Effects of a school-based intervention to reduce cardiovascular disease risk factors in elementary-school children: The Cardiovascular Health in Children (CHIC) Study

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Objective: **To test a classroom-based intervention to reduce cardiovascular disease risk factors in elementary school children.**
Study design: **This was a randomized, controlled field trial in 12 schools across North Carolina, stratified by geographic region and urban/rural setting. Subjects were 1274 third and fourth graders (48% boys). The intervention, taught by regular classroom and physical education teachers, provided all children an 8-week exercise program and 8 weeks of classes on nutrition and smoking. Data were analyzed at the school level with survey regression models and at the individual level with multivariate analysis of variance and analysis of covariance models; 95% confidence intervals were computed.**
Results: **Children in the intervention group had significantly greater knowledge (7.9% more correct) and a significant increase in self-reported physical activity than children in the control group. Trends for the intervention group were a reduction in total cholesterol level (–5.27 mg/dl), an increase in aerobic power, a reduction in body fat, and smaller rise in diastolic blood pressure than control children.**
Conclusions: **This classroom-based, public health approach improved children's cardiovascular disease risk profiles; it is practical and fairly easy to incorporate into the school day. All children directly receive the potential benefits of the intervention without a risk of labeling. This program can improve health knowledge, habits, and health outcomes of young children at a time when health habits are being formed. (J Pediatr 1996;128:797-805)**

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The need for early intervention to promote cardiovascular health in children is recognized,[1, 2] because children exhibit risk factors for cardiovascular disease that often persist into adulthood.[3, 4] Fatty streaks and atherosclerotic lesions have been found at postmortem examination in the aorta and coronary vessels of 6- to 30-year-olds and were related to antemortem CVD risk factors such as cholesterol and ponderal index in male subjects.[5] The Pathobiological Determinants of Atherosclerosis in Youth research group reported all sub-

ANOVA	Analysis of variance
BMI	Body mass index
BP	Blood pressure
CI	Confidence interval
CVD	Cardiovascular disease
pV_{O_2}	Predicted aerobic power

jects aged 15 to 34 years had fatty streak lesions of the aorta on autopsy, with fibrous plaque lesions of the right coronary artery found in 11% to 15% of men and in 8% to 10% of women.[6] An earlier report by the same group showed that such lesions were strongly related to serum cholesterol and smoking.[7] Although the American Academy of Pediatrics recommends that those with a family history of CVD receive cholesterol screening,[8] studies indicate that such testing is often omitted, even in children with positive family histories of premature CVD.[9-11]

Many researchers recommend a population approach to improving cardiovascular health behaviors in children.[3-4, 12-14] This can be done through teaching and other interventions provided to all children in a variety of settings such as schools and other community locations. The few large-scale randomized, controlled studies of school-based programs to reduce CVD risk in children have early results that are inconclusive.[15-23] The Heart Smart Program modified school lunches, the physical education program, school health services, and extracurricular activities. Children in intervention schools showed some improvement in knowledge and a trend toward more healthful food choices; there was improvement in high-density lipoprotein cholesterol levels in one of the two intervention schools.[19] Four school-based, public health–type intervention programs for children are in progress as part of the Child and Adolescent Trial for Cardiovascular Health study.[20] Reports from this study include pilot study results[21, 22] and baseline data[23]; intervention effects have not yet been reported.

A major purpose of the Cardiovascular Health in Children study, a controlled, randomized field trial, was to determine whether a school-based intervention could improve total serum cholesterol, blood pressure, measures of obesity (body fat and body mass index), exercise tolerance, self-reported physical activity, smoking habits, and knowledge in third- and fourth-grade children. The intervention reported here was a classroom-based approach including knowledge, attitudes, and physical activity components for all children. This article presents the short-term results of this intervention.

METHODS

Setting and sample. This segment of the Cardiovascular Health in Children study was conducted in 12 schools in North Carolina, a state in the top quintile for deaths in the United States as a result of stroke and CVD.[24] Half the schools were in rural areas and half in urban areas. Urban schools were located in cities with a population of at least 50,000. Rural schools were located in counties that did not include any cities of more than 50,000, and in towns with populations of less than 2500. Because the heart disease mortality rate in North Carolina is lower in the western mountain region than in the eastern coastal plain or the central piedmont,[25] the study design incorporated geographic region. Two schools were randomly selected within each of six strata or blocks (defined by three state geographic regions—eastern coastal, central piedmont, or western mountain—and by two settings—rural or urban). Initially 108 schools agreed to participate; study schools were randomly selected from 33 of those that met study criteria as clearly rural or urban.

Subject inclusion criteria were as follows: assignment to the third or fourth grade regardless of age; ability to read and write English; no mental, emotional, or physical handicap identified by parents or teachers; no chronic illness such as diabetes or moderate to severe asthma reported by parents, teachers, or child; ability to participate in an exercise program; and at least one relative available to respond to a questionnaire about family history. Although both parental consent and child assent were required for a child to be in the study, a majority (58.1%) of the third and fourth graders in the study schools participated.

Intervention. Schools, which were stratified by region (coastal, piedmont, mountain) and setting (rural, urban), were randomly assigned to the intervention or control group. In the intervention schools regular classroom teachers used the American Heart Association Lower and Upper Elementary School Site Program Kits[26] to provide instruction to all the third and fourth graders twice a week for 8 weeks. Content included information about selecting "heart healthy" foods, the importance of getting regular physical exercise, the dangers of smoking, and ways to combat pressure to smoke. An experienced elementary educator was a member of the research team. She conducted day-long training sessions for third- and fourth-grade teachers at each intervention school, and she was available to the teachers for consultation and guidance in planning and implementing classroom activities. The elementary educator also visited each classroom during the course of the intervention to confirm that the intervention was being performed as planned.

In addition, children received a physical activity intervention three times a week. An investigator (R.G.M.) designed 24 lesson plans that were used by physical education teachers. This intervention included a brief warm-up, 20 minutes of various fun, noncompetitive aerobic activities designed to work the major muscle groups, and a cool-down period. Lesson plans offered aerobic activities such as jumping rope to music, "endless relay," parachute and other small-group games, and aerobic dance.

Children in the control group schools did not receive any specific intervention. However, they received their usual health instruction and were assessed and reassessed in the same manner as the intervention group; that is, they were asked about their health behaviors and were examined for cholesterol, BP, aerobic power, skin folds, and BMI. The parents of all children in both the control and the intervention groups received a written report of their child's physical testing results about 4 weeks after each testing period.

Variables and their measurement. The variables studied are consistent with the Bruhn and Parcel Development of Positive Health Behavior model, which considers family influences and child developmental/personal characteristics as factors in predicting health behaviors and health status outcomes.[27] The family influences studied were parents' education and family history of CVD. Parental education, used as an indication of family socioeconomic status, was determined from parents' questionnaires. The highest grade the father completed in school was used unless it was unavailable, in which case the mother's educational level was used. Family history of CVD was determined by asking parents if they or their parents (the child's grandparents) had ever had any of these conditions: angina, angioplasty, heart attack, coronary bypass surgery, high blood pressure, or stroke and if these occurred before age 55 in men and 60 in women. We included grandparents because the mean ($\pm$SD) age of the parents was only 36.0 ($\pm$5.7) years.

Child developmental/personal characteristics. Age and gender were obtained from the child. The child's race was determined from the parents' questionnaires. Health behaviors studied were physical activity and smoking habits. Students were asked if they had ever smoked a whole cigarette and if they "smoke now." To encourage truthful answers, children were reassured that parents and teachers would not receive this information. For physical activity score, the children filled out a revised form of the "Know Your Body Health Habits Survey," which we adapted for grades 3 and 4.[28] Health knowledge was assessed only at posttest by a questionnaire based on the "Heart Smart" test.[27] We eliminated some questions from the original document and added five questions about the dangers of smoking. Thus the Healthy Heart Knowledge test was a 25-item, multiple-choice questionnaire covering nutrition (9 items), exercise (8 items), smoking (5 items), and general heart health (3 items).

Health status outcomes. Blood pressure was measured on the right upper arm by a research assistant who used a Baumanometer mercury sphygmomanometer* (W. A. Baum Co. Inc., Copiague, N.Y.) and appropriately sized cuffs according to American Heart Association recommendations for children.[29] Blood pressure was taken and recorded twice at the first, fourth, and fifth Korotkoff phases; the fourth phase was used as diastolic BP. Mean systolic BP and diastolic BP measurements were used in the analyses. Total serum cholesterol was measured in the nonfasting state with the Reflotron device (Boehringer Mannheim Diagnostics, Indianapolis, Ind.) with rigorous internal and external quality control procedures. We predicted aerobic power, using the Eurofit submaximal cycle ergometry test using a Bodyguard Professional Cycle Ergometer (Monark, Varberg, Sweden), adapted for children. The Eurofit test is one of the best aerobic power predictors for children.[30] Polar Pacer heart rate monitors (Polar CIC, Inc., Washington, N.Y.) were used to obtain heart rates continuously during the cycle test.[31] Triceps and subscapular skinfolds were measured on the right side of the body with a Lange skinfold caliper (Cambridge Scientific Industries, Cambridge, Md.). The skinfold sites were located and measured at least twice according to National Health and Nutrition Examination Survey procedures,[32] and mean measures at each site were summed for analyses. Height was measured to the nearest 0.1 cm with a stadiometer (Perspective Enterprises, Inc., Portage, Mich.); weight was measured to the nearest 0.1 kg with a balance beam scale (Detecto Scale, Inc., Jericho, N.Y.). Both measurements were made with children clothed but shoeless. Body mass index was calculated as weight divided by squared height (in kilograms per meter squared).

Data collection procedures. Baseline data were collected in the schools following a systematic geographic pattern. Posttest data were collected in the same order within 2 weeks of completion of the 8-week intervention. Parental information was obtained through mailed questionnaires. Questionnaires were administered to the children in their classrooms or the library. Physiologic data were collected on smaller groups of children in empty classrooms, gymnasiums, or media rooms. Height, weight, and skin folds were measured at Station 1, cholesterol and blood pressure at Station 2, and aerobic power at Station 3. All variables were measured in the same sequence. After completing assessments, each child received a small prize.

Statistical methods. Chi-square tests were used to examine baseline demographic differences between the intervention and control groups in their distributions of gender, race, grade, and parental education. Analyses of skin folds used the natural logarithm of each sum because the distribution of the skinfold data was skewed. The role of important covariates was assessed with multivariate ANOVA, as were intervention group differences in knowledge and for changes in cholesterol, Systolic BP, diastolic BP, log sum of skin folds, BMI, pV_{O_2}, and physical activity score. These mod-

*Details on all instruments, data collection, and quality control procedures are available by request from the authors.

Table I. Demographic characteristics of the study groups at baseline

Demographic variables	Group: Intervention (n = 588)	Group: Control (n = 686)	Chi-square *p*
Gender			
Male	48%	49%	0.883
Female	52%	51%	
Race			
Black	20%	21%	0.179
White	76%	73%	
Other	4%	6%	
Grade			
Third	53%	50%	0.145
Fourth	47%	50%	
Parental education			
Less than high school graduate	16%	19%	0.145
High school graduate, some college	55%	57%	
College graduate +	29%	24%	
Age (yr)*			
8	35%	31%	0.364
9	46%	48%	
10	17%	19%	
11	2%	2%	

*One child in the intervention group was age 7. This was not included in the percentages.

els did not include smoking because so few children were smoking either at baseline or posttesting. Statistical analyses (except for knowledge) compared the changes from baseline to posttest scores of the two groups, adjusting for baseline values and demographic variables (gender, race, grade, and parental education). Knowledge, which was only assessed at posttest, was directly compared for the two groups adjusting for the demographic measures.

School level analyses. Because randomization was conducted at the school level, survey data regression analysis (SUDAAN) software[33] was used to perform survey data regression, accounting for the study's stratified cluster randomization, the correlation of individuals from the same school, and sampling weights. This type of analysis is recommended by Zucker et al.[34] for studies using cluster randomization. Survey regression assesses differences between intervention groups at the school level by comparing aggregated residuals after accounting for variation related to child level factors. School, the unit of randomization, was used as the primary sampling unit within each of the six region-by-locale strata. For this study design, survey regression analyses appropriately estimate variances and thus produce proper hypothesis tests and confidence intervals.

Individual level analyses were also performed as supplementary analyses to help clarify trends. Because of the individual variation between subjects in biologic attributes, important clinical changes could be obscured by school level analyses, through a reduction in statistical power. However, knowledge and attitudes are more likely to be similar within classes and schools. Thus it is reasonable to expect more variation (and less correlation) within schools for physiologic variables than for knowledge and attitudes. For these individual level analyses, a multivariate ANOVA was performed first to determine whether there was a significant overall intervention effect across all outcomes. Because this effect was significant ($p < 0.0001$), analyses of covariance adjusting for the design, demographic factors, and the baseline value were used to analyze intervention effects (i.e., change from baseline) for each dependent variable. (Knowledge used an ANOVA adjusting for design and demographics). The results from the school level analyses can be expected to differ from those of the individual level analysis if the outcome measure has a relatively high subject-to-subject variability (and low correlation) within schools.

All analyses were done with region, setting-within-region, and demographic variables as covariates. Regression diagnostics (jacknife residuals, plots, leverages, and Cook's D statistics) were performed for the analysis of covariance and ANOVA models to assess model fit and outliers' influence on models.[33] The 95% CIs were calculated for differences between the intervention and control group.

RESULTS

Sample. The sample included 1274 children, 616 (48.4%) boys and 658 (51.6%) girls, aged 7 to 11 years (mean ± SD = 8.9 ± 0.8 years). Socioeconomic status data were obtained from 80% of the fathers and 96% of the mothers. Half of the children were third graders (51.2%). Geographic distribution was as follows: eastern coastal plain 32.3%, central piedmont 35.4%, and western mountains 32.3%; 49.4% of the subjects lived in rural areas and 50.6% in urban areas. Racial/ethnic composition was 74.3% white, 20.4% black, and 5.3% other; "other" included Asian (1.4% of total subjects), Hispanic (1.1%), Native American (1.2%), and mixed or unspecified other (1.6%). As shown in Table I, there were no substantial differences in baseline demographic characteristics of the two groups. Further, there were no significant differences in race and gender distributions between our subjects and the total population of third and fourth graders at the study schools.[35]

Each of the four demographic variables (gender, race, grade, and parental education) showed significant associations with the outcome variables (all multivariate analyses of variance with $p < 0.001$). After adjusting for those demographics and for the study design, the two groups were still significantly different ($F_{8,1186} = 24.81$, $p < 0.001$) when all dependent variables were examined simultaneously. All subsequent individual level analyses adjusted for these demographics.

Intervention effects. Table II presents unadjusted descriptive statistics of baseline and posttest values for each group; absolute change and percent change between baseline and posttest are also shown for each variable. Adjusted mean differences between the two groups for change from baseline to posttest, with 95% CIs, are shown for both the school level and individual level analyses in Table III. Regression diagnostics showed outliers did not overly influence models.

School-based analyses of physiologic variables. The school-based analyses (Table III) show clinically meaningful differences between the intervention group and the control group for change from baseline to posttest for cholesterol and diastolic BP. These differences were suggestive but not statistically significant. The decrease in the cholesterol level from baseline to posttest was greater in the intervention group than in the control group (mean difference −5.27 mg/dl [95% CI −12.11, 1.57]). The unadjusted raw data in Table II shows that diastolic BP increased in both groups—4.6 mm Hg in the intervention group and 5.7 mm Hg in the control group. After adjusting for demographics and baseline values, diastolic BP of children in the intervention group did not rise as much as in children in the control group (−1.32 [95% CI −3.65, 1.00]) (Table III).

School-based analyses of behavior and knowledge. Mean self-reported physical activity scores increased 3.73 [0.37, 7.08] significantly more in the intervention group than in the control group. The descriptive results in Table II show that the intervention group increased 23% from baseline to posttest, whereas the control group only increased 15%. Smoking prevalence was very low for both groups at baseline and at posttest. At baseline, current smoking was 0.1% and 1.1% and experimental smoking ("ever smoked") was 3.5% and 4.3%. Heart health knowledge (percent correct) was only measured at posttesting. Total heart health knowledge at posttest was 7.86% correct higher in the intervention than in the control schools (95% CI 3.89, 11.83). Scores for knowledge subscales are shown in Table II.

Individual level analyses of physiologic variables. The intervention reduced mean total cholesterol more than in the control group; the difference between groups in change score was −4.88 mg/dl (95% CI −7.65, −2.11) (Table III). Although adjusted differences between the groups for change score were nonsignificant for BP, the intervention group had a somewhat smaller mean increase in diastolic BP than the control group. Means and CIs for difference between intervention and control subjects in systolic BP and diastolic BP change from baseline are shown in Table III. Body fat was reduced in the intervention group but increased in the control group; the intervention group had a mean reduction in skinfold thickness (mean change was −0.9 mm [−2.9%]), but there was an average increase of 0.3 mm (1.1%) in the control group (Table II). As shown in Table III,

Table II. Physical variables, behavior, and knowledge: Baseline and posttest intervention means and standard errors (unadjusted)

	Intervention group (n = 588)		Control group (n = 686)	
Measure	**Mean**	**SE**	**Mean**	**SE**
Cholesterol (mg/dl)				
Baseline	168.28	1.26	164.99	1.07
Posttest	161.32	1.21	163.58	1.18
Absolute change	−6.79	0.85	−1.40	0.78
Percent change	−3.20	0.52	−0.39	0.47
Systolic blood pressure (mm Hg)				
Baseline	103.43	0.41	104.06	0.38
Posttest	107.35	0.37	108.24	0.38
Absolute change	3.96	0.38	4.18	0.35
Percent change	4.32	0.38	4.46	0.35
Diastolic blood pressure (mm Hg)				
Baseline	68.24	0.35	67.88	0.33
Posttest	72.88	0.39	73.66	0.34
Absolute change	4.63	0.44	5.74	0.39
Percent change	8.06	0.72	9.72	0.62
Skin folds (mm)				
Baseline	25.58	0.57	26.14	0.55
Posttest	24.63	0.57	26.43	0.59
Absolute change	−0.90	0.21	0.25	0.17
Percent change	−2.91	0.67	1.14	0.57
Body mass index (kg/m^2)				
Baseline	18.26	0.14	18.47	0.14
Posttest	18.50	0.14	18.70	0.14
Absolute change	0.24	0.03	0.18	0.04
Percent change	1.40	0.17	1.15	0.21
Height (cm)				
Baseline	135.49	0.29	136.28	0.28
Posttest	137.80	0.30	138.18	0.29
Absolute change	2.23	0.05	1.85	0.03
Percent change	1.65	0.03	1.36	0.02
Weight (kg)				
Baseline	33.90	0.36	34.70	0.35
Posttest	35.51	0.37	36.12	0.37
Absolute change	1.60	0.07	1.32	0.07
Percent change	4.76	0.17	3.91	0.22
PVO_2 (ml/kg/min)				
Baseline	42.59	0.40	41.58	0.39
Posttest	45.22	0.39	42.89	0.41
Absolute change	2.66	0.29	1.34	0.25
Percent change	8.27	0.81	4.44	0.65
Physical activity score				
Baseline	64.52	1.27	62.57	1.08
Posttest	66.71	1.23	62.32	1.11
Absolute change	1.89	1.46	−0.76	1.25
Percent change	22.66	3.24	15.09	2.89
Knowledge (% correct)	67.27	0.65	58.79	0.57
Exercise	51.45	0.85	41.59	0.69
Nutrition	72.32	0.84	66.06	0.78

Table III. Mean differences of intervention group versus control group* with 95% confidence intervals†

Measure	School level analysis		Individual level analysis	
	Mean difference	95% CI	Mean difference	95% CI
Cholesterol (mg/dl)	–5.27	–12.11, 1.57	–4.88	–7.65, –2.11‡
Systolic blood pressure (mm Hg)	–0.65	–2.10, 0.79	–0.50	–1.66, 0.65
Diastolic blood pressure (mm Hg)	–1.32	–3.65, 1.00	–0.95	–2.25, 0.34
Skin folds§	–0.04	–0.11, 0.03	–0.05	–0.07, –0.02‡
Body mass index (kg/m^2)	0.05	–0.07, 0.18	0.11	–0.02, 0.24
Predicted aerobic power (ml/kg/min)	1.76	–0.70, 4.22	1.73	0.80, 2.66‡
Physical activity score	3.73	0.37, 7.08‡	3.90	–0.20, 8.01
Knowledge total (% correct)	7.86	3.89, 11.83‡	8.37	6.36, 10.73‡

*Regression models controlled for demographics (gender, race, grade, parental education) and baseline level (except for knowledge).
†95% Confidence intervals from covariate ANOVAs (changes from baseline to posttest) and ANOVA (knowledge total).
‡95% CI excludes zero.
§Changes in natural logarithm transformations of sum of triceps and subscapular skin folds.

the change score difference between groups, although small, was significant for change in the natural log of the sum of triceps and subscapular skin folds (–0.05 [–0.07, –0.02]). Both groups showed similar small increases in BMI (Table II). The difference between each group's change in BMI was small and not significant (Table III). Both groups increased in pVo_2; the control group only increased 1.3 ml/kg per minute (+4.4%), whereas the intervention group increased 2.7 ml/kg per minute (an 8.3% increase) (Table II). The mean difference between groups for change from baseline to posttest was 1.73 (95% CI 0.80, 2.66) (Table III).

Individual level analyses of behavior and knowledge. Although the intervention group increased physical activity more than the control group subjects, the difference between groups at posttest was not statistically significantly different for change from baseline; the mean difference between the groups was 3.90 (95% CI –0.20, 8.01]. Posttest healthy heart knowledge scores (percent correct) for the intervention group subjects were significantly higher than those of the control group (8.37% [95% CI 6.36, 10.37]).

DISCUSSION

This study tested an 8-week school-based intervention for third and fourth graders. The classroom-based intervention incorporated health education and regular supervised physical activity; both components were given to all children in the schools assigned to the intervention group. When compared with the control group at posttest, children in the intervention group had lower total serum cholesterol, decreased body fat, increased aerobic power, greater heart health knowledge, and higher self-reported activity. Blood pressure normally rises as children grow,[36] but the diastolic BP of children in the intervention schools did not increase as much as in children in the control group.

Data were analyzed first at the school level and, as a supplement, at the individual level. The primary analyses were done at the school level because randomization was at that level. These analyses were more conservative and accounted for within-school correlations.[34] In these analyses, the variables more easily influenced by group level interventions, that is, knowledge and behavior (self-reported physical activity), improved significantly in the intervention schools. This finding is consistent with the Bruhn and Parcel model.[27] The lack of significant findings for school level analyses of physiologic measures is not surprising, because the between-subject variability of physiologic measures within each school was much larger than any potential change that could be produced by an 8-week intervention. As expected, mean differences and 95% CIs were similar for both sets of analyses, but not identical. The differences in findings by these two types of analyses were expected and were related to differences in variance estimates by the statistical programs. Ordinary regressions (analysis of covariance/ANOVA) produce estimates with the number of individuals used as the sample size, whereas the school level analyses use the school as the primary sampling unit to account for the intraschool variation, and use weights based on the probability of a particular school in the sampling frame being selected to participate in the study.

A limitation of the study is the method used to measure cholesterol and the number of measures made. We did a second finger prick and repeated cholesterol measurements for all subjects with a cholesterol level <100 mg/dl or >200 mg/dl; in all cases the second measure was virtually identical to the first. Studies have indicated that results obtained with the Reflotron device are reliable,[37] and the results show the same variation as other methods: coefficient of variation <5%.[38-40] However, other studies have shown a bias, sometimes positive[41,42] and sometimes negative.[38,40,41] We would have preferred to use venous blood samples obtained in the fasting state, which would have allowed us to measure lipid profiles and lipoprotein subfractions. However, study size, the school-based data collection method, and the use of multiple settings across the entire state made it more practical to use a single finger stick measure. In addition, after talking with many school principals, we were convinced that requiring a venipuncture would drastically reduce participation in the study. We did use strict internal and external quality control procedures for the cholesterol measurement. Although multiple measures of cholesterol during a period of several weeks are required for a clinical diagnosis of hypercholesterolemia,[43] it was not possible to repeat measures in that manner in this school setting. In addition, diagnosis of hypercholesterolemia was not the intent of our study, and that was made clear to the parents in our letters reporting the results of the assessments.

Another variable that might have been measured more precisely and externally validated was physical activity. Although our 25-item physical activity questionnaire had been pilot tested for content validity with third and fourth graders, it was not externally validated. Unfortunately, the questionnaire does not produce an outcome with an easily recognizable unit, such as metabolic equivalents of activity per day. However, it is similar in format and scoring to the weekly activity checklist recently externally validated by Sallis et al.[44] Furthermore, changes in physical activity scores are still internally valid for comparing the intervention group with the control group.

An additional limitation is the potential effect of seasonality on the physiologic results. To reduce this possibility, data were collected within a short time span for all groups within each of the three geographic areas. Thus any potential seasonal effect would be similar within each geographic region, which was a stratification factor, and therefore intervention group comparisons would still be internally valid.

The fact that children in both of the groups showed large increases in diastolic BP and small increases in BMI in less than 3 months is intriguing. We examined the subjects' change in height during this time to determine whether these changes could be logically related to accelerated growth at this age. Indeed, the mean change in height in the intervention and control groups was 1.9 and 2.2 cm, respectively. However, the change in height was very weakly correlated with changes in diastolic BP and BMI. Thus we cannot explain the increases in BMI and BP; further research is needed to determine whether this phenomenon occurs in other populations of third and fourth graders. Because the same research assistants measured BP at both times, and the interrater reliability of simultaneous measurement of BP by these research assistants in pilot testing was high ($r > 0.80$), we believe our results are an accurate representation of short-term change in BP in our sample.

Predicted aerobic power (pV_{O_2}) increased for both groups, but the intervention group had twice the increase of the control group. In our laboratory, an increase of 1 to 2 ml/kg per minute in maximum V_{O_2} is common, simply related to the learning effects of the test-retest situation. Familiarity with the test has a tendency to lower heart rate responses at a submaximal workload, thus increasing pV_{O_2}. We observed a 1.3 ml/kg per minute increase in the control subjects, as expected. The 2.7 ml/kg per minute increase in aerobic power found in our intervention group is greater than that reported for 8 to 10 weeks of training in children by Ignico and Mahon[45] and Stewart and Gutin,[46] and similar to that reported by Rowland et al.[47] for 11 weeks of training in sedentary adolescents. However, it is less than would be expected from a high-intensity training program with children.[48] The rather moderate exercise program that we implemented, along with classroom teaching, was sufficient to cause improvement in some CVD risk factors.

Our short, classroom-based intervention was more effective than other controlled school-based programs. 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 intervention, serum cholesterol was only slightly reduced (–0.4%)[49] compared with –2.4% in our classroom-based group. In the San Diego Family Health Project,[16] diet changed somewhat, but activity changed only minimally. 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 Heart Smart program also included a physical activity component, their results indicated primarily an improvement in knowledge, with an increase in physical fitness seen only in the fifth-grade boys.[19] Our results suggest that even a modest increase in physical activity can be important in modifying CVD risk factors in children.

Other studies with significant effects have involved parents in the intervention[16, 19]; we chose to test a simpler and more practical model and thus limited the interventions to the school day and to children only. We were able to obtain clinically important intervention effects without time-consuming, active involvement of the parents in the intervention. The parents completed questionnaires and received feedback about the risk factors of their children and therefore had some limited involvement in the study. This intervention approach was practical because it built on programs readily available to schools and did not require additional teachers or expensive materials to deliver the classroom component. Any qualified physical educator can teach the physical activity component.

A classroom-based or public health approach provides the intervention for all children and thus avoids the possibility of "labeling" at-risk children as somehow different, while giving all children the potential benefits of the intervention.

A public health or population approach also prevents the possibility of misclassification and eliminates additional screening costs. Because there is evidence that risk factors continue into adulthood,[4-6] it is logical to assume that an intervention that reduces mean levels of risk factors in a majority of the children, if carried out for a longer period of time, could eventually have an impact on mortality rates and morbidity.

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