A Public Health vs a Risk-Based Intervention to Improve Cardiovascular Health in Elementary School Children: The Cardiovascular Health in Children Study

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ABSTRACT

Objectives. This study sought to determine the population effects of both classroom-based and risk-based interventions designed to reduce cardiovascular disease risk factors in children.

Methods. Elementary school children (n = 2109; age range: 7–12 years) were randomized by school to a classroom-based intervention for all third and fourth graders, a risk-based intervention only for those with 1 or more cardiovascular disease risk factors, or a control group. The 8-week interventions involved both knowledge–attitude and physical activity components.

Results. School-level analyses showed that physical activity in the risk-based group and posttest knowledge in the classroom-based group were significantly higher than in the control group. With regard to trends shown by individual-level analyses, cholesterol dropped more in the classroom-based than in the control group, and skinfold thickness decreased 2.9% in the classroom-based group and 3.2% in the risk-based group (as compared with a 1.1% increase in the control group).

Conclusions. Both classroom-based and risk-based interventions had positive effects on physical activity and knowledge, with trends toward reduced body fat and cholesterol. However, the classroom-based approach was easier to implement and evidenced stronger results than the risk-based intervention. (*Am J Public Health.* 1999;89:1529–1535)

There is growing recognition that the atherosclerotic process begins in youth.[1–5] In addition, multiple studies show that risk factors for coronary artery disease and stroke begin in childhood and tend to persist through adulthood.[6–11] While this evidence supports the need for primary prevention of cardiovascular disease in youth, there is no consensus regarding the best approach. Physicians and some researchers advocate an individual approach that targets interventions at children with a family history of cardiovascular disease,[12–14] while other researchers recommend a public health approach that targets all children in a variety of settings (e.g., schools and other community locations).[1,15,16] Still others recommend both approaches.[17,18] A few large-scale randomized, controlled studies have tested (with limited results) the public health approach in school-based interventions designed to improve cardiovascular disease risk factors in children.[19–23] However, no study has compared the effectiveness of a public health approach with that of an intervention targeting youths who exhibit positive cardiovascular disease risk factors.

The Cardiovascular Health in Children study was a controlled, randomized field trial comparing the effects of 2 school-based interventions designed to improve cardiovascular disease risk factors in third- and fourth-grade children. The dependent variables were total serum cholesterol (the primary outcome variable), blood pressure, measures of obesity (body fat and body mass index [BMI]), exercise tolerance, self-reported physical activity, smoking habits, and heart health knowledge. The interventions were (1) a classroom-based approach including knowledge, attitudes, and physical activity components for all children (classroom-based, public health approach) and (2) a similar program of knowledge, attitudes, and physical activity provided in small groups only to those with identified risk factors (risk-based approach). This article presents the short-term results of both of these interventions for all subjects in each intervention group (as compared with a control group).

Methods

Setting and Sample

The Cardiovascular Health in Children study was conducted in 18 schools in North Carolina. Three schools were randomly selected within each of 6 strata or blocks (defined by 3 geographic regions in the state [Eastern Coastal, Central Piedmont, and Western Mountain] and by 2 settings [rural or urban]) and randomized to 1 of the 2 intervention groups or to the control group. Thus, 6 schools were assigned to each of the 3 groups. Schools were randomly selected from 33 schools that agreed to participate and were clearly located in rural or urban settings.

Children were eligible to be included in the study, regardless of age, if they were assigned to the third or fourth grade. Even though both parental consent and child assent were required for a child to take part in the study, most (60.4%) of the third and fourth graders in the schools participated. As a means of assessing the population effects of the interventions, analyses included all of the study schools' consenting

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third and fourth graders regardless of whether they participated in the intervention.

Interventions

Public health approach. The classroom-based intervention was taught to all third and fourth graders in the school. American Heart Association lower and upper elementary school site program kits[24] were used by regular classroom teachers twice a week for 8 weeks. Content focused on how to select "heart healthy" foods, the dangers of smoking and ways to combat pressure to smoke, and the importance of engaging in regular physical exercise. In addition, children received a physical activity intervention 3 times per week. One of the investigators (R.G.M.) compiled lesson plans that were used by physical education teachers. Each lesson plan included a brief warmup; 20 minutes of various fun, noncompetitive aerobic activities designed to work the major muscle groups; and a cooldown period.

Risk-based approach. The children in schools assigned to the risk-based intervention received an intervention only if 1 or more cardiovascular disease risk factors were found at baseline testing. The risk factors examined were high serum cholesterol, obesity, physical inactivity, and risk for future smoking. Children with a cholesterol level above the 75th percentile for age and sex, according to Lipid Research Clinic standards, were considered to have high cholesterol.[25] Children were considered to be obese if they had both a BMI and a sum of triceps and subscapular skinfolds above the 90th percentiles for age and sex.[26,27] Physical inactivity was assessed on the basis of submaximal predicted aerobic power; boys with power ratings below 39 mL/kg/minute and girls with ratings below 34 mL/kg/minute were considered at risk.[28] Children were considered at increased risk for smoking if at least 1 parent was a current smoker or had stopped smoking within the previous 2 years.

Three risk-based interventions were used: (1) nutrition classes, attended by children who were at risk owing to elevated cholesterol levels and/or obesity (n = 393); (2) physical activity classes, attended by those at risk owing to low aerobic capacity (n = 213); and (3) "don't start smoking" classes, attended by those at an increased risk of smoking (n = 455). Children could receive more than 1 intervention if they exhibited multiple risk factors at baseline. All interventions for the risk-based groups were conducted in groups of 5 to 8 children, over 8 weeks, during regular school hours. The nutrition and smoking classes were taught by registered nurses twice a week. The physical activity intervention was taught 3 times a week by physical educators and included the same activities as those in the classroom-based intervention. Most (77.2%, n = 645) of the children in the risk-based intervention schools were assigned to at least 1 intervention; 26.8% (n = 224) of these children were assigned to 2 interventions, and 11.5% (n = 96) were assigned to all 3.

Control condition. Children in the control schools did not receive any intervention. Parents of all study children, including those in the control group, received a written report of the results of their child's physical testing about 4 weeks after each test.

Variables and Their Measurement

Demographic data were collected through parent questionnaires (parent's education, child's race) and from the child (age and sex). Health behavior variables included smoking habits and physical activity. Students were asked whether they had ever smoked a whole cigarette and whether they "smoke now." As a means of encouraging truthful answers, children were reassured that parents and teachers would not receive this information. For physical activity score, the children completed a revised form of the Know Your Body Health Habits Survey,[29] which was adapted for grades 3 and 4. Health knowledge was assessed (at posttest only) with a questionnaire adapted from the Heart Smart test.[30] The 25-item questionnaire, designed to tap the primary content of the interventions, tested knowledge about smoking, heart healthy eating habits, and exercise.

Health status outcome variables included blood pressure, total serum cholesterol, submaximal predicted aerobic power, skinfolds, and BMI. Blood pressure was measured on the right upper arm by a research assistant; a Baumanometer mercury sphygmomanometer and appropriately sized cuffs were used (in accordance with American Heart Association recommendations for children).[31] Blood pressure was taken and recorded twice at the first, fourth, and fifth Korotkoff phases. Total nonfasting serum cholesterol was measured with the Reflotron (Boehringer Mannheim Diagnostics, Indianapolis, Ind); rigorous internal and external quality control procedures were employed. Predicted aerobic power was estimated from heart rates measured by calibrated Polar Pacer heart rate monitors (Polar CIC, Inc, Port Washington, NY) during a Eurofit submaximal cycle ergometry test conducted on a Bodyguard Professional Cycle Ergometer (ØGLÆND DBS A.S., distributed by Country Technology, Gay Mills, Wis) adapted for children.[32]

Triceps and subscapular skinfolds were measured on the right side of the body via Lange skinfold calipers (Cambridge Scientific, Cambridge, Md). The skinfold sites were located and measured at least twice according to National Health and Nutrition Examination Survey procedures[33]; mean measures at each site were summed for analysis. A stadiometer (Perspective Enterprises, Portage, Mich) was used to measure height (to the nearest 0.1 cm), and a balance beam scale (Detecto Scales, Inc, Webb City, Mo) was used to measure weight (to the nearest 0.1 kg). Both measures were taken with children clothed but shoeless. BMI was calculated as weight in kilograms divided by height in meters squared.

Procedures for Data Collection

Physiologic data were collected in 1990 and 1991 at the schools in classrooms, gyms, or media rooms. All variables were measured in the same sequence. After completing all testing, each child received a small prize. Parental information was obtained through mailed questionnaires. Each parent and child gave written consent. The intervention began within a week of baseline testing; posttest data were collected within 2 weeks of completion of the 8-week intervention (i.e., 8–10 weeks after the baseline test for all schools).

Statistical Analyses

All analyses adjusted for the stratified, clustered randomization design.[34] Even though the risk-based intervention was assigned only to the subset of children with cardiovascular disease risk factors, analyses included all third and fourth graders in the schools to allow us to assess the population-level effects of interventions assigned to those at risk.

Baseline demographic differences between intervention groups in terms of their distributions of sex, race, grade, and parental education were examined via χ^2 tests. Skinfold data were skewed; thus, all analyses of skinfolds used their natural logarithms. Because the mean was close to zero, skinfold changes from baseline were adjusted by a shift constant (log 10) to improve computing accuracy.

Two levels of analysis were used: school (primary sampling unit) and individual subject. Because randomization was at the school level, school-level analyses were performed to take into account possible within-school correlations.[35] Individual-level analyses (the secondary analyses) were conducted because individual variation in biological attributes could obscure important clinical changes in the school-level analyses as a result of reduced statistical power.

School-level analyses. SUDAAN software (Research Triangle Institute, Research Triangle Park, NC) was used to perform survey data regression, accounting for the study's stratified, cluster randomization and the corre-

TABLE 1—Demographic Characteristics of the 3 Groups at Baseline: Cardiovascular Health in Children Study, 1990–1991

	Group, %			
	Classroom Based (n = 588)	Control (n = 686)	Risk Based (n = 835)	χ^2, *P*
Sex				
Male	48	49	51	.452
Female	52	51	49	
Race				
African American	20	21	17	.003**
White	76	73	80	
Other	4	6	3	
Grade				
3rd	53	50	48	.210
4th	47	50	52	
Parent education				
Less than high school	16	19	24	<.001**
High school and some college	55	57	58	
College graduate or higher	29	24	18	
Age, y				
8	35	31	35	.578
9	46	48	45	
10	17	19	18	
11	2	2	2	

**$P \leq .01$.

lations of individuals from the same school. Analyses of covariance (ANCOVAs) adjusting for potential confounders and baseline values were used to examine intervention effects for each dependent variable. Intervention effects of total knowledge at posttest were assessed with analyses of variance (ANOVAs) that adjusted for potential confounders. The overall intervention effect was tested initially, and simultaneous Bonferroni 95% confidence intervals (CIs) were calculated for the difference between each intervention and the control group.

Individual-level analyses. Because some group demographics differed significantly, multivariate analyses of variance (MANOVAs) were used to assess for potential confounders as well as intervention group differences in knowledge and for changes in cholesterol, systolic and diastolic blood pressure levels, log sum of skinfolds, BMI, predicted aerobic power, and physical activity score. When a significant MANOVA intervention effect was found, ANCOVAs adjusting for the design, confounders, and the baseline value were used to analyze intervention effects for each dependent variable. Intervention effects for total knowledge at posttest were assessed with an ANOVA adjusting for design and potential confounders.

As a means of controlling for multiple comparisons, the Dunnett test was used to compare each intervention group with the control group at a .05 significance level. Regression diagnostics (jackknife residuals, leverages, and Cook's D statistics) were performed for the ANCOVA and ANOVA models to assess model fit and the influence of outliers on models.[36]

Results

The sample included 2109 children (1043 [49.5%] boys and 1066 [50.5%] girls) aged 7 to 12 years (mean ± SD = 8.9 ± 0.8). Half of the children were third graders (50.1%). The racial–ethnic composition of the sample was as follows: 76.6% White, 19.1% African American, and 4.3% "other." The last category included Asian (1.1% of total subjects), Hispanic (0.9%), and Native American (0.9%) subjects and subjects of mixed or unspecified ethnic backgrounds (1.4%). There were no significant differences in race or sex distributions between our subjects and the total population of third and fourth graders at the study schools (North Carolina Department of Public Instruction, unpublished data, 1991).

Baseline demographic characteristics of the 3 groups are shown in Table 1. There were no significant age, sex, or grade differences. However, there were significant differences between the study groups in regard to race and parental education; there were more non-White subjects in the control group, while the risk-based intervention sample contained more parents with less than a high school education. Subsequent analyses adjusted for these baseline demographic characteristics to reduce possible bias.

Results of the 8-week intervention are shown in Table 2 in the form of summary statistics (adjusted and unadjusted). Mean differences between groups and statistical results are also shown in Table 2. Regression diagnostics showed that outliers did not overly influence models.

School-Based Analyses

Table 3 summarizes the survey data regression analyses comparing the 3 groups. In these analyses, only self-reported physical activity score and total healthy heart knowledge showed significant intervention effects. Total knowledge in the classroom-based intervention schools was significantly greater than that in the control schools (7.86; 95% CI = 3.32, 12.40). The physical activity score improved significantly only in the risk-based schools (3.87; 95% CI = 1.35, 6.39).

Individual-Level Intervention Effects

The MANOVA done initially to assess changes in all of the outcome variables (and total healthy heart knowledge at posttest) adjusted for the 4 demographic variables of sex, race, grade, and parental education, as well as for the study design. This model showed a significant overall intervention effect ($F_{16,3882}$ = 15.12, $P < .001$). All subsequent individual-level analyses adjusted for these same covariates. MANOVAs using percentage changes and total knowledge at posttest produced the same *P* values. Because these were secondary analyses, significant findings indicate only trends in the data (see Table 4).

Physical variables. There were statistically significant differences among the 3 groups in regard to changes in cholesterol ($P < .01$), but only the classroom-based approach reduced mean cholesterol significantly more than in the control group. Adjusted differences among the groups were nonsignificant for systolic blood pressure but were significant for diastolic blood pressure ($P = .03$). Both the classroom-based and risk-based groups exhibited a significantly smaller increase in diastolic blood pressure than the control group.

Differences between groups were significant in regard to change in the natural log of the sum of triceps and subscapular skinfolds ($P < .01$). Both intervention groups significantly decreased body fat, while body fat in the control group increased. All 3 groups showed significant changes in BMI ($P < .01$). However, the risk-based intervention subjects exhibited a significantly greater increase in BMI than the control group children, the opposite of the intended effect. The 3 groups differed significantly in predicted aerobic power ($P < .01$), but only the classroom-based group had a significantly greater increase than the control group.

TABLE 2—Physical Variables, Behavior, and Knowledge: Cardiovasculer Health in Children Study, 1990–1991

	Classroom-Based Group (n = 588)				Control Group (n = 686)				Risk-Based Group (n = 835)			
	Unadjusted		Adjusted		Unadjusted		Adjusted		Unadjusted		Adjusted	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Cholesterol, mmol/L												
Baseline	4.35	0.03	...	...	4.27	0.03	...	...	4.25	0.03	...	...
Posttest	4.17	0.03	...	...	4.23	0.03	...	...	4.18	0.03	...	...
Change	-0.18	0.02	-0.13	0.03	-0.04	0.02	-0.01	0.03	-0.07	0.02	-0.04	0.03
Change, %	-3.2	0.52	-2.4	0.63	-0.4	0.47	0.2	0.59	-0.8	0.44	-0.2	0.60
Systolic blood pressure, mm Hg												
Baseline	103.4	0.41	...	...	104.1	0.38	...	...	104.9	0.36	...	...
Posttest	107.4	0.37	...	...	108.2	0.38	...	...	108.6	0.34	...	...
Change	4.0	0.38	3.8	0.43	4.2	0.35	4.3	0.40	3.7	0.31	4.0	0.41
Change, %	4.3	0.38	4.1	0.42	4.5	0.35	4.6	0.39	4.0	0.31	4.3	0.40
Diastolic blood pressure, mm Hg												
Baseline	68.2	0.35	...	...	67.9	0.33	...	...	68.3	0.31	...	...
Posttest	72.9	0.39	...	...	73.7	0.34	...	...	73.0	0.34	...	...
Change	4.6	0.44	4.6	0.48	5.7	0.39	5.6	0.45	4.8	0.38	4.4	0.46
Change, %	8.1	0.72	8.1	0.75	9.7	0.62	9.5	0.70	8.3	0.60	7.8	0.71
Skinfolds, mm												
Baseline	25.6	0.57	...	...	26.1	0.55	...	...	26.2	0.51	...	...
Posttest	24.6	0.57	...	...	26.4	0.59	...	...	25.2	0.51	...	...
Change	-0.9	0.21	...[a]	...[a]	0.3	0.17	...[a]	...[a]	-1.0	0.20	...[a]	...[a]
Change, %	-2.9	0.67	...[a]	...[a]	1.1	0.57	...[a]	...[a]	-3.2	0.58	...[a]	...[a]
Blood mass index, kg/m^2												
Baseline	18.3	0.14	...	...	18.5	0.14	...	...	18.5	0.13	...	...
Posttest	18.5	0.14	...	...	18.7	0.14	...	...	18.7	0.13	...	...
Change	0.2	0.03	0.3	0.05	0.2	0.04	0.2	0.05	0.3	0.03	0.3	0.05
Change, %	1.4	0.17	1.6	0.27	1.2	0.21	1.1	0.25	1.6	0.18	1.9	0.25
Height, cm												
Baseline	135.5	0.29	...	...	136.3	0.28	...	...	135.7	0.25	...	...
Posttest	137.8	0.30	...	...	138.2	0.29	...	...	137.8	0.26	...	...
Change	2.2	0.05	2.3	0.06	1.9	0.03	1.9	0.05	2.2	0.04	2.2	0.05
Change, %	1.7	0.03	1.7	0.04	1.4	0.02	1.4	0.04	1.6	0.03	1.7	0.04
Weight, kg												
Baseline	33.9	0.36	...	...	34.7	0.35	...	...	34.4	0.32	...	...
Posttest	35.5	0.37	...	...	36.1	0.37	...	...	36.0	0.34	...	...
Change	1.6	0.07	1.6	0.10	1.3	0.07	1.3	0.09	1.7	0.06	1.7	0.09
Change, %	4.8	0.17	4.9	0.28	3.9	0.22	4.1	0.26	4.9	0.18	5.1	0.26
Predicted aerobic power, mL/kg/minute												
Baseline	42.6	0.40	...	...	41.6	0.39	...	...	42.8	0.34	...	...
Posttest	45.2	0.39	...	...	42.9	0.41	...	...	45.0	0.36	...	...
Change	2.7	0.29	2.4	0.35	1.3	0.25	0.7	0.32	2.0	0.27	1.8	0.33
Change, %	8.3	0.81	7.8	0.89	4.4	0.65	2.9	0.84	6.3	0.67	6.2	0.84
Physical activity score												
Baseline	64.5	1.27	...	...	62.6	1.08	...	...	67.0	1.09	...	...
Posttest	66.7	1.23	...	...	62.3	1.11	...	...	68.4	1.06	...	...
Change	1.9	1.46	3.7	1.52	-0.8	1.25	0.2	1.44	1.3	1.23	4.7	1.44
Change, %	22.7	3.24	29.1	3.71	15.1	2.89	19.1	3.51	21.9	2.85	32.5	3.52
Knowledge, % correct												
Posttest	67.3	0.65	64.3	0.74	58.8	0.57	55.9	6.70	60.1	0.52	57.35	0.71

Note. Adjustments involved sex, race, grade, and parental education.
[a]Adjustment models did not fit the skewed sum of skinfolds; a logarithmic transformation was used in the analysis.

Behaviors and knowledge. Changes in physical activity scores were significantly different among the 3 groups ($P < .01$). However, neither intervention group differed significantly from the control group. Smoking prevalence rates at baseline and at follow-up in all 3 groups were very low, and there were no significant differences between groups. After adjustment for design and confounders, total healthy heart knowledge at posttest (percentage correct) differed significantly among the groups ($P < .01$). Only the mean score of the classroom-based group was significantly higher than that of the control group.

Discussion

This study tested two 8-week school-based interventions: a classroom-based intervention for all students and a risk-based intervention only for those with specific cardiovascular disease risk factors. Each intervention incorporated health education (i.e., knowledge) and regular supervised physical activity. The main effects in the intervention schools (as compared with the controls) were greater heart health knowledge in the classroom-based group and greater increases in physical activity in the risk-based group. However, trends found

TABLE 3—School-Based Results Showing Overall Intervention Effects and Group Comparisons: Cardiovascular Health in Children Study, 1990–1991

Measure	Significant Covariate(s)	Overall Intervention Effect (*P*)[a]	Mean Difference From Control (Simultaneous Bonferroni[b] 95% CI): Classroom-Based Group	Mean Difference From Control (Simultaneous Bonferroni[b] 95% CI): Risk-Based Group
Cholesterol	Race	.466	-0.14 (-0.34, 0.07)	-0.05 (-0.29, 0.19)
Skinfolds[c]	Grade	.438	-0.04 (-0.10, 0.03)	-0.04 (-0.12, 0.04)
Diastolic blood pressure	Race	.462	-1.32 (-3.98, 1.33)	-0.94 (-3.29, 1.40)
Systolic blood pressure	Race, grade	.600	-0.65 (-2.30, 1.00)	-0.22 (-1.84, 1.39)
Body mass index	. . .	.500	0.05 (-0.09, 0.20)	0.11 (-0.13, 0.36)
Predicted aerobic power	Sex	.607	1.76 (-1.06, 4.58)	0.78 (-3.75, 5.32)
Physical activity score	Sex, race	.027	3.73 (-0.11, 7.56)	3.87* (1.35, 6.39)
Total knowledge	Sex, race, grade, education	.004	7.86* (3.32, 12.40)	1.26 (-2.47, 4.90)

Note. CI = confidence interval.
[a]*P* values for ANCOVAs (changes from baseline to posttest) and ANOVA (total knowledge).
[b]$\alpha = .05/2 = .025$.
[c]Natural log transformation of sum of triceps and subscapular skinfolds.
$^*P \leq .05$.

with the individual-level analyses showed that children in the classroom-based intervention had more knowledge about heart health, showed a reduction in cholesterol and in skinfolds, and exhibited an increase in predicted aerobic power. Blood pressure normally rises as children grow,[37] but the diastolic blood pressure of children in the classroom-based intervention schools did not increase as much as that of children in the control group. Trends found in the risk-based group (vs the controls) were a smaller increase in diastolic blood pressure, a decrease in sum of skinfolds, and an increase in BMI. The finding of a decrease in skinfolds and an increase in BMI is not uncommon with interventions that increase physical activity, because the activity tends to reduce body fat but add muscle mass, which is heavier than fat.

The risk-based approach assumes that the greatest benefit will be achieved by focusing resources on the individuals with the greatest risk. Analyses of data from our risk-based intervention schools assessed the impact of changes in the risk profiles of high-risk individuals on overall population values. Because they were at the extremes of the distribution, changes in high-risk children could have had a relatively greater effect on the population's mean values.[18] Our study demonstrated that implementation of a risk-based approach required at least as many resources per school and achieved a lower level of improvement in the health of the target population. The results from the classroom-based, public health approach showed stronger trends than did the risk-based intervention. The only overall positive effects noted in the risk-based intervention schools were a minor reduction in skinfolds and a smaller increase in diastolic blood pressure. Thus, a classroom-based approach, targeting all students, would yield a greater benefit in the health of the population than an intervention targeting only those at high risk.

Table 4—Individual Results, With Adjustment for Design Effects and Control for Covariates: Cardiovascular Health in Children Study

Measure	Significant Covariates	Difference[a] From Mean Change of Control (95% CI): Classroom-Based Group	Difference[a] From Mean Change of Control (95% CI): Risk-Based Group
Cholesterol	Race	-0.13* (-0.20, -0.08)	-0.03 (-0.09, 0.02)
Skinfolds[b]	Grade	-0.04* (-0.06, -0.02)	-0.05* (-0.06, -0.03)
Diastolic blood pressure	Race, grade	-1.10* (-2.19, -0.02)	-0.96 (-1.96, 0.03)
Systolic blood pressure	Race, grade	-0.22 (-1.20, 0.75)	-0.47 (-1.37, 0.42)
Body mass index	. . .	0.06 (-0.05, 0.17)	0.11* (0.01, 0.21)
Predicted aerobic power	Sex	1.32* (0.54, 2.11)	0.69 (-0.03, 1.41)
Physical activity score	Sex, race	2.65 (-0.81, 6.10)	2.01 (-1.16, 5.18)
Total knowledge	Sex, race, grade, parental education	8.48* (6.79, 10.17)	1.34 (-0.21, 2.89)

Note. Controlled covariates were sex, race, grade, parental education, and (for ANCOVAs) pretest level of variable. CI = confidence interval.
[a]Dunnett test at $\alpha = .05$.
[b]Natural log transformation of sum of triceps and subscapular skinfolds.
$^*P \leq .05$.

Other factors may have contributed to the greater success of the classroom-based intervention. Perhaps children at this age respond better to a unified, peer group effort. Possibly, teachers in the classroom-based group reinforced the intervention during other parts of the school day. In addition, providing the intervention for all of the children avoided the possibility of "labeling" at-risk children as somehow different while giving all children the benefits of the intervention.

The school-level analyses did not reveal significant differences in the physiologic measures. This is not surprising, because the variability of the physiologic measures among subjects in each school was much larger than any potential change that could be produced by an 8-week intervention. The variables more easily influenced by group-level interventions, knowledge and behavior (physical activity), both improved significantly in the classroom-based intervention schools. Another explanation is that our sample did not include enough schools to provide sufficient power for school-level analyses.

We were able to obtain intervention effects without active involvement of the parents. Although most studies producing significant effects have included parents,[13,19,21,23,38] we chose to test a simpler and more practical model and thus limited the interventions to those provided within the school day to children only. The classroom-based approach is practical because it builds on programs readily available to schools and should not require additional teachers or expensive materials. Any qualified physical educator can teach the physical activity component.

Our short, classroom-based intervention was somewhat more effective than those described in other controlled school-based studies. The Know Your Body program in New York used a teacher-delivered, 2-hour-per-week curriculum for fourth through eighth graders; after a full year of the intervention, cholesterol was only slightly reduced (by 0.4%).[39] In the San Diego Family Health Project,[40] diet changed somewhat, but activity changed only minimally. While the Heart Smart program also includes a physical activity component, results indicate only a clear knowledge improvement.[41]

The Cardiovascular Health in Children intervention was more intense than these other studies, involving regular physical activity as well as health knowledge, which may explain these differences. Although the Child and Adolescent Trial for Cardiovascular Health resulted in large changes in the school lunch program and physical education at the intervention schools, significant intervention effects on lipids, blood pressure, and measures of obesity were not reported.[42] Perhaps the differences between the Child and Adolescent Trial for Cardiovascular Health and Cardiovascular Health in Children results are related to the time frame of analysis; results of the latter study were tested immediately after a short (8-week) intervention, whereas outcomes of the former were measured 2.5 years after the pretest, following a 2-year-long intervention.

Conclusions

Many lifelong health behaviors are formed in the early years of life, suggesting that the elementary school years offer a critical time to intervene. We need to identify and implement interventions that effectively improve cardiovascular health behaviors and reduce risk factors in children. The Cardiovascular Health in Children study offers one such intervention. This study is the first large randomized, controlled study to compare a large-group, classroom-based intervention with a small-group, risk-based approach to improving cardiovascular health in children of elementary school age.

The study demonstrated that both the classroom-based approach and the risk-based approach can somewhat improve cardiovascular risk profiles in elementary school children. However, the results from the large-group, classroom-based approach showed stronger trends and were much easier to implement in the school system. Thus, our results support the public health approach to improving children's cardiovascular health by preventing the development of risk factors in some and by reducing risk factors in those who are already at risk. We would suggest, however, that to produce long-term population effects, school-based interventions should be conducted at least annually throughout the elementary, middle, and even high school years. □

Contributors

J. S. Harrell conceptualized the study, oversaw implementation, and wrote the paper. R. G. McMurray designed part of the intervention, helped to plan the study, and contributed to the writing of the paper. S. A. Gansky did all data analysis and contributed to the writing of the paper. S. I. Bangdiwala planned the data analysis and participated in designing the study. C. B. Bradley oversaw all field data collection and assisted in writing the paper.

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