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Pathways: a school-based, randomized controlled trial for the prevention of obesity in American Indian schoolchildren¹⁻³

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ABSTRACT

Background: Childhood obesity is a major public health problem in the United States, particularly among American Indian communities.

Objective: The objective was to evaluate the effectiveness of a school-based, multicomponent intervention for reducing percentage body fat in American Indian schoolchildren.

Design: This study was a randomized, controlled, school-based trial involving 1704 children in 41 schools and was conducted over 3 consecutive years, from 3rd to 5th grades, in schools serving American Indian communities in Arizona, New Mexico, and South Dakota. The intervention had 4 components: 1) change in dietary intake, 2) increase in physical activity, 3) a classroom curriculum focused on healthy eating and lifestyle, and 4) a family-involvement program. The main outcome was percentage body fat; other outcomes included dietary intake, physical activity, and knowledge, attitudes, and behaviors.

Results: The intervention resulted in no significant reduction in percentage body fat. However, a significant reduction in the percentage of energy from fat was observed in the intervention schools. Total energy intake (by 24-h dietary recall) was significantly reduced in the intervention schools but energy intake (by direct observation) was not. Motion sensor data showed similar activity levels in both the intervention and control schools. Several components of knowledge, attitudes, and behaviors were also positively and significantly changed by the intervention.

Conclusions: These results document the feasibility of implementing a multicomponent program for obesity prevention in elementary schools serving American Indian communities. The program produced significant positive changes in fat intake and in food- and health-related knowledge and behaviors. More intense or longer interventions may be needed to significantly reduce adiposity in this population. *Am J Clin Nutr* 2003;78:1030-8.

KEY WORDS Obesity, American Indians, schoolchildren, prevention programs, randomized trials

INTRODUCTION

Childhood obesity is well recognized as an increasing public health problem in the United States (1, 2). The number of 6-11-y-old children with a body mass index (BMI) above the 85th percentile (of the 1963 National Health Examination Survey) increased from 15% in 1963 to 22% in 1994. Although nationwide data on obesity rates in American Indian commu-

nities are still limited, the available surveys indicate that 34% of men and 40% of women have a BMI > 30, which is markedly higher than the all-race national averages of 24% and 25% (3, 4). A 1990 national survey of 9464 American Indian children aged 5-18 y reported that 39% had a BMI above the 85th percentile of the second National Health and Nutrition Examination Survey (5). Other tribe-specific or regional surveys reported prevalences ranging from 25% to 46% in that age group (6-8). The Pathways Study was designed to evaluate the effectiveness of a school-based, multicomponent intervention to prevent or reduce excess weight gain in elementary schoolchildren. This article reports the final results of the 3-y intervention.

SUBJECTS AND METHODS

Study design

The Pathways Study was organized in 2 phases. During the first 3-y phase, all components of the intervention were developed and tested, and measurement instruments were validated. The approach for measuring the main outcome variable, percentage body fat (%BF), was also defined and validated. The results of this feasibility phase were previously reported in detail (9, 10). In the second phase, an intervention was implemented for 3 consecutive years.

Study population

School selection was based on the following eligibility criteria: 1) a projected 3rd grade enrollment of ≥ 15 children, 2) $\geq 90\%$ of 3rd grade children of American Indian ethnicity, 3) retention from 3rd to 5th grade over the past 3 y of $\geq 70\%$, 4)

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TABLE 1
Components of the Pathways intervention

Component	Objective	Content
Classroom curriculum	Targeted at 3rd, 4th, and 5th grades	12 wk/y (8 wk in the 5th grade), twice weekly for 45-min as a classroom lesson
	Promote healthful eating behaviors and increased physical activity	Lessons linked by adventures of imaginary American Indian characters on their journey to healthy living
	Integrate social learning constructs with American Indian traditions	
Food service	Reduce percentage of energy from fat to $\leq 30\%$ Introduce dietary practices aimed at increasing the use of lower-fat foods and fruit and vegetables	Pathways guidelines for food-service personnel Regular visit by Pathways nutritionist to support and monitor school-lunch preparation
Physical education	Increase energy expenditure	Three 30-min physical-education sessions per week during school time Exercise break during classroom time
	Encourage moderate-to-high amounts of physical activity in all children	
	Promote practice of health-related physical activity during and after school	Guided play during recess
Family	Keep families informed and involved in the program	Family fun nights, workshops, and events at school
	Extend positive health behaviors learned at school to family members by promoting involvement of family and child in school-based program activities	Family packs linked to classroom curriculum
	Create a supportive environment for children to adopt positive health practices	

school meals prepared and administered on site, 5) availability of minimum facilities to deliver a physical activity program at the school, and 6) approval of the study by school, community, and tribal authorities. In addition, schools that were considering closing or merging in the next 3 y were excluded.

A total of 41 schools in 7 American Indian communities were enrolled. All schools worked in partnership with a participating academic institution: White Mountain Apache and San Carlos Apache (Johns Hopkins University, Baltimore), Navajo (University of New Mexico, Albuquerque), Sicangu Lakota and Oglala Lakota (University of Minnesota, Minneapolis), and the Tohono O'odham Nation and Gila River Indian Community (University of Arizona, Tucson). The University of North Carolina at Chapel Hill served as the coordinating center.

Children were enrolled in the study, and baseline measurements were made at the end of the 2nd grade. To ensure that the average %BF was similar in both groups, schools were assigned to intervention and control groups by a process of stratified randomization. After the baseline measurements were made, upper and lower %BF strata were defined for schools at each site, and random allocation was determined for each stratum.

The study protocols were approved by tribal, school, and university authorities. Written informed consent was obtained from the parents, and verbal consent was obtained from the children for all measurement procedures and for intervention activities as required by school boards and tribal health authorities.

Intervention components

The Pathways Study intervention consisted of 4 components (Table 1): classroom curriculum, food service, physical activity, and family involvement. Each component was developed and pilot-tested during the feasibility phase of the study and was based on formative research performed at each site (11).

The intervention approach combined constructs from social learning theory and principles of American Indian culture and practices. Several indigenous learning modes (eg, story telling) were also incorporated into the intervention (12).

Classroom curriculum

The classroom curricula for 3rd, 4th, and 5th grades were designed to promote healthful eating behaviors and to increase physical activity. Two 45-min lessons were delivered by teachers each week for 12 wk during the 3rd and 4th grades. This component was decreased to 8 wk during 5th grade to allow for the follow-up measurements during the final 2 mo of the school year.

Food service

The food service intervention provided nutrient guidelines and practical tools for reducing the fat content of school meals while complying with nutrient requirements as defined by the US Department of Agriculture School Lunch and Breakfast programs. The Pathways Behavioral Guidelines for food service staff provided skill-building techniques for use in planning, purchasing, and preparing lower-fat school meals.

Physical education

The physical education (PE) program aimed at increasing energy expenditure in the school environment by implementing a minimum of three 30-minute sessions per week of moderate-to-vigorous physical activity. The PE program was based on the SPARK (Sports, Play and Active Recreation for Kids) program (13), with the addition of an American Indian Games module. In addition, the program included exercise breaks of 2–10 min duration, which were designed to increase energy expenditure and promote physical activity in the classroom. Typically, these exercise breaks consisted of simple exercises

that could be performed in the classroom or outside, during recess.

Family involvement

The goal of the family-involvement component was to introduce families to the Pathways intervention and to assist them in creating a supportive environment for healthy behaviors. The activities also offered families an interactive forum to discuss practical aspects of the Pathways program and to extend their knowledge on healthy lifestyle and eating behaviors. The family component consisted of 1) family action packs, which were take-home materials related to the Pathways intervention, including snack packs with samples of low-fat foods and tips for preparing healthful snacks at home; and 2) family events at schools, which included cooking demonstrations and activities for healthier lifestyle, with the direct involvement of children.

Training

Each intervention component included a specific training plan. Teachers and food service staff were trained annually in local or regional meetings. Concepts and procedures were reinforced at regular visits to school classrooms and kitchens. PE teachers, aides, or regular teachers in charge of PE at each intervention school were trained annually by licensed SPARK instructors or by Pathways instructors who had experience in delivering that program. These Pathways staff also acted as mentors for PE teachers, offering regular support and filling in for PE teachers when needed to ensure a minimum of PE every week.

Measurements

To avoid operator bias, measurement teams were not involved in delivering the intervention. Training, certification, and cross-validation of measurement staff were done centrally or regionally, supervised by the Measurement Committee.

Anthropometry

A full set of anthropometric and body-composition data were collected at baseline (end of 2nd grade) and at follow-up (end of 5th grade). Interim measurements of weight and height were also obtained annually, at the end of the school year, for use by the Data Safety and Monitoring Board for safety monitoring. Measurements were performed in a dedicated room at each school while the children were wearing light clothing and no shoes. All measurements were made early in the morning, on arrival at school. Weight was measured with the use of self-calibrating precision digital scales (Seca 770; Vogel & Halke GmbH, Hamburg, Germany) and height with a fixed Shorr measuring board (Shorr Productions, Olney, MD). Two measurements were obtained and the average was recorded. Triceps and subscapular skinfold thicknesses were measured in triplicate with Lange calipers. Bioelectrical impedance was measured in duplicate with a single-frequency tetrapolar plethysmograph (Valhalla Scientific, Valhalla, NY). Calibration of scales, calipers, and bioimpedance instruments were checked before each use. Maximum acceptable ranges were defined for all measurements.

Percentage body fat

%BF was estimated from bioelectrical impedance and anthropometry with the use of an equation developed and validated specifically for this study (14). This equation has been shown to be highly predictive of %BF in American Indian children ($R^2 = 0.84$). In instances where ≤ 2 of the variables used in the prediction equation were missing, a reduced equation (without the missing variables) was used to predict %BF if the reduced equation produced an R^2 of ≥ 0.7 for the prediction of %BF in the same data set used for development of the full prediction equation. For all measurements, deviation from a set range of the 2 measurements would trigger a repeat measurement by the quality control supervisor. In addition, every 10th child was measured a third time by the QC supervisor. Operators deviating from the supervisor's measurements beyond a set range were excluded from further measurement and sent to retraining.

Physical activity

Physical activity was measured with the use of both a motion sensor and a self-reported activity questionnaire. Minute-by-minute recordings of vector magnitudes, measured with a 3-dimensional accelerometer (TriTrac R3D; Hemokinetics, Iowa City) were collected for 24 h on a random sample of 15 children in each school at the end of the 2nd grade. At the end of the 5th grade, measurements were taken on those same children who were still enrolled; additional children were randomly selected at each school to replace those lost to follow-up.

The physical activity questionnaire was designed to assess activity during the preceding 24 h with the use of a standardized checklist of activities that were selected during the feasibility phase of the study. An activity index was derived from estimates of the energy cost of each activity weighted by its duration (none, a little, a lot).

Knowledge, attitudes, and behavior

A questionnaire about knowledge, attitudes, and behavior was developed and pilot-tested during the feasibility phase of the Pathways Study to measure knowledge, attitudes, and behaviors related to diet and physical activity among American Indian schoolchildren (15). Three scales assessed knowledge of concepts taught in the Pathways curriculum in each grade (3rd, 4th, and 5th). The α coefficients of these scales, measured during the feasibility phase in 5th grade children, were 0.54, 0.50, and 0.51, respectively. Additional scales assessed self-efficacy related to physical activity ($\alpha = 0.69$), self-efficacy to eating a healthy diet ($\alpha = 0.75$), and healthy food intentions ($\alpha = 0.74$).

Questionnaires were distributed to children in their classrooms. Trained Pathways staff read aloud each question and the corresponding answer choices. Children followed along and marked their answers on the questionnaire.

Dietary intake

Food intake during school lunch was measured by direct observation, as previously described (16). Groups of 2–3 children were observed during lunch, in a noninvasive manner, by 2 trained Pathways staff. Food intake was calculated after all food left on the tray was measured. Twenty-four-hour dietary



recall was performed only at the end of the study (5th grade), because a pilot study performed during the feasibility phase showed that 2nd graders could not provide reliable answers about their food intake.

Menu data were collected from 38 schools for breakfast and from 41 schools for lunch, representing menus offered during a 5-d period. All meal-composition data were analyzed with the use of the Nutrition Data System at the University of Minnesota.

Process evaluation

Process evaluation was conducted annually by Pathways investigators and staff not involved in the intervention. Eighteen survey instruments were used to cover all 4 components of the intervention in the 21 intervention schools. Types of data collected included attendance logs for training sessions (teachers, food service personnel, and PE instructors) and for family event (parents or guardians), PE calendars, kitchen-visit contact forms, and student and parent evaluation forms (17). Interim results were used by the Steering Committee to track the implementation of the intervention at each study site, and aggregate results were used to evaluate the overall implementation of the program.

Study organization, data management, and safety

The study was coordinated by a Steering Committee that included the principal investigators, the project officer (from the National Heart, Lung, and Blood Institute), and 2 American Indian representatives elected by all American Indian study personnel. Scientific and ethical issues were monitored throughout the duration of the study by an external Data Safety and Monitoring Board.

Weight and height were measured annually to detect any potential adverse effects of the intervention on growth. Children with BMIs below the 5th percentile of the Centers for Disease Control and Prevention 2000 growth charts or with growth velocity below the 3rd percentile of Tanner's reference values (18) were identified. Parents were notified when their children met one of these criteria and were referred to the local primary care facility. Children with both low BMI and low growth velocity were followed up by letter, visit, or telephone call, and the principal of the school was notified. To monitor possible adverse effects of the PE intervention, all schools were asked to keep a log of physical activity-related injuries.

Statistical analysis

Mixed linear models were used to test for intervention effects, with %BF at the end of 5th grade as the primary outcome variable. Fixed effects were baseline %BF and treatment group. Field sites and schools within sites were treated as random effects. Preliminary tests were done to identify possible site-by-treatment or sex-by-treatment interaction effects for the main outcome variable, but none were statistically significant. Therefore, mixed models with only main effects terms are presented. Similar mixed models were constructed for the secondary outcome variables. Some outcome variables were not controlled for baseline values, either because no baseline data were available (24-h dietary recall and knowledge of 4th and 5th grade curricula) or because the repeated measurements were not done in the same group of children (school lunch

observation and physical activity by motion sensor). The SAS procedure PROC MIXED (SAS Institute, Cary, NC) was used to estimate all the models.

The primary statistical analysis applied the intention-to-treat principle, which calls for all subjects to be analyzed according to their treatment assignment at the time of randomization, regardless of whether they complete the study or not. Therefore, imputed values were used for missing data at follow-up (5th grade). For this, a prediction equation was developed with the use of data from control schools (19) and a procedure based on Rubin's multiple imputation method (20). A secondary analysis was performed that included only students with both 2nd and 5th grade %BF measurements.

RESULTS

A flow chart for enrollment and follow-up is presented in **Figure 1**. Of the 2059 2nd-grade students in the 41 participating schools, 1760 received parental permission to be measured and 1704 were measured, which represented the number of children who were actually present at the schools on measurements days. The mean age of children at baseline was 7.6 ± 0.6 y. Detailed results from baseline measurements are reported elsewhere (21). All 41 schools completed the 3-y study. Of the 1704 children screened at baseline, 1409 (83%) were measured at the end of the intervention period.

Weight, %BF, height, BMI, and triceps and subscapular-skinfold thicknesses are presented in **Table 2**. There were no significant interactions by sex; therefore, data are shown with values from boys and girls combined. There were no statistically significant differences between the intervention and control groups in any of the anthropometric variables at baseline or follow-up, and estimates of the magnitude of the differences in changes from baseline to follow-up between the control and intervention groups were small. %BF increased by $\approx 7\%$ in both groups. Imputation of %BF for children who were lost to follow-up did not change these results. With the use of data from children who completed the study, the mean difference in change in %BF between the intervention and control schools was 0.2 (95% CI: $-0.84, 1.31$). After imputation this difference was 0.0 (95% CI: $-0.85, 0.82$).

The distributions of BMI in boys and girls in the intervention and control schools are shown in **Figures 2 and 3**, compared with reference values from the Centers for Disease Control and Prevention's Growth Charts 2000 (Internet: www.cdc.gov/growthcharts). The distribution of BMI among children in the Pathways Study was clearly shifted toward higher values compared with the reference. At baseline, 47% of the children in the intervention school had BMIs greater than the 85th percentile of the Centers for Disease Control and Prevention's reference values, whereas 48% of children in the control schools had a BMI that exceeded this cutoff. At the 5th grade follow-up the percentage of children with a BMI greater than the 85th percentile was 53% in the intervention schools and 56% in the control schools.

At baseline there were 3 children with a BMI below the 5th percentile in the intervention schools (0.3%) and 7 in control schools (0.8%). At follow-up, the number was the same in both groups: 6 (0.8%).



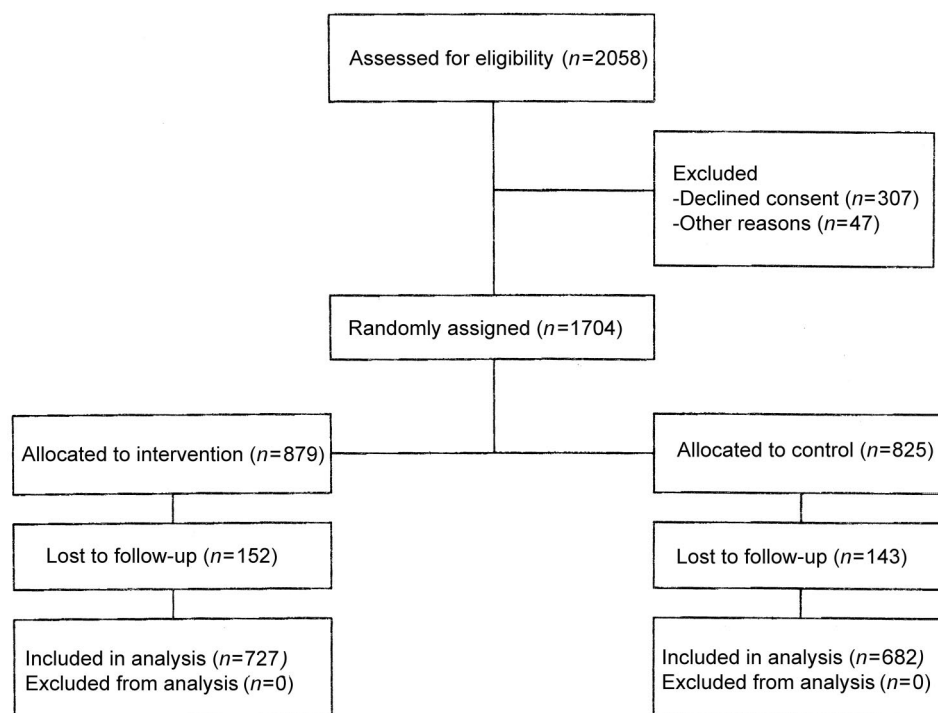


FIGURE 1. Flow chart for enrollment and follow-up in the Pathways Study.

Dietary intake

The total energy intake and the percentage of energy from fat as measured by 24-h dietary recall and direct observation of children eating lunch at school are shown in **Table 3**. The 24-h recall showed a significantly lower total daily energy intake (1892 compared with 2157 kcal/d) and percentage of energy from total fat (31.1% compared with 33.6%) in the intervention group than in the control group. The data from school-lunch observation confirmed a lower fat intake in the intervention group but no difference in energy intake between the 2 groups.

Analyses of the menus and recipes showed the same trends as seen in the data from the lunch observation (data not shown). The energy content of the lunches served was 683 kcal in the intervention schools and 688 kcal in the control schools. The percentage of energy as fat was 28.2% in the intervention school and 32.0% in the control school.

Physical activity

Results of the physical activity measures at baseline and follow-up are presented in **Table 3**. The motion sensor measurements indicated no significant difference over a 24-h period between the children measured in the intervention and control schools. Self-reported physical activity levels (by Physical Activity Questionnaire) were higher among intervention-than control-school students at the end of the trial (**Table 3**). No increase in PE-related injuries was detected in the intervention schools on the basis of injury logs maintained by the schools (data not shown).

Knowledge, attitudes, and behavior

Knowledge targeted in the 3rd, 4th, and 5th grade Pathways curricula increased significantly in the children in the interven-

TABLE 2

Anthropometric measurements of American Indian children in the Pathways Study¹

	Baseline		Follow-up		Mean difference at follow-up ²	95% CI	P
	Intervention (n = 879)	Control (n = 825)	Intervention (n = 727)	Control (n = 682)			
Percentage body fat	32.8	33.3	40.3	40.0	0.2	-0.84, 1.31	0.664
Percentage body fat with imputation	—	—	39.8	39.8	0.0	-0.85, 0.82	0.974
Height (cm)	129.9	130.4	148.1	147.6	0.5	0.03, 0.97	0.038
Weight (kg)	32.5	32.9	49.0	49.0	-0.0	-0.86, 0.86	0.996
BMI	19.0	19.1	22.0	22.2	-0.2	-0.50, 0.15	0.298
Triceps skinfold thickness (mm)	13.3	13.3	17.2	17.2	0.1	-0.67, 0.83	0.837
Subscapular	10.6	10.6	15.0	15.0	-0.1	-0.85, 0.70	0.848

¹ Results from mixed models. See Subjects and Methods for specific models and details of imputation procedure for percentage body fat. Sample sizes correspond to body fat measurements and may vary slightly from other variables because of missing values.

² Calculated from mean values at follow-up (intervention - control).

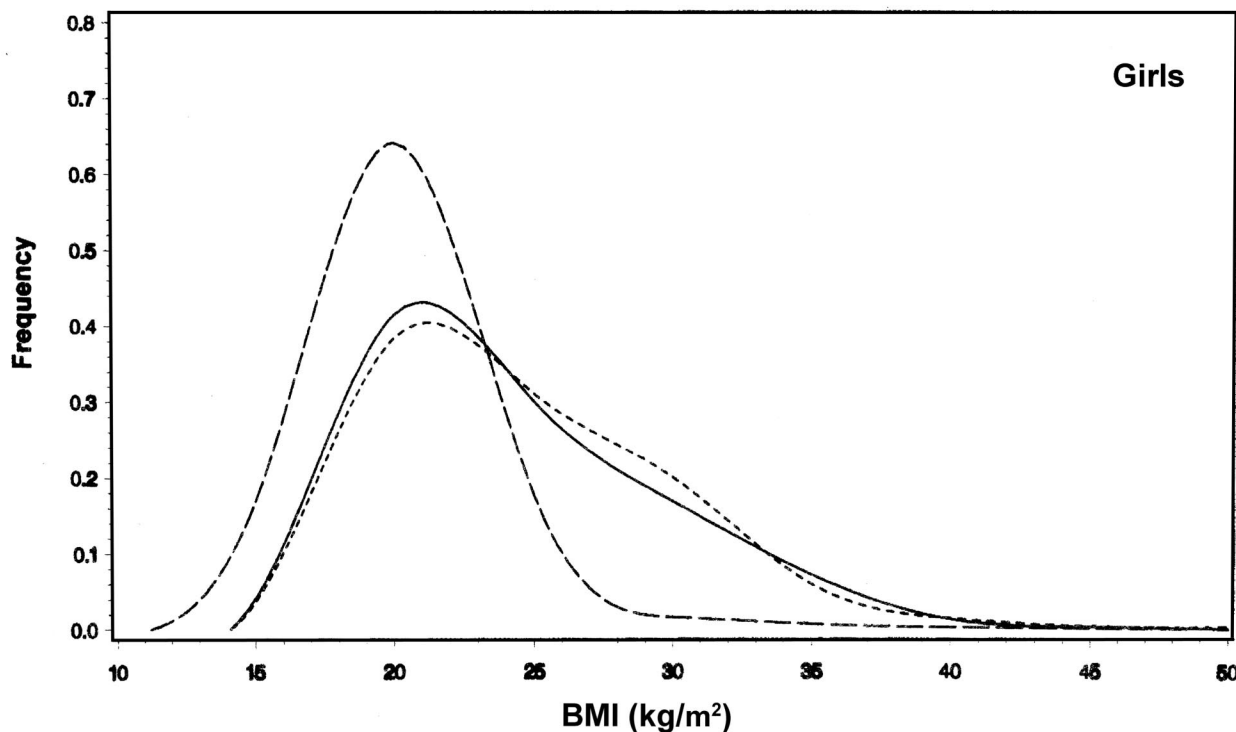


FIGURE 2. Frequency distribution of BMI at follow-up for girls in the intervention (—) and control (---) groups from the Pathways Study. The distribution from the Centers for Disease Control and Prevention's 2000 growth charts reference population is also depicted (-.-.).

tion schools compared with the control schools (Table 3). The difference tended to be largest for the information targeted in the 3rd grade curriculum (intervention group: 0.77; control group: 0.65). Self-efficacy to be physically active was higher in the intervention group than in the control group; however, there was no significant difference between the 2 groups in self-efficacy to choose healthy foods. Nevertheless, children who received the intervention reported more healthy food choice intentions than did control children.

Family participation

Intervention schools held 9 different family events throughout the 3 y. The events took place at each school and attracted, on average, 59% of the children enrolled in the study, or 0.9 adults per child. Relative to anecdotal reports of parental attendance at other school events, this attendance level appeared to be very good.

Process evaluation data indicated a strong degree of implementation for the classroom curriculum, with 94% of lessons completed. Seventy-eight percent of the food service guidelines were implemented, with a progression of 51%, 80%, and 87% for years 1, 2, and 3, respectively. The minimum of 3 PE sessions/wk was achieved by 81% of schools in the first year and by essentially 100% in years 2 and 3. However, only 56% of the schools reached the recommended goal of 5 sessions/wk. Average student attendance at family events over 3 y was 58%. The process evaluation data also indicated that a large majority of those attending family events enjoyed the activities and reported learning something new about diet, physical activity, and health.

DISCUSSION

A general aim of the Pathways Study was to implement a multicomponent school-based intervention for the primary prevention of obesity in public schools serving American Indian communities. Our study received strong support from tribal, educational, and community authorities, particularly the daily support of teachers, parents, and principals, who had to be actively involved in delivering and supporting the program. Almost the entire intervention was delivered by school personnel, teachers, and food service staff; the Pathways staff focused on research measurements and training and support of school staff.

The primary aim of the study was to reduce the rate of body fat gain in intervention schools, documented by a significant difference in the rate for the control schools after 3 y. This goal was not reached, and %BF in both groups was essentially identical at the end of the intervention period.

Over the past 30 y, several school-based studies have implemented and evaluated programs aimed at reducing cardiovascular disease risk or obesity prevalence (22–34). Several of these programs were targeted at only obese children and thus did not attempt to modify risk behaviors in nonobese children. The results from true primary prevention interventions that included at least a dietary and a physical activity component show that most interventions were able, to a variable degree, to reduce dietary fat intake, increase physical activity during school time, increase consumption of fresh fruit and vegetables, and reduce television viewing (23, 31–34). However, these studies also indicate the resiliency of body weight and adiposity in this age group: virtually none of these interven-



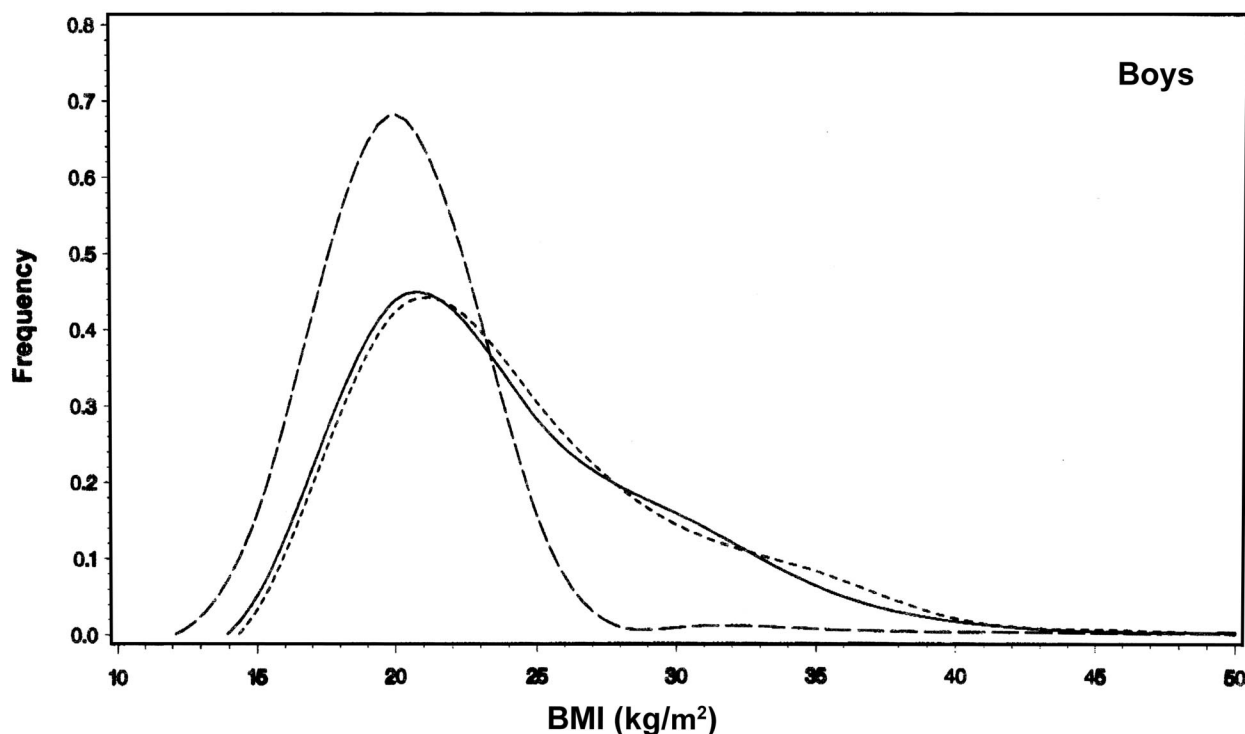


FIGURE 3. Frequency distribution of BMI at follow-up for boys in the intervention (—) and control (---) groups from the Pathways Study. The distribution from the Centers for Disease Control and Prevention's 2000 growth charts reference population is also depicted (· · ·).

tions, which ranged in duration from 1 to 4 y, significantly reduced average body weight or adiposity in interventions. One of these studies, the Planet Health intervention (31), showed a significant reduction in obesity prevalence, defined by a com-

bination of BMI and triceps-skinfold thickness, but only in girls.

A reduction in the rate of body fat accumulation in children requires a net decrease in positive energy balance, leaving less

TABLE 3

Diet, physical activity, and knowledge, attitudes, and behaviors in American Indian children in the Pathways Study¹

	Mean at baseline		Mean at follow-up		Mean difference at follow-up ²	95% CI	P
	Intervention	Control	Intervention	Control			
Dietary							
24-h Dietary recall (n = 621)							
Energy (kcal)	—	—	1892	2157	-265	-437, -94	0.003
Fat (% of energy)	—	—	31.1	33.6	-2.5	-3.9, -1.1	0.001
School-lunch observation (n = 683)							
Energy (kcal)	522.9	573.6	500.2	494.4	5.8	-40.0, 51.5	0.804
Fat (% of energy)	33.1	34.1	28.2	32.4	-4.2	-7.1, -1.3	0.005
Physical activity							
Motion sensor (n = 278) (average vector magnitude/min)							
	282.04	303.13	267.22	246.79	20.43	-19.05, 59.92	0.310
Questionnaire (n = 1503)							
	0.35	0.35	0.27	0.24	0.04	0.01, 0.06	0.001
Knowledge							
3rd Grade curriculum (n = 1150)							
	0.46	0.46	0.77	0.65	0.11	0.08, 0.15	0.001
4th Grade curriculum (n = 1150)							
	—	—	0.70	0.67	0.04	0.01, 0.06	0.013
5th Grade curriculum (n = 1150)							
	—	—	0.55	0.48	0.07	0.03, 0.11	0.001
Attitudes							
Physical activity self-efficacy (n = 1146)							
	0.66	0.66	0.78	0.75	0.03	0.00, 0.06	0.060
Food self-efficacy (n = 1149)							
	0.69	0.72	0.75	0.76	-0.02	-0.05, 0.02	0.332
Reported behaviors							
Food choice intentions (n = 1150)							
	0.46	0.46	0.66	0.53	0.12	0.07, 0.18	0.001

¹ Results are from mixed-models analyses. See Subjects and Methods for models used.

² Calculated from mean values at follow-up (intervention - control).


unspent energy available for storage as adipose tissue. This can be achieved by reducing energy intake, increasing energy output through physical activity, or both. Because our intervention was aimed at all children at the school and not only at those with excess body weight, restriction of energy intake was not an option. Furthermore, the federal school lunch and breakfast programs have minimum mandatory amounts of calories to be served at school cafeterias. Thus, instead of targeting calories, our food service intervention aimed at reducing the energy density of foods by reducing their fat content and at increasing the availability of less energy-dense foods, such as fresh fruit and vegetables. These changes resulted in a significantly lower percentage of energy as fat at lunch in the intervention schools than in the control schools: 28.2% compared with 32.4% (Table 3).

The 24-h dietary recall at the end of the study showed a significantly lower total daily energy intake in the intervention group, ≈ 150 kcal/d less than in the control group. Because there were no significant differences in weight, adiposity, or physical activity between the groups, this difference in energy intake may be the result of reporting bias. Alternatively, the reduction in energy intake in the intervention schools may have occurred too late in the study to cause a significant difference in body weight or adiposity by the time of the follow-up measurement. Excess weight gain during the 3-mo summer recess, which was not assessed, is another possible mechanism.

The second approach to reduce excess positive energy balance was to increase energy expenditure by increasing the time children spent in moderate-to-vigorous physical activity. By including physical activity breaks throughout the day, our physical activity intervention sought to increase the daily active time and reduce sedentary time, an approach positively associated with weight maintenance in reduced-obese children (35). Although the motion sensor data indicated a positive trend toward more active time in the intervention schools, this measurement did not confirm the significant increase in PE found by self-report on the questionnaire. Note that whereas the motion sensor data are a direct measurement of physical activity, the questionnaire provides the self-reported frequency of a limited number of activities.

The significant effect of the intervention on the fat content of the school menus and the dietary fat intake of children show that a reduction in caloric density and in the consumption of saturated fat are feasible while maintaining adequate total energy and micronutrient intakes. Food preparation techniques to reduce fat content and the introduction of low-fat products were ultimately widely accepted by children and by food service personnel. However, these changes were only progressively implemented, and only 51% of scheduled guidelines were implemented during the first year of the intervention.

In summary, the Pathways Study showed that significant reductions in the fat content of school menus and in the dietary fat intake of children can be achieved by training and supporting food service staff. The study also showed that properly trained teachers can achieve significant changes in the health-related knowledge and behaviors of 7–10-y-old children with the use of a culturally appropriate classroom curriculum. The intervention showed positive but no statistically significant trend in the level of physical activity during school time. The lack of effect of the intervention on %BF suggests that more

intense or longer interventions may be needed to modify the continuing trend toward higher adiposity in this population. 

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All authors were members of the study's Steering Committee and had direct responsibility, as principal investigators or field center coordinators, for the oversight of the study, including its design and the collection and interpretation of data. JS and the staff at the study's coordinating center were responsible for data processing and analysis. BC drafted this manuscript, which was reviewed and approved by all authors. None of the authors had financial interests related to this study.

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