Effectiveness of School Programs in Preventing Childhood Obesity: A Multilevel Comparison

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Objectives. In light of the alarming increase in childhood obesity and lack of evidence for the effectiveness of school programs, we studied the effects of school programs in regard to preventing excess body weight.

Methods. In 2003, we surveyed 5200 grade 5 students along with their parents and school principals. We measured height and weight, assessed dietary intake, and collected information on physical and sedentary activities. We compared excess body weight, diet, and physical activity across schools with and without nutrition programs using multilevel regression methods while adjusting for gender and socioeconomic characteristics of parents and residential neighborhoods.

Results. Students from schools participating in a coordinated program that incorporated recommendations for school-based healthy eating programs exhibited significantly lower rates of overweight and obesity, had healthier diets, and reported more physical activities than students from schools without nutrition programs.

Conclusions. Our finding that school programs are effective in preventing childhood obesity supports the need for broader implementation of successful programs, which will reduce childhood obesity and, in the longer term, comorbid conditions and health care spending. (*Am J Public Health.* 2005;95:432–435. doi:10.2105/AJPH.2004.045898)

A major public health crisis facing today's youth is the pandemic increase in excess body weight.[1,2] In the United States, over the past 4 decades, childhood obesity rates have increased 3- to 4-fold and are moderately higher than the rates in Canada, Australia, and Europe.[2–5] Excess body weight has a negative impact on self-esteem and contributes to a spectrum of comorbidities, such as hypertension, type 2 diabetes, cardiovascular disease, and multiple cancers, that result in diminished quality of life and life expectancy and account for billions of dollars in health care spending.[6–11]

Insufficient physical activity and poor nutrition due to the consumption of calorie-dense foods are acknowledged as primary mechanisms underlying the rise in excess body weight.[12] Physical activity and nutrition are therefore the primary foci of health promotion initiatives aimed at preventing or reducing childhood overweight and obesity.[12] The Centers for Disease Control and Prevention (CDC) has issued guidelines for school programs aimed at promoting physical activity and healthy eating.[13,14] The CDC guidelines for healthy eating programs include recommendations regarding school policies, curriculums, instructions to students, integration of school food services and nutrition education, staff training, family and community involvement, and program evaluation.[13] In practice, school programs vary considerably as a result of differences in content, community involvement, financial support, and delivery. Thus, the effectiveness of such programs varies and is currently not well established.[15,16] To support evidence-based health policies promoting broader implementation of successful programs, it is crucial to establish the effectiveness of school programs. In this respect, there have been calls to "identify methods and materials for evaluating effectiveness,"[13(p23)] as well as acknowledgment of "the need for well-designed studies"[15(p149)] that are of "good methodological quality, involving large numbers of participants in appropriate settings."[16(p73)]

In our study, we evaluated the effectiveness of school programs in regard to preventing overweight and obesity, improving dietary quality, and increasing physical activity. This population-based investigation involved a large number of participants from the relatively homogeneous Canadian province of Nova Scotia, where more than 95% of elementary school children attend similarly funded public schools.

METHODS

The Survey

The 2003 Children's Lifestyle and School-Performance Study (CLASS) was a large study of 5th-grade students, their parents, and their school principals. Of the 291 public schools in the province of Nova Scotia with grade 5 classes, 282 (96.9%) participated by completing a short survey and distributing a consent form and questionnaire to parents of all 5th-grade students. Parental consent was obtained for 5517 students, resulting in an average response rate of 51.1% per school. CLASS representatives visited these schools to administer a slightly modified version of the Harvard Youth Adolescent Food Frequency Questionnaire (YAQ),[17] along with an additional survey on physical and sedentary activities, and to measure the heights and weights of participating students.

Comparisons of School Prevention Programs

We compared excess body weight, diet, and physical activity across schools with and without nutrition programs. Information on these programs was available through a survey on general school characteristics that was completed by the principals of 279 of the 282 (98.9%) participating schools. We created 2 categories of schools with nutrition programs. The first included schools reporting that they had policies or practices in place to offer healthy menu alternatives. The second included 7 schools that are part of a coordinated program incorporating aspects of each of the CDC recommendations for school-based healthy eating programs.[13] This initiative began in 1997 and developed into the

Annapolis Valley Health Promoting Schools Project (AVHPSP), currently funded by Health Canada through the Canadian Diabetes Strategy. Details on this intensive and multifaceted program are available elsewhere.[18]

Assessment of Dietary Intake and Quality

The YAQ provides detailed information on the frequency and kinds of foods that students consume. On the basis of this information, one can calculate students' intake of foods from recommended food groups. Furthermore, on the basis of this information and information on the nutrient composition of foods,[19] one can assess students' nutrient and calorie intakes. In the present study, we focused on 3 critical dietary measures: (1) number of daily servings of fruits and vegetables, (2) percentage of calorie intake from dietary fat, and (3) a summary measure of overall dietary quality. In the case of the latter measure, we applied the Diet Quality Index-International, a summary instrument that encompasses dietary adequacy, variety, moderation, and balance.[20]

Of the 5517 children whose parents provided informed consent, 5200 completed the YAQ. We excluded 234 children (4.5%) with reported energy intakes of less than 500 kcal (2092 kJ) or more than 5000 kcal (20 920 kJ) per day.[21]

Assessment of Physical and Sedentary Activities

We assessed participation in physical and sedentary activities using the student survey, which was completed by 5197 children. Physical activity was defined as reported weekly number of engagements in organized sports and leisure time physical activities. Sedentary activity was defined as daily number of hours watching television, using the computer, and playing video games.

Assessment of Overweight and Obesity

We defined overweight and obesity using the international body mass index cutoff points established for children and youth.[22] These cutoffs are based on health-related adult definitions of overweight (more than 25 kg/m^2) and obesity (more than 30 kg/m^2); however, they have been adjusted to age- and gender-specific categories for use with children.[22]

Public schools in Nova Scotia are administered through 7 school boards, one of which did not allow height and weight measurements to be taken. Therefore, 4298 children were available for the analyses of overweight and obesity.

Statistical Analysis

We used multilevel regression methods to examine the effects of school programs on the following outcomes: overweight, obesity, fruit and vegetable consumption, fat intake, dietary quality, and participation in physical and sedentary activities. We considered school program as a contextual factor and treated it as a second-level covariate.[23,24] Overweight, obesity, and physical and sedentary activities were treated as first-level binary outcomes in the multilevel logistic regression analyses, for which we calculated odds ratios and 95% confidence intervals.

Square-root-transformed number of fruit and vegetable servings, percentage of energy intake from fat, and dietary quality score were normally distributed and were considered as first-level outcomes in the multilevel linear regression analysis. To facilitate interpretation of our findings, we exponentiated the resulting beta coefficients to represent "relative increments" or "relative risks" of school programs associated with (1) a quadratic increment in consumption of fruits and vegetables, (2) a 1% increment in energy from fat, and (3) a 10% increment in dietary quality score.[25] All analyses were adjusted for gender, area of residence (urban or rural), and parental education and income as first-level covariates and neighborhood income as a second-level covariate. Analyses focusing on dietary outcomes were further adjusted for energy intake.[21] We considered missing covariate categories as separate categories, but we do not present their estimated values.

Response Weights

Calculations of response weights to overcome nonresponse bias were based on postal code–level estimates of household income, which were available through the Canada census for both participating and nonparticipating 5th-grade students. Because response rates in the lowest income deciles appeared slightly lower, we weighted our analyses. However, because the software used in this study did not allow weighting to be applied to multilevel logistic regression analyses, we did not weight these analyses. Unilevel logistic regression analyses had demonstrated that weighting only marginally affected the magnitude of the risk estimates of interest. All analyses were performed with the S-Plus and HLM programs.[26,27]

RESULTS

Of the 5200 grade 5 students who completed the YAQ, 3656 (70.3%) attended one of the 199 study schools without a nutrition program, 1350 (26.0%) attended one of the 73 schools with a nutrition program, and 133 (2.6%) attended one of the 7 schools participating in the AVHPSP. Table 1 presents characteristics of students from these 3 sets of schools. Students from schools that are part of the AVHPSP exhibited lower rates of overweight and obesity and had better dietary habits in terms of higher consumption of fruits and vegetables, less calorie intake from fat, and higher dietary quality index scores. Also, these students reported more participation in physical activities and less participation in sedentary activities. Characteristics of students from schools without a nutrition program and students from schools with a nutrition program (other than the AVHPSP) were similar (Table 1).

Table 2 presents data on the differences between students from schools with a nutrition program and students from schools that are part of the AVHPSP relative to students from schools without a nutrition program. Rates of overweight and obesity among students from schools that are part of the AVHPSP were significantly lower than rates among students from schools without a nutrition program. Also, students from AVHPSP schools reported more consumption of fruits and vegetables, better dietary quality, and less fat intake, although the latter did not reach statistical significance. Furthermore, this group of students reported more participation in physical activities and less in sedentary activities, but these differences were also not statistically significant. Overweight and obesity rates among students from schools with a nutrition program were somewhat lower than those of students

TABLE 1—Body Weight, Diet, and Activities of Grade 5 Students in Nova Scotia, Canada, by School Program Category

	No Program	Nutrition Program	AVHPSP Program
Overweight, %	32.8	34.2	17.9
Obese, %	9.9	10.4	4.1
Mean no. of fruit/vegetable servings per day	5.7	5.8	6.7
Calories from fat, %	30.3	30.3	29.4
Overall diet quality, index score	62.3	62.1	64.5
Physical activity, %			
≤3 times/wk	21.9	24.6	19.9
4-6 times/wk	33.5	32.3	35.4
≥7 times/wk	44.5	43.1	44.7
Sedentary activities, %			
≤3 h/d	49.9	50.6	56.6
4-6 h/d	29.5	28.5	27.8
≥7 h/d	20.6	20.9	15.6

Note. AVHPSP = Annapolis Valley Health Promoting Schools Project. The overweight category includes obesity. All estimates are weighted for nonresponse bias.

TABLE 2—Effects of School Programs on Excess Body Weight, Diet, and Activities Among Grade 5 Students

	Nutrition Program OR or RR (95% CI)	AVHPSP Program OR or RR (95% CI)
Overweight (relative to normal weight)[a]	0.91 (0.77, 1.09)	0.41 (0.32, 0.53)
Obesity (relative to normal weight)[a]	0.85 (0.63, 1.15)	0.28 (0.14, 0.57)
Fruit and vegetable consumption[b]	1.03 (0.98, 1.08)	1.23 (1.07, 1.40)
Fat consumption[b]	0.98 (0.67, 1.43)	0.36 (0.11, 1.13)
Overall diet quality[b]	1.03 (0.96, 1.10)	1.29 (1.11, 1.50)
Physical activities (≤3 times per week)[a]	1.12 (0.94, 1.34)	0.79 (0.44, 1.42)
Sedentary activities (≥7 hours per day)[a]	0.96 (0.79, 1.15)	0.74 (0.41, 1.32)

Note. AVHPSP = Annapolis Valley Health Promoting Schools Project. Odds ratios (ORs) and relative risks (RRs) are adjusted for differences in gender, urban or rural residency, parental education, and parental and neighborhood income. RRs are further adjusted for energy intake and weighted for nonresponse bias. The reference category for all outcomes is students from schools without a nutrition program. The overweight category includes obesity.

[a]OR from multilevel logistic regression of overweight, obesity, and physical and sedentary activities.

[b]RR (or relative increment) from multilevel linear regression representing the association of school programs with a quadratic increase in consumption of fruit and vegetables, an increase of 1% of energy from fat, or a 10% increase in diet quality score.

from schools without a program, but not significantly so. Diet and activities were similar among students from schools with and without a nutrition program (Table 2).

DISCUSSION

School-based healthy eating and physical activity programs provide a great opportunity to enhance the future health and well-being of children because they can reach almost all children and may (1) enhance learning and provide social benefits, (2) enhance health during critical periods of growth and maturation, (3) lower the risk for chronic diseases in adulthood, and (4) help to establish healthy behaviors at an early age that will lead to lifelong healthy habits.[28] The effectiveness of school-based healthy eating and physical activity programs is critical to evidence-based health policy and to justify broader implementation of successful programs. However, because only a limited number of studies have been conducted, and results have varied, the effectiveness of these programs is not well established.[15,16] For example, in a systematic review of intervention studies, Campbell et al. found only 7 studies on prevention of childhood obesity, 4 of which revealed programs that were effective and 3 of which revealed programs that were not.[15]

Our study adds to the current knowledge base in this area by demonstrating the effectiveness of some programs and the absence of effectiveness of others: Students from schools with a program (i.e., AVHPSP[18]) consistent with the CDC recommendations for school-based healthy eating programs exhibited substantially less overweight and obesity. However, students from schools that provide healthy menu alternatives did not have substantially healthier body weights than students from school without programs. Various factors may have contributed to the latter finding. For example, the benefits of potentially successful programs only recently introduced may have been missed, or "bias by indication,"[29] whereby schools with high obesity rates are more likely to initiate programs, may have masked possible benefits of school programs. Nevertheless, the magnitude of the difference between AVHPSP schools and schools offering healthy menu alternatives suggests that children insufficiently choose healthy foods if they are offered and that school initiatives should follow integrated approaches if they are to be effective.

Approximately 30% of the schools studied reported having policies or practices in place to provide healthy menu alternatives, and 7 schools were part of a coordinated AVHPSP program focused on making healthy choices the easy choice for students. Comparing students from these schools with students from schools without a program provides an alternative to intervention studies in regard to evaluating effectiveness. Intervention studies rely on preintervention and postintervention comparisons and thus have better inferential potential. However, preintervention observations are generally not available for programs, such as the AVHPSP,[18] that have gradually evolved from grassroots efforts and community mobilizations. As previously demonstrated in evaluations of other prevention initiatives, the present comparisons are the types of comparisons most suitable for evalu-

ating the effectiveness of such programs.[30] This approach also addresses the CDC's call to identify methods and materials for evaluating effectiveness.[13]

Our study involved a large, population-based comparison of school programs in a relatively homogeneous setting wherein almost all children attend similarly funded public schools. Also, the relatively high response rate and our adjustment for nonresponse bias should be considered as strengths, although the exactness of such adjustments is difficult to verify. Similarly, we adjusted our analyses for various known or potential confounders, but we cannot exclude confounding through factors that were not considered. Furthermore, overweight and obesity were defined on the basis of measurements of height and weight and thus were not subject to self-report biases. Although the YAQ items and questions on physical and sedentary activities have been validated for this age group, responses are subjective and subject to error. The strengths and limitations just described should be considered when interpreting the present findings and making comparisons with the results of other studies.

In summary, as a result of the rapid recent increases in childhood obesity, prevention is a public health priority. Intensive and multifaceted school programs that encompass the CDC guidelines were demonstrated to be effective in preventing childhood obesity. Broader implementation of and investment in such programs is justified in that they have a high potential to reduce childhood obesity and, in the longer term, comorbid conditions and health care spending. ■

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Contributors

P.J. Veugelers conducted the statistical analyses and wrote the article. Angela Fitzgerald assisted in the interpretation of the findings and the writing of the article.

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Human Participant Protection

This study, including the informed consent procedure, was approved by the health sciences human research ethics board of Dalhousie University. Informed consent was obtained from parents before the participation of their children.

References

1. Ebbeling CB, Pawlak DB, Ludwig DS. Childhood obesity: public-health crisis, common sense cure. *Lancet.* 2002;360:473–482.

2. Dietz WH. Overweight in childhood and adolescence. *N Engl J Med.* 2004;350:855–857.

3. Sherry B, Dietz WH. Pediatric overweight: an overview. In: Bray GA, Bouchard C, eds. *Handbook of Obesity.* New York, NY: Marcel Dekker Inc; 2004: 117–134.

4. Tremblay MS, Katzmarzyk PT, Willms JD. Temporal trends in overweight and obesity in Canada, 1981–1996. *Int J Obes Relat Metab Disord.* 2002;26: 538–543.

5. McLennon J. Obesity in children: tackling a growing problem. *Aust Fam Physician.* 2004;33:33–36.

6. Calle EE, Thun MJ, Petrelli JM, Rodriguez C, Heath CW. Body-mass index and mortality in a prospective cohort of U.S. adults. *N Engl J Med.* 1999;341: 1097–1105.

7. Manson JE, Bassuk SS. Obesity in the United States: a fresh look at its high toll. *JAMA.* 2003;289: 229–230.

8. Calle EE, Rodriguez C, Walker-Thurmond K, Thun MJ. Overweight, obesity, and mortality from cancer in a prospectively studied cohort of U.S. adults. *N Engl J Med.* 2003;348:1625–1638.

9. Fontaine KR, Redden DT, Wang C, Westfall AO, Allison DB. Years of life lost due to obesity. *JAMA.* 2003;289:187–193.

10. Peeters A, Barendregt JJ, Willekins F, Mackenbach JP, Mamun AA, Bonneux L. Obesity in adulthood and its consequences for life expectancy: a life-table analysis. *Ann Intern Med.* 2003;138:24–32.

11. Caterson ID, Franklin J, Colditz GA. Economic costs of obesity. In: Bray GA, Bouchard C, eds. *Handbook of Obesity.* New York, NY: Marcel Dekker Inc; 2004:149–156.

12. Nicklas T, Johnson R. Position of the American Dietetic Association: dietary guidance for healthy children ages 2 to 11 years. *J Am Diet Assoc.* 2004;104: 660–677.

13. Centers for Disease Control and Prevention. Guidelines for school health programs to promote lifelong healthy eating. *MMWR Recomm Rep.* 1996; 45(RR-9):1–41.

14. Centers for Disease Control and Prevention. Guidelines for school and community programs to promote lifelong physical activity among young people. *MMWR Recomm Rep.* 1997;46(RR-6):1–36.

15. Campbell K, Waters E, O'Meara S, Summerbell C. Interventions for preventing obesity in childhood: a systematic review. *Obes Rev.* 2001;2:149–157.

16. Wilson P, O'Meara S, Summerbell C, Kelly S, Effective Health Care Review Team. The prevention and treatment of childhood obesity. *Qual Safety Health Care.* 2003;12:65–74.

17. Rockett HR, Wolf AM, Colditz GA. Development and reproducibility of a food frequency questionnaire to assess diets of older children and adolescents. *J Am Diet Assoc.* 1995;95:336–340.

18. Annapolis Valley Health Promoting Schools. Making the healthy choice the easy choice. Available at: http://www.hpclearinghouse.ca/features/AVHPSP.pdf. Retrieved December 8, 2004.

19. Health Canada. Canadian Nutrient File (CNF). Available at: http://www.hc-sc.gc.ca/food-aliment/ns-sc/nr-rn/surveillance/cnf-fcen/e_cnf_downloads.html#dload_table. Retrieved December 8, 2004.

20. Kim S, Haines PS, Siega-Riz AM, Popkin BM. The Diet Quality Index-International (DQI-I) provides an effective tool for cross-national comparison of diet quality as illustrated by China and the United States. *J Nutr.* 2003;133:3476–3484.

21. Willet W. *Nutritional Epidemiology.* 2nd ed. New York, NY: Oxford University Press Inc; 1998.

22. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. *BMJ.* 2000; 320:1–6.

23. Von Korff M, Koepspell T, Curry S, et al. Multilevel analysis in epidemiologic research on health behaviors and outcomes. *Am J Epidemiol.* 2000;135: 1077–1082.

24. Veugelers PJ, Yip AM, Kephart G. Proximal and contextual socioeconomic determinants of mortality: multilevel approaches in a setting with universal health care coverage. *Am J Epidemiol.* 2001;154: 725–732.

25. Veugelers PJ, Yip AM. Socio-economic disparities in health care use: does universal coverage reduce inequalities in health? *J Epidemiol Community Health.* 2003;57:424–428.

26. *S-Plus-6 for Windows User's Guide.* Seattle, Wash: Insightful Corp; 2001.

27. Raudenbush S, Bryk A, Cheong YF, Congdon R. *HLM 5: Hierarchical Linear and Nonlinear Modeling.* Lincolnwood, Ill: Scientific Software International; 2000.

28. Baranowski T, Mendlein J, Resnicow K, Frank E, Weber-Cullen K, Baranowski J. Physical activity and nutrition in children and youth: an overview of obesity prevention. *Prev Med.* 2000;31:S1–S10.

29. Miettinen OS, Cook EF. Confounding: essence and detection. *Am J Epidemiol.* 1981;114:593–603.

30. Leaver CA, Allman DA, Myers T, Veugelers PJ. Effectiveness of HIV prevention in Ontario, Canada: a multilevel comparison. *Am J Public Health.* 2004;94: 1181–1185.