Sustained Benefit Over Four-Year Follow-Up of Michigan's Project Healthy Schools

Nicole Corriveau, BS, Taylor Eagle, BS, Qingmei Jiang, MA, MS, Robert Rogers, BA, Roopa Gurm, MS, Susan Aaronson, RD, MA, Lindsey Mitchell, MPH, Jean DuRussel-Weston, RN, MPH, Eva Kline-Rogers, RN, MS, Kim A. Eagle, MD, and Elizabeth A. Jackson, MD, MPH

Objectives. We determined the sustainability of effects of a school-based intervention to improve health behaviors and cardiovascular risk factors among middle school children.

Methods. We administered a questionnaire and health screenings to 5 schools in Ann Arbor and 2 schools in Ypsilanti, Michigan. We assessed demographics, physiological factors, diet, physical activity, and sedentary behaviors from 1126 students who received a health curriculum (Project Healthy Schools) in the fall of sixth grade in 2005, 2006, and 2007. We administered the questionnaire and screening again in the spring and each subsequent spring through ninth grade to all available, consenting students.

Results. In the 4 years following the school-based intervention, total cholesterol, low-density lipoprotein cholesterol, and triglycerides improved, and for most years systolic and diastolic blood pressure improved. Serum glucose and body mass index did not change. Physical activity increased and sedentary behaviors diminished.

Conclusions. Project Healthy Schools is associated with sustainable improvements in both cardiovascular parameters and healthy behaviors. (*Am J Public Health.* 2015;105:e19–e25. doi:10.2105/AJPH.2015.302835)

The rate of childhood obesity in the United States has more than tripled in the past 30 years. As of 2012, almost one third of children and adolescents were overweight or obese.[1] Obesity sets the stage for a host of potential health problems, including cardiovascular disease, diabetes, cancer, kidney disease, osteoarthritis, and depression.[2] Being obese as a child increases the risk of being obese as an adult, leading to increases in cardiovascular risk.[3] Consequently, sustainable community-based interventions that improve wellness among children and adolescents have significant public health implications. However, data on long-term changes in health behaviors after such interventions are limited.

Project Healthy Schools (PHS) is a collaboration between the University of Michigan and local community organizations, including public schools. It is designed to increase physical activity and promote healthier choices to reduce childhood obesity and the associated long-term cardiovascular risks. PHS has collected data on long-term changes after the implementation of a school-based wellness curriculum, which offers a unique opportunity to examine the sustained effects of a school-based intervention in communities with varying demographics and resources. We examined changes in health behaviors and physiological parameters from baseline to 4 years postintervention among students who had received the PHS curriculum in their middle schools to address the potential long-term benefit of implementing this program.

PHS promotes 5 main goals:

1. eating more fruits and vegetables,
2. choosing less sugary foods and beverages,
3. eating less fast and fatty foods,
4. being active every day, and
5. spending less time in front of a screen (i.e., televisions, computers, video games, or mobile devices).

The program has 3 key components: education, environmental change, and measurement. The educational component consists of 10 in-class, hands-on lessons that are taught to sixth-grade students by a PHS health educator, a program staff member working in the schools, or a teacher from the school. The lessons are presented in the homeroom class period or built into the health or science curriculum. Each lesson is approximately 20 minutes, resulting in a total of 3 hours and 20 minutes of health education in the classroom. These learning activities are designed to be fun and interactive for middle school children while emphasizing the program's 5 goals. PHS targets the middle school population, because during this time students are gaining more independence and are better able to make lifestyle decisions. In addition to the in-class learning activities, a series of larger assemblies are held throughout the year that promote healthy lifestyles, and classroom awards are presented for the practice of healthy habits.

The PHS environmental change component incorporates significant modifications in the school cafeteria in cooperation with the school's food service vendor. Such modifications include adding a salad bar with fresh vegetable choices, adding healthy snack options such as carrots and celery with peanut butter, and replacing high-sugar beverages and fried snacks with healthier alternatives.

The effectiveness of the program is measured through an optional health screening and a health behavior questionnaire that assesses dietary, physical activity, and sedentary habits. Full details of the PHS program have been published elsewhere.[4,5]

METHODS

Sixth- and seventh-grade students from 5 schools in Ann Arbor, Michigan (median household income $56 612), and 2 schools in neighboring Ypsilanti, Michigan (median household income $28 610), were eligible for this study.[6] We selected these schools because they represented all public middle schools in these 2 communities and were the first set of schools to incorporate PHS into their curricula. We sent home consent forms and a description of the PHS program to the parents. Students who participated in this study were enrolled in the fall during the years 2005, 2006, and 2007 and completed a follow-up measurement in the spring through 2009 and 2010.

All sixth-grade students received the PHS curriculum in their first middle school year, but we included only those who provided written consent and whose parents also provided written consent in our analysis. We included only students who participated for at least 2 years in our analysis. Students were allowed to opt out of the laboratory screening and physical assessment, the completion of the self-reported questionnaire, or both. We administered surveys and health screenings before and after the PHS intervention to the sixth- and seventh-grade students and each subsequent year in the spring, through ninth grade. If students were absent for the day of screening, we scheduled a make-up screening; however, we did not provide additional time to make up a missed survey.

Data Collection

We collected demographic information regarding age, race/ethnicity, and gender for all consenting students. Information collected as part of the wellness screening included resting heart rate, heart rate recovery, blood pressure, height and weight, and serum lipids. We measured resting heart rate using a stethoscope over the student's upper sternum for 1 minute while the student was sitting quietly. We measured heart rate recovery for 1 minute in a similar manner after the student completed a step test. The step test consisted of students stepping up and down on a bench following a 96 beats per minute cadence for 3 minutes under program supervision. We measured blood pressure 3 times using an automated blood pressure monitor, Mabis, model 04–244-001 (Mabis Health Care, Waukegan, IL). We averaged the final 2 measurements and recorded them as the mean systolic and diastolic blood pressure.

We measured height using a stadiometer with the student's shoes removed. We measured weight to the nearest 0.1 kilogram. We standardized measurement techniques across all health screening workers. We calculated body mass index (BMI; defined as weight in kilograms divided by the square of height in meters) and adjusted it for gender and age on the basis of the national averages according to the Centers for Disease Control and Prevention.[7] We defined overweight and obesity as a BMI in the 85th to less than 95th percentile and 95th percentile or higher, respectively. We measured serum lipids using 30- to 50-mircoliter finger-prick blood samples analyzed with a Cholestech LDX machine (Hayward, CA). We did not take the lipid panel in the fasting state. The research team and school administrators determined that it would be unwise to suggest middle school students fast throughout the night and morning, recognizing that the time of lipid assessment varied between schools.

We collected these physiological measurements in the fall of each sixth- or seventh-grade school year (before the initiation of the PHS curriculum), in the spring of the sixth- or seventh-grade year (post-PHS intervention), and then annually each spring through ninth grade (in all consenting, available students).

We collected data on health behaviors with a standardized questionnaire. This questionnaire is an abbreviated School Physical and Nutrition survey, a validated tool used to evaluate students of this age group.[8] Questions pertaining to diet included a 24-hour recall of servings of fruit, vegetables, meat, fried meat, snack-type food, and dairy products. We also recorded servings of French fries or chips and sugar-containing beverages. We reported student responses on a scale from 0 to 3 or more times.

We recorded physical activity throughout the 7 days before testing. We asked students to recall the number of days in which they participated in vigorous activity for 20 or more minutes and moderate activity for 30 or more minutes. We also addressed physical education classes, school-based sports teams, and participation in teams outside school. Students self-reported sedentary activities, including watching television, mindless computer time (e.g., time spent on social media sites, chatting with friends, or playing games), and time spent playing video games, on an hourly scale of 0 to 6 hours or more per day.

We trained study site coordinators and provided them with a protocol for data entry. We created standardized data forms to ensure a high degree of accuracy in data entry. We flagged incomplete forms, inconsistencies, and values outside the set limits; investigated them for error; and corrected them whenever possible. We excluded inconsistencies that could not be resolved from analysis.

Statistical Analysis

We summarized categorical variables using counts and percentages; we summarized discrete survey and continuous variables using means and SDs. To assess changes between baseline and each follow-up, we used a repeated-measures analysis of variance with unstructured variance and covariance structure for continuous physiology measurements because of its ability to handle missing values. We used the Wilcoxon signed-rank test for discrete survey variables. We conducted all analyses using SAS version 9.3 (SAS Institute, Cary, NC).

We entered all data into Microsoft Access, version 15.0 (Microsoft Corp., Redmond, WA) at the Michigan Cardiovascular Outcomes Research and Reporting Program. Univariate analyses using questionnaire data included the χ^2 test for comparisons between discrete variables and the *t* test for continuous variables. For all analyses, we considered a *P* value of less than .05 significant.

RESULTS

We included results from 1126 middle school students (Table 1). A larger number of students in Ann Arbor than in Ypsilanti completed both the surveys and the screenings. Approximately half of all students were girls in both Ann Arbor and Ypsilanti. A majority of the Ann Arbor students who completed the surveys and screenings were White, whereas 43% of the Ypsilanti students were African American and 38% were White. Overweight and obese rates were modestly higher among the Ypsilanti students.

Among students who participated in the health screening, we noted improvements in several physiological parameters after the PHS curriculum, many of which were sustained over a long-term period (Table 2; Figure 1). For the

TABLE 1—Baseline Characteristics Among Middle-School Children in 2 Communities: Project Healthy Schools, Michigan, 2005–2010

Characteristic	Survey, No., Mean ±SD, or No. (%)	Screening, No., Mean ±SD, or No. (%)
Ann Arbor schools		
Sample size	740	889
Age, y	13.6 ±0.51	12.9 ±0.44
Girl	362 (52)	362 (52)
Race/ethnicity[a]		
African American	83 (12)	100 (11)
Asian	103 (15)	137 (16)
Caucasian	428 (62)	535 (61)
Hispanic	27 (4)	33 (4)
Native American	8 (1)	9 (1)
Other	44 (6)	61 (7)
Body mass index (kg/m^2) categories		
Overweight (85th to < 95th percentile)		154 (18)
Obese (≥ 95th percentile)		118 (14)
Ypsilanti schools		
Sample size	230	237
Age, y	13.7 ±0.61	13.1 ±0.57
Girl	110 (48)	110 (48)
Race/ethnicity[a]		
African American	97 (43)	103 (43)
Asian	2 (1)	2 (1)
Caucasian	87 (38)	90 (38)
Hispanic	12 (5)	12 (5)
Native American	3 (1)	3 (1)
Other	27 (12)	28 (12)
Body mass index (kg/m^2) categories		
Overweight (85th to < 95th percentile)		46 (20)
Obese (≥ 95th percentile)		52 (23)

Note. Surveys included items on diet and activities (physical and sedentary activities). We did not collect height and weight as part of the survey. Screening included physiological measures.
[a]Race/ethnicity was an optional variable on the survey; not all students indicated their race/ethnicity for this study.

Ann Arbor group, we noted improvements in total cholesterol, low-density lipoprotein (LDL) cholesterol, and triglycerides in the first year. These improvements were sustained among students who completed follow-up in the second through fourth years following the program. Among the Ypsilanti students, we noted significant improvements in total cholesterol, LDL cholesterol, and triglycerides in the first year. These improvements were sustained through all 4 follow-up years for total cholesterol and LDL cholesterol.

We also observed reductions in systolic and diastolic blood pressure in the first year post-PHS intervention in the Ann Arbor group, but in subsequent years the blood pressure was mildly increased. For the Ypsilanti students, we observed an increase in blood pressure at each time point measured. In both groups mean blood pressures were not clinically elevated.

We also examined resting heart rate and heart rate recovery, which are indirect measures of fitness. For the Ann Arbor students, resting heart rate decreased post-PHS intervention and continued to be lower than baseline for each subsequent year; heart rate recovery was not significantly improved. For the Ypsilanti students, resting heart rate was mildly lower among those followed through years 3 and 4; heart rate recovery was improved in the first year but not in subsequent years. In both the Ann Arbor and Ypsilanti groups, BMI increased over the 4 years of follow-up.

Using data collected from the surveys, we observed changes in self-reported behaviors related to physical and sedentary activities. We determined these changes by comparing responses at baseline (preintervention) to their annual follow-up responses (postintervention) for students who were available at the time of follow-up. Ann Arbor students reported increases in physical activity each year, but some increases were not statistically significant (Table 3). We noted increased sport participation for all but the fourth year. This may reflect the transition to high school, where many teams have tryouts and thus are not completely inclusive.

In regard to sedentary activities, we observed no changes in television time per day; however, we noted reductions in video game time in all 4 years. We observed increases in computer time in the second through fourth years following the program. The Ypsilanti students demonstrated favorable changes in physical activity and sports team participation, which increased each year with the exception of year 3; however, many of these comparisons were not statistically significant, likely owing to a smaller sample size.

Among the Ypsilanti students, we noted decreases in time spent watching television for all years (statistical significance was not reached for year 2). Additionally, time spent playing video games decreased for years 2 through 4 of follow-up. Computer time was similar for all years examined.

We also examined dietary behaviors over time. Students were asked about the numbers of servings of healthy (fruits and vegetables) and unhealthy (chips and sugary beverages) foods at each follow-up examination. In general, both groups exhibited few changes in dietary patterns (data available as a supplement to the online version of this article at http://www.ajph.org). Ann Arbor students reported a modest increase in fruit consumption and a trend in increased vegetable intake after year 1. We noted a slight decrease in fried meats in year 4 among Ypsilanti students and an increase in vegetable consumption (significant in year 2).

TABLE 2—Physiological Measurements: Project Healthy Schools, Michigan, 2005–2010

Measure	Baseline, No. or Mean ±SD	First Follow-Up, No. or Mean ±SD	Second Follow-Up, No. or Mean ±SD	Third Follow-Up, No. or Mean ±SD	Fourth Follow-Up, No. or Mean ±SD
Ann Arbor schools					
Sample size	889	883	806	272	262
Lipids, mg/dL					
Total cholesterol	167.69 ±1.03	157.59 ±1.04***	152.07 ±1.11***	140.51 ±1.36***	150.13 ±1.26***
LDL cholesterol	89.35 ±1.01	85.73 ± 0.97***	82.83 ±1.01***	72.78 ±1.33***	84.49 ±1.16***
HDL cholesterol	53.84 ±0.48	49.95 ± 0.46***	50.37 ±0.49***	49.62 ±0.62***	48.39 ±0.69***
Triglycerides	129.39 ±3.00	113.63 ± 2.60***	98.38 ±2.12***	98.05 ±3.22***	92.95 ±2.99***
Random glucose, mg/dL	96.50 ±0.65	94.58 ±0.71**	96.95 ±0.72	96.65 ±0.95	92.40 ±0.78***
Blood pressure, mm Hg					
Systolic blood pressure	101.76 ±0.62	97.26 ±0.65***	105.81 ±0.47***	108.76 ±0.60***	111.45 ±0.56***
Diastolic blood pressure	60.43 ±0.39	57.02 ±0.39***	62.02 ±0.31***	61.77 ±0.41**	63.03 ±0.42***
Resting heart rate, BPM	81.08 ±0.40	79.58 ±0.35***	78.49 ±0.36***	78.20 ±0.60***	75.94 ±0.65***
Heart rate recovery, BPM	103.65 ±0.63	104.22 ±0.57	102.52 ±0.59	101.96 ±0.94	101.43 ±0.97*
Body mass index, kg/m^2	19.81 ±0.13	20.25 ±0.14***	21.31 ±0.17***	21.99 ±0.17***	22.65 ±0.18***
Ypsilanti schools					
Sample size	237	237	235	149	50
Lipids, mg/dL					
Total cholesterol	159.97 ±2.24	148.64 ±1.75***	148.16 ±1.84***	149.25 ±1.87***	147.21 ±2.98***
LDL cholesterol	90.32 ±1.91	78.98 ±1.59***	80.68 ±1.66***	78.92 ±1.85***	73.64 ±2.70***
HDL cholesterol	51.03 ±1.00	51.83 ±1.00	49.74 ±1.01	48.76 ±1.01*	51.15 ±1.63
Triglycerides	100.72 ±4.92	91.33 ±3.67*	95.64 ±4.07	110.78 ±5.61	93.05 ±5.65
Random glucose, mg/dL	97.85 ±1.05	96.21 ±0.82	96.33 ±0.98	94.72 ±1.23*	98.43 ±2.16
Blood pressure, mm Hg					
Systolic blood pressure	106.54 ±0.65	108.03 ±0.67**	111.67 ±0.72***	111.63 ±0.83***	115.04 ±1.24***
Diastolic blood pressure	62.31 ±0.45	62.87 ±0.46	63.53 ±0.50*	65.27 ±0.58***	69.84 ±0.82***
Resting heart rate, BPM	79.78 ±0.73	81.30 ±0.68*	79.00 ±0.68	77.03 ±0.80**	76.70 ±1.34*
Heart rate recovery, BPM	111.23 ±1.22	106.93 ±1.32**	111.37 ±1.49	111.09 ±1.68	115.20 ±2.33
Body mass index, kg/m^2	21.62 ±0.35	22.24 ±0.41**	23.01 ±0.40***	24.05 ±0.42***	24.69 ±0.49***

Note. BPM = beats per minute; HDL = high-density lipoprotein; LDL = low-density lipoprotein. *P* values indicate that there is a significant difference in physiological means between each follow-up and baseline measurement.
*$P \le .05$; **$P \le .01$; ***$P \le .001$.

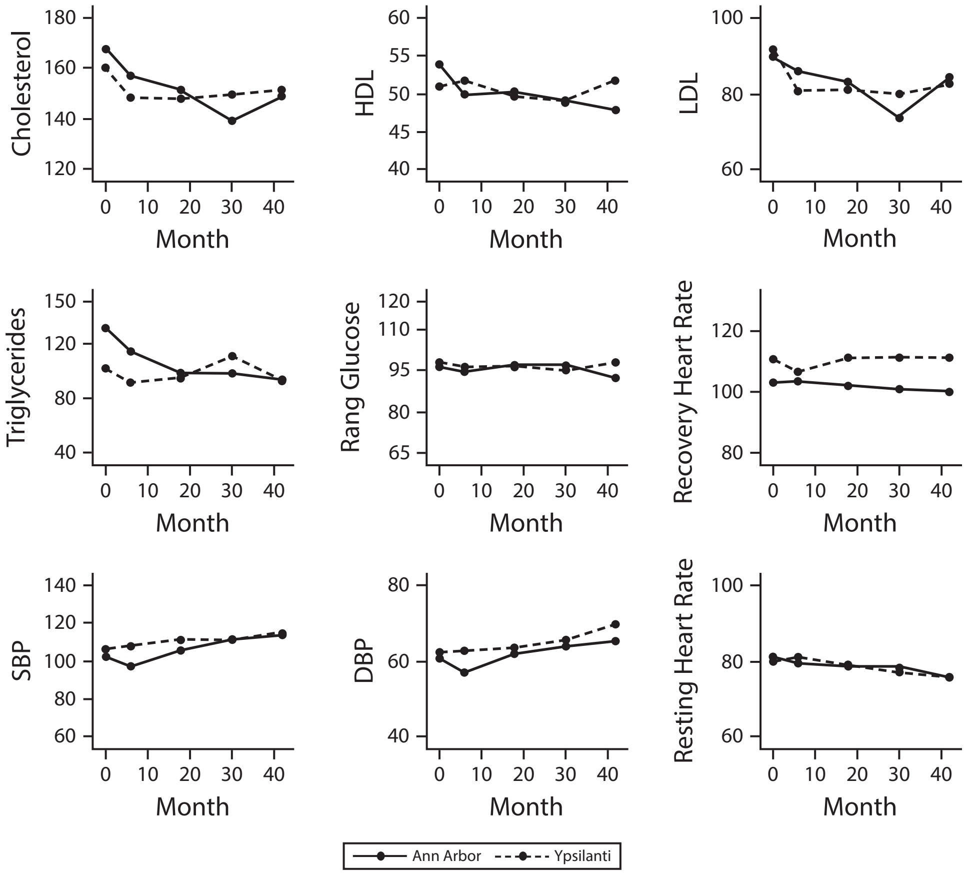
DISCUSSION

The school-based PHS intervention, which incorporates substantial community involvement, was associated with improvements in physiological markers of cardiovascular risk, including serum lipids and blood pressure, over a 4-year follow-up period. We observed increases in physical activity and reductions in sedentary behaviors. Among the middle school students we followed through their first year of high school, we observed sustained improvements in total cholesterol and LDL cholesterol.

Physiological Measures

Several large cohort studies of children have reported that higher lipid levels were associated with cardiovascular disease events in adulthood, whereas others have observed a strong correlation between blood pressure levels in childhood and those in adulthood.[9–13] The Bogalusa Heart Study, a longitudinal study of children followed into adulthood in Bogalusa, Louisiana, suggested lipid levels during childhood are strongly associated with lipid levels and severity of atherosclerosis in adulthood.[10] Using autopsy data, Bogalusa investigators observed that serum lipids, blood pressure, and BMI in childhood were positively correlated with fatty streak and fibrous plaque deposition in the aorta and coronary arteries.[14] The investigators concluded that health education in schools was a unique opportunity for long-term cardiovascular prevention. A similar association between lipid levels in childhood and those in young adulthood was observed in the 2446 children from the Muscatine study in Muscatine, Iowa.[11]

We did not see an improvement in glucose over time, but a major limitation was the collection of samples in a nonfasting state for some children. Because of the importance of breakfast and the need to complete physiological evaluations during school hours, we were



Note. DBP = diastolic blood pressure; HDL = high-density lipoprotein; LDL = low-density lipoprotein; SBP = systolic blood pressure.

FIGURE 1—Physiological measures: Project Healthy Schools, Michigan, 2005–2010.

unable to ensure that all participants had fasted.

The lack of change in BMI over time is somewhat unsurprising. Changes in BMI often require an intensive effort with individual counseling.[15,16] Long-term follow-up from the Cardiovascular Health Trial, a school and family intervention, did not demonstrate an improvement in BMI.[9,17] Planet Health observed improvements in rates of obesity among girls randomized to an intervention compared with a control group. However, no difference was noted in the boys. Planet Health was a randomized trial of a school-based intervention, which incorporated health messages into 4 major themes in addition to physical education classes.[18] This suggests that more intensive physical education may benefit some children. By contrast, PHS is embedded in the classroom for 10 sessions during the fall as opposed to multiple times per day throughout the year. Further research is warranted to examine gender differences related to the intensity of the educational wellness curriculum.

In our previous work, we observed a correlation between heart rate recovery, a marker of fitness, and higher LDL cholesterol and lower high-density lipoprotein (HDL) cholesterol.[19] Heart rate recovery was also associated with BMI and resting heart rate; those who were less fit (i.e., had a higher heart rate recovery) had higher BMIs and higher resting heart rates. We observed reductions in resting heart rate, which was sustained in the Ann Arbor cohort. Among the Ypsilanti students, we observed reductions for most years. We did not observe a significant change in heart rate recovery for either group. This may relate to changes in school sport participation. Over time, many school systems have implemented pay-to-play policies. Furthermore, team sports in later grades often start with tryouts and thus do not include all children who want to participate. Understanding the access barriers to exercise venues (team sports or alternative activities) in relation to indicators of health, including heart rate recovery, is necessary to improve cardiovascular health among children and adolescents.

Health Behaviors

By contrast to our heart rate findings, we observed increases in reported vigorous and moderate physical activity more for the Ann Arbor group than for the Ypsilanti group. School sport team participation was highly variable in the Ypsilanti groups. This likely stems from a small sample size at each follow-up. The differences we observed between groups may also reflect differences in resources available to schools and families in the 2 communities.[20] In an earlier study of these communities, we observed significant differences between school-based activities and

TABLE 3—Self-Reported Physical Activity and Sedentary Behaviors at Baseline and Annual Follow-Up Among School Children in 2 Communities: Project Healthy Schools, Michigan, 2005–2010

Variable	First Follow-Up, Mean		Second Follow-Up, Mean		Third Follow-Up, Mean		Fourth Follow-Up, Mean	
	Baseline	Follow-Up	Baseline	Follow-Up	Baseline	Follow-Up	Baseline	Follow-Up
Ann Arbor schools								
Sample size	740	672	739	739	263	263	252	252
Physical Activities								
20-min vigorous physical activity, sessions/wk	4.61	4.95***	4.61	4.76	4.54	4.85	4.48	4.65
30-min moderate physical activity, sessions/wk	3.49	3.94***	3.47	4.08***	3.48	4.22***	3.5	3.72
School sports team, no. of teams	1.15	1.61***	1.13	1.32***	1.25	1.45*	1.23	1.20
Sedentary activities								
TV time, h/d	1.56	1.52	1.59	1.55	1.43	1.47	1.43	1.34
Computer time, h/d	1.07	1.13	1.06	1.29***	0.95	1.36***	0.93	1.32***
Video games time, h/d	0.80	0.70**	0.80	0.67**	0.67	0.54**	0.66	0.52*
Ypsilanti schools								
Sample size	230	225	223	223	143	143	50	50
Physical Activities								
20 min vigorous physical activity, sessions/wk	3.99	4.29	3.94	4.04	3.97	3.63	3.92	3.56
30 min moderate physical activity, sessions/wk	3.25	3.60	3.22	3.22	3.21	3.26	3.38	2.88
School sports team, no. of teams	0.57	0.65	0.58	1.02***	0.56	0.85**	0.56	1.04**
Sedentary activities								
TV time, h/d	2.71	2.42*	2.7	2.57	2.82	2.33***	3.15	2.34**
Computer time, h/d	1.35	1.38	1.35	1.53	1.45	1.60	1.65	1.56
Video games time, h/d	1.43	1.45	1.43	1.19*	1.33	1.07*	1.72	1.20*

Note. P values indicate that there is a significant difference between a follow-up and the baseline. Each comparison included only those students who were available at the time of follow-up.
$^{*}P \le .05$; $^{**}P \le .01$; $^{***}P \le .001$.

sports teams. We also noted higher BMIs and greater time spent in sedentary behaviors (video games and television watching) among the Ypsilanti students.

Regarding sedentary behaviors, we observed encouraging reductions in video game playing for both groups. Also encouraging was decreased television watching in the Ypsilanti group. The Ann Arbor students did not demonstrate such a reduction in time spent watching television; however, they also remained at a lower average number of hours per day spent watching television at all time points measured. Watching television, which includes exposure to numerous food commercials, has been strongly associated with obesity among children.[21] We have observed a significant association with television watching and consuming unhealthy snacks, including chips and sugary drinks, and reduced fitness levels.[19,21]

Planet Health, another school-based trial, observed a similar result with reductions in television watching.[18] The researchers observed that reductions in television watching predicted obesity change in the 2-year follow-up, whereas a second study noted reductions in sedentary behavior and BMI.[22] We did not observe reductions in computer time, but it is likely that children are required to use computers for school and homework in late middle school and high school. End-of-year exams and projects may also affect the amount of time students spend on computers during the spring months before the school year ends. Therefore, the increase in computer time observed was not surprising, as this was the same time frame as the PHS follow-up measurements. Further research is needed to fully assess this finding.

We expected to see improvements in physical activity, sedentary behaviors, and dietary behaviors. However, we did not observe significant improvements in dietary behaviors over time. With the inclusion of more schools using the PHS curriculum, we will be able to examine factors associated with sustainable changes in diet over time.

Limitations

PHS is a community, school-based intervention; thus this is a real-world observational study of middle school children, not a randomized controlled trial. Our population was heterogeneous; our data are thus subject to inherent limitations and potential biases. We did not collect contact information, including parental information, home telephone numbers, and addresses. Therefore, we included only students who provided consent, attended the same middle school for sixth through eighth grade or seventh through ninth grade, and attended school on the day of the follow-up evaluation. Thus, we did not include students who moved out of these communities, attended a private or charter school, did not provide consent, or were not at school on the day we obtained follow-up data.

Additionally, we faced the challenge of having to reobtain consent for the students between their third and fourth year, as our initial consent status lasted only 3 years. This resulted in a high attrition rate and may have led to a potential selection bias toward healthier students both at baseline, when initial consents were obtained, and at follow-up in subsequent years. We especially saw drop-out in the Ypsilanti schools, demonstrating a need to focus efforts on retaining students of lower socioeconomic status. We examined baseline data between students who were and those who were not available for long-term follow-up. Although we observed no differences between groups regarding baseline characteristics (race, gender, or obesity status), we recognize that the missing data may depend on hidden factors that we do not or are unable to measure.

In addition, on the basis of a power analysis, the third- and fourth-year follow-up populations for the Ypsilanti community are undersized. Where significance was shown in an underpowered sample, it is likely that similar significance would be seen in a larger sample.

Students were not required to fast before the physiological screening. This may have resulted in less accurate lipid panels for students who did not fast. Lastly, there is potential for bias because of the self-reported nature of the behavioral data, but this effect would likely remain constant throughout the subsequent years of follow-up.

Conclusions

After the implementation of PHS' educational and environmental changes, we observed significant improvements in total cholesterol and LDL cholesterol in 2 communities over 4 years. We also saw behavioral improvements in physical activity and video game screen time. Despite this study's high attrition rate—which may have led to potential selection bias, especially in the Ypsilanti schools—it seems school-based interventions such as PHS may result in long-term and sustainable improvements in cardiovascular parameters and healthy behaviors. Further research to determine the intensity of school-based interventions and predictors of long-term health improvement is warranted. ■

About the Authors

Nicole Corriveau, Taylor Eagle, Qingmei Jiang, Robert Rogers, Roopa Gurm, and Eva Kline-Rogers are with the Michigan Clinical Outcomes Research and Reporting Program, Ann Arbor. Susan Aaronson, Lindsey Mitchell, and Jean DuRussel-Weston are with M-Healthy, University of Michigan Health System, Ann Arbor. Kim A. Eagle and Elizabeth A. Jackson are with the Department of Internal Medicine, University of Michigan Health System.

Correspondence should be sent to Elizabeth A. Jackson, MD, MPH, Associate Professor of Internal Medicine, Division of Cardiovascular Medicine, University of Michigan Health System, 24 Frank Lloyd Wright Drive, Ann Arbor, MI 48106-0363 (e-mail: lisjacks@med.umich.edu). Reprints can be ordered at http://www.ajph.org by clicking the "Reprints" link.

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Contributors

N. Corriveau, T. Eagle, R. Rogers, S. Aaronson, L. Mitchell, J. DuRussel-Weston, E. Kline-Rogers, K. A. Eagle, and E. A. Jackson conceptualized and designed the study. N. Corriveau, T. Eagle, and E. A. Jackson drafted the article. N. Corriveau, T. Eagle, Q. Jiang, R. Rogers, R. Gurm, S. Aaronson, L. Mitchell, J. DuRussel-Weston, E. Kline-Rogers, K. A. Eagle, and E. A. Jackson revised the article and approved the final version. Q. Jiang and R. Gurm analyzed and interpreted the study data.

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Human Participant Protection

The University of Michigan institution review board approved Project Healthy Schools.

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