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The Child and Adolescent Trial for Cardiovascular Health (CATCH)

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The Child and Adolescent Trial for Cardiovascular Health (CATCH) is a field study conducted in elementary schools that was designed to assess the outcomes of health behavior interventions for the primary prevention of cardiovascular disease. Beginning in 1991, third grade students ($N = 5106$*) from ethnically diverse backgrounds in 96 public schools in California, Louisiana, Minnesota, and Texas were randomized to intervention or control status. Twenty-eight schools participated in a third through fifth grade intervention that included food service modifications, enhanced physical education, and classroom health curricula. An additional 28 schools received these components plus family education. Outcomes were assessed using pre-randomization measures in early third grade and follow-up at the end of fifth grade. At the school level, the two primary endpoints were changes in the fat content of food service lunch offerings and the amount of moderate to vigorous physical activity in the physical education programs. At the individual student level, endpoints included psychosocial factors, measures of eating and physical activity patterns, and physiologic measures. In the intervention school lunches, the percentage of energy intake from fat fell significantly more (from 38.7% to 31.9%) than in control lunches (from 38.9% to 36.2%) (*$P < 0.001$*). The intensity of physical activity in CATCH intervention schools was increased significantly compared with the control schools (*$P < 0.02$*). Self-reported energy intake from fat among students in the intervention schools was significantly reduced (from 32.7% to 30.3%) compared with the controls (from 32.6% to 32.2%) (*$P < 0.001$*). Intervention students reported significantly more daily vigorous physical activity than controls (58.6 vs. 46.5 minutes) (*$P < 0.003$*). Blood pressure, body size, and cholesterol measures did not differ significantly between treatment groups. No evidence of deleterious effects of the intervention on growth or development was observed. The CATCH intervention was able to modify the fat content of school lunches, increase daily school physical activity, and improve individual eating patterns and physical activity in children during three school years. Follow-up of this cohort continues.* (J. Nutr. Biochem. 9:525–534, 1998) © *Elsevier Science Inc. 1998*

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Introduction

Cardiovascular disease (CVD) remains the leading cause of death in the United States and most developed countries.[1,2] Epidemiologic data link CVD to the lifestyles of a population; risk factors include cigarette smoking, sedentary behavior, and dietary intakes that are high in calories, saturated fat, and sodium.[2,3] These behaviors are learned in childhood and adolescence, established by young adulthood, and form the basis of the insidious development of atherosclerosis.[4–8] Because of the widespread practice of these health impairing behaviors, population-wide prevention strategies aimed at young people, which are complemented by interventions for those at elevated risk, are widely recommended.[2,9]

Schools are an ideal site for prevention programs because of their access to most children and adolescents and the existence of trained staff, policies, and environments that can support healthy behavior.[10] Traditionally schools have provided information and knowledge concerning health. However, programs based on this premise showed little evidence of influencing health behaviors.[11] Beginning in the late 1970s, a series of school health promotion programs based on behavior change models from social psychology, rather than only on traditional educational models, were tested.[12] These programs focused on preventing cigarette smoking and promoting healthful eating or physical activity patterns, primarily with innovative classroom curricula. These demonstrated success in changing short-term behavior.[12–21] Longer-term behavioral outcomes were noted for programs that were multi-year, included environmental components, or elicited broad parent and community support.[17,18,22,23]

The Child and Adolescent Trial for Cardiovascular Health (CATCH)[24] was designed to augment the CVD prevention research of the 1980s with young people by a study of adequate sample size, a sophisticated research design, a multi-component behavioral health intervention over three grades, and children of diverse communities. This paper describes the main results of the CATCH as reported elsewhere.[25]

Methods

Subjects

The CATCH included four field centers (University of California at San Diego, University of Minnesota, University of Texas at Houston, and Tulane University School of Public Health and Tropical Medicine), a coordinating center (New England Research Institute, Watertown, MA) and the National Heart, Lung, and Blood Institute (NHLBI) project office.

Recruitment of schools was based on distance from each of the four study centers, ethnic diversity, food service characteristics (potential for intervention), and commitment to offering at least 90 minutes a week of physical education and to participate in a 3-year study.[26] Schools also were required to commit to random assignment to treatment or control status.

The study involved 5106 initially third grade students (mean age 8.76 years at baseline) in 96 public schools from 12 school districts[19,26] who agreed to provide a blood sample at baseline. Those who agreed to a blood sample at follow-up formed the primary cohort for student-level study findings.

Design

The schools were randomized to either intervention (56 schools; 14 per field center) or control status (40 schools; 10 per field center). Randomization occurred after all baseline measurements were completed. The intervention schools were further randomized into two equal sub-groups: one group received a school-based program consisting of school food service modifications, physical education, and the CATCH curricula (28 schools; seven per field center); the other group received the same school-based program plus a family-based program (28 schools; seven per field center). The CATCH interventions began in the 1991–92 school year and continued as students progressed through grade five (1993–1994). The control group received their usual health curricula, physical education, and food service programs, but none of the CATCH interventions. The design of the study is described in detail elsewhere.[20,21]

The primary study comparison was between the 56 intervention and 40 control schools with respect to changes from baseline (Fall 1991) to the end of the intervention period. There were two primary endpoints at the school level by which the effectiveness of the CATCH food service and physical education interventions were assessed. These were reducing the total fat and sodium content of the food served to 30% of energy and to 600 to 1000 mg/serving, respectively; and increasing the amount of physical education time that students spent in moderate-to-vigorous physical activity to 40% of class time. At the individual student level, serum cholesterol was the primary endpoint and was the basis of sample size determination, with expected differences of 5 mg/dL between intervention and control schools at follow-up. Secondary endpoints included changes in psychosocial factors; self-reported dietary fat, dietary sodium intake, and time engaged in moderate-to-vigorous physical activity; and systolic blood pressure. The other study comparison, the addition of the home/family component, was addressed by examining differences in secondary endpoints between the two intervention conditions.

Measurements of school and student level outcomes were made at the beginning of third grade (Fall 1991). Follow-up measurements were made in Spring 1994. A substantial portion of students left the district prior to the end of the study, transferring to other schools, but were tracked within a 100-mile radius and measured to enable analysis according to the intention to treat principle.[20]

The CATCH intervention program

The CATCH intervention consisted of school-based (school food service, physical education, curricula) and family-based (home curricula, fun nights) components.[24] School food service changes and physical education enhancement were continuous programs over the 3 school years. The classroom and home curricula were implemented by classroom teachers over a defined time period during each school year, and addressed eating habits (3rd through 5th grades), physical activity (4th and 5th grades), and cigarette smoking (5th grade only). Below is an overview of the intervention components with detail provided elsewhere.[21,24]

Eat Smart was the food service intervention and the goal was to provide children with tasty meals that were lower in fat (to 30% of energy), saturated fat (to 10% of energy), and sodium (600–1000 mg/serving), while maintaining recommended levels of essential nutrients and child participation in the school meal programs.[27,28] Food service personnel participated in a 1-day training session at the beginning of each school year. Monthly follow-up visits to the schools and booster sessions provided further information, help in planning, and support.[27,28]

CATCH PE was the physical education intervention. It was implemented in third grade, and sought to increase the amount of enjoyable moderate and vigorous physical activity during physical

education classes at school, and had the goal to increase the amount of moderate to vigorous physical activity to 40% of the physical education class.[29–31] Physical education specialists and teachers had 1 to 1.5 days of CATCH training each school year.

The classroom curricula included the Adventures of Hearty Heart and Friends, Go for Health-4, and Go for Health-5, for the 3rd through 5th grades, respectively.[32,33] They consisted of 15, 24, and 16 lessons over 5, 12, and 8 weeks in the 3rd, 4th, and 5th grades, respectively. Each lesson was 30 to 40 minutes in length. The curricula targeted specific psychosocial factors and involved skills development focused on eating behaviors and physical activity patterns.[34] Additionally, *F.A.C.T.S. for Five* was a four-session tobacco use prevention curriculum implemented in the 5th grade. Classroom teachers attended 1 to 1.5 days of training each year to implement the curricula using standardized protocols at all sites to insure comparable implementation.[34]

The family program was the home curricula and involved activity packets that complemented the classroom curricula.[15] These packets were sent home with the students and required adult participation to complete. There were 19 activity packets over the course of 3 school years. Score cards to record points for completing home activities were used for giving small rewards to encourage family participation. In addition, during the third and fourth grades, students invited their family members to a family fun night to culminate the classroom activities. The fun nights consisted of dance performances by the students, food booths, healthy snacks, recipes, and games. These fun nights followed a standardized protocol across all sites.[35]

Measures

Program implementation. Process measures were developed to monitor implementation fidelity of the interventions as well as potential confounding influences and policies within the schools. These have been presented in detail elsewhere.[30,34–39]

Outcome measures at the school level. The Eat Smart program was assessed at baseline, in the spring of the fourth grade, and at follow-up, by trained observers who collected recipes, menus of meals offered, vendor product information for 5 consecutive days from food service personnel, and student participation in school meals. The reliability and quality control procedures of these methods are described elsewhere.[28,40] Recipe and menu analysis was carried out utilizing the Nutrition Data System of the University of Minnesota Nutrition Coding Center (NCC).[41] These analyses provide specific micro- and macronutrient content of foods served.

CATCH PE was assessed by an instrument called the System for Observing Fitness Instruction Time (SOFIT).[42] During each of the six semesters of the study, every school was visited twice by trained observers who used SOFIT to observe the type and intensity of the children's activities and the behaviors of the physical education specialist or teacher in physical education classes. Training and quality control procedures are described elsewhere.[29]

Outcome measures at the individual level. The Health Behavior Questionnaire (HBQ) was a class-administered, 45-minute instrument designed to evaluate factors associated with diet, exercise, and smoking at baseline, in the spring of the third and fourth grades, and at follow-up. It included psychosocial data on dietary knowledge, intentions, usual food choices, social reinforcement and support, and self-efficacy. The reliability and validity of the instrument, assessed during the pilot phase of CATCH and with the baseline data, were found to be adequate.[43,44]

A 24-Hour Dietary Recall measured total daily food and nutrient intake in a random subsample of 30 students per school at both baseline and follow-up.[45] A nonquantified food record[45] was completed by students on the previous day and was used as a prompt for the interviewer who conducted the 24-hour recall. The data were directly entered into a laptop computer during the interview and the NCC database was used for evaluation.[41] This method has previously been shown to be reliable and valid.[45,46]

The Self-Administered Physical Activity Checklist (SAPAC) was developed and validated during the CATCH trial.[47] It was administered in the fifth grade only to assess type, duration, and intensity of selected leisure time physical activities, television watching, and video games.[47] Children reported the number of minutes they spent during the previous day in various common physical activities and selected sedentary activities.[48]

Outcome physiologic measures. A detailed description of the physiologic measures in CATCH has been previously published,[23] and are briefly summarized below. All of these measures were performed at baseline and the fifth grade follow-up.

Nonfasting venipuncture blood samples were drawn for lipid determination. Serum was sent to a central laboratory (Miriam Hospital, Providence, RI) for analysis of total cholesterol. The laboratory successfully participated in the Centers for Disease Control and Prevention Lipid Standardization Program.[49]

Blood pressure was measured using the Dinamap Automated Device, model 8100XT (Critikron, Inc., Tampa, Florida). Arm size was measured for selection of the appropriate cuff size while the participant was seated for 5 minutes in a quiet room. Five recordings of systolic and diastolic pressure and pulse rate were taken at 1-minute intervals. The average of the last three readings was used for outcome analyses. The intraclass correlation coefficients for Dinamap readings 3, 4, and 5 in the baseline and follow-up data ranged from 0.54 (systolic blood pressure, third grade) to 0.88 (pulse rate, fifth grade).

Height, weight, and triceps and subscapular skinfolds of each student were measured using the Stadiometer, a balance scale, and Lange calipers, respectively. Skinfold thickness was measured three times at each site, with intraclass correlation coefficients exceeding 0.97. Height was measured to the nearest 0.1 cm, weight to the nearest 0.1 kg, and the skinfolds to the nearest mm. Body mass index (BMI) is defined as weight (kg) divided by height (m) squared.

Aerobic fitness was assessed in all students utilizing a group-administered timed 9-minute run. The test-retest reliability coefficient of the 9-minute run with third grade students was 0.90. Standards of performance for youth are well-established and correlations with more complex measures of fitness were estimated during the pilot phase.[47,50]

Statistical methods

The statistical approach for analyzing CATCH data has been described elsewhere in detail.[20,51–53] All endpoints were analyzed by the single-stage, mixed-model strategy in order to take advantage of the special design feature of CATCH, namely, that randomization was performed at the school level although most of the outcome data were collected by repeated measurement on individuals. Analytical models for the various CATCH endpoints took into account the measurement level, frequency, and nature of each outcome variable.

Safety

The safety aspects of the CATCH programs were monitored by an independent Data and Safety Monitoring Board (DSMB), which met periodically to review the data. Quality control procedures were implemented throughout the study and monitored by the Quality Control Subcommittee of the CATCH Steering Committee. Protocols were approved by the Institutional Review Boards of each center. Parental and school consent was obtained.

Table 1 Number of children in the CATCH longitudinal cohort, by race, gender, and site

	Anglo-American		African-American		Latino		Other		
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Total
California	507	458	44	52	107	111	56	44	1379
Louisiana	510	390	174	188	11	12	10	4	1299
Minnesota	609	509	18	21	5	13	19	43	1237
Texas	268	279	77	100	222	227	8	10	1191
Total	1,894	1,636	313	361	345	363	93	101	5106

Results

Participation and implementation fidelity

Among the 96 schools measured at baseline, there were no significant differences between the study conditions for all relevant variables, insuring equivalency between groups. All 96 schools maintained their participation in their allocated treatment condition over the 3-year study period.

For the student level measurements, the CATCH cohort was defined as those for whom lipid assessment was completed at baseline and follow-up ($N = 4019$). The CATCH students measured at baseline included 60.4% ($N = 5106$) of the third grade students enrolled. There were no significant differences by site, gender, or ethnic group between those who did and did not participate. Table 1 presents baseline characteristics. At fifth grade follow-up, 72% of the students at baseline (3651 of 5106) were in a CATCH school and 28% (1455 of 5106) were not in a CATCH school. Participation for the fifth grade blood measures among students in the CATCH schools was 90% (3297 of 3651) and for those who migrated out 50% (722 of 1455), for a final participation rate of 79% (4019 of 5106). There were no significant baseline differences between conditions for any of the primary and secondary endpoints among those who were lost to follow-up. There were also no significant differences in follow-up participation by intervention assignment or gender, although African-American students and those from California were more likely to have dropped out.

Participation in the intervention programs was consistently high across the 56 intervention schools, as reported elsewhere.[34–36] Training sessions were attended by 86% of school food service cooks, 94% of the physical education specialists, and 86% of the teachers. Over 90% of the school food service guidelines were met during the Eat Smart intervention, and over 80% of specified CATCH physical education activities were implemented.[54,55] Classroom observations revealed that over 88% of the curriculum sessions were completed without modification. Teachers reported completing over 90% of all of the activities in the four curricula. Over 70% of the families participated in some home curricula during each grade level and over 63% attended a family fun night. All of the schools held family fun nights in each of the third and fourth grades, and implemented over 90% of the specified activities for these nights.

School level outcomes

Student participation in school lunch programs was between 70% and 75% on average over the study in all schools. The primary school-level endpoint, the percent of energy from total fat in the meals, was significantly reduced in the intervention school lunches (from 38.7% to 31.9%) compared with the control school lunches (from 38.9% to 36.2%) ($P < 0.0001$). Energy from saturated fat and total energy were also significantly reduced in the intervention school lunches compared with the control school lunches ($P < 0.01$). Sodium content of foods provided rose in both intervention and control schools, although the differences were not significant. A statistically significant increase in potassium (adjusted for food quantity) was seen in the intervention school lunches (from 330.0 mg/MJ to 357.9 mg/1000 MJ) compared with the control school (from 325.3 mg/1000 MJ to 326.6 mg/1000 MJ) ($P < 0.01$).

The average physical education lesson length did not change significantly, remaining at approximately 30 minutes for both groups. Intensity of physical activity, however, increased significantly more in intervention compared with control schools, with higher energy expenditures during the second, fourth, and fifth semesters, and marginally higher energy expenditures during the third and follow-up semesters (Table 2). Time spent at higher levels of activity was equivalent in the two groups at baseline but increased significantly in later semesters (Figure 1). The curves of intervention and reference conditions diverged significantly, as indicated by repeated-measures analysis, for both moderate to vigorous ($F = 2.71$, df = 5,1979, $P = 0.02$) and vigorous physical activity ($F = 2.35$, $P = 0.04$).

Student level outcomes

Response scores for dietary knowledge, dietary intentions, and self-reported food choice changes on the HBQ were significantly greater for the intervention schools at follow-up (Table 3). Perceived social reinforcement for healthful eating patterns also was significantly higher in the intervention groups. The self-efficacy measures for both diet and physical activity, although significantly higher in the intervention groups at the end of the first year of intervention, showed no significant difference at follow-up. Self-reported positive social support for physical activity differed between the end of the third and fourth grades only. The school-plus-family intervention group compared with

Table 2 Observations of physical education classes (SOFIT) at six time points for CATCH intervention and control groups[1]

	Semester 1	Semester 2	Semester 3	Semester 4	Semester 5	Semester 6
Lesson length (minutes)						
C	29.9 ± 0.8	29.3 ± 0.8	29.0 ± 0.8	29.4 ± 0.8	29.3 ± 0.8	30.0 ± 0.8
I	28.9 ± 0.7	30.0 ± 0.7	28.4 ± 0.7	29.8 ± 0.7	29.5 ± 0.7	30.1 ± 0.7
Moderate-to-vigorous activity (% of lesson)						
C	35.2 ± 1.7	34.7 ± 1.7	37.3 ± 1.7	41.1 ± 1.6	45.0 ± 1.6	43.2 ± 1.6
I	38.0 ± 1.4	47.3 ± 1.4[2]	48.4 ± 1.4[2]	50.6 ± 1.3	52.9 ± 1.3	50.2 ± 1.3
Energy expenditure (kcal/kg)						
C	2.19 ± 0.07	2.14 ± 0.07	2.17 ± 0.07	2.19 ± 0.07	2.27 ± 0.07	2.28 ± 0.07
I	2.20 ± 0.06	2.45 ± 0.06[2]	2.35 ± 0.06	2.47 ± 0.06[2]	2.49 ± 0.06	2.46 ± 0.06
Energy expenditure rate (kcal/kg/min)						
C	7.40 ± 0.12	7.30 ± 0.12	7.49 ± 0.12	7.60 ± 0.12	7.97 ± 0.12	7.80 ± 0.12
I	7.62 ± 0.10	8.24 ± 0.10[2]	8.26 ± 0.10[2]	8.35 ± 0.10[2]	8.51 ± 0.10[2]	8.27 ± 0.10

[1]Values shown are mean ± standard error from repeated-measures analysis of variance. School + Family intervention group did not differ from school-only group, $P > 0.50$.
[2]Difference from control significantly greater than at baseline, $P < 0.01$.
C—control. I—intervention.

the school-only intervention group had greater positive changes only for dietary knowledge.

The 24-Hour Food Recall showed increased total daily energy intake among children in both intervention and control schools as they aged, but this increase was greater in the control schools (Table 4). Fat intake was significantly reduced by children in intervention schools at follow-up (from 32.7% to 30.3% of energy consumed) compared with children in control schools (from 32.6% to 32.2% of energy) ($P < 0.01$). Much of this difference came from the intake of saturated fatty acids falling in the intervention schools (from 12.7% to 11.4% of energy) but changing little in children in the control schools (from 12.5% to 12.1%) ($P < 0.01$). Polyunsaturated and monounsaturated fat intakes were also significantly reduced in the intervention schools compared with the controls ($P < 0.02$). Dietary cholesterol was significantly reduced among children in the intervention group (from 223 mg to 206 mg) compared with the controls (from 218 mg to 225 mg) ($P < 0.05$). Sodium consumption, adjusted for energy intake, also marginally increased among intervention students ($P = 0.06$). Vitamins and other micronutrients remained at recommended levels in the intervention group (data not shown).[56]

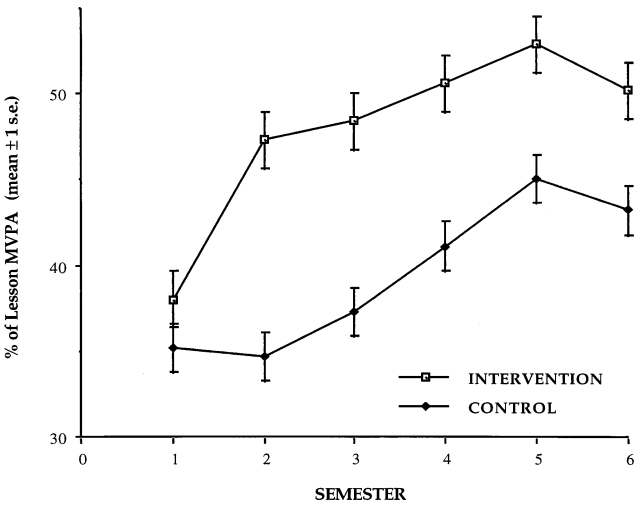

Figure 1 Moderate to vigorous physical activity (MVPA) observed during CATCH physical education classes at six time points, 1991–1994. Adjusted mean ± 1 SE. CATCH intervention, introduced during Semester 2, increased the percentage of time spent in moderate to vigorous and vigorous activity as measured by classroom observation system (SOFIT). Intervention and control curves diverged significantly according to repeated measures analysis of variance with class session as unit of analysis; for moderate-to-vigorous activity, F = 2.17, df = 5,1979, $P = 0.02$; for vigorous activity, F = 2.35, df = 5,1979, $P = 0.04$. Analysis was controlled for CATCH site, location of lesson, specialty of teacher, and random variation among schools and weeks of observation.

SAPAC was administered at the fifth grade follow-up only.[47] Total minutes of daily physical activity reported by this method were not significantly different between the intervention and control schools (intervention mean = 145.5 min vs. control = 154.8 min). However, vigorous physical activity where the student reported breathing hard, was significantly higher in the intervention schools (intervention mean = 58.6 min vs. control = 46.5 min; $P < 0.003$).

Total blood cholesterol declined in the intervention schools (from 4.39 mmol/L to 4.35 mmol/L) as well as in the control schools (from 4.41 mmol/L to 4.38 mmol/L) (Table 5). Apo-B cholesterol fell among children in the intervention schools (from 2.33 mmol/L to 2.31 mmol/L) and the controls (from 2.31 mmol/L to 2.30 mmol/L). The differences were not statistically significant.

Measures of body size including height, weight, BMI, and skinfolds did not differ between the intervention and control groups at baseline or follow-up (Table 5). Growth was within the normal limits of expected patterns for this age period. Similarly, pulse rate and systolic and diastolic blood pressure were not significantly different among the groups.

The 9-minute distance run by students increased with age, in intervention schools by 100 yards and in control schools by 84 yards. The difference between conditions was not significant.

Table 3 Results of the health behavior questionnaire at four time points for CATCH intervention and control groups

Scale (Range)	Group	Baseline	Semester 2	Semester 4	Semester 6
C. Dietary Knowledge (±14)	C	4.2 ± 0.3	5.8 ± 0.3	7.4 ± 0.3	8.0 ± 0.3
	S	5.1 ± 0.3	9.2 ± 0.3[1]	9.9 ± 0.3[1]	10.3 ± 0.3[1]
	SF[2]	5.2 ± 0.3	9.9 ± 0.3[1]	10.9 ± 0.3[1]	10.9 ± 0.3[1]
A. Dietary Intentions (±13)	C	1.5 ± 0.3	2.5 ± 0.3	1.7 ± 0.3	−0.4 ± 0.3
	I	1.9 ± 0.2	6.4 ± 0.2[1]	5.0 ± 0.2[1]	1.4 ± 0.2[1]
B. Usual Food Choice (±14)	C	0.9 ± 0.3	1.0 ± 0.3	0.5 ± 0.3	−0.8 ± 0.3
	I	0.9 ± 0.2	4.2 ± 0.2[1]	3.3 ± 0.2[1]	0.7 ± 0.2[1]
H. Food Choice, Social Reinforcement (±21)	C	−0.9 ± 0.4	1.2 ± 0.4	1.1 ± 0.4	−0.7 ± 0.4
	I	−0.3 ± 0.3	7.1 ± 0.3[1]	7.3 ± 0.3[1]	4.2 ± 0.3[1]
HF. Food Choice, Friends Reinforcement (±7)	C	−1.6 ± 0.2	−1.4 ± 0.2	−1.6 ± 0.2	−2.4 ± 0.2
	S	−1.4 ± 0.2	−0.1 ± 0.2[1]	−0.0 ± 0.2[1]	−2.1 ± 0.2
	SF[2]	−1.4 ± 0.2	0.4 ± 0.2[1]	−0.3 ± 0.2[1]	−1.6 ± 0.2
HP. Food Choice, Parent Reinforcement (±7)	C	0.9 ± 0.1	1.6 ± 0.1	1.5 ± 0.1	1.3 ± 0.1
	I	1.1 ± 0.1	3.0 ± 0.1[1]	3.1 ± 0.1[1]	2.4 ± 0.1[1]
HT. Food Choice, Teacher Reinforcement (±7)	C	−0.1 ± 0.2	1.0 ± 0.2	1.2 ± 0.2	0.5 ± 0.2
	I	0.0 ± 0.1	3.9 ± 0.1[1]	4.4 ± 0.1[1]	3.6 ± 0.1[1]
I. Dietary Self-Efficacy (±15)	C	5.7 ± 0.3	6.4 ± 0.3	6.8 ± 0.3	6.7 ± 0.3
	I	6.0 ± 0.2	7.9 ± 0.2[1]	7.1 ± 0.2[1]	6.2 ± 0.2
E1. Physical Activity, Positive Reinforcement (±11)	C	5.4 ± 0.2	5.8 ± 0.2	6.3 ± 0.2	6.2 ± 0.2
	I	5.3 ± 0.1	6.5 ± 0.1[1]	6.6 ± 0.1[1]	6.1 ± 0.1
E2. Physical Activity, Negative Support (±7)	C	3.2 ± 0.1	4.0 ± 0.1	4.6 ± 0.1	4.9 ± 0.1
	I	3.6 ± 0.1	4.4 ± 0.1	4.9 ± 0.1	5.2 ± 0.1
J. Physical Activity, Self-Efficacy (±5)	C	2.2 ± 0.1	2.6 ± 0.1	2.9 ± 0.1	3.1 ± 0.1
	I	2.3 ± 0.1	3.0 ± 0.1	3.2 ± 0.1	2.9 ± 0.1

Note: The scales are based on a series of questions, scored + 1 for correct or healthy response, −1 for incorrect or less healthy responses.
[1]Difference from control significantly greater than at baseline, $P < 0.005$.
[2]Response with school + family intervention stronger than with school alone, $P < 0.05$.
C—control. I—intervention. S—school intervention alone. SF—school + family intervention.

Table 4 Total daily intakes (24-hour recall) at baseline and follow-up for CATCH intervention and control groups[1]

	Group	Baseline	Follow-up
Calories (Kcal)	C	2030 ± 32	2182 ± 35
	I	2043 ± 25	2067 ± 28[2]
Calories from fat (%)	C	32.6 ± 0.3	32.2 ± 0.4
	I	32.7 ± 0.3	30.5 ± 0.3[3]
Calories from saturated fat (%)	C	12.5 ± 0.1	12.2 ± 0.2
	I	12.7 ± 0.1	11.5 ± 0.2[3]
Calories from polyunsaturated fat (%)	C	5.9 ± 0.1	6.1 ± 0.1
	I	5.7 ± 0.1	5.6 ± 0.1[3]
Calories from monounsaturated fat (%)	C	11.9 ± 0.1	11.6 ± 0.2
	I	11.9 ± 0.1	11.1 ± 0.1[2]
Calories from carbohydrates (%)	C	53.7 ± 0.4	54.8 ± 0.5
	I	53.9 ± 0.3	55.9 ± 0.4[2]
Calories from protein (%)	C	14.9 ± 0.2	14.2 ± 0.2
	I	14.6 ± 0.1	14.8 ± 0.2[2]
Cholesterol (mg)	C	218 ± 7	226 ± 8
	I	223 ± 6	206 ± 6[2]
Sodium (mg)	C	3042 ± 62	3158 ± 69
	I	2929 ± 46	3113 ± 56
Sodium (mg/1000 kcal)	C	1514 ± 20	1469 ± 22
	I	1451 ± 15	1529 ± 18[2]

[1]Cohort subjects with paired data, n = 96 schools, 1182 students. Control (C): n = 40 schools, 473 students. Intervention (I): n = 56 schools, 709 students. Baseline value is unadjusted mean ± SE. Follow-up mean ± SE adjusted for baseline, site, gender, race, number of meals eaten at school, and school random effect. School + family intervention group did not differ from school-only group, $P > 0.30$.
[2]$P < 0.10$.
[3]Difference between intervention and control significantly greater than at baseline, $P < 0.01$.

Table 5 Selected risk factor variables at baseline and follow-up for CATCH intervention and control groups[1]

	Group	Paired obs	Baseline	Follow-up
Height (m)	C	1648	1.325 ± 0.001	1.465 ± 0.001
	S	1177	1.325 ± 0.002	1.466 ± 0.001
	SF	1183	1.329 + 0.002	1.464 + 0.001
BMI (kg/m^2)	C	1627	17.68 ± 0.08	19.68 ± 0.05
	S	1163	17.49 ± 0.09	19.71 ± 0.06
	SF	1169	17.68 ± 0.09	19.79 ± 0.06
Triceps (mm)	C	1649	12.5 ± 0.1	15.2 ± 0.2
	S	1180	12.1 ± 0.2	15.3 ± 0.2
	SF	1185	12.6 ± 0.2	15.3 ± 0.2
Subscap (mm)	C	1649	8.4 ± 0.1	11.1 ± 0.2
	S	1180	8.1 ± 0.2	11.0 ± 0.2
	SF	1184	8.3 ± 0.2	11.3 ± 0.2
Pulse (bpm)	C	1648	86.9 ± 0.2	82.9 ± 0.4
	S	1179	87.0 ± 0.3	83.2 ± 0.4
	SF	1184	86.9 ± 0.3	82.6 ± 0.4
Systolic BP (mmHg)	C	1647	104.8 ± 0.2	109.8 ± 0.2
	S	1180	104.9 ± 0.2	109.9 ± 0.3
	SF	1183	105.4 ± 0.2	109.8 ± 0.3
Diastolic BP (mmHg)	C	1647	53.5 ± 0.2	55.6 ± 0.2
	S	1180	53.0 ± 0.2	56.2 ± 0.3
	SF	1183	54.0 ± 0.2	55.6 ± 0.3
Cholesterol (mg/dL)	C	1625	170.4 ± 0.7	169.1 ± 0.7
	S	1159	168.4 ± 0.8	168.4 ± 0.9
	SF	1152	170.8 ± 0.8	169.0 ± 0.9
HDL-C (mg/dL)	C	707	51.3 ± 0.4	49.2 ± 0.3
	S	512	50.7 ± 0.4	48.6 ± 0.4
	SF	523	52.9 ± 0.5	49.4 ± 0.4
ApoB-C (mg/dL)	C	706	89.2 ± 0.7	89.3 ± 0.6
	S	511	90.1 ± 0.8	89.0 ± 0.7
	SF	522	90.3 ± 0.9	88.3 ± 0.7

[1]Cohort subjects with paired data, n = 4019. Baseline value is unadjusted mean ± SE. Follow-up mean ± SE adjusted for baseline, site, gender, and race. Height, body mass index (BMI), triceps, and subscapular skinfolds adjusted for age; pulse, blood pressure (BP), and lipids adjusted for height and BMI. Adjusted follow-up means did not differ among experimental groups, $P > 0.30$.
C—control. S—school-only intervention. SF—school + family intervention. HDL-C—high density lipoprotein cholesterol. ApoB-C—apolipoprotein B cholesterol.

Discussion

CATCH is the largest and most rigorous school-based health promotion field trial that has been implemented to date. CATCH maintained the involvement of 96 public elementary schools, with considerable ethnic and geographic diversity, using a multi-component intervention. The results of the trial should be considered in terms of its effectiveness for primary prevention and its potential as a model for school-based health promotion.

CATCH was successful in meeting two of the three primary outcomes of the study. At the school level, cafeterias in the intervention schools were able to significantly modify their lunch offerings to approach the national recommendations of 30% total fat energy and 10% saturated fat energy, with much of the reduction coming from saturated fats. Positive results were also observed for CATCH PE: the percentage of physical education class time devoted to moderate to vigorous physical activity significantly increased in the intervention schools compared with the control schools, surpassing the study and Year 2000 goals of 50% of class time.[10] At the individual level, however, the decreases in serum cholesterol levels among students in the intervention schools compared with control students, although in the hypothesized direction, were not significant.

Postulated changes in secondary endpoints also were found as a result of CATCH. Seven of the 11 scales of the HBQ were significantly higher for the intervention group at follow-up. The food recall data revealed changes in the daily eating patterns of students in the intervention schools, with intervention students significantly decreasing their intake of total fat, saturated fat, and cholesterol. However, no intervention effect was noted on sodium intake by the students. Results from the activity recalls are concordant with the increases in moderate to vigorous physical activity in physical education classes, with significantly higher levels of self-reported vigorous activity reported by students in the intervention schools. No significant differences were found in blood pressure. Therefore, review of the secondary endpoints suggest significant and consistent changes in targeted psychosocial factors, lower-fat eating patterns, and increased physical activity among children in the intervention schools, but no detectable changes in risk factors.

The changes in children's eating patterns are notable. National goals for consumption of fat and cholesterol of approximately 30% of energy and 200 mg, respectively, were met during a 3-year program.[57,58] As in the school lunch offerings, these changes were accomplished without loss of energy from protein or carbohydrates in the childrens' diet. Data on height and weight also suggest that this

recommended eating pattern did not inhibit growth. Similar results are shown in the Dietary Intervention Study in Children (DISC),[59] which focused on lowering cholesterol in youth with elevated blood cholesterol levels, with intensive one-on-one interventions outside of the school setting.

Changes in sodium intake were small and nonsignificant despite attempts to reduce salt. This may be due to the difficulty in quantifying sodium intake by the recall method or the recognized "hiadow" quality of sodium in common processed foods.

The lack of changes in cholesterol levels and other physiologic risk factors, although disappointing, is not surprising given several other observations. The magnitude of changes in food intake and physical activity across the population, although statistically significant, was modest. The observed changes in dietary fats and cholesterol, when analyzed by the Keys equation, which relates fat intake to blood cholesterol, predict changes of a magnitude similar to those observed here.[60] This is also a period of important growth and development for these children, with the onset of puberty occurring for many during the study.[61] The effect of diet and exercise changes, such as those described here, may be obscured by these more substantial developmental changes. As suggested in the recently released DISC study,[59] it may be more important for this age group to demonstrate the ability of the program to modify nutrition and physical activity behaviors leading to lifetime health habits rather than to reduce immediate risk factor levels. Such modest modifications in health habits throughout the population may produce considerable public health effects.

The secondary comparison in the study, between the school-based programs and the school-plus-family programs, revealed only a modest benefit in dietary knowledge by adding the family component. Previous reports have indicated that family involvement in health promotion programs is difficult due to low levels of parent participation.[62] CATCH was able to obtain some participation by over 70% of the parents during each of the 3 years of the intervention. This participation, however, was limited to working with their child on at least one of five to eight activity packets each year and to attending family fun nights.[34] An earlier study using home curricula with third grade children demonstrated significant short-term dietary improvement among children whose families participated, but the implementation methods were more intensive than in CATCH.[15] These findings suggest that a family-based program also may need to be greater in dose or more intensive in implementation than was possible in CATCH. It is likely that to demonstrate more substantial modifications in health habits and changes in physiologic risk factors, family involvement will be necessary.

CATCH demonstrated that a school-based program involving school food service, physical education, classroom curricula, and family programs can be successfully implemented in diverse populations in four areas of the country. There were no significant inconsistencies by site, gender, or ethnic group with respect to the primary and secondary endpoints, which suggests that the results reported were found across all of the schools and students who participated in the CATCH intervention program. The CATCH programs, which involve a total of approximately 20 extra hours per year of class time, were delivered with a high degree of compliance by food service staff, physical education specialists, and regular classroom teachers, based on direct observations by CATCH evaluation staff. This was achieved with carefully prepared protocols and 1 to 2 days of training each year. These findings suggest that CATCH was compatible with the needs and structures of schools and school staff, and could successfully be implemented across diverse schools and students.

The control schools were observed to change at a greater positive rate with respect to diet and physical activity variables than the negligible changes that had been anticipated from previous studies and national surveys. These findings reduced the magnitude of differences attributable to the program. This observation has been noted in several prominent population-based trials.[63] A willingness to participate in a randomized trial of school health promotion programs may indicate a greater interest in this area and a desire to make changes. Despite controlled publicity and other safeguards instituted by CATCH, some contamination by centralized food services, physical education staff, and transfers of staff within the districts was possible because the study involved existing infrastructures. Some of the changes noted in the control schools over time, along with other public health efforts, could reflect these observations.

The CATCH study had several limitations. The first was the statistical power of the study.[24] The targeted endpoint for power calculations was a differential between conditions of 5.1 mg/dL cholesterol, which may not have been attainable with a population intervention, or even with children at high risk.[59] This could not be determined at the outset of CATCH and limited our ability to detect any physiologic effects. The second limitation was participation rates. At baseline 60.4% of the third grade populations in the 96 schools agreed to participate and provided adequate blood samples. Because participation required written (active) consent by the child and parent, moderate rates of participation could be expected, especially because the evaluation involved blood samples from the children. Multiple methods to improve participation were implemented including several notices and phone calls to parents, and individual and classroom rewards for participation. Fortunately, there were no differences by treatment condition, site, gender, or ethnic group in participation at baseline. The third limitation was the amount of intervention that was feasible in public elementary schools. The classroom curricula involved classroom time, food preparation, and skill development activities, which were limited by costs, staff time, and competing classroom instructional requirements. The students had 3-month summer vacations, when they were not reached, and when recidivism could occur. More intensive family programs were not possible, because the home curricula were already seen as unique. Staff training time was limited by the school districts and budgets for substitutes, and 1 to 2 days per year were found to be appropriate for the tasks asked of the school staff, and yielded high attendance rates across sites. Finally, the CATCH intervention did not encompass community members, mass media, grocery stores, parks and recreation facilities, and other resources that might be important in the maintenance of children's healthy behaviors.[17]

The results of the CATCH intervention lead to several interpretations and recommendations. CATCH demonstrates that the policies and practices of schools can be changed without substantial new school resources and time. The changes observed positively affected health behaviors and met national recommendations.[10,57,58,64] These changes, when spread across the entire school-based population, have the potential to produce long-term cardiovascular health benefits. Moreover, these school-based programs were introduced with minimal but concentrated and effective training of existing school personnel and modest follow-up support from CATCH intervention staff. CATCH, therefore, provides an important model of a school-based health promotion program for the primary prevention of cardiovascular disease that should be feasible and effective for America's schools.

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