant proportion of their daily nutrition requirements (as much as 51% of daily energy intake)[22] via the US Department of Agriculture (USDA) National School Lunch Program (NSLP) and School Breakfast Program.

Healthier Options for Public Schoolchildren (HOPS) was an elementary school–based obesity prevention intervention targeting children aged 6 to 13 years that included nutrition and physical activity components. The goal was to improve overall health status and academic achievement by using replicable strategies. We hypothesized that the intervention would improve academic performance and help to maintain a healthy weight in the intervention children versus a control group.

METHODS

The pilot study described here was implemented over 2 school years (2004–2005 and 2005–2006) and included 6 elementary schools (4588 children; 48% Hispanic) in Osceola, Florida. All schools had similar demographic and socioeconomic characteristics and were chosen from a convenience sample. In a quasi-experimental design, schools were nonrandomly assigned to 1 of 4 intervention schools or 1 of 2 control schools by school administration. Because 1 control school was found after the start of the study to have an exceptional physical education program (state and federal grants including the Carol M. White Physical Education Program [PEP] grant) that could potentially confound the results (which was ultimately supported by post hoc analyses), it was removed from the sample.

Intervention

HOPS was designed to test the combined effect of (1) including nutritious ingredients and whole foods (e.g., as close to original form, and thus most nutritious as possible, such as fresh fruits and vegetables and whole grains) acquired through public school food distribution networks, in USDA NSLP school-provided meals, which provided daily examples of the good nutrition principles taught in the education curricula; (2) providing a nutrition and healthy lifestyle curricula that taught elementary-aged children and adults about good nutrition and healthy lifestyle management, including an emphasis on increased levels of physical activity; and (3) fostering other school-based wellness activities such as gardens.

Dietary intervention. The dietary intervention consisted of modifications to school-provided breakfasts, lunches, and extended-day snacks in the intervention schools. Menus were modified to include (1) more high-fiber items (e.g., whole grains and fresh fruits and vegetables); (2) fewer high-glycemic items (e.g., high-sugar cereals and processed flour goods); and (3) lower amounts of total, saturated, and *trans* fats. These modifications included the substitution of healthier ingredients for less healthy ingredients, rather than an outright ban on "child-friendly" foods. For example, chicken patties coated with whole grain flour were served instead of patties coated with white flour, and reduced-fat dairy products, including USDA Foods (also known as "USDA Commodities"), were provided in place of whole-milk (higher fat) products. Study staff, including a registered dietitian, worked closely with the USDA Food and Nutrition Service, as well as the school administration and foodservice personnel, to ensure intervention fidelity. Nutrition analyses of breakfast and lunch menus showed that intervention menus, on average, contained approximately twice as much fiber and 23% less fat than did control menus.[23–25]

Curricula component. The curricula component consisted of a school-based holistic nutrition and healthy lifestyle management program for elementary-aged children and adults. These curricula sought to teach children, parents, and school staff about good nutrition and the benefits of daily physical activity with the goal of improving the health and academic achievement of children in a replicable and sustainable manner. Replication and sustainability were assisted by incorporating USDA Team Nutrition materials, which are available to US schools, as well as The OrganWise Guys (The OrganWise Guys Inc., Duluth, GA; http://www.organwiseguys.com), which is used by many USDA county extension agents in the United States who conduct nutrition education in low-income schools every day.

Programming included a monthly thematic set of nutrition activities developed by the study staff in collaboration with elementary school education experts. Each month, a multimedia set of educational materials that highlighted nutrient-dense foods and healthy lifestyle management lessons were sent to the intervention schools. The materials included Foods of the Month posters, tips for conducting Foods of the Month tastings, Foods of the Month parent newsletter inserts, Foods of the Month activity packets, healthy lifestyle handouts, school gardening instructions, and other materials aligned with special programming such as American Heart Health Month, National Nutrition Month, and National School Breakfast and Lunch Weeks.

In addition to the monthly educational programming, each intervention school received an OrganWise Guys kit. The OrganWise Guys curriculum integrates nutrition, physical activity, and other lifestyle behavior messages to help children understand the importance of making healthy lifestyle choices and to motivate them to make these changes in their own lives. The OrganWise Guys kit includes print (books and activity posters) and electronic (videos and Internet activities) media, as well as school assemblies and a physical activity program (WISERCISE!, described below).

Fruit and vegetable gardens at intervention schools provided a fun and creative component to the nutrition curriculum, with the goal of teaching children how the nutritious fruits and vegetables served in their school cafeterias, their homes, and in restaurants are grown, cultivated, and harvested. Sustainability was assisted by USDA master gardeners.

Physical activity component. The physical activity component, which varied among the intervention schools, consisted of increased opportunities for physical activity during the school day in ways that were feasible within the constraints of testing mandates. In Florida, acceptance of more time for physical activity was difficult until the governor mandated 150 minutes of physical activity, per week, for elementary school children, which was not passed until the fall of 2007 in Florida House Bill CS/CS/HB 967—Physical Education.[26] Thus, the amount and types of physical activity varied among intervention schools throughout the study. Year 1 did not include a physical activity intervention. At the beginning of study year 2, students were provided pedometers and OrganWise Guys tracking books to record the number of steps taken each day. However, the pedometers broke easily and the students often lost them. Therefore, although a previous study showed that a pedometer program was useful in increasing the daily physical activity of children by approximately 1000 more steps per day as compared with that in nonparticipants,[27] the use of pedometers was discontinued midyear in our study during year 2. Schools were asked instead to conduct daily physical activity in the classroom during regular classroom time by using a 10- to 15-minute desk-side physical activity program (WISERCISE!, The OrganWise Guys Inc; or TAKE10!, ILSI Research Foundation, Washington, DC). These desk-side physical activities are matched with core academic areas, such as spelling and math, which allows teachers to stay on task while increasing the daily physical activity of their students. Schools also were asked to implement structured physical activity during recess and to lead other activities, such as walking clubs, that encouraged children and adults to increase their physical activity each day.

Measures

Demographic and anthropomorphic information—including date of birth, gender, grade, and race/ethnicity—were collected by the study coordinators at baseline (fall 2004) and each fall and spring (2004–2006). The participants were asked to remove their shoes and heavy outer clothing and to empty their pockets before being measured. Anthropometric data included height (by stadiometer: Seca 214 Road Rod Portable Stadiometer, Seca North America East, Hanover, MD) and weight (by balance scale: LifeSource 321 Scale, A&D Medical, San Jose, CA), which were used to create an age- and gender-specific body mass index (BMI; weight in kilograms divided by height in meters squared) percentile score. Children were classified according to BMI percentile for age and gender in accordance with the Centers for Disease Control and Prevention standardized groups as follows: (1) normal weight (BMI less than 85th percentile), (2) at risk for overweight (BMI 85th percentile or higher but less than 95th percentile), and (3) obese (BMI 95th percentile or higher).[28]

The Florida Comprehensive Achievement Test (FCAT) is administered to all Florida public school children beginning in the third grade. The average score throughout the state is 300. A score of 300 to 399 (level 3) indicates that a student answered many questions correctly but was generally less successful with questions involving the most challenging content. Level 3 meets the state learning requirements and allows students to matriculate to the next grade level. A score of 200 to 299 (level 2) meets the minimum requirements only and indicates that a student had limited success with challenging content on the FCAT. A level 2 in certain years (grade 3 for example) on certain portions of the FCAT could result in students being retained in their current grade level per the Florida Board of Education.[29] FCAT reading and math scores for each child were provided by school administration.

Data Analysis

The analysis presented here included children who qualified for free or reduced-price meals in the USDA NSLP proxy. Free meals are available to children from families with incomes at or below 130% of the poverty level; reduced-price meals are available to children from families with incomes between 130% and 185% of the poverty level. For example, for the period July 1, 2008, through June 30, 2009, 130% of the poverty level was $27 560 for a family of 4; 185% was $39 220.[30] By including children who most likely received school-provided lunch every day, we improved the intervention's internal validity and thus decreased potential confounders (e.g., children with a higher socioeconomic status likely eat better in general, regardless of eating the school lunch, and are more likely to bring lunch from home).

The unit of analysis for this pilot study was a school rather than an individual; thus, cluster randomization was taken into account. With cluster randomization, the mean response under each experimental condition is subject to 2 sources of variation: cluster-to-cluster and across individuals within a cluster. Approaching the analytical plan from an individual level only, rather than a cluster level, would not take into account the between-cluster variation and can cause an inflation of type I errors in which any intervention effect may become confounded with the natural cluster-to-cluster variability. Although we realize that this trial did not include a large number of schools to conduct a robust cluster analysis, we applied a 2-stage approach to the data analysis. The first stage was at the individual level. In this first stage, we analyzed all individual-level covariates to derive school-specific means that were adjusted for individual-level covariates. The second stage was at the school level. In the second stage, we analyzed school-specific means and appropriately adjusted for school-specific covariates to evaluate any intervention effects.

The univariate analysis consisted of simple frequency statistics for all demographic variables. Chi-square analyses were performed to test for associations between the intervention condition and demographic characteristics. Tests for independent samples were applied to capture differences in the percentages of change in BMI percentile group from baseline to the end of the intervention. For all children aged 2 to 20 years, BMI-for-age was used to assess weight in relation to stature and to calculate *z*-scores that were based on the 2000 CDC growth charts.[31]

Repeated-measures analysis tested for changes in trends over time (the 2-year study period, or 4 points in time) in BMI percentile group and FCAT scores. All tests were 2-tailed and $P < .05$ was considered statistically significant. For the repeated-measures analysis, only those children who had data in both years were retained in the final models. For the repeated-measures analysis of BMI, the sample size was 645 children. For the repeated-measures analysis of the FCAT scores, the sample size was 350. All analyses were performed by using both the SAS version 9.1 (SAS Institute Inc, Cary, NC) and SPSS version 15 (SPSS, Chicago, IL).

RESULTS

A total of 1197 children who qualified for free or reduced-price meals through the USDA NSLP were included in the analysis (68% Hispanic, 9% Black, 15% White, 8% other; mean age = 7.84 ± 1.67 years). A total of 974 children were in the intervention schools and 199 were in the control school. There were no

TABLE 1—Change in BMI Percentile Group by HOPS Intervention Condition, Fall 2004 Through Spring 2006

	Same in Fall 2004 and Spring 2006			Decrease Between Fall 2004 and Spring 2006			Increase Between Fall 2004 and Spring 2006		
BMI Percentile in Fall 2004	Intervention, % (SD)	Control, % (SD)	*P*	Intervention, % (SD)	Control, % (SD)	*P*	Intervention, % (SD)	Control, % (SD)	*P*
Normal (BMI < 85%)	52.1 (50)	40.7 (49)	.02	...	...		8.1 (27)	11.9 (32)	.24
Overweight (85% < BMI < 95%)	7.3 (26)	8.5 (27)	.67	6.4 (24)	6.8 (25)	.87	4.1 (19)	6.8 (25)	.27
Obese (BMI ³95%)	17.6 (38)	22.9 (42)	.18	4.4 (20)	2.5 (15)	.27	...	...	

Note. BMI = body mass index; HOPS = Healthier Options for Public Schoolchildren.

significant differences between the intervention and control groups in gender (P=.063) or the proportion of Blacks (P=.950), Hispanics (P=.063), or children of other ethnicity (P=.42), but there was a significant difference in the proportion of Whites (P=.002). Specifically, in the intervention schools, 69.6% were Hispanic, 13.7% were White, 8.8% were Black, and 7.9% were of other ethnicity. In the control school, 62.2% were Hispanic, 23.0% were White, 8.2% were Black, and 6.6% were of other ethnicity. There was no significant difference between the intervention and control schools in the percent of children who were overweight or obese (P=.06).

Anthropometric Results

As shown in Table 1, significantly more children in the intervention schools than in the control school stayed within the normal BMI percentile range for both years of the study (P=.02). Although not statistically significant (P=.27), more obese children (4.4%) in the intervention schools than in the control school (2.5%) decreased their BMI percentile. Conversely, fewer intervention children in the normal (8.1%) and at-risk-for-overweight (4.1%) groups gained weight versus the same 2 groups in the control school (11.9% and 6.8%, respectively) during the 2 intervention years (P=.24 and P=.27, respectively).

Academic Results

No significant differences were found at baseline in either math or reading FCAT scores between the intervention and control schools (P=.46 and P=.68, respectively). Overall, as shown in Table 2, intervention children had significantly higher FCAT math scores than did the control children in both years of the intervention (P<.001). We found a similar trend for FCAT reading scores in the overall sample, although the difference was not statistically significant (P=.08). After we controlled for ethnic group, the repeated-measures ANOVA showed that in both study years, all 3 ethnic intervention groups showed a statistically significant improvement in FCAT math scores compared with the control groups. Specifically, Hispanic children in the intervention schools showed an over 20-point gain in FCAT math scores versus Hispanic children in the control school, whose scores decreased over the same time period (P=.006). Similarly, both Black and White students in the intervention schools had statistically significant gains of over 40 points (P<.05) and over 20 points (P<.02), respectively, versus the same ethnic group in the control schools.

When we dichotomized the FCAT math scores by both level 2 and level 3, the same trends were found as in the raw scores (Table 3), that is, significant gains for the intervention schools versus the control school (P=.008 and P=.001, respectively). After we controlled for ethnic group, we found a significant improvement in math scores greater than or equal to level 3 for Hispanics (P=.004) and for non-Hispanic Whites (P=.04). Math scores greater than or equal to level 2 improved in non-Hispanic Blacks (P=.002), and reading scores greater than or equal to level 2 significantly improved as well (P=.05).

Although not statistically significant (P=.08), the same overall trends were seen for FCAT reading scores. Intervention children showed gains in FCAT reading scores in both years of the intervention, whereas control school students showed a decrease in mean FCAT reading scores during the same time period. After control for ethnicity, all 3 ethnic groups in the

TABLE 2—Change in Raw Math and Reading by HOPS Intervention Condition from 2003–2004 to 2005–2006 School Years for Overall Sample and by Ethnicity

	FCAT Raw Score 2003–2004, Mean (SD)	FCAT Raw Score 2004–2005, Mean (SD)	FCAT Raw Score 2005–2006, Mean (SD)	P[a]
All students				
Math				.001
Intervention	285.6 (58.7)	296.4 (59.3)	307.9 (51.3)	
Control	279.2 (45.0)	285.5 (53.8)	276.2 (60.9)	
Reading				.08
Intervention	286.7 (64.2)	291.3 (59.8)	292.4 (57.7)	
Control	282.9 (55.4)	279.9 (65.7)	281.7 (55.8)	
Hispanic students				
Math				.006
Intervention	281.7 (61.0)	290.8 (62.4)	303.4 (52.7)	
Control	277.9 (46.8)	281.2 (59.8)	270.1 (67.6)	
Reading				.09
Intervention	282.4 (65.5)	284.7 (61.6)	288.2 (57.7)	
Control	275.7 (62.2)	269.9 (72.1)	276.8 (58.1)	
White students				
Math				
Intervention	309.3 (54.8)	319.8 (43.5)	330.8 (39.7)	.016
Control	292.9 (37.4)	304.7 (29.1)	299.7 (36.6)	
Reading				.16
Intervention	308.5 (60.8)	320.0 (43.4)	315.5 (54.6)	
Control	297.6 (23.2)	306.4 (45.1)	294.7 (53.9)	
Black students				
Math				.04
Intervention	270.9 (34.0)	306.8 (46.4)	311.5 (41.5)	
Control	243.8 (22.3)	264.8 (52.2)	267.6 (44.1)	
Reading				.53
Intervention	265.5 (51.8)	302.1 (51.2)	294.9 (53.3)	
Control	284.8 (59.2)	287.8 (54.6)	279.6 (33.2)	

Note. FCAT = Florida Comprehensive Achievement Test; HOPS = Healthier Options for Public Schoolchildren.
[a] P value for the difference between the intervention and control schools from fall 2004 to spring 2006.

TABLE 3—Percentage of Children at Levels 2 and 3 and Above in FCAT Math and Reading by HOPS Intervention Condition, School Years 2004–2005 and 2005–2006

	FCAT Level 2			FCAT Level 3		
	School Year 2004–2005, % (SD)	School Year 2005–2006, % (SD)	P[a]	School Year 2004–2005, % (SD)	School Year 2005–2006, % (SD)	P[a]
All students						
Math			.008			.001
Intervention	80.4 (40)	85.5 (35)		54.0 (49)	64.5 (47)	
Control	74.3 (44)	67.1 (47)		41.4 (49)	32.9 (47)	
Reading			.85			.55
Intervention	76.1 (43)	73.6 (44)		54.7 (49)	53.6 (49)	
Control	75.7 (43)	75.7 (43)		50.0 (50)	51.4 (50)	
Hispanic students						
Math			.15			.004
Intervention	77.4 (42)	82.1 (38)		50.3 (50)	61.5 (48)	
Control	72.3 (45)	70.2 (46)		36.2 (48)	25.5 (44)	
Reading			.74			.47
Intervention	72.3 (45)	72.3 (45)		50.3 (50)	51.3 (50)	
Control	70.2 (46)	70.2 (46)		42.6 (49)	48.9 (50)	
White students						
Math			.08			.04
Intervention	89.2 (31)	97.3 (16)		67.6 (47)	91.9 (27)	
Control	86.7 (35)	73.3 (46)		60.0 (50)	53.3 (51)	
Reading			.20			.50
Intervention	91.9 (27)	83.8 (37)		78.4 (41)	67.6 (47)	
Control	93.3 (26)	100.0 (00)		86.7 (35)	73.3 (46)	
Black students						
Math			.002			.43
Intervention	88.9 (32)	92.6 (26)		55.6 (50)	55.6 (50)	
Control	33.3 (57)	33.3 (58)		33.3 (57)	33.3 (58)	
Reading			.05			.15
Intervention	81.5 (39)	70.4 (46)		59.3 (50)	51.9 (51)	
Control	33.3 (57)	33.3 (58)		00.0 (00)	33.3 (58)	

Note. FCAT = Florida Comprehensive Achievement Test; HOPS = Healthier Options for Public Schoolchildren.
[a] *P* value for the difference between the intervention and control schools.

intervention schools gained points in FCAT reading scores over the 2-year intervention, whereas White and Black control school children showed decreases in scores (Table 2).

When the FCAT results were stratified by BMI percentile group (Table 4), we saw significant improvements in math scores greater than or equal to level 3 for those in the intervention schools who were normal weight ($P<.004$) or obese ($P<.004$). We also found significant improvements in the intervention school children for math scores greater than or equal to level 2 for those who were obese ($P<.003$).

DISCUSSION

To our knowledge, this pilot project is one of the first to examine the effect of a school-based obesity prevention intervention on weight and academic performance simultaneously among low-income children. Our longitudinal analysis showed that over the 2-year period, children attending the intervention schools, regardless of ethnic background, were significantly more likely to have higher FCAT math scores than were children in the control school. Although not statistically significant, a similar trend was found for FCAT reading scores (Tables 2 and 3). Similarly, weight decreases were noted in the intervention schools compared with the control school (Table 1). These findings indicate that school-based interventions targeting obesity prevention can have indirect positive effects on academic performance among low-income children who are at high risk for both obesity and poor academic achievement.

Few studies have tested the hypothesis that a school-based obesity-prevention intervention is effective at improving both overall health and academic performance, among high-risk children in particular. The Child and

TABLE 4—Distribution of Children at FCAT Math and Reading Levels 2 and 3 by BMI Percentile Group and HOPS Intervention Condition, School Years 2004–2005 and 2005–2006

	FCAT Math			FCAT Reading		
	School Year 2004–2005, Mean (SD)	School Year 2005–2006, Mean (SD)	P^a	School Year 2004–2005, Mean (SD)	School Year 2005–2006, Mean (SD)	P^a
FCAT Level 2						
Normal (BMI < 85%)			.08			.25
Intervention	76.3 (42)	84.2 (36)		75.0 (43)	73.7 (44)	
Control	72.4 (45)	62.1 (49)		82.8 (38)	82.8 (38)	
Overweight (85% < BMI < 95%)			.78			.48
Intervention	84.0 (37)	84.0 (37)		82.0 (38)	80.0 (40)	
Control	86.7 (35)	86.7 (35)		80.0 (41)	66.7 (48)	
Obese (BMI ≥ 95%)			.003			.79
Intervention	86.5 (34)	89.2 (31)		74.3 (43)	68.9 (46)	
Control	69.2 (47)	61.5 (49)		65.4 (48)	73.1 (45)	
FCAT Level 3						
Normal (BMI < 85%)			.004			.62
Intervention	52.0 (50)	63.15 (48)		55.9 (49)	55.9 (49)	
Control	37.9 (49)	27.58 (45)		51.7 (50)	51.7 (50)	
Overweight (85% < BMI < 95%)			.61			.92
Intervention	48.0 (50)	72.00 (45)		52.0 (50)	44.0 (50)	
Control	53.3 (51)	53.33 (51)		46.7 (51)	46.7 (51)	
Obese (BMI ≥ 95%)			.004			.78
Intervention	62.2 (48)	62.16 (48)		54.1 (50)	55.4 (50)	
Control	38.5 (49)	26.92 (45)		50.0 (50)	53.8 (50)	

Note. BMI = body mass index; FCAT = Florida Comprehensive Achievement Test; HOPS = Healthier Options for Public Schoolchildren.
[a]*P* value for the difference between the intervention and control schools.

Adolescent Trial for Cardiovascular Health (CATCH), a National Heart, Lung, and Blood Institute–sponsored multicenter, school-based intervention study promoting healthy eating, physical activity, and tobacco nonuse by elementary students, is probably the most widely known school-based intervention program.[32] CATCH analyses that were not stratified by socioeconomic status showed no statistically significant changes in obesity, blood pressure, or serum lipids in the intervention group compared with controls. Although our study did not measure changes in serum lipids, we did find significant differences in blood pressure (reported elsewhere)[33] and positive changes in both weight and academic achievement. Similarly, several studies have reported associations between diet or nutrition and academic performance, but few have examined children at the highest risk.[13–17] Other studies noted that obesity and overweight inhibit academic performance, that physical activity reduces overweight and obesity, and that physical activity increases academic performance.[34,35] Although we did not include measures to quantify physical activity, it was an integral component of the intervention.

Our intervention has implications for national school and agricultural policy. School-based nutrition programs such as the one described here offer assistance in alleviating poor nutrition and food insufficiency. The Nutrition and WIC Reauthorization Act of 2004 mandates the development of wellness policies at every elementary school that participates in the USDA NSLP. Other federal nutrition-based initiatives, such as USDA technical assistance to school foodservice departments, the Institute of Medicine's Committee to Review the National School Lunch and School Breakfast Programs Meal Patterns and Nutrient Standards, and increases in fresh fruit, vegetable, and whole-grain offerings and education opportunities as part of the 2008 Farm Bill,[36] support improvements in the nutritional well-being of children during the school day. Together, these initiatives enhance food offerings provided to schoolchildren through the USDA NSLP programs and offer opportunities for children to be socialized into healthy eating habits. The prominent role school programming can and will play in addressing the childhood obesity crisis and its attendant implications on health and academic achievement cannot be discounted.

Because HOPS was a school-based prevention intervention, eating and exercise habits outside of school (including extended periods of out-of-school time, such as holidays and summer vacation) could not be controlled, thus perhaps affecting the internal validity of the study. However, because the sample included only children who qualified for the free and reduced-price meals program of the NSLP, a high proportion of the children can be expected to have consumed multiple meals each day at school. Additional methodologic limitations included that the study population was not selected at random, that there was limited geographic variability, and that only 1 school served as a control. Also, although the intervention involved nutrition and healthy lifestyle curricula and physical activity components, the design did not include assessment of intervention exposures (such as minutes of the curricula used). Last, there has been considerable debate about the validity of standardized tests, such as the FCAT, in adequately measuring academic achievement, particularly among minorities.[37–39]

The strengths of this pilot study were the large sample size (over 1100 children), the diversity of the sample (high minority representation), multiple measures of the same group over an extended time period (2 years), and the analysis of a homogeneous socioeconomic status group (free or reduced-priced meals in the USDA NSLP participation as proxy), thus adhering to intervention fidelity and improving internal validity. These pilot data argue for a large-scale, randomized, multicenter study similar to the one presented here to improve external validity.

School-based obesity prevention interventions that include changes to school-provided meals, nutrition and healthy lifestyle education, and physical activity components show promise in improving health and academic performance, particularly among elementary-aged children from low-income backgrounds. These findings are particularly encouraging given that many children from low-income backgrounds receive a significant proportion of their daily nutrition requirements at school. ■

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Contributors

D. Hollar originated the study and supervised all aspects of its implementation, assisted with data collection and analyses, and led the writing of the article. S.E. Messiah led the analyses and assisted with the writing of the article. G. Lopez-Mitnik analyzed data. T.L. Hollar assisted with data collection and analyses and writing of the article. M. Almon provided technical assistance for dietary intervention implementation. A.S. Agatston reviewed the article.

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The lead author had full access to the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Human Participant Protection

The Sterling institutional review board, Atlanta, GA, approved the study. Letters were sent home to the parents of students attending the 6 study schools. Parents signed consents for their minor children if they did not want their child to participate.

References

1. Ogden CL, Carroll MD, Curtin LR, McDowell MA, Tabak CJ, Flegal KM. Prevalence of overweight and obesity in the United States, 1999–2004. *JAMA.* 2006;295(13):1549–1555.

2. Institute of Medicine. *Preventing Childhood Obesity. Health in the Balance.* Washington, DC: National Academy Press; 2004.

3. Centers for Disease Control and Prevention. 2008. Available at: http://www.cdc.gov/nchs/pressroom/07newsreleases/obesity.htm. Accessed November 9, 2008.

4. Ford ES, Chaoyang L. Defining the metabolic syndrome in children and adolescents: will the real definition please stand up? *J Pediatr.* 2008;152(2):160–164.

5. Cook S, Auinger P, Li C, Ford ES. Metabolic syndrome rates in United States adolescents, from the National Health and Nutrition Examination Survey, 1999–2002. *J Pediatr.* 2008;152(2):165–170 Epub 2007 Oct 22.

6. National Institutes of Health. *The Third Report of the National Cholesterol Education Program Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III).* Bethesda, MD: National Institutes of Health; 2001. NIH publication 01-3670.

7. Vanhala M, Vanhala P, Kumpusalo E, Halonen P, Takala J. Relation between obesity from childhood to adulthood and the metabolic syndrome: population-based study. *BMJ.* 1998;317(7154):319.

8. Guo SS, Roche AF, Chumlea WC, Gardner JD, Siervogel RM. The predictive value of childhood body mass index values for overweight at 35 y. *Am J Clin Nutr.* 1994;59(4):810–819.

9. Zametkin AJ, Zoon CK, Klein HW, Munson S. Psychiatric aspects of child and adolescent obesity: a review of the past 10 years. *J Am Acad Child Adolesc Psychiatry.* 2004;43(2):134–150.

10. Vila G, Zipper E, Dabbas M, et al. Mental disorders in obese children and adolescents. *Psychosom Med.* 2004;66(3):387–394.

11. Taras H, Potts-Datema W. Obesity and student performance at school. *J Sch Health.* 2005;75(8):291–295.

12. Mustillo S, Worthman C, Erkanli A, Keeler G, Angold A, Costello EJ. Obesity and psychiatric disorder: developmental trajectories. *Pediatrics.* 2003;111(4 pt 1):851–859.

13. Halterman JS, Kaczorowski JM, Aligne CA, Auinger P, Szilagyi PG. Iron deficiency and cognitive achievement among school-aged children and adolescents in the United States. *Pediatrics.* 2001;107(6):1381–1386.

14. Kleinman RE, Hall S, Green H, et al. Diet, breakfast, and academic performance in children. *Ann Nutr Metab.* 2002;46(suppl 1):24–30.

15. Alaimo K, Olson CM, Frongillo EA Jr. Food insufficiency and American school-aged children's cognitive, academic, and psychosocial development. *Pediatrics.* 2001;108(1):44–53.

16. Murphy JM, Wehler CA, Pagano ME, Little M, Kleinman RE, Jellinek MS. Relationship between hunger and psychosocial functioning in low-income American children. *J Am Acad Child Adolesc Psychiatry.* 1998;37(2):163–170.

17. Woodward-Lopez G, Ikeda J, Crawford P. *Improving Children's Academic Performance, Health and Quality of Life: A Top Policy Commitment in Response to Children's Obesity and Health Crisis in California.* The Center for Weight and Health College of Natural Resources, University of California, Berkeley. Available at: http://nature.berkeley.edu/cwh/PDFs/CewaerPaper_Research.pdf. Accessed November 12, 2008.

18. Datar A, Sturm R. Childhood overweight and elementary school outcomes. *Int J Obes (Lond).* 2006;30(9):1449–1460.

19. Datar A, Strum R, Magnabosco JL. Childhood overweight and academic performance: national study of kindergartners and first-graders. *Obes Res.* 2004;12(1):58–68.

20. Li X. A study of intelligence and personality in children with simple obesity. *Int J Obes Relat Metab Disord.* 1995;19(5):355–357.

21. Mo-suwan L, Lebel L, Puetpaiboon A, Junjana C. School performance and weight status of children and young adolescents in a transitional society in Thailand. *Int J Obes Relat Metab Disord.* 1999;23(3):272–277.

22. Briefel RR, Wilson A, Gleason PM. Consumption of low-nutrient, energy-dense foods and beverages at school, home, and other locations among school lunch

participants and nonparticipants. *J Am Diet Assoc.* 2009;109(2 suppl):S79–S90.

23. Almon M, Gonzalez J, Agatston AS, Hollar TL, Hollar D. The HOPS Study: dietary component and nutritional analyses. Poster presented at: Annual Nutrition Conference of the School Nutrition Association; July 17, 2006; Los Angeles, CA.

24. Almon M, Gonzalez J, Agatston AS, Hollar TL, Hollar D. The dietary intervention of the Healthier Options for Public Schoolchildren Study: A school-based holistic nutrition and healthy lifestyle management program for elementary-aged children. *J Am Diet Assoc.* 2006; 106(8):A53.

25. Gonzalez J, Almon M, Agatston A, Hollar D. The continuation and expansion of dietary interventions of the Healthier Options for Public Schoolchildren Study: a school-based holistic nutrition and healthy lifestyle management program for elementary-aged children. *J Am Diet Assoc.* 2007;107(suppl 3):A76.

26. Florida House Bill CS/CS/HB 967—Physical Education. Available at: http://www.myfloridahouse.gov/Sections/Bills/billsdetail.aspx?BillId=35827. Accessed July 20, 2009.

27. ILSI Research Foundation. *Delta H.O.P.E. Tri-State Initiative. Final Report to the Mississippi Alliance for Self-Sufficiency for the period: August 2003 to June 2007.* Washington, DC: International Life Sciences Institute.

28. Centers for Disease Control and Prevention. Body mass index percentiles for children. Available at: http://apps.nccd.cdc.gov/dnpabmi. Accessed February 22, 2009.

29. Achievement Levels FCAT. Available at: http://fcat.fldoe.org/fcatpub3.asp. Accessed February 6, 2009.

30. US Department of Agriculture, Food & Nutrition Service. National School Lunch Program Fact Sheet. Available at: http://www.fns.usda.gov/cnd/Lunch/AboutLunch/NSLPFactSheet.pdf. Accessed February 6, 2009.

31. Centers for Disease Control and Prevention, National Center for Health Statistics. Clinical growth charts. Available at: http://www.cdc.gov/nchs/nhanes/growthcharts/clinical_charts.htm. Accessed February 6, 2009.

32. Webber LS, Osganian SK, Feldman HA, et al. Cardiovascular risk factors among children after a 2 1/2-year intervention—The CATCH Study. *Prev Med.* 1996;25(4):432–441.

33. Hollar D, Messiah SE, Lopez-Mitnik G, Hollar TL, Agatston AS. Effect of a school-based obesity prevention intervention on weight and blood pressure in 6–13 year olds. *J Am Diet Assoc.* 2010;110(2):261–267.

34. Shephard RJ. Curricular physical activity and academic performance. *Pediatr Exerc Sci.* 1997;9(2):113–126.

35. Dwyer T, Sallis JF, Blizzard L, Lazarus R, Dean K. Relation of academic performance to physical activity and fitness in children. *Pediatr Exerc Sci.* 2001;13:225–237.

36. Food, Conservation and Energy Act of 2008, HR 2419, 110th Cong. Available at: http://www.govtrack.us/congress/billtext.xpd?bill=h110-2419. Accessed July 20, 2009.

37. Linn RL. A century of standardized testing: controversies and pendulum swings. *Educ Assess.* 2001;7(1): 29–38.

38. Kubiszyn T, Borich G. *Educational Testing and Measurement: Classroom Application and Practice.* New York, NY: John Wiley & Sons, Inc.; 2007.

39. Perrone V. Association for Childhood Education international position paper on standardized testing. 1991. Available at: http://www.acei.org/onstandard.htm#question. Accessed July 20, 2009.