ORIGINAL PAPER

Effective Multi-level, Multi-sector, School-based Obesity Prevention Programming Improves Weight, Blood Pressure, and Academic Performance, Especially among Low-Income, Minority Children

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Abstract: **Introduction**. Successfully addressing childhood onset obesity requires multi-level (individual, community, and governmental), multi-agency collaboration. **Methods**. The Healthier Options for Public Schoolchildren (HOPS)/OrganWise Guys® (OWG) quasi-experimental controlled pilot study (four intervention schools, one control school, total N=3,769; 50.2% Hispanic) was an elementary school-based obesity prevention intervention designed to keep children at a normal, healthy weight, and improve health status and academic achievement. The HOPS/OWG included the following replicable, holistic components: (1) modified dietary offerings, (2) nutrition/lifestyle educational curricula; (3) physical activity component; and (4) wellness projects. Demographic, anthropometric (body mass index [BMI]), blood pressure, and academic data were collected during the two-year study period (2004–6). **Results**. Statistically significant improvements in BMI, blood pressure, and academic scores, among low-income Hispanic and White children in particular, were seen in the intervention versus controls. **Conclusion**. Holistic school-based

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obesity prevention interventions can improve health outcomes and academic performance, in particular among high-risk populations.

Key words: Obesity, children and adolescents, nutrition, physical activity, blood pressure, school-based programming, academic achievement.

Childhood onset obesity and related health consequences continue to be major clinical and public health issues in the U.S., particularly among African Americans and Hispanic/Mexican Americans, and low-income children.[1,2] Childhood onset obesity is related to numerous cardiovascular risk factors that tend to track from childhood into adulthood such as elevated blood pressure and lipids.[3–7] Additionally, studies document mental health consequences of childhood obesity whereby overweight and obese children are more likely than others to have low self-esteem and higher rates of anxiety disorders, depression, and other psychopathology.[8–11] Though less well understood, there is evidence suggesting an association between improvements in weight measures and better academic performance.[12] These issues are especially salient with respect children of lower economic status who experience food insecurity. Specifically, students who experience food insufficiency may also score lower in math, and experience social and psychological difficulties.[13,14]

Successfully addressing the public health problem of childhood obesity will require multi-level, multi-agency collaboration directed to the multiplicity of factors affecting weight management; focusing on individual behavior change alone, in isolation from broader social, cultural, physical, economic, and political contexts has not worked. Multi-level approaches address interpersonal characteristics (e.g., feeding styles, family demands), community characteristics (e.g., foods available in schools and other institutional cafeterias, presence of vending machines and fast food, lack of access to physical activity facilities), and government influences (e.g., policies regarding food, education, urban design, marketing).[15] Schools, as central institutions for socialization of children and hubs of community-wide activity, are ideal locales for organizing obesity-prevention programming. This is especially true for programming directed at young children because children generally attend school five days per week throughout most of the calendar year, and schools in the U.S. are located in communities of every socioeconomic, racial, and ethnic group. 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 through the United States Department of Agriculture (USDA) National School Lunch Program (NSLP) (reportedly as much as 51% of daily energy intake).[16]

The Healthier Options for Public Schoolchildren (HOPS)/The OrganWise Guys (OWG) program is a school-based obesity prevention intervention implemented in the elementary school setting targeting 6–12 year olds, including nutrition and physical activity components. The overall goal of HOPS/OWG is to reduce childhood obesity rates, and improve health status and academic achievement using multi-level strategies to change knowledge about, and associated behaviors regarding, good nutrition and healthy living that can be replicated easily in other school settings and communities surrounding schools.

Methods

Design. The HOPS/OWG was implemented in August 2004 and included approximately 3,769 (50.2% Hispanic) children attending five elementary schools (four intervention, one control) in central Florida. Demographic, anthropometric (height, weight, body mass index [BMI]), clinical (systolic and diastolic blood pressure), and academic (Florida Comprehensive Assessment Test) data were collected during the two-year study period (2004–5). Each school's student body had similar demographic and socioeconomic characteristics; the schools were chosen as a convenience sample. In a quasi-experimental design, schools were non-randomly assigned to one of four intervention groups or one of two control groups by school district administration. Because one control school was found (after the study began) to have an exceptional physical education program (state and federal grants including the Carol M. White Physical Education Program [PEP] grant) that could confound results, ultimately supported by *post hoc* analyses, it was removed from the sample. Students who moved among schools of different treatment status were dropped from the sample. Thus, exposure to intervention for children in the sample was consistent over time. The HOPS/OWG intervention included modified dietary offerings, nutrition and lifestyle educational curricula, a physical activity component, and other school-based wellness projects. One section of the analyses presented here focuses only on children from low-income families, which was measured by a child's qualification for Free or Reduced Price Meals in the USDA NSLP proxy. Specifically, free meals are available to children from families with incomes at or below 130% of the federal poverty level; reduced-price meals 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 is $27,560 for a family of four; 185% is $39,220.[17] By including children who most likely received school-provided lunch every day, we improve the intervention's internal validity and thus decrease potential confounders (e.g., higher socioeconomic status children likely eat better in general,[18] regardless of eating the school lunch or not, and are more likely to bring lunch from home).

The Sterling Institutional Review Board (Atlanta, Georgia), which reviewed the study protocol and procedures to ensure the protection of study participants, approved the study. Letters were sent home to parents of students attending the six study schools. Parents signed statements for their minor children if they did not want the child to participate.

Intervention. The HOPS/OWG study was designed to test the feasibility and efficacy of the combined effect of (1) including nutritious ingredients and whole foods (acquired via existing public school food distribution networks) in school-provided meals; (2) providing holistic nutrition and healthy lifestyle curricula that teach elementary-aged children, their parents, teachers, and staff about good nutrition and healthy lifestyle management, including increased physical activity; and (3) fostering other school-based wellness activities such as cultivating fruit and vegetable gardens. Central to success of interventions was the multi-sector, multi-agency collaboration, particularly among study partners including district school administration, school administration, district foodservice departments, school cafeterias, district wellness committee members,

University Extension county nutrition educators, the USDA Food and Nutrition Service (FNS), and *Organic Gardening* (a magazine), among others.

Dietary intervention: School menu modeling. The dietary intervention, led by the study's principal investigator and a registered dietitian, consisted of modifications to school-provided breakfasts, lunches, and snacks in intervention schools, as well as a nutrient-dense education curriculum for use in the cafeteria that included OWG characters, under copyright approval from The OWG Inc. Menus were modified to include more high-fiber items, such as whole grains, fresh fruits, and vegetables; fewer items with high-glycemic effects, such as high-sugar cereals and processed flour goods; and lower amounts of total, saturated, and trans fats. These modifications were intended to model the nutrition messages being taught in classrooms reflecting the core tenets of the *USDA Dietary Guidelines for Americans.* Accordingly, the majority of changes to intervention school menus resulted from of the substitution of healthier ingredients for less healthy ingredients, rather than an outright ban on so-called child-friendly food items. For example, whole grain flour-coated chicken patties were served instead of processed white flour-coated chicken patties, and reduced fat dairy products, including USDA Foods (also known as *USDA Commodities*), were provided in place of whole milk (higher fat) products. Thus, the focus was on the quality of the calories, not on a reduction of calories. Study staff, including a registered dietitian, worked closely with the USDA FNS, as well as school administration and foodservice staff, to ensure intervention fidelity for this component. Nutrition analyses of breakfast and lunch menus showed intervention menus, on average, contained approximately two times more fiber and 23% less fat than control menus.[19–21]

Curriculum component. The curriculum component consisted of a school-based holistic nutrition and healthy lifestyle management program for elementary-aged children and adults. These curricula were designed to teach children, their parents, teachers, 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 manner that would be replicable in other school settings. Teachers were trained on how to use the Foods of the Month (FoM) and The OrganWise Guys® (OWG) curricula at the beginning of the study period, with ongoing technical assistance available from study staff.

Programming included a monthly thematic set of nutrient-dense-foods educational activities developed by study staff in collaboration with elementary school education experts and a registered dietitian. Each month, a multi-media set of educational and instructional materials, highlighting nutrient-dense foods, were sent to intervention schools, including FoM posters, tips for conducting FoM tastings, FoM parent newsletter inserts, FoM student activity packets, 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 just described, each intervention school received an OWG kit of materials. The OWG curriculum brings together 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 OWG kit includes print (books, activity posters) and electronic media (videos, Internet activities), as well as school assemblies

and a physical activity program (WISERCISE®), all of which are matched to state core academic standards. The kindergarten through second grade set of OWG materials are intended to be used very often by classroom teachers, on average, one to two hours each week. Implementation of The OWG materials for grades three through five is less intense due to other demands on children in these grades as schools aim to comply with federal and state testing mandates.

The OWG classroom-based education and physical activity program was evaluated and found to be effective in improving weight measures of children. The W.K. Kellogg Foundation funded a four-year intervention (Fall 2003 to Spring 2007) targeting 30,000 low-income, primary African American elementary-aged schoolchildren in Arkansas, Louisiana, and Mississippi. Measurements of BMI were assessed on 1,400 students. At baseline (Fall 2005), 53.1% of students were classified as having a normal BMI percentile (BMI $<$85th percentile). At the completion of the intervention (Spring 2007), more students (59.1%) were classified in the normal category. The number of children considered obese fell over the two-year intervention; specifically, the proportion of students in the obese category (BMI $\geq$95th percentile) decreased from 24.4% to 20.2% from 2005 to 2007.[22]

Fruit and vegetable gardens at intervention schools provided a fun and creative addition to the nutrition curriculum that taught children how the nutritious fruits and vegetables served in their school cafeterias, their homes, and in restaurants are raised. Participation in the school gardening program varied by site. In some locations, all children participated in some way or another; in other locations, gardens were tended by specific grades or specific classrooms.

Physical activity component. The physical activity component consisted of increased opportunities for physical activity (in ways that were feasible for schools within the constraints of testing mandates) during the school day. In Florida, it was hard to obtain buy-in for more time for physical activity until the governor mandated 150 minutes of physical activity per week for elementary schoolchildren (a mandate passed in Fall 2007). Thus the amount and types of physical activity varied among intervention schools throughout the study period. During the second year of the study, students were provided with pedometers and OWG tracking books so they could track the number of steps they took each day. However, the pedometers broke easily, and students tended to lose them. Therefore, although pedometers have been found to be useful in increasing daily physical activity of school-aged children in another study (W.K. Kellogg Foundation Project Report by ILSI Research Foundation to Mississippi Alliance for Self-Sufficiency, 2007) the use of pedometers was discontinued. Instead, schools were encouraged to implement daily physical activity in the classroom using a 10–15 minute desk-side physical activity program (TAKE10! or WISERCISE©) during regular teaching time. These desk-side physical activities are matched with core academic areas, such as spelling and math, to encourage adoption of daily physical activity, in addition to recess and physical education time. Teachers were trained on the desk-side physical activity program and asked to implement these desk-side physical activities each day. Schools also were asked to implement structured physical activity during recess and walking clubs, which encouraged children and adults to walk laps around tracks before the start of each school day.

Measures. *Demographic, anthropometric, and physiologic*. Demographic information including date of birth, gender, grade, and race/ethnicity were collected by study coordinators at baseline (Fall 2004) and each Fall and Spring (2004–6). Anthropometric data included height (Seca 214 Road Rod Portable Stadiometer) and weight (LifeSource 321 Scale), which were used to create an age and gender-specific body mass index ([BMI], weight in kg/height in meters squared) percentile score. Participants were asked to remove their shoes and heavy outer clothing, and to empty pockets prior to being measured and weighed. Children were classified according to their BMI percentile for age and sex in accordance with Centers for Disease Control and Prevention standardized groups as follows: (1) normal weight (BMI $<$ 85th percentile); (2) At Risk for Overweight (BMI $>$85th percentile but $<$95th percentile); and (3) Obese (BMI $\geq$95th percentile).[23] Systolic and diastolic blood pressure, as well as pulse, were measured using WelchAllyn® Spot Vital Signs automated measurement machines, which included cuff sizes from very small child through large adult. Each child had his/her blood pressure measured three times during each data collection session. These three measures were averaged to create one measurement of each type (systolic, diastolic, and pulse), which were used in analyses.

Measures. *Academic*. The Florida Comprehensive Achievement Test (FCAT) is a standardized measurement of student achievement administered to all Florida public school children beginning in the third grade. The FCAT reading and math scores for each child were provided by school administration.

Data analysis. The results presented here reflect two sets of analyses: 1) all children in the four intervention schools and one control school (N=3,769); or 2) children of low-income background only in the four intervention schools and one control school (N=1,172), which was measured by a child's qualification for Free or Reduced Price Meals in the USDA NSLP proxy.

Because the unit of analysis for this pilot study is a school, rather than a piece of individual-level data, cluster randomization was conducted. With cluster randomization, the mean response under each experimental condition is subject to two 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 could cause an inflation of type I errors, where any intervention effect may become confounded with the natural cluster-to-cluster variability. While we realize that this trial did not include a large number of schools to conduct a robust cluster analysis, we applied a two-stage approach to the data analysis:

First stage. Individual level. In the first stage, we analyzed all individual-level covariates to derive school-specific means that are adjusted for individual-level covariates.

Second stage. School-level. In the second stage, we analyzed school-specific means and appropriately adjusted for school-specific covariates to evaluate any intervention effects.

Univariate analysis consisted of simple frequency statistics for all demographic variables. Chi-squared analyses were performed to test for associations between 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.

Repeated measures analysis tested for changes in trends over time (the two-year study period or four points in time) in BMI percentile group, and FCAT scores. For the repeated measures analysis, only those children with data in all years were retained. P-value was significant if less than .05. All tests were two-tailed. The SAS statistical software package version 9.1 (Cary, NC) and SPSS v. 15 SAS 9.1 was used for all statistical analyses.

Results

Entire sample. Just over one half (50.2%) of the study sample was Hispanic, 33.4% White, 8.0% Black, and 8.4% other (multi-ethnic, Asian, American Indian). The average age was eight years (range 4–13) and 51% were females. Ethnicity by specific school site is described in Table 1. There were no significant differences by ethnicity or baseline BMI percentile between treatment arms.

Anthropomorphic and physiologic results. With respect to weight measures, intervention children experienced a greater decrease in their BMI percentile than control children during year one (2004–5) of the study, but it was not until year two (2005–6) that the difference between improvements in BMI percentiles reached statistical significance with intervention children improving more than control children ($p=.007$) (Table 2).[24] While weight improvements were achieved during the school year for both groups, repeated measures analysis showed during summer females in the control school experienced a significant increase in systolic blood pressure (sbp) ($p<.0001$) (98.37 to 101.44 mmHg), whereas sbp remained stable in the intervention group (98.5 mmHg) (Figure 1). However, among males both the intervention and control groups displayed significant increases during summer ($p<.0001$, 100.83 to 101.94 mmHg, 99.28 to 101.93 mmHg, respectively) (Figure 2). Significant increases in diastolic blood pressure were seen during summer in both genders and in both intervention and control groups ($p<.0001$) (Figures 3 and 4).[25]

Sub-sample (free/reduced lunch children only). *Anthropomorphic and academic results.* A total of 1,197 children who qualified for free/reduced school lunch were used for the Group 2 analysis (68% Hispanic, 9% Black, 15% White, 8% other; mean age 7.84 ± 1.67). Raw FCAT Math and Reading scores were not significantly different between groups prior to commencement of interventions. Repeated measures ANOVA found children in the intervention schools were significantly more likely to reduce their body mass index Z score ($p<.01$) and their weight Z score ($p<.05$) in comparison with those children in the control schools over the two-year intervention period (Table 3). With respect to academic achievement, after controlling for race, repeated measures ANOVA found that in both study years, Hispanic and White children in intervention schools were significantly more likely to have higher FCAT math scores ($p<.001$) than their counterparts in the control school. While not significant, intervention children had higher FCAT reading scores in both years of the intervention versus controls (Table 4).[25]

Table 1.

HEALTHIER OPTIONS FOR PUBLIC SCHOOL CHILDREN/THE ORGANWISE GUYS ETHNIC DISTRIBUTION BY SCHOOL AND INTERVENTION ARM

		Total Number of Children Enrolled					Total Number of Children Enrolled in Free/Reduce Lunch				
	School	Black n %	Hispanic n %	White n %	Other n %	Total # of Children	Black n %	Hispanic n %	White n %	Other n %	Total # of Children
Intervention schools	#1	29 6.07	301 62.97	101 21.13	47 9.83	478	9 6.04	119 79.87	8 5.37	13 8.72	149
	#2	64 8.89	355 49.31	230 31.94	71 9.86	720	18 8.78	138 67.32	32 15.61	17 8.29	205
	#3	53 5.61	484 51.22	352 37.25	56 5.93	945	12 4.58	212 80.92	25 9.54	13 4.96	262
	#4	102 11.47	442 49.72	268 30.15	77 8.66	889	47 13.06	210 58.33	69 19.17	34 9.44	360
	Intervention totals	248 8.2	1582 52.17	951 31.36	251 8.27	3032	86 8.8	679 69.9	134 13.7	77	976
Control school	#1	53 7.19	310 42.06	309 41.93	65 8.82	737	16 8.16	122 62.24	45 22.96	13 6.63	196
	Control totals	53 7.19	310 42.06	309 41.93	65 8.82	737	16 8.16	122 62.24	45 22.96	13 6.63	196
Grand total		301 8.0	1892 50.20	1260 33.43	316 8.37	3769	102 8.7	801 68.3	179 15.3	90 7.7	1172

Table 2.

CHANGE IN BODY MASS INDEX PERCENTILES FOR 2004–5 AND 2005–6 SCHOOL YEARS

	Changes in Body Mass Index Percentiles mean (SD)	
	2004–5	**2005–6**
Intervention	−1.46 (16.3)	−1.73 (13.6)
Control	−0.95 (23.2)	−0.47 (12.1)
p-value	NS	p=.007

Source: Hollar D, Hollar TL, Agatston AS. School-based early prevention interventions decrease body mass index percentiles during school year, but children experience increase in percentiles during summer. Circulation. 2007;116:II_843–II_844.

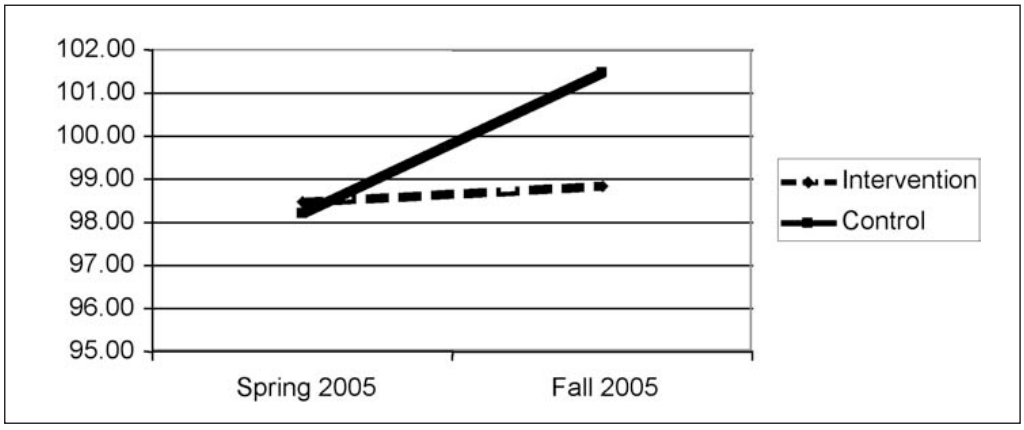

Figure 1. Systolic blood pressure for female children during summer.

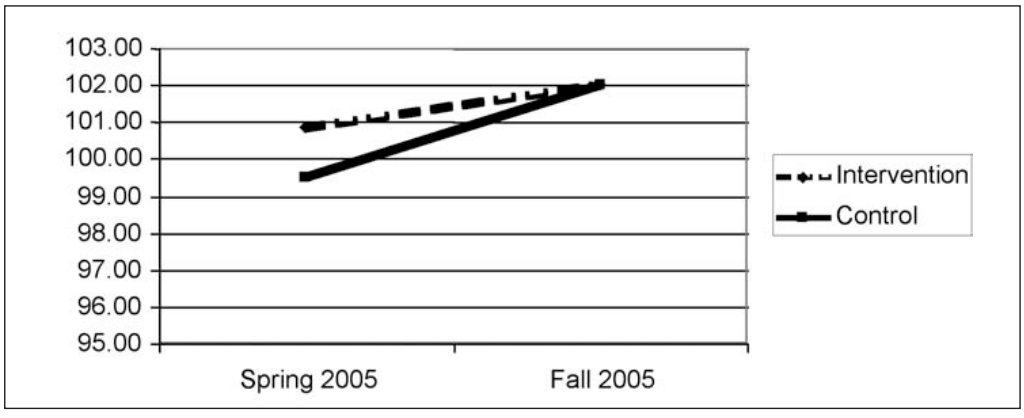

Figure 2. Systolic blood pressure for male children during summer.

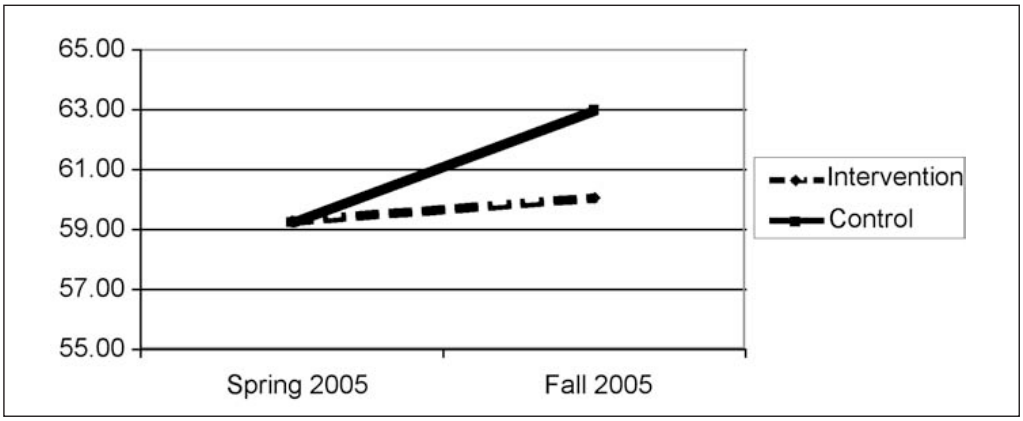

Figure 3. Diastolic blood pressure for female children during summer.

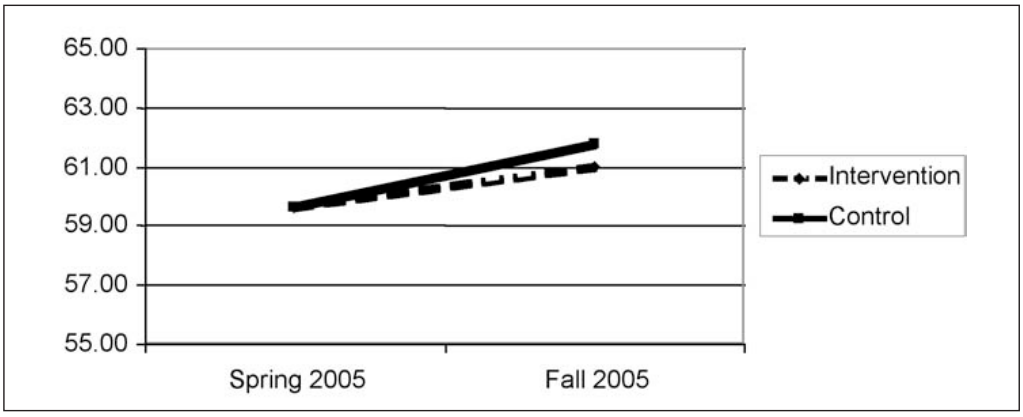

Figure 4. Diastolic blood pressure for male children during summer.

Discussion

Participation in the HOPS/OWG interventions was associated with statistically significant improvements in weight, blood pressure, and academic scores of elementary-aged children, particularly for Hispanic and White children. Overall, BMI percentiles improved during the school year for all children, with significant improvements experienced by intervention children. However, summertime appears to be a less healthy time for elementary-aged children; only intervention girls experienced stable rates in systolic blood pressure during summer, and all children experienced significant increases in diastolic blood pressure during summer.

With respect to the children qualified for Free and Reduced Price Meals through the USDA NSLP, significant improvements in weight measures (BMI Z scores and weight Z scores) and significantly higher standardized test scores were associated with the nutrition and physical activity interventions. This study shows that schools can be effective environments to implement strategies to lower or modify weight and its associated

Table 3.

CHANGE IN BMI Z SCORES BY INTERVENTION CONDITION FROM 2004 TO 2006 SCHOOL YEARS FOR CHILDREN QUALIFIED FOR FREE OR REDUCED PRICES MEALS/LOW-INCOME CHILDREN

Measure	Treatment (# of schools)	Fall 2004	Spring 2005	Fall 2005	Spring 2006	p-value (Fall 04–Spring 06)
BMI (z-score)	Intervention (4 schools)	0.61(1.19)	0.56(1.18)	0.76(1.07)	0.71(1.09)	.0013
	Control (1 school)	0.98(0.88)	0.97(0.87)	1.02(0.87)	1.05(0.85)	
Weight (z-scores)	Intervention (4 schools)	0.61(1.14)	0.61(1.13)	0.64(1.14)	0.65(1.12)	.011
	Control (1 school)	0.90(0.98)	0.89(1.01)	0.90(1.01)	0.95(1.00)	

health risks, which is particularly encouraging given that the majority of children in the U.S. attend school and thus intervention exposure can be maximized.

Evidence regarding efficacy of school-based obesity interventions for health promotion and weight control has been limited.[26] The Child and 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 non-use by elementary school students, is probably the most widely known and large-scale school-based intervention program.[27] The primary physiologic goal was to reduce serum total cholesterol levels. Behavioral goals included reduction of dietary fat (total, saturated) and sodium intake, increased physical activity, and prevention of the onset of smoking. The study began in 1991, with all intervention activities completed by Spring 1994. Children were followed for three more years. Overall, changes in obesity, blood pressure, and serum lipids in the intervention group, compared with the control group, were not statistically significant, unlike in our study, where there were significant differences in blood pressure and weight. However, different risk factor patterns for boys and girls were noted for the other study.

Strengths. The strengths of this pilot study are the large sample size (over 3,700 children), the diversity of the sample (high minority representation), and the use of objective measures of health improvement and academic achievement, and multiple measures of the same group of children over an extended time period (two years). Certainly, these pilot data argue for the importance of a large-scale randomized, multicenter study similar to that presented here.

Limitations. Some limitations of this research must be noted. First, HOPS/OWG is

Table 4.

CHANGE IN RAW MATH AND READING BY HOPS INTERVENTION CONDITION FROM 2003–2004 TO 2005–2006 SCHOOL YEAR FOR OVERALL SAMPLE AND BY ETHNICITY

Ethnicity	FCAT Subject	Intervention Condition	FCAT Raw Score 2003–2004	FCAT Raw Score 2004–2005	FCAT Raw Score 2005–2006	p-value From Fall 04 to Spring 06
All	Math	Intervention	285.6(58.7)	296.4(59.3)	307.9(51.3)	0.0005
		Control	279.2(45.0)	285.5(53.8)	276.2(60.9)	
	Reading	Intervention	286.7(64.2)	291.3(59.8)	292.4(57.7)	0.08
		Control	282.9(55.4)	279.9(65.7)	281.7(55.8)	
Hispanic	Math	Intervention	281.7(61.0)	290.8(62.4)	303.4(52.7)	0.006
		Control	277.9(46.8)	281.2(59.8)	270.1(67.6)	
	Reading	Intervention	282.4(65.5)	284.7(61.6)	288.2(57.7)	0.09
		Control	275.7(62.2)	269.9(72.1)	276.8(58.1)	
White	Math	Intervention	309.3(54.8)	319.8(43.5)	330.8(39.7)	0.016
		Control	292.9(37.4)	304.7(29.1)	299.7(36.6)	
	Reading	Intervention	308.5(60.8)	320.0(43.4)	315.5(54.6)	0.16
		Control	297.6(23.2)	306.4(45.1)	294.7(53.9)	
Black	Math	Intervention	270.9(34.0)	306.8(46.4)	311.5(41.5)	0.04
		Control	243.8(22.3)	264.8(52.2)	267.6(44.1)	
	Reading	Intervention	265.5(51.8)	302.1(51.2)	294.9(53.3)	0.53
		Control	284.8(59.2)	287.8(54.6)	279.6(33.2)	

Source: Hollar D, Messiah SE, Lopez-Mitnik G, et al. Effect of an elementary school-based obesity prevention intervention on weight and academic performance among low income children. Am J Public Health. 2010;10(4):1–8. Epub 2010 Feb;e1–e8.

a school-based prevention intervention, thus, researchers could not control eating nor exercise habits outside of school. Similarly, there are concerns about lack of study control over eating and physical activity during extended periods of out-of-school time, such as holidays and summer vacation, which is likely associated with the increase in diastolic blood pressure observed above, making consistent implementation of interventions impossible. However, it is worth pointing out that despite these limitations regarding control of out-of-school dietary habits and physical activity, children improved their overall health status over the course of the two-year intervention. Secondly, despite the use of simple-to-use blood pressure measurement equipment and training on measurement technique prior to each data collection period, the measurements were taken by study coordinators operating in nonclinical settings; thus measurement may be susceptible to error. Additionally, despite standardized approaches (including three measurements at each data collection period that were averaged to create a single measure for each physiologic variable) to measuring blood pressure at four times over two years, our findings are susceptible to error from measurement and from variation in blood pressure between measurement periods. We think, however, that the longitudinal nature of data collection and the large sample size have assisted in overcoming this limitation. Third, the study population was not selected at random, it was of limited geographic variability (one school district), and only one school served as control. As described in the methods section above, one control school was excluded because of an exceptional and concurrent physical activity intervention that could possibly confound results. Additionally, one component of the physical activity intervention, the pedometer program, was discarded during the study period; however, the authors think that because this was the case in all intervention locations, integrity of the physical activity intervention was maintained. Lastly, although HOPS/OWG involved nutrition and healthy lifestyle curriculum and physical activity components, the design did not include assessment of intervention exposures (e.g., minutes curricula used; minutes of physical activity).

Conclusions. 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 achievement, particularly among elementary school-aged children from low-income backgrounds. In light of recent dramatic increases in obesity in the U.S., these findings are promising, given that many children from low-income backgrounds receive a significant proportion of their daily nutrition requirements at school.

Concerns over the positive intervention effects being lost during summertime, evidenced by increases in diastolic blood pressure measures of all children during summer, lead us to conclude that models should consider including summer programming. Post-study programmatic expansion efforts are attempting to address this concern through the development of community-based partnerships to expand upon and extend outward (from schools) the nutrition and healthy living interventions. Specifically, the HOPE2 Project, a $2 million obesity prevention project recently funded by the W.K. Kellogg Foundation, takes a multi-level, multi-agency approach to obesity prevention and treatment by creating "obesity prevention laboratories," whereby synergies of combining proven-effective programs operated by multi-disciplinary collaborators

are achieved. In so doing, *laboratories* are created that include elementary schools, University Extension, non-profit foundations and organizations, memberships of professional associations (American Dietetic Association Foundation, School Nutrition Association), state departmental agencies (Agriculture, Education, and Health), federal agencies (USDA), national foundations (W.K. Kellogg Foundation), state and regional foundations/corporations (Health Care Service Corporation; Blue Foundation for a Healthier Florida), community-based service organizations, and for-profit companies, among others. These multi-level, multi-agency "laboratory" partners bring strong sets of skills (including nutrition education and outreach, program evaluation, dissemination of best practices/results) and the potential for leveraging of skills and resources, to shape policies and programs affecting the health of the diverse populations of children and families in sustainable ways, all year long.

This research and the creation of obesity prevention laboratories that use schools as hubs of prevention activity are especially important in our current agricultural and school-policy context. School-based nutrition programs, such as the model tested in our study, offer assistance in alleviating poor nutrition and food insufficiency. The Nutrition and WIC Reauthorization Act of 2004 mandated 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 food-service 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[28]), support improvements in the nutrition well-being of children during the school day. Together, these initiatives enhance the food offerings provided to schoolchildren through the USDA NSLP programs (and associated breakfast, snack, and supper feeding programs) and offer opportunities for children to become accustomed to healthy eating habits. The prominent role school programming can and will pay in addressing the childhood obesity crisis, child nutrition status, food insecurity, and the attendant health and academic achievement implications, cannot be discounted.

Notes

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