Published in final edited form as:
*Int J Obes (Lond)*. 2009 August ; 33(Suppl 4): S4–20. doi:10.1038/ijo.2009.112.

# HEALTHY study rationale, design and methods:

## moderating risk of type 2 diabetes in multi-ethnic middle school students

**The HEALTHY Study Group**

## Abstract

The HEALTHY primary prevention trial was designed and implemented in response to the growing numbers of children and adolescents being diagnosed with type 2 diabetes. The objective was to moderate risk factors for type 2 diabetes. Modifiable risk factors measured were indicators of adiposity and glycemic dysregulation: body mass index ≥85th percentile, fasting glucose ≥5.55 mmol $l^{-1}$ (100 mg per 100 ml) and fasting insulin ≥180 pmol $l^{-1}$ (30 μU $ml^{-1}$). A series of pilot studies established the feasibility of performing data collection procedures and tested the development of an intervention consisting of four integrated components: (1) changes in the quantity and nutritional quality of food and beverage offerings throughout the total school food environment; (2) physical education class lesson plans and accompanying equipment to increase both participation and number of minutes spent in moderate-to-vigorous physical activity; (3) brief classroom activities and family outreach vehicles to increase knowledge, enhance decision-making skills and support and reinforce youth in accomplishing goals; and (4) communications and social marketing strategies to enhance and promote changes through messages, images, events and activities. Expert study staff provided training, assistance, materials and guidance for school faculty and staff to implement the intervention components. A cohort of students were enrolled in sixth grade and followed to end of eighth grade. They attended a health screening data collection at baseline and end of study that involved measurement of height, weight, blood pressure, waist circumference and a fasting blood draw. Height and weight were also collected at the end of the seventh grade. The study was conducted in 42 middle schools, six at each of seven locations across the country, with 21 schools randomized to receive the intervention and 21 to act as controls (data collection activities only). Middle school was the unit of sample size and power computation, randomization, intervention and primary analysis.

### Keywords

type 2 diabetes; adolescents; primary prevention

## Introduction

In 2002, in response to dramatic increases in type 2 diabetes (T2D) in the pediatric population, the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) of the NIH (National Institutes of Health) sponsored a collaborative agreement, Studies to Treat Or Prevent Pediatric Type 2 Diabetes (STOPP-T2D), to develop and conduct both a treatment and a prevention trial of T2D in children and adolescents. The prevention investigators and sites collaborated to develop and conduct a series of pilot and feasibility studies ultimately culminating in the middle school-based HEALTHY primary prevention trial. HEALTHY was



Conflict of interest

T Baranowski has received consulting fees from McDonald's Global Advisory Committee. G Foster has received consulting fees from General Mills and ConAgra Foods. The remaining authors declare no conflict of interest.

conducted in 42 schools over three school years from 2006 to 2009. Half of the schools were randomly assigned to receive an intervention that was designed to reduce risk factors for diabetes by implementing changes on multiple levels—environmental, social and individual.

Here, we report on the overall rationale, design and methods of the HEALTHY study. The HEALTHY Study Group was composed of investigators from seven field centers (Baylor College of Medicine, Houston, TX, USA; Oregon Health & Science University, Portland, OR, USA; University of California at Irvine, Irvine, CA, USA; Temple University, Philadelphia, PA, USA; University of North Carolina at Chapel Hill, Chapel Hill, NC, USA; University of Pittsburgh, Pittsburgh, PA, USA; and University of Texas Health Science Center at San Antonio, San Antonio, TX, USA), the NIDDK project office, the coordinating center (George Washington University, Rockville, MD, USA), the study chair and other experts. Throughout its development, protocols and materials were approved by a Data and Safety Monitoring Board, appointed by NIDDK, and by the Institutional Review Boards of each participating institution.

## Background and rationale

### Status of risk factors for type 2 diabetes in US adolescents

HEALTHY was originally conceived to test whether a multi-component school-based intervention could reduce the development of T2D in middle school aged youth. However, the 2003 pilot study designed to determine the prevalence of diabetes, pre-diabetes and diabetes risk factors in eighth grade students in schools similar to HEALTHY schools showed a low prevalence of actual T2D but a high prevalence of pre-diabetes and other diabetes risk factors.[1] As a result, it was determined that the primary objective of the HEALTHY trial would be to determine whether the intervention could moderate diabetes risk factors for T2D in middle school students followed from sixth through eighth grades. These risk factors included body mass index (BMI) ≥85th percentile, fasting glucose ≥5.55 mmol $l^{-1}$ (100 mg per 100 ml, impaired fasting glucose or IFG) and fasting insulin ≥180 pmol $l^{-1}$ (30 μU $ml^{-1}$).

Obesity is a major risk factor for insulin resistance that precedes the development of impaired glucose tolerance (pre-diabetes) and T2D. In the last few decades, there has been a dramatic increase in childhood overweight and obesity and this rise has matched the increase in T2D in youth. The 85th percentile, which is approximately equivalent to a BMI of 25 kg $m^{-2}$ in adults, has been reported as the level above which youth develop T2D.[2] The proportion of youth aged 12-17 years with a BMI ≥85th percentile has increased from 15.2% in the 1970s to 25% in the 1990s[3] to 31% in youth aged 12-19 during 1999-2002.[4] Recently, it has been suggested that the prevalence has reached a plateau, although further tracking of data will be needed to confirm or refute this finding.[5] The prevalence of obesity among African American, Mexican American and American Indian youth exceeds that of other ethnic groups. In 2004, the prevalence of obesity was 20% in non-Hispanic Black children and 19% in Mexican American children, compared with 16% in non-Hispanic White children; the prevalence was highest in Mexican American boys (22%) and African American girls (24%).[6] In addition, youth with a positive family history of obesity and those exposed to diabetes *in utero* have a high risk of being overweight. The vast majority of youth who are overweight will progress to being obese as adults, and this will result in an increased risk for long-term morbidity and mortality.[7-9]

In our 2003 pilot study, 49% of the participating eighth grade students had a BMI ≥85th percentile for gender and age, 19.8% were overweight (BMI ≥85th and <95th percentile) and 29.2% were obese (BMI ≥95th percentile).[1] Racial/ethnic differences showed that there was a nearly 2.5-fold greater percentage of Hispanics and 3.5-fold greater percentage of American Indian students compared with Whites in the obese category. In addition, BMI ≥85th percentile

was associated with a higher rate of IFG (fasting glucose ≥5.55 mmol $l^{-1}$) and insulin resistance (fasting insulin ≥180 pmol $l^{-1}$).

Impaired fasting glucose and impaired glucose tolerance (2-h glucose values ≥140 mg per 100 ml after an oral glucose load) are indicative of pre-diabetes. IFG is an accepted indicator of risk for T2D, and impaired glucose tolerance confers risk for glucose-related complications[10] and a high likelihood that normal insulin secretion is impaired.[11] In adults, pre-diabetes progresses to diabetes at a rate of ~10% per year.[12] In youth, although there are limited data to determine the rate of progression from pre-diabetes to diabetes, Weiss *et al.*[13] have described a rate of progression in a limited number of obese youth with pre-diabetes because of impaired glucose tolerance of 24% over a mean of 20.4±10.3 months. The main feature of those who progressed was excessive weight gain during the observational period.

Minority and overweight youth had higher mean fasting glucose levels than the general population of American youth.[14,15] In 2000, 7.6% of adolescents had fasting glucose values ≥5.55 mmol $l^{-1}$, although nearly double the percentage of Hispanic youth (13.5%) met that cutoff.[16] In our 2003 pilot study, we found a much higher rate of pre-diabetes because of IFG in our eighth grade sample, which was predominantly minority and heavily Hispanic. The mean fasting glucose value was 5.5 mmol $l^{-1}$ (98.2 mg per 100 ml) and 40.5% of youth in our study had IFG. As progression to pre-diabetes and diabetes is associated with elevation of fasting glucose levels, population-wide reduction in glucose levels would suggest a reduction in the risk of developing diabetes.

Insulin resistance is generally an antecedent to the development of T2D, which, when coupled with relative insulin deficiency, leads to outright disease. A fasting insulin level ≥180 pmol $l^{-1}$ is suggestive of insulin resistance[17] and is a measure that can easily be performed in a school setting. Weiss *et al.*[18] have reported mean fasting insulin values in obese and severely obese subjects to be 188 and 232 pmol $l^{-1}$ (31.3 and 38.6 μU $ml^{-1}$), respectively. In our pilot study, the mean fasting insulin value was 180 pmol $l^{-1}$ (30.1 μU $ml^{-1}$) and 36.2% of eighth grade students had fasting insulin levels ≥180 pmol $l^{-1}$. There was a 2-fold increase in mean fasting insulin levels when comparing those with a BMI <85th percentile (135 pmol $l^{-1}$ or 22.5 μU $ml^{-1}$) with those with a BMI ≥95th percentile (269 pmol $l^{-1}$ or 44.8 μU $ml^{-1}$). Similarly, the percentage with fasting insulin values above 30 μU $ml^{-1}$ increased by nearly 4.5-fold across the three BMI categories. Hispanics and American Indians had the highest mean fasting insulin levels and a 1.5-2-fold greater proportion with values ≥180 pmol $l^{-1}$. As minority youth have the highest rates of obesity, IFG and insulin resistance, and have been reported to be at highest risk for T2D during childhood and adolescence, the HEALTHY trial targeted middle schools with predominantly minority populations.

## Rationale for middle school-based intervention

Middle school was selected as representing a strategic time and place in which to study interventions to influence risk factors for T2D.

Children in the sixth to eighth grades (middle school) are generally 11-14 years old and in early adolescence. This is a time of both physical and metabolic as well as emotional and mental growth and development. Middle school children are typically progressing through puberty with increases in growth hormone secretory dynamics and sex steroid secretion that increase growth velocity and alter body composition, resulting in an increase in insulin resistance and other risk factors for T2D. Diet and physical activity behaviors are in flux during this period, and this transition represents an optimal opportunity to encourage healthier behaviors. Students at this age are developmentally capable of increasing and assuming personal responsibility for behavior change and choices.

The school is the primary social environment of youth. No other institution has as much contact with children.[19] Policy recommendations and guidelines for increasing physical activity in youth include the school as an important environmental influence on physical activity.[20,21] Children who participate in the National School Breakfast (NSB) and National School Lunch Program (NSLP) receive up to two-thirds of their daily energy requirements from these meals, in addition to energy consumed from after-school snacks and in some cases twilight or evening meals. Schools also provide a broad platform for obesity prevention including classroom health curricula and physical education (PE) programs.

The school environment presents significant opportunities for obesity prevention[22,23] and for influencing activity and eating habits.[24-26] Richter *et al*.[27] performed an extensive review of the environmental factors that relate to physical activity and nutrition in youth. They considered the key factors to be the number and type of exercise programs, exercise facilities, policies, types of health promotion activities, presence or absence of certain foods, ways in which food is displayed, and the presence of positive or negative consequences of physical activity and eating. In addition, teacher influences and role modeling and the social network affect the psychosocial culture and the social norms of the school. All of these factors are considered to be part of the school climate, which can influence health behaviors of students, faculty and staff.[28-30]

In addition, school-based learning activities provide a knowledge base and rationale for change. Both retrospective and prospective research[31-35] show that well-designed and implemented programs are effective in promoting a wide range of beneficial health behaviors among adolescents, including reduction in drug use, improvement in nutrition practices and enhancing exercise self-efficacy.

Many adolescent behaviors are shaped more by peers and social influences than by parental or other adult influences,[32,33] and the school provides an environment conducive to fostering peer communications. Strong associations have been found between adolescents' actions and their peers' conduct through perceived normative behaviors and modeling.[36] For example, perceived norms significantly predict the intention to drink regular soda.[37] Furthermore, healthy and unhealthy behaviors often cluster among adolescents. The Youth Risk Behavior Surveillance system found significant relationships between sedentary lifestyle and unhealthy nutrition practices.[38] For example, low physical activity among adolescents was associated with low fruit and vegetable consumption.

A comprehensive intervention that alters the nutrition and physical activity practices of middle school children has the potential to prevent excessive weight gain and obesity. Preventing or lessening obesity should ameliorate insulin resistance and prevent glucose intolerance (pre-diabetes) and diabetes.

## Study design

### Cluster design primary prevention trial

HEALTHY was a primary prevention trial with a public health objective of preventing the development of risk factors for T2D in adolescents. The targeted population was clustered together in middle schools, and hence HEALTHY was considered a cluster design trial.[39,40] The cluster, or school, was the level of sample size and power computation, randomization, intervention, intent-to-treat and primary analysis. All members of the cluster—in our case, students—were exposed to the intervention. Data were collected at both the cluster (school) and the within-cluster (individual students and school staff) levels. Within-cluster data were collected only from those individuals providing appropriate informed consent. Methods of analysis adjusted for the variability both between and within clusters.

HEALTHY applied two sampling schemes available to cluster designs. For the primary analysis, a cohort of sixth grade students enrolled at study start were followed through the 3 years of middle school to end of study at the end of their eighth grade. In addition, a second recruitment and enrollment was undertaken in the eighth grade to enroll any eighth grader not in the cohort. Data were collected from this second cross-sectional sample documenting the length of time in the current school, which was interpreted as exposure to the intervention. A secondary dose-response type analysis was conducted by combining the cohort with the cross-sectional sample.

## Treatment arms

The intervention consisted of four integrated components denoted nutrition, physical education, behavior and communications. (1) The nutrition intervention component[41] was designed to implement changes in the quantity and nutritional quality of food and beverage offerings throughout the total school food environment, including cafeteria meals and after-school snacks provided through federal programs such as the NSLP and SBP, as well as a *la carte* and vending machines. Nutrition intervention goals were enhanced with messaging, cafeteria-based educational events, taste tests to introduce new food items and food service staff training sessions. (2) The PE intervention component[42] provided lesson plans and accompanying equipment to increase both participation and number of minutes spent in moderate-to-vigorous physical activity. The PE teachers attended training sessions that included classroom management techniques. A PE teacher assistant was provided to help deliver the intervention. (3) The behavior intervention component[43] provided brief classroom activities designed to increase knowledge, enhance decision-making skills, promote peer involvement and interaction, and enhance social influence. A combination of individual and group behavior change initiatives promoted healthier behaviors through self-monitoring, goal setting and problem solving. A HEALTHY assistant was provided to help deliver the intervention. Although the behavior intervention component was primarily school based, the study investigators recognized the important role played by parents and family members in enabling behavioral goals. Family outreach newsletters and take-home packages of materials were distributed that provided information and strategies to support and reinforce youth in accomplishing behavioral goals. (4) The communications integration component[44] enhanced and promoted changes in nutrition, activity and behavior through messages, images, events and activities. Social marketing principles were applied to make HEALTHY a ‘brand’ identified with good lifestyle practices. Taking advantage of the force of peer influence, volunteer student peer communicators were recruited and trained to help deliver the intervention components.

Each school year was divided in two, for a total of six semesters. The first semester of the first year (fall 2006) was devoted to recruitment of sixth graders and baseline measurements. The intervention was delivered in the five remaining semesters. All the four intervention components were integrated around a series of themes targeting specific behaviors and building on each other (see Table 1). The phased roll-out of messages and activities kept the program fresh and relevant. The themes highlighted the overarching emphasis of promotional and educational campaigns and activities. Nutrition and activity were continuously targeted. Each was initially delivered as a separate theme and then integrated into the theme of energy balance. Finally, in the second half of the eighth grade school year (semester 6), a wrap-up campaign consolidated the previous themes to address maintenance of a healthy lifestyle. The targeted behaviors listed in Table 1 were emphasized consistently to reinforce messages addressing healthy lifestyle behaviors and changes. In recognition of the mental and physical growth of the students, behaviors became sequentially more complex, starting with education and knowledge-based activities and extending to self-monitoring, goal setting and problem solving.

Perhaps what made HEALTHY unique among previous school-based programs was not just the multiple nature of the intervention components, but their integration into a single, unified entity. The whole became more robust than just the sum of the parts as the HEALTHY program took advantage of synergistic combinations of intervention elements to disseminate knowledge, develop behaviors and skills, enhance awareness of and attendance at events and activities, and recognize accomplishments. Messages, lessons and skills developed and learned in one component were reinforced and practiced in another. For example, specific facts and information provided as part of the classroom learning activities were also delivered in messages posted on the cafeteria line, in 'HEALTHY Habit' reminders by the PE teacher during end-of-class cool-down, and through schoolwide public address system announcements. Administration of the intervention components was coordinated by a 'flighting plan' that specified day-by-day and week-by-week timing, sequencing, placement and order for all study activities and materials. The plan was developed specifically for each intervention school, taking account of days off and other school scheduling. The plan ensured operational execution of the intervention as designed for optimal penetration of messages within a single conceptual and integrated framework.

Control school study activities emphasized recruitment and data collection. No 'placebo' intervention was delivered. Activities and efforts to retain the involvement of control schools and students throughout the trial were implemented.[45] At the end of the study, control schools were given a set of intervention materials (excluding equipment and training sessions).

## Goals and objectives

Primary and secondary objectives are stated in Table 2.

The primary objective was to moderate risk for T2D in middle school students. As noted above, the modifiable risk factors measured were indicators of adiposity and glycemic dysregulation: BMI ≥85th percentile, fasting glucose ≥5.55 mmol $l^{-1}$ (100 mg per 100 ml) and fasting insulin ≥180 pmol $l^{-1}$ (30 μU $ml^{-1}$).

The major secondary objectives included evaluating the ability of the intervention to influence lifestyle changes and choices both in and out of school, such as increased intake of healthy foods and beverages and time spent in physical activity, with corresponding decreases in nutrient-poor foods and beverages and time spent in sedentary behaviors. To understand the feasibility of such intervention programs, we examined the cost-effectiveness of the intervention. To interpret our findings, we evaluated the degree to which the components of the intervention were delivered and administered as planned. We collected information on academic performance, attendance and comportment in intervention versus control schools during the study to detect either beneficial or deleterious trends associated with the intervention. In recognition of the increasing amount of publicity and public concern about health-related obesity in US adolescents, we monitored the influence of changes in the school environment that were not mandated by the study but were due to decisions and changes in policies, guidelines and recommendations at the school district, local, state and national levels. Finally, these data contributed to our understanding of the etiology of risk of T2D in this age group. In addition to a comparison of intervention versus control, the control schools provided natural history data about secular trends in nutrient intake and physical activity, components of the metabolic syndrome (lipids, adiposity, blood pressure, fasting glucose) and pubertal status and their relationship to other factors.

## Study participants

The HEALTHY study first recruited and enrolled the six schools at each of the seven field centers (42 schools total), and then recruited and enrolled students from within each school as

needed for data collection. Student recruitment efforts were identical in both intervention and control schools.[45]

School eligibility criteria are given in Table 3. Schools had to be representative of the adolescent population at risk for T2D in terms of minority composition and/or lower socioeconomic status, as determined by the percentage eligible for free or reduced cost lunch. Historical levels of annual out-migration must have been below 25% to ensure adequate retention of the initial cohort. In addition, for sample size and power purposes, we required that at least 50 members of the initial cohort be retained at the end of the study in eighth grade. This was determined by assuming a 50% recruitment rate in the sixth grade student population based on pilot experience,[1] and then applying the historical attrition levels provided by the school to project to the end of the study. To deliver the PE intervention component, the school had to meet certain minimum space and scheduling criteria. The school had to agree to let the study conduct minimal data collection of height, weight, gender, age and race/ethnicity of all sixth graders at baseline for the purpose of comparing students who consented with those who did not. The school also had to assist the study with distributing materials to the students' homes, although all postage and materials were paid for by the study. Schools had to have or obtain FWA (Federal Wide Assurance) as mandated by the federal government to participate in federally funded research. Owing to the increased level of involvement, the schools and their employees were considered 'agents' of the field centers and, therefore, each school had to operate under FWA. There was no formal document *per se* comparable to a school-level informed consent form or letter of intent. Study investigators experienced in conducting research in schools advised that this would be unenforceable and have little or no meaning over the years as school administrators came and went. The study did seek consensus buy-in from throughout the school and district administrative structure to participate in the study and follow the protocol, including random assignment to either intervention or control.

Schools received annual compensation for participation that could be used at the discretion of the school administration for program enhancement. Schools assigned to intervention received $2000 in year 1, $3000 in year 2 and $4000 in year 3, and those assigned to control $2000 in year 1, $4000 in year 2 and $6000 in year 3. The control school amounts became higher because the intervention schools received additional compensation in terms of PE equipment and food service costs. The amounts escalated each year as a retention strategy.

As the intervention was implemented schoolwide in schools randomized to intervention, all students were exposed. Student eligibility criteria were applied in both intervention and control schools to participate in scheduled data collection and evaluation. To be enrolled in the cohort followed across the sixth, seventh and eighth grades, students had to be enrolled in sixth grade in fall 2006, be able to participate in the school's standard PE program, not have been previously diagnosed with diabetes, and provide parent/guardian's informed consent and minor child informed assent to participate in data collection and evaluation procedures. Similar eligibility criteria were applied to the additional cross-sectional sample of students enrolled in eighth grade to participate in end of study data collection. Students were compensated for participating in the three data collections with $50 at baseline (sixth grade), $10 at interim (seventh grade) and $60 at end of study (eighth grade).

In addition to schools and students, the study also involved various members of the school staff as participants. In those schools assigned to the intervention, staff participation in the intervention was subsumed under the school's FWA. Staff members did not need to provide consent for engaging in intervention activity, but signed informed consent forms to participate in data collection and were compensated for their time and effort. Appropriate informed consent was also obtained from parents who provided feedback on the program and from student peer

communicators who participated in intervention delivery activities, which involved training and time.

## Outcome measures and evaluations

Measurements and observations were made at the school, grade and student levels. There were three major data collection periods: (1) baseline data were collected in the fall of 2006 when the student cohort was starting sixth grade, (2) interim data were collected in the spring of 2008 when the student cohort was ending seventh grade and (3) end of study data were collected in the spring of 2009 when the students were ending eighth grade. Table 4 lists data collection measures and procedures and indicates when they were collected and recorded.

**Demographic characteristics—**Student demographic and descriptive characteristics were collected at baseline and end of study. Students provided sex, date of birth and race/ethnicity by self-report. Ethnicity (Hispanic yes/no) and race were asked as two separate questions with laminated cards showing and defining choices. Nevertheless, we found that the students themselves did not make such distinctions and, having identified themselves as Hispanic, did not respond to the follow-up question of race. The parent/guardian completed a self-report form by mail with items for socioeconomic status (highest level of education attained by head of household), family history of diabetes in first-degree blood relatives, diagnosis of diabetes in the child and current medications used.

**Health screening—**At baseline and end of study, students participated in a comprehensive health screening; in addition, interim height and weight were collected in the seventh grade. Measurements were made by trained staff who used the standard equipment adhering to calibration procedures provided by the study and the equipment manufacturers. Students were instructed to wear light, loose-fitting clothing. To ensure privacy, measurements were made behind a screen. Height (Perspective Enterprises PE-AIM-101 stadiometer) and weight (SECA Alpha 882 and SECA Large Capacity 634 electronic scales) were measured without shoes. Blood pressure was measured using an automatic inflatable digital blood pressure monitor (Omron HEM-907 or HEM-907XL) three times, the first taken after the subject had been sitting quietly for at least 5 min and the second and third taken at 1 min intervals. Appropriate cuff size was selected according to manufacturer's specifications based on a single measurement of student's upper arm circumference. Waist circumference was taken using a tape measure on bare skin measured just above the iliac crest. Fasting blood was drawn to determine insulin, glucose and lipids. On the evening before data collection, the study staff called the students scheduled for the next day's blood draws to remind them not to eat any food or drink anything except water after midnight and not to eat breakfast. At check-in, students were questioned about the last time they had anything to eat or drink and were rescheduled if they had not fasted. Standard procedures were followed by licensed phlebotomists with experience in working with children. A study physician was available by phone in case of adverse events. A numbing cream was applied with appropriate consent. On account of local restrictions, two sites were not permitted to draw blood on school property and used mobile vans parked nearby.

**Laboratory analysis—**Blood was drawn, processed and shipped per protocol to the central blood laboratory at the University of Washington Northwest Lipid Research Laboratories (Seattle, WA, USA) for all analyses.[46] Analyses of glucose were performed on a Roche P module autoanalyzer by the hexokinase method using a reagent from Roche Diagnostics. Insulin was measured by a two-site immunoenzymometric assay performed using a Tosoh 1800 autoanalyzer. The inter-assay and intra-assay precision analysis consistently showed a coefficient of variation <10%. The assay sensitivity level was 12 pmol $l^{-1}$ (2.0 μU $ml^{-1}$). The assay had a high specificity, as cross-reactivity with human C-peptide and proinsulin was 0 and 2%, respectively. A reference interval for the assay for apparently healthy donors was

established at <102 pmol $l^{-1}$ (17.0 μU $ml^{-1}$). Measurements of total plasma cholesterol in plasma, cholesterol in the lipoprotein fractions and triglycerides were performed enzymatically on the Roche modular-P autoanalyzer using methods standardized to the Centers for Disease Control and Prevention Reference Methods.[47] Determination of high-density lipoprotein cholesterol was performed after precipitation of apolipoprotein B-containing particles by dextran sulfate $Mg^{2+}$. Low-density lipoprotein cholesterol was calculated using the Friedewald equation.[48] This approach for calculating low-density lipoprotein is clinically reliable if the measurements of total and high-density lipoprotein cholesterol are performed with a high level of accuracy and the triglycerides are <4.5 mmol $l^{-1}$ (400 mg per 100 ml).[49] In the case of elevated triglycerides, a complete lipoprotein separation by ultracentrifugation, which allows quantitation of the individual lipoprotein classes, was performed using the Lipid Research Clinics Beta Quantification procedure.[50] The inter-assay coefficients of variation are consistently <1.5% for total cholesterol and triglycerides and <2% for high-density lipoprotein cholesterol. The measurement of relative proportion of hemoglobin subclasses and calculation of the HbA1c level was performed using an automated non-porous ion exchange high-performance liquid chromatography system (G-7 Tosoh Biosciences Inc.). The laboratory, using the Tosoh G7, has successfully completed National Glycohemoglobin Standardization Program Level 1 laboratory certification for traceability of values to the DCCT (Diabetes Control and Complications Trial) Reference Method. The intra-assay coefficient of variation is 0.047% and the inter-assay coefficient of variation 0.070%.

**Self-report instruments—**Students completed several standard self-report instruments. Sexual maturation or pubertal stage was determined using the gender-specific pubertal development scale from which the Tanner score was determined.[51-53] The form was completed on hand-held devices (personal digital assistant, or PDA) at baseline and end of study. Also completed in this time frame were instruments to determine the levels of dietary intake, physical activity and sedentary behavior. Students completed the 2-day version of the SAPAC (Self-Administered Physical Activity Checklist) to estimate the physical activity levels and sedentary behaviors.[54,55] Students' self-reported dietary intake using a semi-quantified food frequency questionnaire that solicited information from the past week; the Block Kids FFQ asked about intake of 100 food items and solicited information concerning portion sizes using a serving size visual.[56-58] Standard software was applied to determine estimates of usual intake for a variety of nutrients, including calculations of daily frequency and amounts for individual food items as well as by food group. Two health-related quality of life instruments were completed by students at all three data collection periods: (1) the visual-analog feeling thermometer from the EuroQoL (EQ-5D) preference assessment instrument[59] and (2) the Health Utilities Index, [60,61] a preference-weighted health state classification system, the latter completed on PDA.

**Fitness—**Measurement of student fitness was based on the number of laps completed during the 20-meter shuttle test (20-MST).[62-64] The test required the subjects to run back and forth between two lines set 20 m apart. The running pace was determined by audio signals emitted from a pre-recorded CD. The test was completed when the participant was not able to complete the distance at the stipulated pace on two laps. A score for the test was assigned on the basis of how many stages and laps were completed. The 20-MST was administered during PE class at baseline and at end of study.

**Cost assessment—**Cost data were collected at the school level only. The goal was to assess all resource use and costs, regardless of whether a monetary transaction took place. Total school food environment and PE cost data were collected at both intervention and control schools. For the school food environment this included: food, labor and central kitchen costs; revenues (total a *la carte* cash sales by day, cash meal and program sales, United States Department of Agriculture reimbursements); meal and program participation (total number of serving days,

count by day and by free/reduced/paid category). PE costs included time PE teachers spent in class teaching students, equipment and supplies. Additional data were retrieved from intervention schools only and included: intervention materials and supplies, salaries, training costs and travel costs of study staff dedicated to delivering the intervention. Costs of school environment changes, in-kind donations and outside grants were also collected.

**Total school food environment—**To measure the total school food environment, sales and production records for foods and beverages from cafeteria meals and programs, a *la carte* and vending machines were collected at all three data collection periods. Data were collected consecutively for 20-day periods. Production records and meal participation rates were extracted from source documents provided by the food service manager at each school. Sales data were provided by cash register records or by the food service manager at each school, or in the case of snack and beverage vending, by the party responsible for the vending machines (school specific). Foods were analyzed for nutrient content using the Nutrition Data System for Research software (University of Minnesota Nutrition Coordinating Center, Minneapolis, MN, USA).

**PE activity level—**Activity level in PE classes was collected in both intervention and control schools at all three data collection time points. Data were recorded on heart rate monitors worn by consented students during the PE class. The sample of specific classes and students was selected by an unbiased scheme generated by the coordinating center. Heart rate monitor data were summarized as minutes of moderate-to-vigorous physical activity (defined as heart rate ≥130 beats per minute).

**Academic performance—**Although the potential health benefits of the proposed intervention were extremely important, scholastic achievement is the primary purpose of schools. If the HEALTHY intervention was successful but associated with an adverse impact on scholastic performance, it would have little chance of being widely adopted. Therefore, data were collected to document scholastic performance on the respective state accountability tests and the total number and passing rates of students taking the test. These tests were taken by sixth, seventh and eighth graders in intervention and control schools every year. Grade and school level data were recorded—no individual student data were collected. In addition, data were collected to determine the rates of grade level absences and referrals for disciplinary action. Policy and practice related to disciplinary referrals and any changes were recorded. These data detected relative change in the school from before the study to its end.

**Environmental influences—**Primary prevention trials such as HEALTHY are typically conducted in response to an identified public health need. This meant that although the HEALTHY researchers were trying to study the impact of an intervention that changed the environment, legislatures, action groups and the general public were also at work to change the environment both individually and collectively.[65] These changes could have occurred in and around the school environment, which affect the study school's nutrition and physical activity programs during the intervention period. These influences could have occurred at either or both control and intervention schools and may have been because of federal, state or local mandates, policies or decisions. It was necessary to document external independent programmatic policy and environmental changes to assess their potential effects.[66] Assessing these potential confounding effects was critical in a multi-year intervention that focused on the impact of a strong environmental intervention. It was particularly important for HEALTHY because of the increasing national awareness of the prevalence of obesity and low physical activity levels among children and adolescents.[3] National recommendations, referenda and initiatives were being proposed that could influence the trial's primary outcome in both intervention and control schools. Data were collected annually related to levels of physical

activity and nutrition that may occur in the school but that were not necessarily part of the study intervention, including: (1) aspects of the environment in the school, in the school neighborhood, during school hours and after or before school, (2) relevant grants and research program initiatives, (3) local, state or federal mandates and (4) promotions and advertising. Longitudinal changes from one year to the next or from the beginning of the study to the end, as well as group (control versus intervention) differences, helped to interpret study outcomes.

**Process evaluation—**In addition to the above, data were collected in intervention schools specifically to conduct ongoing process evaluation to assess the extent to which the intervention was delivered and received as intended.[67] By monitoring the delivery of key intervention components and providing timely feedback to the intervention staff, process evaluation data were used to help ensure fidelity of intervention delivery. Monitoring and providing feedback on the intervention ensured adequate implementation of the intervention components and were used to help explain study outcomes.

## Safety, risk management and follow-up procedures

Only fasting blood draws were anticipated to result in the occurrence of reportable adverse and serious adverse events related to the study. The intervention was judged to involve no greater risk than what is normally found in the school environment and handled per established school practices and procedures. Known side effects of drawing blood and applying a numbing cream were recorded, including discolored skin (paleness or redness), swelling, itching or rash where numbing cream was applied, small bruise at point of venipuncture, feeling dizzy or light headed, fainting or loss of consciousness, and upset stomach or mild nausea. A serious adverse event was defined as any event that occurred during the administration of or as a result of the health screening blood draw, caused bodily or psychological damage, and involved the on-site presence of emergency medical personnel (that is, not just the school nurse). To avoid and minimize these risks, only people trained and experienced in blood drawing techniques were allowed to draw blood following standard sterile procedures. A physician was available on-site or by phone at all times during data collection involving blood draw. The students were given a healthy breakfast after the fasting blood draw.

As a follow-up to the health screening, parents were given written results of their child's physical assessments at baseline and end of study (BMI, blood pressure, fasting glucose and lipids) with normal ranges and interpretation. Where considered necessary for the child's health, study staff initiated follow-up contact and recommended action as needed. Parents were notified of test results indicating diabetes (fasting glucose $\geq$7.0 mmol $l^{-1}$ or 126 mg per 100 ml) by phone within 48 h. A study team health professional called the parents and followed up with a letter providing more information about interpretation and recommended action. In case of clinically important elevated values (fasting glucose 5.55-6.9 mmol $l^{-1}$ or 100-125 mg per 100 ml, systolic blood pressure >150 mm Hg, diastolic blood pressure >95 mm Hg, total cholesterol >7.8 mmol $l^{-1}$ or 300 mg per 100 ml, low-density lipoprotein cholesterol or low-density lipoprotein-c >4.9 mmol $l^{-1}$ or 190 mg per 100 ml, triglycerides >5.6 mmol $l^{-1}$ or 500 mg per 100 ml), a health professional on the study staff called the parents as soon as possible, usually within 5-10 days. The health care professional provided information about interpretation and recommended that the family contact a physician for further testing and diagnosis. The health care professional answered any questions and provided assistance with accessing medical care if needed. In addition, the parent letter interpretation noted that fasting glucose 5.55-6.9 mmol $l^{-1}$ (100-125 mg per 100 ml) was a high level and, although not indicative of diabetes, needed to be followed up with evaluation by a health care provider.

## Management and structure

Similar to other collaborative groups, HEALTHY was governed by a Steering Committee composed of the field center and coordinating center principal investigators, NIDDK project officer and study chair. Members of the study group, including staff at the field centers, coordinating center and central cores and labs, were assigned to various committees that reported to the Steering Committee. The study supported three central cores: the central blood laboratory (Northwest Research Lipid Laboratory, Seattle, WA, USA), the communications and social marketing core (Planit Agency, Baltimore, MD, USA) and the qualitative process evaluation data core (University of North Carolina, Chapel Hill, NC, USA).

The NIDDK appointed an External Advisory Board of experts to review and approve the HEALTHY protocol. The NIDDK appointed an independent group of external experts to serve as the DSMB (Data and Safety Monitoring Board), with responsibility for reviewing and approving protocols and monitoring study progress and safety. The DSMB also reviewed major interim milestones: successful recruitment of schools and students, successful delivery of the intervention as designed, and evidence based on interim height and weight data collection that the control schools were not performing better than the intervention schools on the primary outcome.

Figure 1 shows the field center personnel structure. HEALTHY study staff operated in three general categories: (1) administrative staff included investigators, project coordinator and school coordinator; (2) intervention staff included health promotion coordinator, physical activity coordinator, research dietitian, student media coordinator, HEALTHY assistants and PE teacher assistants; (3) research staff included research assistants, data entry clerks, and temporary data collection and recruitment personnel, such as phlebotomists, nurses and interviewers. The project coordinator supervised, managed and coordinated the staff and overall study implementation. The project coordinator was assisted by the school coordinator who coordinated the logistics of study events and activities at the schools. The study imposed separation of intervention and research staff and functions to maintain objectivity.

Study staff involved in intervention conduct and delivery were specialists with relevant educational backgrounds and experience. They provided training, monitoring, support and guidance to the local school staff. The health promotion coordinator had responsibility for the behavior and parts of the communications components, including working with and training classroom teachers and student peer communicators. The physical activity coordinator worked with the PE teaching teams to assist in the implementation of the program by conducting training, developing strategic plans jointly with the PE teacher, and providing guidance. The research dietitian worked with the school food service workers and management to monitor and assist with study changes to the nutrition/food service environment, develop strategic plans jointly with the food service manager, and conduct training sessions for the school food service staff. The student media coordinator assisted with the acquisition and processing of audio messages and images produced by the students themselves as part of the social marketing campaign in the later grades. Communication intervention events and activities were attended by a broad cross-section of intervention staff members, consistent with the integrative nature of these activities. HEALTHY assistants worked with the health promotion coordinator to facilitate implementation of the behavior and communications intervention activities. PE teacher assistants worked with physical activity coordinators to help the PE teacher deliver the PE intervention in class.

At each field center, a small number of research study staff were permanently hired to engage in data collection and management. For baseline, interim and end of study data collection, additional staff were hired on a temporary basis, including more research assistants as well as data entry, phlebotomy and nursing specialists. One of the co-investigators was an

endocrinologist available as an on-call resource for consultation regarding adverse events and abnormal laboratory results.

Staff attended central training on an annual basis, delivered separately to intervention and research staff. Research staff had to pass criteria to become certified in equipment set-up and calibration and measurement of height, weight, waist circumference and blood pressure. All staff members obtained security clearance and background checks as required to operate in the schools.

## Statistical issues

**Sample size and power—**Sample size was determined for the number of schools (clusters) needed in each treatment arm.[39] The trial was powered to detect a 10% reduction in the percent of students with a BMI ≥85th percentile in the intervention versus control schools at the end of eighth grade. This translated into a decrease from 50% in the control schools, based on pilot study findings, to 45% in the intervention schools. Sample size calculations assumed a two-sided significant level $\alpha = 0.05$ and 90% power. The average number of eighth graders per school in the cohort at end of study was assumed to be 50. The intracluster correlation coefficient, or ICC, which adjusts for the correlation within a single school (between students) compared with across schools, was set at 0.02, based on pilot data adjusting for gender, ethnicity and field center. The primary analysis adjusted for baseline outcome value, so sample size also adjusted for the correlation between baseline and end-of-study values, estimated at 0.9. Finally, we adjusted for student dropout and withdrawal. Student dropout and withdrawal were primarily for reasons unrelated to the intervention, such as family relocation. These students were removed from the cohort. However, a much smaller percentage of students remained in the school but had missing outcome data (for example, refused measurement, absent on all measurement and make-up days). These students remained in the cohort and end-of-study outcome values were imputed. On the basis of the study group experience, this percentage was assumed to be no more than 5%. For the purposes of sample size calculation, we assumed a conservative imputation scheme based on control school data, which decreased the detectable difference.

On the basis of the above assumptions, 16 schools per arm were needed. The required sample size of 16 schools per arm was adjusted upward so that there were an equal numbers of schools per field center (divisible by 7) and an even number of schools per field center (half randomized to each arm). Therefore, 21 schools per arm were needed for a total of 42 schools.

**Randomization and masking—**The coordinating center developed a stratified randomization scheme. The stratification factors were field center and sixth grade size to assign comparable within cluster (school) sample sizes across treatment arms at each field center. Schools were notified of random assignments in the spring of 2006 to allow the schools assigned to the intervention time to place orders for appropriate changes in food and beverage items.

Therefore, treatment assignment was known to both key school officials and to study staff. To minimize staff bias, study staff who delivered the intervention appeared in the intervention schools only and were separate from study staff who administered data collection procedures in both intervention and control schools.

The study took measures to keep students and their parents masked to the assignment. HEALTHY was presented identically at both control and intervention schools to students and their parents during recruitment and enrollment. In brochures and informed consent forms, HEALTHY was described as a study being conducted in 42 schools to ‘see if a program created to help middle school children lower their risk of being overweight and having diabetes can

work.' The program was not specified. Because the intervention was administered at the school level, students and their parents could not provide consent about being exposed to the intervention, but only about participating in data collection procedures, which were thoroughly covered in the informed consent process. In addition, local publicity about a school's participation in a national study was discouraged. There was a minimal amount of cross activity between schools at the middle school level, but HEALTHY branded items were distributed at both intervention and control schools as part of retention and incentives so that the study logo was a familiar sight. Perhaps the greatest potential for crossover occurred where a single food service corporation served both intervention and control schools and wanted to take advantages of efficiencies by placing only one order. The study staff administering the nutrition intervention component actively monitored school orders and purchases, and formed alliances at the district and corporate food service levels to restrict the intervention to only the three assigned schools.

**Dropout and withdrawal—**HEALTHY followed the dictates of good research practice to make every effort to retain the study subject for the duration of the trial despite any lack of adherence to the protocol. In the cluster or group-randomized trial, the 'subject' that is the unit of primary outcome analysis and computation of sample size is the cluster, or the school in our case. During the study's 3 years, a school could have closed, could have withdrawn from the study, or could have refused to adhere to the protocol in whole or in part. We were fully prepared to enter into negotiations or modifications as needed to collect as much data as possible according to the original schedule, with the highest priority being given to collecting the primary outcome at end of study and to applying an imputation scheme, if necessary. Fortunately, our school retention efforts were successful and we did not have to deal with school dropout or withdrawal. We did experience acts of nature, such as wildfires in California and hurricanes in Texas, that had temporary effects on school functioning above and beyond our control and certainly unrelated to the study.

Within the school, student turnover across the study period was anticipated and an upper limit of 25% per year was established as a school eligibility criterion. This trial design presupposes that the major reasons for loss to follow-up are equally distributed in both intervention and control and are due to factors unrelated to the study, most typically families' geographical relocation.[68] We attempted to track and document the students who left the cohort at interim data collection in seventh grade, but found that the level of effort required to obtain current contact information for our student demographic was beyond the study's resources. We also found that the school policies and practices regarding documentation and tracking of students varied widely and frequently produced incorrect information. Therefore, we were not able to collect specific information about student dropout and withdrawal related to transfer from the school. Owing to the in-depth involvement of study staff in the school environment, we were certain that we would learn if any student or family complained that the study made them leave the school. This never happened.

Students who transferred out of the school over the course of the study were removed from the cohort. The other possibility for missing data came from students who remained in the school but refused or were absent on data collection days. These students remained in the cohort and efforts were made on a one-on-one basis to accommodate data collection, with priority being given to the primary outcome. Missing primary outcome data in the cohort were imputed. It is important to remember that the students at schools assigned to the intervention could not refuse to take part in the intervention, which was implemented at the entire school or grade level, but could refuse or withdraw from data collection.

To evaluate the integrity and interpretation of the HEALTHY study outcomes, analysis is planned to compare the end of study cohort with the two possible sources of missing primary

outcome data, that is, students who transfer out and students who remain in the school but withdraw consent or refuse to participate in end of study data collection. The analysis must also compare intervention versus control to understand the nature of missing data. These comparisons will apply the concepts of missing completely at random (MCAR) and missing at random (MAR). MCAR exists when missing values are distributed across all observations with no difference across subgroups characterized by gender, race/ethnicity and so on. MAR means that differences across subgroups regarding rates of missingness do exist, but not within subgroups; for example, Hispanic and White subgroups may differ from each other, but within each subgroup there is no difference by gender.[68] Each type of missing data has ramifications for study interpretation and inference.

**Analysis plan and methods—**Methods of analysis accounted for the structure of the cluster design trial, with measures of variance both between cluster (school) and within cluster (between students within the same school).[39,40] General linear mixed models (GLMM) were used to analyze differences between intervention and control schools.[69,70] GLMM provides a method for analyzing data when the responses are correlated and normally distributed random effects are assumed. The responses can be continuous, discrete or count data. The clustering of observations within schools is taken into account by fitting a random effects parameter for school. Correlation between all interschool observations is taken into account by the selection of covariance structure. GLMM models allow for fixed (for example, gender, race) and time-varying covariates (for example, Tanner stage, waist) as well as for adjustment for individual-level and cluster-level covariates (for example, baseline values). Interaction terms may be included. These methods apply to analysis of point-in-time as well as longitudinal measures from a cross-sectional or cohort sample, respectively.

The primary analysis was performed on the cohort enrolled in sixth grade and measured at end of study in eighth grade. Students in the cohort provided both consent and assent and data to determine the primary outcome, BMI percentile, that is, valid measurements of height and weight, gender and age. Students diagnosed with diabetes at baseline were not eligible for the cohort. Intent-to-treat principles were applied as described above. Baseline value was included in the model as a covariate. A secondary cross-sectional analysis of the outcome was performed on the entire eighth grade sample (cohort plus end of study recruits).

## Preliminary studies

The trial protocol represented the culmination of a series of pilot and feasibility studies conducted by the prevention study group in preparation for the primary prevention trial. This series of studies was conducted to guide all aspects of the HEALTHY study, including recruitment procedures, selection of primary and secondary outcome measures, scheduling and logistics, development of the intervention components separately, and their integration. Feasibility, impact and acceptability were also determined by collecting formative research data and by consulting with local advisory boards. Each site assembled an advisory board composed of key role players, such as state or district level superintendent or administrators from the Department of Education, powerful or visible parents (such as current or past PTA president), school principals, classroom and PE teachers, and food service directors at district or state level. These groups reviewed the proposed research, provided feedback, and suggested alternative strategies and approaches. Although constrained by the logistics and scheduling of the school year, the prevention study group developed and conducted eight pilot or feasibility protocols from winter 2003 through fall 2005.

The first pilot study was conducted in winter 2003 to determine the feasibility of recruiting students (that is, obtaining parent informed consent and student informed assent) to participate in a health screening that included the HEALTHY health screening procedures and also tricep

and subscapular skinfolds and an OGTT (oral glucose tolerance test). Results have been reported.[1,71,72] Although recruitment of a representative sample and performing all of the data collection procedures were successful, we found almost no undetected diabetes (<1%) but high levels of T2D risk factors. Of 1740 eighth graders, 49% had a BMI ≥85th percentile, 40.5% had fasting glucose values ≥5.55 mmol $l^{-1}$ (100 mg per 100 ml), 36.2% had fasting insulin values ≥180 pmol $l^{-1}$ (30 μU $ml^{-1}$) and 14.8% had all three. On the basis of these results, the HEALTHY trial targeted prevention of modifiable risk indicators for T2D.

Subsequent pilot protocols were conducted specifically for the design and development of the intervention. The PE intervention component was piloted in fall 2003 to test the acceptability of the study lesson plans to teachers and students, and to gauge the intervention's ability to attain satisfactory levels of moderate-to-vigorous physical activity. This was followed in winter 2004 with a pilot to evaluate the feasibility of the nutrition intervention component's ability to achieve targeted changes in the school food environment.[73,74] Formative research conducted in spring 2004 elicited information from sixth grade students, their parents and middle school staff regarding attitudes about school activities, food and nutrition messages, physical activity, and student behaviors and preferences to inform the development of a school-based social marketing campaign. In fall 2004, the study group conducted a pilot study that implemented and integrated both the PE and nutrition intervention components with a schoolwide communications campaign of activities, education and promotion. Additional formative research in spring 2005 took further steps to refine and specify student, parent, and faculty perceptions and reactions to a variety of proposed messages and approaches. Finally, two pilots were conducted in fall 2005, one to evaluate the behavior intervention component for feasibility and acceptability, and one to test refined aspects of the PE intervention component to train and guide the PE teachers as well as to assess lesson plans for seventh and eighth grades.

## Results of sample comparisons

Table 5 compares intervention versus control schools on key baseline characteristics. The randomization scheme resulted in equitable distribution in size of school (average 873 students per intervention school and 863 per control school), size of sixth grade (average 265 students for intervention and 266 for control), percentage enrolled by providing signed informed consent (62.2% intervention, 62.5% control), percentage of students qualified for free/reduced meals (77% intervention, 74% control) and percentage either Hispanic or Black race/ethnicity (77% intervention, 70% control). By and large, the schools included only grades 6 through 8 (19 intervention, 20 control).

At baseline in fall 2006 before the initiation of the intervention, two sets of data were collected in students. One was the comprehensive health screening of HEALTHY student participants already described. The other was grade-wide data collection among all sixth graders of gender, date of birth, race/ethnicity, height and weight for the purpose of comparing participants versus non-participants. Both data collections used identical procedures, but the grade-wide data collection was conducted any time before lunch, whereas the health screening was conducted early in the morning after at least an 8-h fast. In addition, the grade-wide data collection did not include student names or other personal identifiers so that signed informed consent was not required by the school or Institutional Review Board. Study staff recorded whether the student was participating in HEALTHY (that is, signed informed consent/assent) or not. Table 6 gives the comparison of participants versus non-participants. Table 7 gives the comparison of baseline health screening results for students in intervention versus control schools. The number of students participating in the health screening is greater than the number of participants measured during the grade-wide data collection because there was no follow-up attempt to measure students who were absent or otherwise unable to be at grade-wide data collection, and because students continued to provide HEALTHY consent after grade-wide

data were collected. Owing to the anonymity of grade-wide data collection, we were not able to update the data, and we recognize that the distinction between participants and non-participants in Table 6 is not entirely accurate.

Table 6 shows significant differences in age, gender distribution, racial/ethnic breakdown and BMI between the sample of students who consented to be measured for the study and the sample who did not. Table 7 shows no significant differences at baseline between the intervention and control school participating students for any of the characteristics or measurements available.

## Discussion

The factors that motivated the NIDDK to fund the HEALTHY study group arose from scientific evidence combined with public awareness that deleterious lifestyle habits and behaviors were endangering the health of US children and adolescents, specifically leading to burgeoning rates of diagnosis of T2D. At this point in our understanding of diabetes treatments and glycemic control, there is no stopping the ravages of T2D in the form of microvascular and macrovascular complications that can lead to such grim consequences as blindness, amputation, kidney failure, heart attack, stroke and death. That this disease is being identified in greater numbers at younger ages has ramifications not only for individuals and families but also for our health care system.

HEALTHY faced many challenges to implementation. Typical of public health trials by the time they get underway, the problem addressed by the primary objective had already been recognized in terms of the contribution of junk foods and increasingly sedentary lifestyles leading to obesity. Strategies to address the problem had already reached the level of public discourse in the popular media, affected public policy making at local, state and federal levels, and influenced decision making in corporate boardrooms. The environment was shifting, and HEALTHY study investigators asked themselves whether the planned intervention would be superseded by new guidelines, regulations and products. To evaluate the extent of any temporal shifts, we took steps to collect data on secular changes that would affect the school health environment.

However, there were reasons to suspect that the HEALTHY intervention would face insignificant competition from these secular trends. These reasons were related to institutional, social and economic factors. As institutions, the schools are primarily responsible for education as measured most commonly by the standard verbal and mathematical test scores. As we learned, other activities were not allowed to interrupt the pursuit of this objective. The conflict between health promotion, learning and activities versus the preparation and administration of standardized tests was evident. Jobs and careers depended on test scores providing proof that the school was discharging its educational mission.

Public schools are also notoriously underfunded. School principals and administrators depend on revenue from snack bars, vending machine pouring contracts, and candy sales to pay for extras such as band uniforms, equipment, school trips or even art teachers. This puts them in conflict with the health community’s desire to shut down these sources of income, which essentially promote foods and beverages that detract from the health of children. We provided study funds to offset lost revenue, but we had to continually work with the school faculty and staff to identify alternative ways to raise money or reward performance that did not involve unhealthy products and practices. We were dealing with a system that was desperate to use the study money along with existing sources of revenue to fund more opportunities.

The HEALTHY study investigators recognized the critical role of parents in the health of their children and considered various strategies to engage parents in school health promotion campaigns and in supporting behavior change in their children. In the end, the study incorporated methods that reached out to parents in their homes rather than depending on

parents to travel to or gather for events and activities. Parent outreach was accomplished in two ways. First, a series of newsletters was distributed to the parents. The newsletters featured first-person stories relating a family's challenges to living healthier, family members' personal histories and struggles, and the approaches they used to adopt a healthier lifestyle. The newsletters also included tips and suggestions in question-and-answer and other formats. Second, packages of activities and challenges were developed and distributed just before the summer and holiday breaks. The materials and supplies included in the package were intended to involve family members of all ages and both genders, along with the student.

As the intervention deliberately unified and integrated the four components, we cannot separate the contribution of any single intervention component. We believe that, despite the significant differences between study participants and non-participants shown in Table 6, the study results are broadly applicable. The percentage male in the study sample was less than that among the non-participants. This may be related to lower maturity levels in sixth grade boys than girls, but the slight preponderance of females in the study sample is actually beneficial because it mirrors the ratio of adolescent females to males diagnosed with T2D (female: male ratio 1.6-1.7:1[2,75,76]). Likewise, the proportion with BMI ≥85th percentile was greater among the sample of participants (53.2 versus 48.6%), indicating that the study sample had a higher representation of adolescents at risk. The racial/ethnic distribution was uneven between participants and non-participants, with the latter having a greater percentage of Hispanics and lesser percentages of Blacks and Whites. In general, the strength of the sample was the substantial representation (>70%) of minorities at greater risk for T2D and our ability to perform meaningful subgroup analyses.

Whether HEALTHY is successful or not, the argument that policies and practices need to be changed will remain. If successful, then the wherewithal needs to be found to translate and implement nationwide an intervention based on the HEALTHY model. If an intervention of this magnitude is not successful, then we need to address how to make even more fundamental changes to tackle the high levels of risk for serious diseases such as T2D.

## Acknowledgments

Members of the writing group were Kathryn Hirst (Chair), Tom Baranowski, Lynn DeBar, Gary D Foster, Francine Kaufman, Phyllis Kennel, Barbara Linder, Margaret Schneider, Elizabeth M Venditti and Zenong Yin. We certify that all applicable institutional and governmental regulations concerning the ethical use of human volunteers were followed during this research.

## References

1. STOPP-T2D Prevention Study Group. Presence of diabetes risk factors in a large US eighth-grade cohort. Diabetes Care 2006;29:212–217. [PubMed: 16443862]
2. Fagot-Campagna A, Pettitt DJ, Engelgau MM, Burrows NR, Geiss LS, Valdez R, et al. Type 2 diabetes among North American children and adolescents: an epidemiologic review and public health perspective. J Pediatr 2000;136:664–672. [PubMed: 10802501]
3. Troiano RP, Flegal KM. Overweight children and adolescents: description, epidemiology, and demographics. Pediatrics 1998;101:497–504. [PubMed: 12224656]
4. Hedley AA, Ogden CL, Johnson CL, Carroll MD, Curtin LR, Flegal KM. Prevalence of overweight and obesity among US children, adolescents, and adults, 1999-2002. JAMA 2004;291:2847–2850. [PubMed: 15199035]
5. Ogden CL, Carroll MD, Flegal KM. High body mass index for age among US children and adolescents, 2003-2006. JAMA 2008;299:2401–2405. [PubMed: 18505949]
6. Harris KM, Gordon-Larsen P, Chantala K, Udry R. Longitudinal trends in race/ethnic disparities in leading health indicators from adolescence to young adulthood. Arch Pediatr Adolesc Med 2006;160:74–81. [PubMed: 16389215]

7. Harlan WR. Epidemiology of childhood obesity: a national perspective. Ann N Y Acad Sci 1993;699:1–5. [PubMed: 8267299]
8. Mossberg H. 40-year follow-up of overweight children. Lancet 1989;2:491–493. [PubMed: 2570196]
9. Must A, Jacques PF, Dallal GE, Bajema CJ, Dietz WH. Long-term morbidity and mortality of overweight adolescents: a follow-up of the Harvard Growth Study of 1922-1935. N Engl J Med 1992;327:1350–1355. [PubMed: 1406836]
10. Weigensberg MJ, Ball GD, Shaibi GQ, Cruz ML, Goran MI. Decreased B-cell function in overweight Latino children with impaired fasting glucose. Diabetes Care 2005;28:2519–2524. [PubMed: 16186290]
11. Nathan DM, Davidson MB, DeFronzo RA, Heine RJ, Henry RR, Pratley R, et al. Impaired fasting glucose and impaired glucose tolerance. Diabetes Care 2007;30:253–259.
12. Diabetes Prevention Program Research Group. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. N Engl J Med 2002;346:393–403. [PubMed: 11832527]
13. Weiss R, Taksali SE, Tamborlane WV, Burgert TS, Savoye M, Caprio S. Predictors of changes in glucose tolerance status in obese youth. Diabetes Care 2005;28:902–909. [PubMed: 15793193]
14. Ford ES, Li C, Imperatore G, Cook S. Age, sex, and ethnic variations in serum insulin concentrations among US youth. Diabetes Care 2006;29:2605–2611. [PubMed: 17130192]
15. Goran MI, Gower BA. Longitudinal study on pubertal insulin resistance. Diabetes 2001;50:2444–2450. [PubMed: 11679420]
16. Duncan GE, Li SM, Zhou XH. Prevalence and trends of a metabolic syndrome phenotype among US adolescents, 1999-2000. Diabetes Care 2004;27:2438–2443. [PubMed: 15451913]
17. Viner RM, Segal TY, Lichtarowicz K, Hindmarsh P. Prevalence of insulin resistance syndrome in obesity. Arch Dis 2005;90:10–14.
18. Weiss MD, Dziura J, Burgert TS, Tamborlane WV, Taksali SE, Yeckel CW, et al. Obesity and the metabolic syndrome in children and adolescents. N Engl J Med 2004;350:2362–2374. [PubMed: 15175438]
19. Story M. School-based approaches for preventing and treating obesity. Int J Obes 1999;23:S43–S51.
20. American Academy of Pediatrics. Physical fitness and activity in schools. Pediatrics 2000;105:1156. [PubMed: 10790480]
21. National Center for Chronic Disease Prevention and Health Promotion. Guidelines for school and community programs to promote lifelong physical activity among young people. J Sch Health 1997;67:202–219. [PubMed: 9285866]
22. Katz DL, O'Connell M, Njike VY, Yeh M-C, Nawaz H. Strategies for the prevention and control of obesity in the school setting: systematic review and meta-analysis. Int J Obes 2008;32:1780–1789.
23. Veugelers PJ, Fitzgerald AL. Effectiveness of school programs in preventing childhood obesity: a multilevel comparison. Amer J Public Health 2005;95:432–435. [PubMed: 15727972]
24. Stone EJ, McKenzie TL, Welk GJ, Booth ML. Effects of physical activity interventions in youth: review and synthesis. Am J Prev Med 1998;15:298–315. [PubMed: 9838974]
25. Sallis JF, McKenzie TL, Conway TL, Elder JP, Prochaska JJ, Brown M, et al. Environmental interventions for eating and physical activity: a randomized controlled trial in middle schools. Am J Prev Med 2003;24:209–217. [PubMed: 12657338]
26. Lytle LA, Murray DM, Perry CL, Story M, Birnbaum AS, Kubic MY, et al. School-based approaches to affect adolescents' diets: results from the TEENS study. Health Educ Behav 2004;31:270–287. [PubMed: 15090126]
27. Richter KP, Harris KJ, Paine-Andrews A, Fawcett SB, Schmid TL, Lankenau BH, et al. Measuring the health environment for physical activity and nutrition among youth: a review of the literature and applications for community initiatives. Prev Med 2000;31:S98–S111.
28. Cullen KW, Baranowski T, Baranowski J, Hebert D, deMoor C, Hearn MD, et al. Influence of school organizational characteristics on the outcomes of a school health promotion program. J Sch Health 1999;69:376–380. [PubMed: 10633323]
29. Glanz K, Lankenau B, Foerster S, Temple S, Mullis R, Schmid T. Environmental and policy approaches to cardiovascular disease prevention through nutrition: opportunities for state and local action. Health Educ Q 1995;22:512–527. [PubMed: 8550374]

30. Paradis G, O'Loughlin J, Elliott M, Masson P, Renaud L, Sacks-Silver G, et al. Coeur en sante St-Henri, a heart health promotion programme in a low income, low education neighbourhood in Montreal, Canada: theoretical model and early field experience. J Epidemiol Community Health 1995;49:503–512. [PubMed: 7499994]

31. Gottfredson DC, Wilson DB. Characteristics of effective school-based substance abuse prevention. Prev Sci 2003;4:27–38. [PubMed: 12611417]

32. Mellanby AR, Rees JB, Tripp JH. Peer-led and adult-led school health education: a critical review of available comparative research. Health Educ Res 2000;15:533–545. [PubMed: 11184213]

33. Story M, Lytle LA, Birnbaum AS, Perry CL. Peer-led, school-based nutrition education for young adolescents: feasibility and process evaluation of the TEENS study. J Sch Health 2002;72:121–127. [PubMed: 11962228]

34. Goldberg L, MacKinnon D, Elliot DL, Moe EL, Clarke G, Cheong JW. The Adolescents Training and Learning to Avoid Steroids (ATLAS) program: preventing drug use and promoting health behaviors. Arch Pediatr Adolesc Med 2000;154:332–338. [PubMed: 10768668]

35. Elliot DL, Goldberg L, Moe EL, DeFrancesco CA, Durham MB, Hix-Small H. Preventing substance use and disordered eating: initial outcomes of the ATHENA (Athletes Targeting Healthy Exercise and Nutrition Alternatives) Program. Arch Pediatr Adolesc Med 2004;158:1043–1051. [PubMed: 15520341]

36. Backman DR, Haddad EH, Lee JW, Johnston PK, Hodgkin GE. Psychosocial predictors of healthful dietary behavior in adoles-cents. J Nutr Educ Behav 2002;34:184–192. [PubMed: 12217261]

37. Kassem NO, Lee JW. Understanding soft drink consumption among male adolescents using the theory of planned behavior. J Behav Med 2004;27:273–296. [PubMed: 15259456]

38. Grunbaum, JA.; Kann, L.; Kinchen, SA.; Williams, B.; Ross, JG.; Lowry, R., et al. Youth Risk Behavior Surveillance, United States, 2001. Jun 28. 2002 Surveillance Summarieshttp://www.cdc.gov/mmwr/preview/mmwrhtml/ss5104a1.htm

39. Murray, DM. Design and Analysis of Group-Randomized Trials. Oxford University Press; New York: 1998.

40. Donner, A.; Klar, N. Design and Analysis of Cluster Randomization Trials in Health Research. Arnold Publishers; London: 2000.

41. Gillis B, Mobley C, Stadler DD, Hartstein J, Virus A, Volpe SL, et al. for the HEALTHY Study Group. Rationale, design and methods of the HEALTHY study nutrition intervention component. Int J Obes 2009;33(Suppl 4):S29–S36.

42. McMurray RG, Bassin S, Jago R, Bruecker S, Moe EL, Murray T, et al. for the HEALTHY Study Group. Rationale, design and methods of the HEALTHY study physical education intervention component. Int J Obes 2009;33(Suppl 4):S37–S43.

43. Venditti EM, Elliot DL, Faith MS, Firrell LS, Giles CM, Goldberg L, et al. for the HEALTHY Study Group. Rationale, design and methods of the HEALTHY study behavior intervention component. Int J Obes 2009;33(Suppl 4):S44–S51.

44. DeBar LL, Schneider M, Ford EG, Hernandez AE, Showell B, Drews KL, et al. for the HEALTHY Study Group. Social marketing-based communications to integrate and support the HEALTHY study intervention. Int J Obes 2009;33(Suppl 4):S52–S59.

45. Drews KL, Harrell JS, Thompson D, Mazzuto SL, Ford EG, Carter M, et al. for the HEALTHY Study Group. Recruitment and retention strategies and methods in the HEALTHY study. Int J Obes 2009;33 (Suppl 4):S21–S28.

46. Marcovina SM, Bowsher RR, Miller WG, Staten M, Myers G, Caudill SP, et al. on behalf of the Insulin Standardization Work Group. Standardization of insulin immunoassays: report of the American Diabetes Association's Workgroup. Clin Chem 2007;53:711–716. [PubMed: 17272483]

47. Warnick GR. Enzymatic methods for quantification of lipoprotein lipids. Methods Enzmol 1986;129:101–123.

48. Friedewald WT, Levy RI, Fredrickson DS. Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. Clin Chem 1972;18:499–502. [PubMed: 4337382]

49. Warnick GR, Knopp RH, Fitzpatrick V, Branson L. Estimating low-density lipoprotein cholesterol by the Friedewald equation is adequate for classifying patients on the basis of nationally recommended cutpoints. Clin Chem 1990;36:15–19. [PubMed: 2297909]
50. Hainline, A., Jr; Karon, J.; Lippel, K., editors. Manual of Laboratory Operations: Lipid Research Clinics Program, Lipid and Lipoprotein Analysis. Vol. 2nd edn. US Department of Health and Human Services, Public Health Service, National Institutes of Health; Bethesda, MD: 1983.
51. Petersen AC, Crockett L, Richards M, Boxer A. A self-report measure of pubertal status: reliability, validity, and initial norms. J Youth Adolesc 1988;17:117–133.
52. Petersen AC, Tobin-Richards M, Boxer A. Puberty: its measurement and its meaning. J Early Adolesc 1983;3:7–62.
53. Robertson EB, Skinner ML, Love MM, Elder GH, Conger RD, Dubas JS, et al. The pubertal development scale: a rural and suburban comparison. J Early Adolesc 1992;12:174–186.
54. Sallis JF, Condon SA, Goggin KJ, Roby JJ, Kolody B, Alcaraz JE. The development of self-administered physical activity survey for 4th grade students. Res Quart Exerc Sport 1993;64:24–31.
55. Sallis JF, Strikmiller PK, Harsha DW, Feldman HA, Ehlinger S, Strone EJ, et al. Validation of interviewer- and self-administered physical activity checklist for fifth grade students. Med Sci Sports Exerc 1996;28:840–851. [PubMed: 8832538]
56. Block G, Hartman AM, Dresser CM, Carroll MD, Gannon J, Gardner L. A data-based approach to diet questionnaire design and testing. Am J Epidemiol 1986;124:453–469. [PubMed: 3740045]
57. Block G, Thompson FE, Hartman AM, Larkin FA, Guire KE. Comparison of two dietary questionnaires validated against multiple dietary records collected during a 1-year period. J Am Diet Assoc 1992;92:686–693. [PubMed: 1607564]
58. Block G, Coyle LM, Hartman AM, Scoppa SM. Revision of dietary analysis software for the health habits and history questionnaire. Am J Epidemiol 1994;139:1190–1196. [PubMed: 8209877]
59. Glick, HA.; Doshi, JA.; Sonnad, SF.; Polsky, D. Economic Evaluation in Clinical Trials. Oxford University Press; Oxford: 2007. Assessing quality-adjusted life years; p. 59-87.
60. Torrance GW, Feeny DH, Furlong WJ, Barr RD, Zhang Y, Wang Q. Multi-attribute preference functions for a comprehensive health status classification system: Health Utilities Index Mark 2. Med Care 1996;34:702–722. [PubMed: 8676608]
61. Feeny D, Furlong W, Torrance GW, Goldsmith CH, Zhu Z, Depauw S, et al. Multiattribute and single-attribute utility functions for the Health Utilities Index Mark 3 System. Med Care 2002;40:113–128. [PubMed: 11802084]
62. Guerra S, Rivero JC, Costa R, Duarte J, Mota J. Relationship between cardiorespiratory fitness, body composition and blood pressure in school children. J Sports Med Phys Fitness 2002;42:207–213. [PubMed: 12032417]
63. Leger L, Lambert J. A maximal 20 meters shuttle run test to predict VO2max. Eur J Appl Physiol 1982;49:1–12.
64. Leger L, Mercier D, Gadoury C, Lambert J. The multistage 20 meter shuttle run test for aerobic fitness. J Sports Sci 1988;6:93–101. [PubMed: 3184250]
65. Wechsler H, McKenna ML, Lee SM, Dietz WH. The role of schools in preventing childhood obesity. The State Education Standard 2004;5:4–12.
66. Centers for Disease Control and Prevention. School Health Index: A Self-Assessment and Planning Guide, Middle School/High School Version. CDC; Atlanta, GA: 2005.
67. Schneider M, Hall WJ, Hernandez AE, Hindes K, Montez G, Pham T, et al. for the HEALTHY Study Group. Rationale, design, and methods for process evaluation in the HEALTHY study. Int J Obes 2009;33(Suppl 4):S60–S67.
68. Gail MH, Mark SD, Carroll RJ, Green SB, Pee D. On design considerations and randomization-based inference for community intervention trials. Stat Med 1996;15:1069–1092. [PubMed: 8804140]
69. Diggle, P.; Heagerty, P.; Liang, KY.; Zeger, SL. Analysis of Longitudinal Data. Oxford University Press; Oxford: 2002.
70. Molenberghs, G.; Verbeke, G. Models For Discrete Longitudinal Data. Springer; New York: 2005.
71. STOPP-T2D Prevention Study Group. Prevalence of the metabolic syndrome among a racially/ethnically diverse group of US eighth-grade adolescents and associations with fasting insulin and

homeostasis model assessment of insulin resistance levels. Diabetes Care 2008;31:2020–2025. [PubMed: 18591405]

72. Jago R, Harrell JS, McMurray RG, Edelstein S, El ghormli L, Bassin S. Prevalence of abnormal lipid and blood pressure values among an ethnically diverse population of eighth-grade adolescents and screening implications. Pediatrics 2006;117:2065–2073. [PubMed: 16740849]
73. Cullen KW, Hartstein J, Reynolds KD, Vu M, Resnicow K, Greene N, et al. Improving the school food environment: results from a pilot study in middle schools. J Am Diet Assoc 2007;107:484–489. [PubMed: 17324667]
74. Hartstein J, Cullen KW, Reynolds KD, Harrell J, Resnicow K, Kennel P. The impact of portion size control for school a la carte items: changes in kilocalories and macronutrients purchased by middle school students. J Am Diet Assoc 2008;108:140–144. [PubMed: 18156001]
75. Pinhas-Hamiel O, Dolan LM, Daniels SR, Standiford D, Khoury PR, Zeitler P. Increased incidence of non-insulin-dependent diabetes mellitus among adolescents. J Pediatr 1996;128:608–615. [PubMed: 8627431]
76. Scott CR, Smith JM, Cradock MM, Pihoker C. Characteristics of youth-onset noninsulin-dependent diabetes mellitus and insulin-dependent diabetes mellitus at diagnosis. Pediatrics 1997;100:84–91. [PubMed: 9200365]

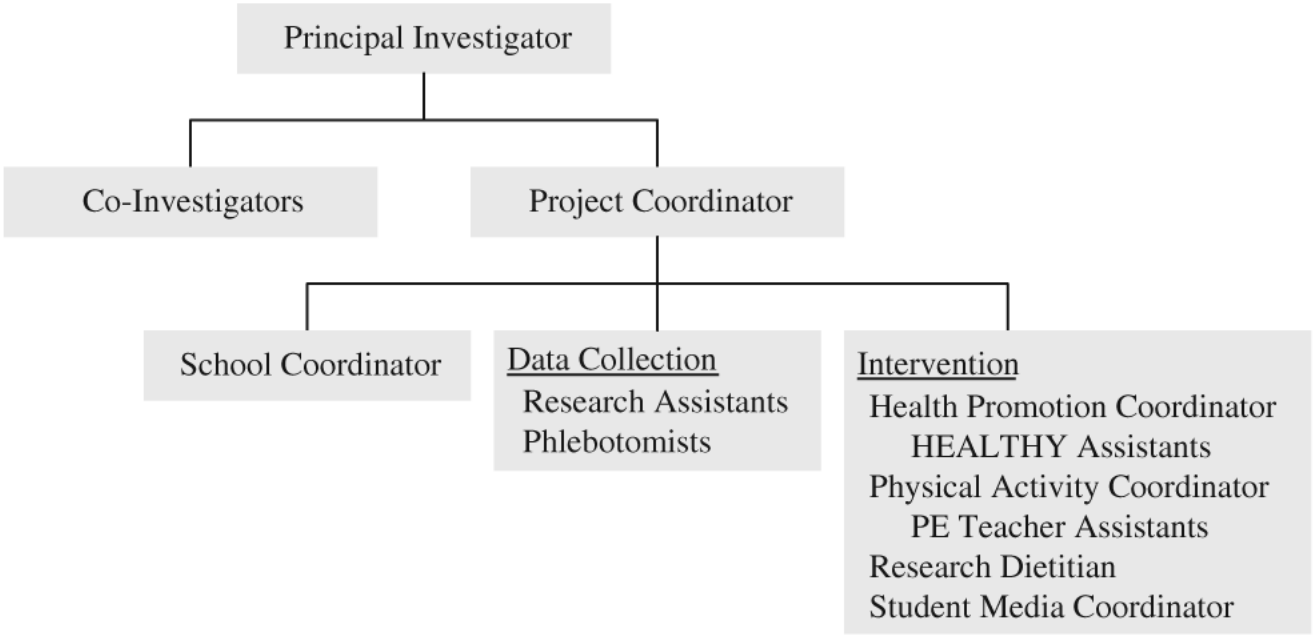


**Figure 1.**
Field center staffing structure.

**Table 1**

Intervention themes and targeted behaviors

| | | |
|---|---|---|
| *A* | *Themes* | |
| | Winter/spring sixth grade | Water versus added sugar beverages |
| | Fall seventh grade | Physical activity versus sedentary behavior |
| | Winter/spring seventh grade | High-quality versus low-quality food |
| | Fall eighth grade | Energy balance: energy in/energy out |
| | Winter/spring eighth grade | Strength, balance and choice for life |
| *B* | *Targeted behaviors* | |
| | Increasing water consumption | |
| | Substituting water for added sugar beverages | |
| | Drinking water for health, nutrition and hydration | |
| | Choosing healthier foods and drinks for meals and snacks | |
| | Substituting nutrient dense, lower energy foods for low nutrient, higher energy foods | |
| | Self-monitoring, goal setting and problem solving to increase intake of water, fruits and vegetables | |
| | Increasing movement and accumulation of time spent being active | |
| | Decreasing time spent in sedentary behavior | |
| | Substituting physical activity for sedentary behavior | |
| | Self-monitoring, goal setting and problem solving to increase physical activity and decrease sedentary behavior | |

**Table 2**

Primary and secondary objectives

| | |
|---|---|
| *A* | *Primary*<br>Moderate risk for type 2 diabetes in middle school students. Modifiable risk factors are indicators of adiposity and glycemic dysregulation. |
| *B* | *Secondary*<br>Evaluate the ability of the intervention to influence lifestyle changes and choices both in and out of school:<br>Increase intake of dietary fiber, fruits and vegetables and decrease intake of high-fat and high-sugar foods.<br>Increase intake of water and low-fat milk and decrease intake of added sugar beverages.<br>Increase amount of physical activity and decrease amount of sedentary behavior.<br>Determine the cost-effectiveness of the intervention.<br>Evaluate the degree to which the components of the intervention are delivered and administered as planned, including the success of the schoolwide communications campaigns to maximize study awareness, disseminate key intervention messages and engage students.<br>Evaluate trends in academic performance, attendance and comportment in intervention versus control schools.<br>Monitor and describe the influence of changes in the school environment that are not mandated by the study but are due to decisions and changes in policies, guidelines and recommendations at the school district, local, state and national levels.<br>Contribute to our understanding of the etiology of risk of T2D in this age group. |

**Table 3**

School eligibility criteria

| | |
|---|---|
| 1 | The student body is representative of the adolescent population at risk for type 2 diabetes, defined as either at least 50% minority (African American, Hispanic/Latino and/or American Indian) and/or greater than 50% eligible for free or reduced lunch. |
| 2 | Annual student attrition from all causes is ≤25%. |
| 3 | Expected cohort size at end of study is at least 50 per school. |
| 4 | School authorities are willing to accept randomization of an individual school to intervention or control. If a school is assigned to the intervention program, this means that the school must arrange for the following if needed: |
| | **a.** Students attend PE class for a minimum of 225 min every 10 days over the course of the intervention. |
| | **b.** PE class attendance is mandatory and continuous for the cohort, that is, sixth, seventh and eighth graders in the intervention school years (with school specified medical exceptions in individual cases). |
| | **c.** The school has at least one play area that satisfies intervention requirements as determined by the field center staff. |
| 5 | School authorities permit grade-wide collection of height, weight, gender, age and race/ethnicity at baseline. |
| 6 | The school assists with mass mailings of study materials to students' homes. |
| 7 | The school district possesses or obtains Federal Wide Assurance (FWA) to conduct research. |
| 8 | Appropriate school authorities agree to adhere to the protocol. |

**Table 4**

Schedule of data collection measures and procedures

| ***Measures and procedures*** | ***Schedule*** | | | | | |
|---|---|---|---|---|---|---|
| | ***Fall sixth (baseline)*** | ***Spring sixth*** | ***Fall seventh*** | ***Spring seventh (interim)*** | ***Fall eighth*** | ***Spring eighth (end of study)*** |
| Student demographics | × | | | | | × |
| *Student health screening* | | | | | | |
| Height and weight | × | | | × | | × |
| Waist circumference | × | | | | | × |
| Blood pressure | × | | | | | × |
| Fasting blood draw[a] | × | | | | | × |
| *Student self-report surveys* | | | | | | |
| Sexual maturity | × | | | | | × |
| Quality of life | × | | | × | | × |
| Dietary intake | × | | | | | × |
| Physical activity/inactivity | × | | | | | × |
| Student fitness | × | | | | | × |
| Economic costs | × | × | × | × | × | × |
| School food environment | × | | | × | | × |
| PE class activity level | × | | | × | | × |
| School academic performance | [b] | × | × | × | × | × |
| Environmental influences | | × | | × | | × |
| Process evaluation[c] | | × | × | × | × | × |

[a] Glucose, insulin, lipids, HbA1c, stored specimens.

[b] Baseline measures of academic performance were collected for school year 2005-2006.

[c] Process evaluation was performed in intervention schools only.

## Table 5

Baseline comparison of intervention versus control schools

| | ***Intervention (N = 21)*** | ***Control (N = 21)*** |
|---|---|---|
| Total number of students[a] | 873 (315-1333) | 863 (342-1523) |
| Total number of sixth grade students[a] | 265 (100-437) | 266 (101-491) |
| Percentage enrolled in study in sixth grade[a] | 62.2% (43.5-86.0%) | 62.5% (45.2-89.2%) |
| Percentage qualified for free/reduced meals[a] | 77% (47-100%) | 74% (49-100%) |
| *Race/ethnic composition* | | |
| Hispanic | 46% | 44% |
| Black | 31% | 26% |
| White | 18% | 25% |
| Other | 5% | 5% |

[a] Mean (minimum-maximum).

## Table 6

Comparison of sixth grade-wide baseline data: participants versus non-participants

| | ***Participants (N = 5657)*** | ***Non-participants (N = 4490)*** | **P-*value*** |
|---|---|---|---|
| Age (years) | 11.32 (0.64) | 11.31 (0.68) | <0.0001 |
| Gender (% male) | 47.7% | 53.0% | <0.0001 |
| *Race/ethnicity* | | | 0.0002 |
| Hispanic | 50.6% | 56.8% | |
| Black | 19.9% | 16.1% | |
| White | 18.9% | 11.6% | |
| Other | 10.6% | 15.5% | |
| BMI (kg $m^{-2}$) | 22.6 (8.7) | 21.8 (5.3) | <0.0001 |
| BMI ≥85th percentile | 53.2% | 48.6% | <0.0001 |

## Table 7

Comparison of sixth grade health screening baseline data: intervention versus control

| | ***Intervention* (N = *3189*)** | ***Control* (N = *3169*)** | **P-*value*** |
|---|---|---|---|
| Age (years) | 11.8 (0.6) | 11.8 (0.6) | 0.5745 |
| Gender (% male) | 48.1% | 47.0% | 0.3896 |
| *Race/ethnicity* | | | 0.2181 |
| Hispanic | 53.2% | 53.0% | |
| Black | 21.7% | 17.7% | |
| White | 16.8% | 20.9% | |
| Other | 8.2% | 8.5% | |
| *Household highest education level* | | | 0.5783 |
| Less than high school | 12.9% | 12.0% | |
| Some high school | 14.7% | 14.9% | |
| High school graduate | 25.0% | 25.4% | |
| Some college or special training | 29.5% | 28.1% | |
| College or university graduate | 12.4% | 13.9% | |
| Postgraduate training or degree | 5.6% | 5.8% | |
| Family history diabetes[a] | 16.0% | 16.8% | 0.6205 |
| *Tanner stage (males)* | | | 0.9411 |
| 1 | 14.9% | 16.1% | |
| 2 | 40.1% | 39.2% | |
| 3 | 38.6% | 37.7% | |
| 4 | 6.1% | 6.8% | |
| 5 | 0.3% | 0.2% | |
| *Tanner stage (females)* | | | 0.5299 |
| 1 | 6.0% | 5.6% | |
| 2 | 13.5% | 12.6% | |
| 3 | 42.8% | 42.6% | |
| 4 | 33.9% | 35.8% | |
| 5 | 3.8% | 3.4% | |
| BMI (kg $m^{-2}$) | 22.3 (5.5) | 22.3 (5.5) | 0.9065 |
| BMI percentile | 73.0 (27.5) | 72.5 (28.3) | 0.5223 |
| BMI ≥85th percentile | 49.3% | 49.4% | 0.9616 |
| Waist circumference (cm) | 75.9 (15.3) | 75.7 (14.9) | 0.6974 |
| Fasting glucose (mmol $l^{-1}$) | 5.2 (0.4) | 5.2 (0.4) | 0.7760 |
| Fasting glucose ≥5.55 mmol $l^{-1}$ | 15.7% | 15.9% | 0.8691 |
| Fasting insulin (pmol $l^{-1}$) | 79.2 (65.8) | 79.9 (72.7) | 0.9559 |
| Insulin ≥180 pmol $l^{-1}$ | 5.6% | 6.7% | 0.4881 |
| Systolic blood pressure (mm Hg) | 107.3 (10.0) | 107.7 (10.2) | 0.6685 |
| Diastolic blood pressure (mm Hg) | 63.5 (8.8) | 64.0 (8.7) | 0.2599 |
| High blood pressure[b] | 12.3% | 14.1% | 0.3551 |
| Total cholesterol (mmol $l^{-1}$) | 4.1 (0.7) | 4.1 (0.7) | 0.3158 |
| High-density lipoprotein (mmol $l^{-1}$) | 1.4 (0.3) | 1.4 (0.3) | 0.5683 |
| Low-density lipoprotein (mmol $l^{-1}$) | 2.2 (0.6) | 2.3 (0.6) | 0.4725 |
| Triglycerides (mmol $l^{-1}$) | 1.0 (0.6) | 1.0 (0.6) | 0.8634 |
| HbA1c (%) | 5.1 (0.3) | 5.1 (0.3) | 0.2523 |

[a] Defined as parent/guardian self-report that the natural mother, the natural father, or any full sister or brother had diabetes.

[b] Defined as ≥118/77 for ages 8-10, ≥120/80 for ages 11-14, ≥125/80 for ages 15-17.