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This study was designed to create, implement, and test a school-based multiple risk factor reduction program for high school students. All tenth graders in four senior high schools (N=1447) from two school districts participated in the study. Within each district, one school was assigned at random to receive a special 20-session CVD risk reduction intervention and one school served as a control. The schools were matched for size and distribution of racial groups before randomization. At a two-month follow-up, knowledge gains were significantly greater for students in the treatment group on each of the risk factor domains tested: nutrition/diet ($p<0.0001$), physical activity ($p<0.0001$), and cigarette smoking ($p<0.0001$). Compared to controls, a higher proportion of those in the treatment group who were not exercising regularly at baseline, reported regular exercise at follow-up ($p<0.0003$). Almost twice as many baseline experimental smokers in the treatment group reported quitting at follow-up while only 5.6% of baseline experimental smokers in the treatment group graduated to regular smoking compared to 10.3% in the control group (p=0.009). Students in the treatment group were more likely to report that they would choose heart healthy snack items ($p<0.0001$). Beneficial treatment effects were observed for resting heart rate ($p<0.0001$), BMI (p=0.05), triceps skinfold thickness (p=0.003), and subscapular skinfold thickness (p=0.01). The results suggest that it is feasible to provide CVD risk reduction training to a large segment of the population through school-based primary prevention approaches.

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INTRODUCTION

Epidemiologic research demonstrates that our modern lifestyle (cigarette smoking, a diet rich in saturated fat and cholesterol, sedentary habits) contributes to the development of cardiovascular disease (CVD).[1] The available evidence suggests that behaviors associated with increased CVD risk are acquired early in life and may accelerate the development of CVD.[1-4] Elevated blood pressure, cigarette smoking, and sedentary lifestyle in college students predict both fatal and nonfatal coronary heart disease.[5,6] Between 10 and 25% of adolescents are at least moderately overweight.[7] Sizeable numbers of children and adolescents show evidence of elevations in blood cholesterol.[8] Analyses of childrens' diets suggest that over 40% of the calories eaten are derived from fat; saturated fats account for 15 to 18% of the calories eaten and dietary cholesterol is well in excess of 300 mg per day.[9,10] Smoking rates among teenagers escalate sharply beginning in junior high school and continue to rise into early adulthood.[11] As Berenson notes, "If today's children grow up like their parents, 20–30% of them will have hypertension as adults. Ninety percent will develop significant atherosclerotic lesions and over 50% will die from hypertension and atherosclerotic lesions."[2] Thus, there is a clear need for early preventive intervention.

Primary prevention programs may prevent CVD, delay the onset and reduce the severity of the disease, and reduce the associated costs of medical care. However, research is needed to develop procedures to help young people reduce risk factor behaviors and to acquire and practice positive health behaviors.

To date, the most promising prevention research has focused on the development of school-based cigarette smoking prevention programs for children in elementary and middle grades.[12] Although single-factor interventions in the field of smoking prevention have produced encouraging results, comprehensive, multiple risk factor reduction interventions are largely lacking. The few comprehensive programs that have been conducted under controlled research conditions and with adequate evaluation components were designed for younger adolescents and/or children.[13,14]

However, there is no evidence that interventions with younger children are more successful in achieving prevention goals than programs designed for older adolescents. Indeed, older adolescents may benefit more from prevention education because they possess the cognitive and behavioral competencies necessary to understand and act upon health and behavior change instruction. In addition, there is no guarantee that programs designed to produce health behavior change at one point in life will protect against the return of or shift to other less healthful lifestyles in later years. Training at one period of development may well require upgrading to be effective in new and perhaps more complex psychosocial environments.[12]

In order to study the impact of CVD prevention education on older adolescents, an investigation was conducted designed to create, implement, and test a school-based multiple risk factor reduction curriculum for tenth-grade high school students. The primary aim was to examine the effectiveness of the curriculum in (1) increasing students' knowledge of CVD risk factor concepts, (2) decreasing CVD risk factor behaviors such as: cigarette smoking, consumption of calories, and foods high in saturated fat, cholesterol, and salt, (3) increasing levels of aerobic physical activity and consumption of complex carbohydrates, and (4) lowering heart rate, blood pressure, Body Mass Index, and skinfold thickness.

Findings from this research have been published previously in both journal article

and book chapter form.[15,16] Publication of the results in *Health Education Quarterly* provides an opportunity to more fully describe the CVD risk reduction curriculum and to explicate the linkages between the curriculum and our conceptual model of health behavior change.

A CONCEPTUAL MODEL FOR HEALTH BEHAVIOR CHANGE

Bandura has synthesized and extended the findings from diverse lines of investigation into a coherent account of the processes governing behavior change. His social-cognitive theory serves as a useful guide in the development of school-based health behavior change interventions.[17] In social-cognitive theory, behavior is developed, altered, and maintained through the interplay of personal, behavioral, and environmental factors. With respect to health, *environmental factors* may include peers and family members who, through the modeling of attitudes about health and the display of personal health behaviors, influence the development of an adolescent's own attitudes toward health and own health-related practices. *Personal factors* would include the adolescent's own valuation of health-related activities, expectations, derived from observation and experience, about the positive and negative consequences of different health behaviors, and expectations about personal abilities to perform behaviors which will secure desired outcomes. *Behavioral factors* would include the number of skills available in the behavioral repertoire of the adolescent and the degree of mastery the adolescent has attained in using these skills.

The goals of our own school-based multiple factor intervention, based principally on Bandura's model, are to provide adolescents with (1) incentives for adopting a heart healthy lifestyle so that such a lifestyle is perceived as attractive; (2) cognitive and behavioral skills enabling them to make changes both in their own behavior and in the environmental contexts providing support for their behavior; (3) additional specific skills for resisting influences to return to old habits (or to adopt bad habits); and (4) specific practice in using skills in order to strengthen their perceived competence in employing newly acquired behaviors effectively.

Increasing the Perceived Incentive Value of Behavior

Incentives play a substantial role in the regulation of human conduct. The authors' model suggests that one important intervention goal is to increase students' intentions to adopt and practice more healthful behavior by producing a positive shift in their valuation of good health practices. In this work, the authors attempt to create this shift, in part, by helping students to perceive (1) the immediate and longer-term positive benefits of adopting healthful behavior, (2) the immediate as well as longer term negative consequences of practicing behaviors which increase risk to health and well-being, and (3) that practice of healthful lifestyles will not produce important, immediate negative effects.

The selection of weak or inappropriate incentives can undermine efforts to increase valuation of good health practices. The results of early cigarette smoking prevention research may serve to illustrate this point. Early prevention research emphasized the harmful long-term health effects of smoking. Numerous antismoking programs were

implemented in junior and senior high schools in attempts to dissuade adolescents from smoking. These programs employed a wide range of techniques including lectures, discussions, posters, and films aimed at increasing students' awareness of the harmful long-term effects. While some studies reported positive changes in knowledge and attitudes, most found little or no effect on students' reported smoking behavior.[18-22] Smoking prevention programs which emphasize long-term health effects may miss the mark because the perceived positive benefits associated with smoking may outweigh the long-term negative health effects. For example, most adolescents believe the traditional health education message that smoking is dangerous to their physical health.[23,24] Despite this knowledge, sources of social influence (i.e., peers, siblings, parents, mass media) may exert considerable pressure on adolescents to adopt the smoking habit.

The social-cognitive model suggests that interventions emphasize proximal outcomes that are salient to the target audience. Emphasis on immediate consequences may be particularly critical for health behavior change among adolescents. For example, formative evaluations conducted by the authors research team indicate that students' interest in health issues stems primarily from concerns for personal appearance and, to a lesser extent, physical conditioning. Therefore, health behavior change interventions aimed, for example, at improving diet and activity practices may achieve behavior change objectives most effectively by emphasizing relationships between good eating and exercise practices and personal appearance and physical condition.

Developing Self-Regulatory Skills for Managing Behavior

Social-cognitive theory advances the proposition that humans can learn to manage their behavior more effectively through acquisition of a variety of self-regulatory skills. Health behavior change interventions must help students to acquire and practice self-regulatory skills which can enable them to manage the multitude of psychosocial influences which play a role in determining health practices. Three basic self-regulatory skills are emphasized in our model: goal-setting, self-monitoring, and social pressure resistance. Brief descriptions of each of the skills are presented below. More complete accounts are provided in Bandura, McGuire, and McAlister, Perry, and Maccoby.[17,25,26]

Self-Monitoring

Effective self-regulation requires first that individuals are able to accurately observe their own behavior. Self-monitoring serves as the focal point of a self-directed change strategy by providing the information necessary for setting realistic performance standards, and for evaluating ongoing changes in behavior.[17] Self-monitoring provides both self-diagnostic and self-motivational functions.[17] Persons can increase their awareness of factors in the social environment that influence their thoughts and actions through self-observation and thus "diagnose" the causes of their own behavior. The motivational effects of self-observation have been identified through research showing that when people monitor their performance, they tend to set standards for progressive improvement and then critically evaluate subsequent performance in light of the new standards.[27,28]

Goal-Setting

Bandura has described the diverse effects of goals on behavior. Goals provide both direction and motivation for behavior change.[17] Most of the experimental work concerned with goals has focused on motivational properties. The motivating effect of goals lies in making self-satisfaction contingent on their achievement. Bandura argues that goals produce motivational effects because people evaluate their own behavior. Goals specify the requirements for a positive self-evaluation. High levels of dissatisfaction with performance are associated with increased effort to meet the performance standard.[17,29] However, goals do not automatically activate self-regulatory behavior. To be effective, (1) goals must be explicit, providing clear and sepecific guidelines for both desired actions and assessment of achievement;[30,31] (2) goals must provide sufficient challenge without being unrealistic; and (3) proximal goals are more effective than distal goals.[32,33] The creation of a series of proximal subgoals can provide specific pathways for action, and their successive attainments may enhance self-efficacy.[17]

Social Pressure Resistance Training

Social-environmental modeling can exert profound influences on the performance of health-related behaviors. For example, advertising has been shown to influence children's food preferences and consumption.[34,35] Vast sums are continuously spent on advertising that promotes consumption of tobacco, alcohol, and fatty foods and "conveniences" that encourage a sedentary lifestyle. Among adolescents, perceptions of peer behaviors probably represent the strongest influence on health behaviors. This has been demonstrated repeatedly for smoking and other substance use.[36,37] Therefore, it is reasonable to promote resistance to the social-environmental influences that encourage unhealthy behaviors.

Methods for teaching social pressure resistance skills are derived from McGuire's social inoculation theory.[25] Social inoculation is viewed as analogous to immunologic inoculation (immunization). Physiologic immunizations provide resistance to infections by introducing weakened, noninfectious forms of organisms into the body, priming production of antibodies to those organisms that will be present in increased numbers if true infection eventually occurs. Social inoculation theory suggests that beliefs can be protected from persuasive appeals by pretreating persons with weak forms of those appeals.[25] McGuire has summarized data from a variety of studies investigating resistance building techniques. The findings suggest that inoculation will be effective to the degree that persons are motivated to acquire a defense for beliefs and to practice defending beliefs against attack.

In the field of school-based health behavior research, social inoculation theory supplies important theoretical machinery for most of the current adolescent smoking prevention interventions shown to be successful in controlled evaluations. In this research, students are presented with a broad variety of sample inducements to smoke followed by opportunities to invent and practice counters to those inducements. The primary objectives are to acquaint students with the powerful social influences which may trigger smoking (e.g., advertising, peer smoking) and to provide them with coping skills, and a strong sense of self-efficacy, to resist these influences when they encounter them in the future. The findings from a number of research terms indicate that

smoking prevention programs which (1) teach adolescents to become aware of the social inducements to smoke and (2) help them to acquire skills to counter the effects of inducements may reduce the rate at which adolescents adopt the smoking habit.[38-42]

Building Perceived Competence

Although skills are important for achieving behavior change, actual adoption of a desired behavior, through use of those skills, is in part a function of an individual's sense of competence and mastery in using a skill. Social-cognitive theory labels this sense of mastery as perceived self-efficacy. Bandura has argued that all psychological interventions produce change by altering perceptions of efficacy.[32] Perceived self-efficacy is defined in Bandura's model as the perception that one can successfully execute behaviors required to achieve an outcome. A variety of studies addressing different domains of functioning have shown that self-efficacy judgements accurately predict behavioral attainments.[33,43-47]

Self-efficacy judgements are constructed and modified by information obtained through performance accomplishments, vicarious experience, social persuasion, and physiologic states.[32] Performance accomplishments are the actual successes (or failures) in the performance of specific behaviors and represent the strongest influence on perceived self-efficacy. In addition, performance in an uncontrolled setting (a real life situation) exerts stronger influence than performance in a controlled setting (e.g., the classroom) or imagined performance. Vicarious experience, observing behaviors modeled by others, exerts the next most powerful influence on perceived self-efficacy. The effects of modeling can be enhanced by showing individuals overcoming obstacles (versus easy performance), using models that are similar to the observer, employing a variety of models, and demonstrating clear consequences that result directly from accomplishment of the modeled behavior. Social (verbal) persuasion exerts the weakest influence on perceived self-efficacy. However, verbal persuasion is the most commonly used source of influence in school health curricula. Persuasion usually takes the form of instruction in specific skills, suggestion that the desired behavioral goals are attainable, and suggestion of possible outcomes associated with different behaviors. The strength of verbal persuasion is highly dependent on the perceived credibility of the information source. Finally, perceived self-efficacy is also influenced by physiologic state or emotional arousal associated with performance of a specific behavior. Perceived efficacy may be enhanced by altering physiologic states themselves or the way an individual interprets physiologic feedback.

CURRICULUM DEVELOPMENT

The general content of the curriculum and the educational methods utilized were derived directly from the conceptual framework provided by social cognitive theory and social inoculation theory, as described above. The specific content was derived directly from formative research with 15 year olds attending local schools not participating in the program. Formative research played a substantial role in the selection of specific motivating messages, types of models and the specific behaviors to be

modeled, performance activities and specific language to be used in educational messages and emphasized consequences of behavior change or failure to change.

The education program consisted of 20 classroom sessions, each lasting 50 minutes. Sessions occurred during regularly scheduled physical education class time. The first session served as an introduction to the program. During this session the concept of a healthy lifestyle was introduced with a short discussion of the major CVD risk factors: smoking, elevated blood pressure, elevated serum cholesterol, and physical inactivity. In addition, personal change notebooks containing visually attractive handouts, worksheets, and homework assignments were distributed to all students. This short introduction was followed by the video-drama *Choices,* produced specifically for the intervention. Actors were chosen from high school drama groups to meet the physical and behavioral characteristics dictated by results of the authors' formative research. *Choices* presented several intertwining vignettes involving teenagers. Each vignette presented the characters with a decision regarding adoption of a particular health-related behavior, and portrayed the cost-benefit analysis involved in each case. The setting of proximal and distal goals, demonstrated attainment or temporary failure to attain goals and the resulting consequences of different personal choices were presented in the video-drama.

The next 12 sessions were divided into four separate modules: physical activity, nutrition, cigarette smoking, and stress. To raise the perceived incentive value of making changes in lifestyle, these modules emphasized information on the important immediate effects on life quality as well as the potential long-term health consequences of adopting healthful behaviors. As previously noted, the emphasis on immediate consequences was considered of primary importance in this age group. The modules also introduced self-regulatory skills specific for each area. These included the setting of specific, proximal change goals, methods of monitoring progress toward proximal goals, problem solving skills, and application of self-managed incentives. Educational methods utilized within each module included discussion oriented information sessions, slide and music-slide presentations, videotaped vignettes modeling peers learning to use skills successfully, guided role-playing simulations to aid in invention of coping strategies for managing high risk situations, and performance-based exercises (e.g., measuring heart rates, stretching exercises, healthful snack preparation, meal planning, relaxation, and guided imagery exercises).

The four informational modules were followed by a two-session competitive game. Students were divided into teams of three or four and were quizzed on information and skills introduced in the prior four modules. Points were awarded to teams responding with correct answers, and point scores were doubled for the second game session. Members of the team with the highest point total in each classroom received $5 gift certificates to a local music store. Students were made aware of the available prizes during the first educational session of the program. Prizes were selected based on results of earlier formative research into salient motivators.

The final module (five sessions) was devoted to training in problem solving and the development of an action plan for behavior change. This module began with each student's choice of a specific long-term lifestyle change goal. Through examples drawn from the previous modules, students were led, step-by-step, through the development of a behavior change plan. Steps in planning included: specification of proximal goals leading to the ultimate long-term behavior change objective, specification of the strategies to be used in achieving proximal goals and identification of the contexts in which

strategies would be implemented, specification of self-incentives for attainment of each of the proximal goals, and completion of a contract to follow the specified action plan for a specified period of time. Students were then encouraged to identify potential physical, psychological, and social-environmental barriers which could deter achievement of the specified action plan. Finally, students were introduced to problem-solving as a method for overcoming barriers to successful behavior change, and used this process with their own specific barriers to change.

RECRUITMENT AND TRAINING OF INSTRUCTORS

Classroom instructors were recruited from a group of recent college graduates with academic backgrounds or experience in health-related fields. A performanced-based teacher training model was used to provide staff with the skills necessary for successful administration of the intervention.

The teaching staff spent three days each week in the classroom delivering the intervention. Teachers spent one day each week at Stanford preparing for the subsequent week's activities. During training sessions, conducted by members of the research staff, teachers were first guided through the instructional protocol to acquaint them with the teaching objectives and strategies for a particular lesson. Teachers then practiced delivering the curriculum to research staff and received feedback and comment from staff members designed to strengthen teaching performance.

SUBJECTS AND METHOD

All tenth graders (N=1447) enrolled in four northern California high schools were asked to complete a survey designed to detect the presence of physical characteristics and behaviors related to risk for coronary heart disease. 70% of the students were 15 years of age, 14% were 14 and 14% were 16 years old. Self-reported ethnic distribution was as follows: 69.0% White, 2.0% Black, 13.1% Asian, 6.4% Latino, 0.3% American Indian, 0.4% Pacific Islander, and 8.9% other. Fifty percent of the students' fathers had completed four or more years of college.

Research Design

Four senior high schools from two school districts participated in the study. Within each district, one school was assigned at random to receive the special intervention and one school served as a control. Within each district, the schools were matched for size and distribution of ethnic groups before randomization. All tenth graders in each treatment school were scheduled to attend the special intervention sessions three days each week for seven weeks. The intervention was delivered as part of the regular physical education curriculum.

Measures

Assessments were performed by trained staff over two days in each of the four schools. Boys and girls were separated into two large classrooms, and completed self-

administered questionnaires and physical measures in groups of 40 to 50 during each class period. Regular school personnel did not participate in any part of the data collection. Measurements were collected at baseline and at a follow-up assessment conducted two months after the completion of the seven-week special intervention (i.e., four months after baseline data collection).

Demographic Variables

Parents' education was measured as the higher of the mother's or father's education level. The predominance of whites in our population precludes meaningful ethnic comparisons. *College Plans:* students indicated their intention to enroll in college on a five-point Likert-type scale.

Knowledge of Cardiovascular Disease Risk Concepts

Multiple-choice tests based on information presented in the curriculum were developed to assess knowledge in the following areas: physical activity, nutrition/diet, and cigarette smoking. Maximum possible scores: physical activity (30), nutrition (30), smoking (8).

Self-Reported Behavior

Physical activity: a checklist was developed featuring 19 different forms of physical activity. Students were asked to indicate (1) which of the activities they engaged in for at least 20 minutes nonstop and (2) the frequency with which they performed these activities. Five of these activities were designated as activities that would provide an aerobic training effect if performed for at least 20 minutes nonstop. Three times per week. Students who reported performing one or more of these activities at the rate of 20 minutes nonstop three times per week or at least three activities at the rate of 20 minutes nonstop one to two times per week were classified as aerobic exercisers. *Nutrition/diet:* a checklist presenting 32 food pairs was developed. One food in each pair was superior with respect to diet-CVD relationships. Students were asked to indicate which food in each of 32 pairs they would usually choose to eat if given the choice. *Cigarette smoking:* students reported frequency of use of tobacco cigarettes. Six frequency levels were provided: never, at least once in my life, at least once per month, at least once per week, almost every day, and every day. Students also reported frequency of alcohol and marijuana use. The use prevalences for alcohol and marijuana in the sample have been presented in an earlier report.[36] While the intervention did not target these substances for behavior change, they were included to assess prevalence and to establish treatment and control group equivalence. Response rates to these potentially sensitive questions were between 90 and 92% for each of the individual substances.

As a check on reported substance use, expired air carbon monoxide (CO) was measured with an Ecolyzer 2000 series carbon monoxide monitor (Energetics Science, Hawthorne, NY). CO measurement has been shown to increase the accuracy of self-

reported drug use.[48] After holding a deep breath for ten seconds, students expired approximately one-half of their air into the room, emptying the remainder of the breath into a polyvinyl breath sample bag. The breath sample bag was attached to the carbon monoxide monitor through a charcoal filter. Measures were recorded to the nearest part per million of carbon monoxide.

Anthropometric/Physiologic Variables

Height and weight were measured on a standard balance beam scale. Students wore lightweight gym clothing with overgarments and shoes removed. Body Mass Index was computed from the formula weight/height^2 which is generally considered to be the preferred index of relative weight as an estimate of adiposity.[49,50] *Subcutaneous skinfold thicknesses* were measured with Harpenden calipers (British Indicators, Ltd., St. Albans, England) according to established guidelines.[51] Two sites (triceps and subscapular) were measured from the right side of the body. *Resting heart rate* and *blood pressure* were measured with an automated blood pressure device (Cardiovan 9200, Paramed Technology, Inc., Palo Alto, CA). Before measurements were started, students sat quietly for three minutes. Measurements were made from the right arm at the approximate level of the heart. Heart rate and mean arterial, systolic and diastolic blood pressures were each measured three times, at one minute intervals. The means of the second and third measurements were used in the analyses.

Statistical Analysis

Of 1447 students responding to the baseline survey, 1130 were available at follow-up (Treatment n = 622, Control n = 508). Analyses of baseline variables and program effects were restricted to students providing data at both baseline and follow-up assessments. To examine the equivalence of treatment and control conditions at baseline, one-way Analysis of Variance (ANOVA) was conducted with continuous variables and chi-square tests were conducted with categorical variables.

To examine program effects, two-way (Treatment x Sex) Analysis of Covariance (ANCOVA) was conducted with continuous variables. Baseline values were used as covariates. Chi-square tests were conducted with categorical variables. Analyses were conducted using the individual as the unit of analysis.

RESULTS

Analyses of Baseline Variables

At baseline, treatment and control groups were compared on a variety of treatment and treatment-related variables. *Ethnic distributions* did not differ significantly (p = 0.17) and there was no significant difference in the proportion of students planning *to enroll in college* (p = 0.16). There was no significant difference at baseline with respect to the proportion of boys and girls participating in each group. [*Treatment:* boys (55.5%), girls (44.5%); *Control:* boys (52.5%), girls (47.5%) p = 0.26]. Parents of

students in the control group received more years of *education* than parents of students in the treatment group ($\chi^2 = 15.8, p < 0.008$).

With respect to *knowledge*, mean scores on the combined knowledge test were very similar at baseline. Whereas boys in the treatment and control conditions were quite similar on *physiologic* and *anthropometric* measures (with the exception of BMI), girls were somewhat different. In general, girls in the control group had less body fat, lower heart rates and lower blood pressures at baseline. Expired air carbon monoxide levels correlated ($r = 0.44$) with reported daily or almost daily cigarette smoking.

With respect to *self-reported behavior,* boys and girls in the treatment and control groups (again, comparing within sex) did not differ in reported cigarette or alcohol consumption or on the food choice score. Boys were similar with respect to the proportion reporting regular aerobic physical activity (treatment: 30.9%, control: 32.9%, $p = 0.60$). A higher proportion of girls in the control group reported regular aerobic physical activity (treatment: 35.8%, control: 53.9%, $p = 0.0001$). Regular exercisers had significantly lower resting heart rates than non-regular exercisers (regular exercisers: mean = 76.1 beats per minute; nonregular exercisers: mean = 78.4 beats per minute; $t = 2.9, p < 0.003$).

Dropout Analysis: Treatment "Dropouts" vs. Control "Dropouts"

The authors examined baseline values of students in both groups who failed to attend the follow-up in order to evaluate the potential threat to internal validity associated with differential attrition. No differences were found between dropouts on knowledge or self-report variables. Differences between groups were observed for triceps skinfold thickness Rx: mean = 14.7 mm; Control: mean = 17.2 mm, $p = 0.02$).

ANALYSIS OF PROGRAM EFFECTS

Changes in Knowledge Scores: Treatment vs. Control

Table 1 presents mean scores at baseline and follow-up. Knowledge gains were significantly greater for students in the treatment group on each of the risk factor domains tested: nutrition/diet (Main effect: $F(1,946) = 369.2, p < 0.0001$; Sex effect: $F(1,946) = 27.8, p < 0.0001$; physical activity (Main effect: $F(1,1078) = 371.8, p < 0.0001$, Sex effect: $F(1,1078) = 33.8, p < 0.0001$); cigarette smoking (Main effect: $F(1,965) = 177.2, p < 0.0001$, Sex effect: $F(1,965) = 10.9, p = 0.001$). Results are presented graphically as an increase in combined knowledge score in Figure 1. In the treatment group, boys increased their combined score an average of 11.1 points and girls an average of 14.2 points. By contrast, in the control group, boys' scores decreased an average of 1.4 points and girls' scores increased an average of only 0.8 points.

Changes in Self-Reported Behavior: Treatment vs. Control

Exercise: Students who, at baseline, were classified as *nonregular exercisers* were a principal target of the intervention. A higher proportion of those in the treatment

Table 1. Mean Values at Baseline and Two Month Follow-up

	Boys				Girls				
	Treatment		Control		Treatment		Control		
	Pre	FU	Pre	FU	Pre	FU	Pre	FU	Rx Effect
Exercise score	12.8(5.3)	17.4(6.8)	13.0(5.0)	11.4(5.9)	13.6(4.4)	19.6(5.1)	13.9(5.2)	13.9(5.5)	0.0001
Nutrition score	6.4(4.6)	11.3(6.7)	6.5(4.9)	6.0(4.6)	7.4(4.3)	14.5(6.2)	8.2(4.8)	8.2(4.9)	0.0001
Smoking score	3.1(1.3)	4.6(2.1)	3.2(1.5)	3.3(1.5)	3.1(1.3)	5.0(1.7)	3.2(1.4)	3.6(1.7)	0.0001
Food choice	10.7(5.4)	12.8(6.5)	11.4(5.9)	10.9(5.1)	13.2(5.5)	15.6(6.1)	13.6(5.4)	12.7(5.1)	0.0001
BMI	21.6(3.5)	21.7(3.6)	20.9(2.7)	21.3(2.7)	22.1(3.9)	21.9(3.8)	21.4(3.0)	21.4(3.1)	0.05
Heart rate	75.2(12.2)	72.9(11.3)	75.9(11.4)	76.3(11.7)	82.7(12.9)	78.6(11.4)	78.2(11.3)	78.6(10.6)	0.0001
Triceps skin fold	11.3(5.1)	11.2(5.3)	11.2(4.9)	10.6(4.8)	20.4(6.5)	20.0(6.3)	18.8(5.2)	20.3(5.6)	0.004
Subscap skin fold	9.7(4.3)	9.6(4.6)	9.3(4.1)	9.1(3.5)	13.9(6.0)	13.4(5.6)	12.1(4.7)	13.0(4.7)	0.01
Systolic BP	119.0(12.1)	123.0(12.0)	122.2(12.6)	124.1(12.8)	116.0(11.0)	114.2(11.3)	113.4(9.6)	113.7(9.5)	0.84
Diastolic BP	58.5(9.1)	59.5(8.9)	59.5(8.5)	59.7(8.3)	60.6(7.5)	60.1(9.2)	59.2(7.7)	57.2(8.3)	0.009

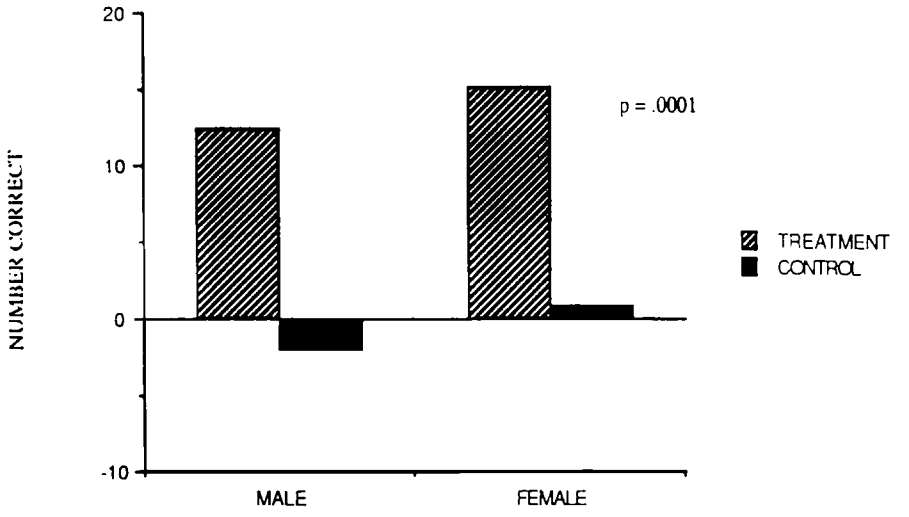

Figure 1. Mean Increase in Number of Correct Answers Given on Knowledge Test.

group who, at baseline, were not exercising regularly became regular exercisers at follow-up (Treatment = 30.2%; Control = 20%, χ^2 (1) = 8.6, $p < 0.0003$). *Nutrition/diet:* At follow-up, students in the treatment group were more likely to report that they would choose heart healthy snack items than their control group counterparts. The mean increase in selection of heart healthy food alternatives for boys and girls in the treatment group was, respectively 2.1 and 2.3. Reported selection for boys and girls in the control group actually decreased (Main effect: $F(1,850) = 56.6$, $p < 0.0001$, Sex effect: $F(1,850) = 10.4$, $p = 0.001$). *Cigarette smoking:* The authors classified students into three groups according to their *baseline* smoking status: (1) never smoked; (2) experimental smokers (smoking on a monthly basis or less); (3) regular smokers (smoking weekly or more). There were no significant differences between groups in (1) the proportion of never smokers "graduating" to smoking at follow-up (treatment 9.7%; control 14.5%, $p = 0.25$) and (2) the proportion of regular smokers reporting cessation at follow-up (treatment 3.5%, control 9.3%, $p = 0.39$). However, in the treatment group more of those students who, at baseline, were experimental smokers reported quitting at follow-up [treatment (28.5%), control (17.6%)] (Fig. 2). In addition, only 5.6% of baseline experimental smokers in the treatment group graduated to regular smoking compared to 10.3% in the control group. The overall chi-square for the analysis examining change in status of baseline experimental smokers was significant (χ^2 (2) = 9.4, $p = 0.009$).

Changes in Physiologic/Anthropometric Variables: Treatment vs. Control

Physiologic/anthropometric variables: The strongest and most consistent effects were achieved with resting heart rate. Both boys and girls in the treatment group reduced their resting heart rate compared to their control group counterparts (Fig.3). Boys and girls in the treatment group decreased resting heart rate on an average of 2.3 and

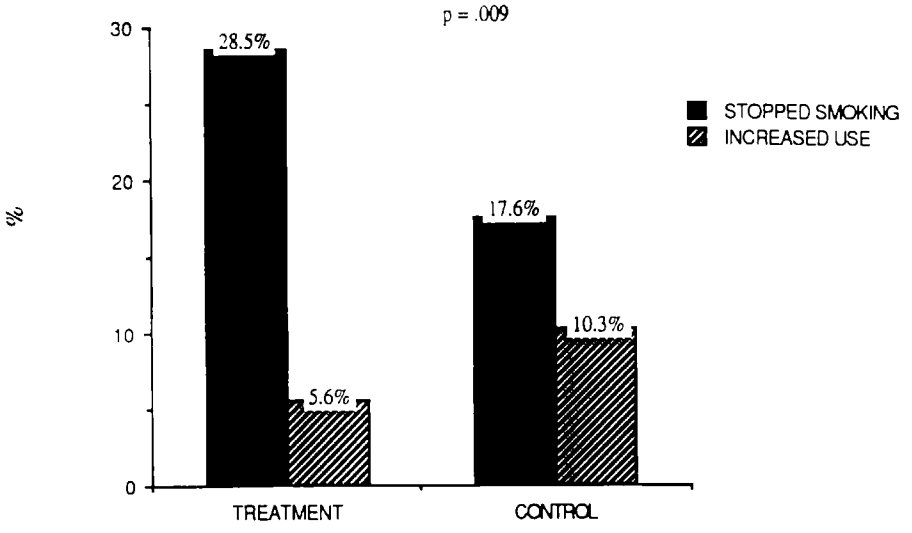

Figure 2. Baseline Experimental Smokers Who Changed Status-Baseline to Follow-up.

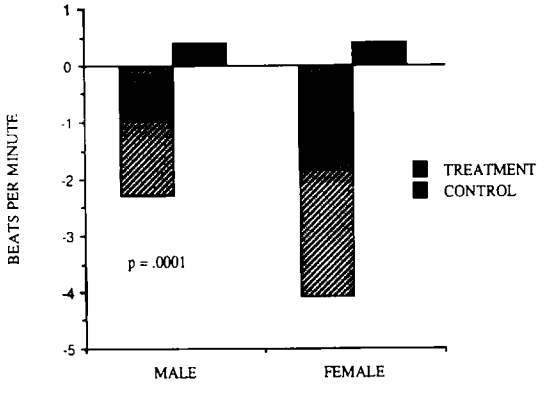

Figure 3. Mean Change in Resting Heart Rate.

4.1 beats per minute respectively. Boys and girls in the control group increased resting heart rate on an average of .4 beats per minute (main effect: $F(1,1065) = 19.9$, $p < 0.0001$, sex effect: $F(1,1065) = 5.8$, $p < 0.02$). Beneficial treatment effects also were observed for BMI (main effect: $F(1,1060) = 3.7$, $p = 0.05$, sex effect: $F(1,1060) = 21.9$, $p < 0.0001$), triceps skinfold thickness (main effect: $F(1,1059) = 8.4$, $p = 0.004$, sex effect: $F(1,1059) = 80.9$, $p < 0.0001$, Sex x Treatment effect: $F(1,1059) = 36.3$, $p < 0.0001$), and subscapular skinfold thickness (main effect: $F(1,1058) = 6.4$, $p = 0.01$, sex effect: $F(1,1058) = 37.5$, $p < 0.0001$, Sex x Treatment effect: $F(1,1058) = 15.9$, $p = 0.0001$).

No treatment effect was observed for systolic blood pressure ($p = 0.84$). Changes in diastolic blood pressure actually favored controls. Boys in the treatment and control groups increased diastolic BP an average of 1.0 mm Hg and 0.2 mm Hg respectively. Girls in the treatment group decreased an average of 0.5 mm Hg while control group girls decreased an average of 2.0 mm Hg (treatment effect: $F(1,1065) = 6.7$, $p = 0.009$).

DISCUSSION

This study is one of the first controlled trials of a school-based CVD risk factor reduction program for high school-age adolescents. The results to date are very promising. Knowledge gains were pronounced. Students in the treatment group increased their knowledge of CVD risk factor concepts an average of 50%. The knowledge gains are evidence that the curriculum was well designed, delivered, and received.

Students' self-reports suggest that significant changes were made in several important CVD risk-related behaviors. With respect to physical activity, a significantly greater proportion of students in the treatment group who were initially classified as nonregular exercisers reported regular physical activity at follow-up. The finding that regular exercisers had significantly lower resting heart rates than nonregular exercisers lends credibility to the validity of the self-report measure.

The impact of the program on cigarette smoking was also encouraging. While smokers with daily habits were largely unaffected, the quit rate among experimental smokers in the treatment group was significantly greater than the quit rate for experimenters in the control group. Smoking prevention programs have targeted younger age groups because attempts to modify smoking behavior during the high school years typically prove unsuccessful. The results suggest that a comprehensive program may be one approach to the problem of reducing smoking among older adolescents who have not adopted smoking on a daily basis.

Self-reports of smoking and use of other substances may be unreliable.[52] However, strong correlations between self-reports and biochemical and observational measures have been consistently reported.[53,54] Extensive efforts were undertaken to assure confidentiality to all participating students. This is reflected in the high response rates to the substance use items. The authors also included a validation measure in the form of expired-air CO, a useful measure of recent cigarette use. Although expired-air CO is not responsive enough to detect the occasional use of cigarettes by experimental smokers, the correlation between CO and frequent smoking increases the author's confidence in the validity of self-reported smoking in this study.

The program also had an impact on important physiologic variables. Effects were particularly strong for resting heart rate. Both boys and girls in the treatment group significantly reduced resting heart rate compared to controls. This finding is encouraging since resting heart rate provides a reasonably good index of physical fitness.

Reductions in body fat were also achieved although the impact of the program appeared more consistent for girls. Reductions in all measures of body fat were observed among girls in the treatment condition while control group girls increased on skinfold thickness measures. Boys in both groups reduced on measures of skinfold thickness but increases in body mass index were greater for boys in the control group.

The intervention had no apparent impact on blood pressure. Systolic blood pressure dropped in treatment girls but diastolic blood pressure dropped in control girls. Between visit variance of blood pressure is very large in adolescents and may well account for these findings.[55]

The relationship between self-reported behavior change and the various related physical measures is worth emphasizing. Resting heart rate is an indirect measure of aerobic capacity and thus related to physical activity. Body mass index and skinfold thickness, as measures of adiposity, may be related to both dietary intake and physical activity. Finding differential group changes in these secondary variables that correspond

to self-reported changes in behavior greatly strengthens confidence in the validity of the authors' self-reported measures, as well as the demonstrated treatment effects.

Although the results of this trial are promising, several limitations should be mentioned. Follow-up assessments were conducted two months after the completion of the educational program. It is unclear whether the gains observed in the treatment group will be maintained over a longer period of time. However, it would seem reasonable to integrate risk reduction programs into the general school curricula at more than one grade level in order to achieve maximum benefit. The authors plan to collect longer term follow-up data to assess the durability of treatment effects.

Treatment and control group equivalence on potentially confounding variables is less certain when only a few schools are included in the research design.[56] Ideally, the authors would wish to randomize schools to treatment and control conditions from a large pool of participating schools. However, practical concerns (i.e., funding limitations and the logistical difficulties of managing multisite studies) have traditionally limited studies to a small number of schools. This somewhat undermines the primary intent of randomization, for equivalence between comparison schools due to randomization is potentially limited when a small number of schools are involved.

Several approaches were used to control for potential confounding variables. These methods served to increase confidence that the demonstrated effects were due to the interventions, by addressing threats to internal validity. First, extreme care was taken to choose schools that were similar on a variety of demographic variables. Then, schools were randomly assigned to treatment and control conditions from within school districts. The decision to randomize from within districts was based on evidence indicating that intradistrict homogeneity was greater than interdistrict homogeneity.

Graham et al.[57] have described a number of variables which, if not equated across experimental conditions, may make interpretation of school-based prevention research difficult. Important correlates include ethnic distribution in the school population, total enrollment, percentage of students bused in, percentage of students not in school a full year and cooperation with researchers. In the present study, ethnic group proportions and total enrollments were well matched for schools within each district, no students were bused into the districts, there was no substantial differential attrition, and cooperation between the schools and the research team was excellent.

In addition to the school characteristics discussed above, schools should ideally be comparable on pretest variables that may be related to the chosen outcome variables. In this study, treatment and control conditions were compared, and found to be comparable, on a variety of baseline treatment and treatment-related variables such as use prevalences of cigarettes, marijuana, and alcohol and baseline CVD knowledge scores. These data suggest good baseline comparability of the experimental groups, despite randomization of only four schools in all. Further, the finding that treatment and control dropouts were similar on most baseline measures adds to the authors confidence that the internal validity of the research was maintained. While dropouts did differ on triceps skinfold thickness, the difference favored controls, making detection of a treatment effect more difficult.

The generalizability of these finding depends, in part, on the representativeness of the study population. The study schools were chosen to reflect a fairly broad range with respect to ethnicity and socioeconomic status. While the school districts contained few Black students (2.0%), other minorities accounted for almost 30% of the sample. Other data also suggest the comparability of the sample to the general popu-

lace. For example, the authors have reported data on substance use in this population.[16] About 47% of the boys and 45% of the girls report current use of alcohol to be monthly or more in frequency. About 22% of the boys and 30% of the girls report smoking at least monthly. These data are quite similar to results reported from larger-scale regional or national samples.[58,59]

In summary, the results of this trial strongly suggest that it is possible to increase adolescents' understanding of CVD risk factor concepts, to modify a number of relevant CVD risk factor behaviors and to effect changes in certain physiologic parameters. Taken together, the findings indicate that potentially effective CVD risk reduction training may be provided to a large segment of the population through school-based primary prevention education.

FUTURE DIRECTIONS FOR SCHOOL-BASED HEALTH BEHAVIOR CHANGE

Dissemination

Officials in the Center for Health Promotion and Education of the federal Centers for Disease Control (CDC) have called dissemination "the most critical problem for school health education."[60] However, very little controlled research has addressed the question of how health behavior change curriculum are best disseminated from research settings to regular school environments.

The authors believe that the issues of provider training and implementation monitoring as identified by Best and colleagues[61] deserve research priority. In discussions with regular classroom teachers concerning the implementation of the Stanford Adolescent Heart Health Program, the staff expressed doubts about their abilities to deliver the curriculum effectively without training. In particular, they sought training to improve both their own knowledge of cardiovascular disease risk concepts and their preparation with respect to nonlecture educational formats. Within the participating school districts, the current standard of teacher preparation for introduction of new curricula is limited to self-study of curriculum materials. Based on discussions with teachers, the authors believe they require specialized instruction and preparation in order to implement programs such as ours effectively. Two specific roles are suggested for teacher training: (1) sophisticated instruction on health concepts applicable to the program, cardiovascular disease risk factors in this case and (2) instruction facilitating the development of innovative teaching skills. While most health behavior change programs emphasize interactive and active learning, it is found that classroom teachers express discomfort with nonlecture teaching methods. Research on the logistics of accomplishing such teacher training, and a confirmation that it is even necessary, is the challenge at hand.

Implementation monitoring is another important component of the dissemination research process. Researchers need to know how the program is actually used in the natural school setting, by regular classroom teachers. Research can focus on several aspects of the implementation process: how the program is perceived, whether the program is delivered as planned, how teacher-student interactions are perceived, whether all planned issues, activities, informational content, and teaching/learning methods are utilized, etc. These evaluations can be made by students, teachers, school

administrators, or trained observers, and can take the form of self-report paper and pencil assessments, structured or open interviews, or direct observation.

Despite its obvious import, dissemination research in the field of school-based health behavior change is still in its infancy. The authors have but scratched the surface in our discussion of relevant issues and methods. Dissemination research must also cross into the areas of organizational behavior, public policy and economic analysis, to name a few. As mentioned above, dissemination of school health behavior change programs presents the most important and challenging directive facing school health researchers today. The authors cannot estimate the potential benefit to the nation's health that would result from effective dissemination of programs like the Stanford Adolescent Health Program. However, the preliminary results of controlled trials suggest the potential for substantial short-term changes in risk factors. At this time effects on long-term outcomes are of course unknown. Only through dissemination research will we learn whether health behavior change programs can be cost-effectively implemented in the schools on a large-scale basis.

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