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Student Scientists Learn about Energy Balance through Science Museum-Academic Partnership

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INTRODUCTION

The concept of energy balance (i.e., calories consumed versus expended) is essential to understanding contributors to and prevention of childhood obesity. Prevailing ecological models of childhood obesity emphasize risk and protective factors within multiple environments, including family, school, and community.^{1,2} However, most school-based obesity prevention curricula focus predominantly on individual behavior change and rarely connect energy balance concepts to children's daily environments.^{3–5} With few exceptions,⁶ the ecological framework of childhood obesity has yet to widely permeate elementary and middle school curricula. The current study ties the ecological framework with social cognitive theories (SCT) of individual behavior change.⁷ SCT is well-suited to examining obesity prevention in school because of its ability to account for multiple social learning influences in children's environment that impact individual behavior. Personal agency represents a key component of SCT, in which individuals are empowered to exercise control over their daily environments to support behavior change.⁸ Helping students to identify energy balance influences in their local environments is a novel approach to support personal⁹ and ecological⁶ obesity prevention efforts among children. Middle school represents an ideal time to introduce such an approach, due to early adolescents' increased autonomy and decision-making over their own health-related behaviors.^{10,11}

ENERGY BALANCE CURRICULUM

We created a collaborative pilot project between a regional community-based science museum, the Montshire Museum of Science, and an academic health research center to develop and evaluate the feasibility of and receptivity to an energy balance curriculum for middle school students. Several recent studies suggest that science and children's museums

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Work was also conducted at: Montshire Museum of Science, One Montshire Road, Norwich, VT 05055

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provide a trusted, community-based resource that can offer energy-balance programs for school-aged children.^{12,13} Museum educators provided expertise in developing and delivering science-based curricula to school-aged children. Health researchers provided expertise on environmental influences on children's diet and physical activity. The curriculum, entitled *Investigations in Nutrition, Diet and Activity*, utilized an inquiry-based, active learning instructional approach in which students were trained as scientific investigators to examine their immediate environments for modifiable influences on diet and activity. Modifiable influences that could be altered to promote healthy habits might include structural characteristics (e.g., adding inexpensive physical education (PE) equipment, such as jump ropes) or policy characteristics (e.g., removing high-fat milk; replacing low intensity PE activities with moderate-to-vigorous activities, such as the mile run). Energy balance provided the core concept of the curriculum, with elements of the scientific method and research design introduced to students incrementally. Although only one lesson focused solely on the built environment, all lessons supported students' ability to identify and understand environmental factors influencing their own energy balance (and the energy balance of their class as a whole). Each lesson was 45 minutes, and met state and national educational standards in science, health, and math. A curriculum specialist from the museum implemented the nine-lesson program, delivered during seven classroom sessions and two museum sessions. Curriculum activities are presented in Table 1. The curriculum culminated in team-based, student-designed research investigations, modeled after existing observational studies by the health scientists. Students presented their findings in a scientific poster format.

EVALUATION

Three elementary schools located in Northern New England were invited to pilot the curriculum. Schools were purposefully selected for their small town/rural setting and economically diverse student body. All 5th and 6th grade classes in each school participated. Each participating teacher received a \$200 classroom stipend for curriculum materials, and student travel to and from the museum was paid for by the study. The study was determined to be exempt from further review by the Committee for the Protection of Human Subjects at Dartmouth College. However, prior to completing written surveys, the museum educator read a statement to students indicating that answering survey questions was voluntary.

Using a pre-post cohort design, student evaluation data consisted of anonymous closed-ended survey questions developed for the current study and evaluated for face validity, and open-ended written comments. Surveys were administered immediately prior to the first curriculum lesson and at the end of the final lesson. Survey items assessed knowledge of nutrition and energy balance concepts (9 true/false items; score range 0–9), and receptivity to each curriculum activity (16 items with 3-point response scales; three open-ended questions). Pre- and post-test data were not linked by student ID. Therefore, we used a two-sample t-test with equal variances and a p-value set conservatively at <.01 to account for the dependency of the observations. Teachers also completed several survey questions about the ease of curriculum implementation after the final lesson. Data were analyzed with Stata Release 10.0 (StataCorp LP, College Station, Texas).

All students who were present on the days of survey administration completed the surveys. Forty-nine students completed the pre-test, and 50 completed the post-test, an average of 8.0 weeks apart. Participating students were evenly divided by gender and grade (pre-test data: 49% female; 51% 5th graders). Seven teachers (100% response rate) completed the post-curriculum survey. Students' knowledge significantly increased between pre- and post-tests [M 5.1 (SD 1.3) vs. M 6.5 (SD 1.3), respectively, $P<.001$]. Total knowledge scores also increased significantly among all subgroups (boys, girls, 5th graders, 6th graders; data not

shown), with scores increasing 1.2 – 1.5 points per group. Curriculum components with the highest levels of student receptivity included the calorimeter lab and the student research investigations (Figure 1). The least well-received activity involved a daily journal of students' physical activity and eating patterns, which students indicated was too time-intensive. The majority of teachers (88%) indicated that it was "very easy" to integrate the unit into their existing health or science classes, and all indicated that the curriculum length was "just right."

FUTURE APPLICATIONS

Based on this pilot study, the curriculum was slightly revised. Two components were dropped due to low receptivity (i.e., daily diet/activity journals) or because content was not directly relevant to energy balance (i.e., "the story of our food"). The built environment unit was moved to the beginning of the curriculum so concepts about risk and protective influences in students' daily environments could inform subsequent lessons. For subsequent implementation in schools, teachers will attend a 3-day summer institute at the museum to prepare them for delivering the majority of the curriculum, with instruction by the museum educator for the research investigation components. Additionally, the museum will establish a "Student Science Symposium" in which school-based student teams present their research investigations to museum personnel, health researchers and other students at the museum. Although the curriculum was designed for 5th and 6th grade students, it could easily be adapted for older or slightly younger grades. Our next steps aim to use a randomized controlled trial design to evaluate whether this curriculum positively influences obesity-related behaviors.

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Figure 1.
Student receptivity to energy balance curriculum activities.

Table 1

Selected learning objectives and student activities from the energy balance curriculum and examples of New Hampshire Educational Standards in Nutrition and Physical Activity (Nutr/PA), Science, and Math that they satisfy.

Learning Objective	Sample Student Activities	Examples of Educational Standards Met
Building the Pyramid: Diet, Food Pyramid	Create class-based food pyramid based on students' meals, compare to USDA MyPyramid. *	Nutr/PA, 2.2. How to use the Food Guide Pyramid
Built Environment: Role of environmental influences on diet and physical activity	Map walking distances around school and community food sources.	Nutr/PA, 3.4. Cultural influences on food choices Nutr/PA, 2.3. Peer influences on physical activity
What Does 200 calories look like? Serving sizes, food substitutions, environmental control over diet	Estimate and predict calories in snack-sized portions of different foods (e.g., chips, peanut butter, carrots, apple). Identify food sources of snacks in your environment. Make substitutions and determine how serving sizes change (e.g., plate of vegetables vs. piece of chocolate). Calorimeter Lab.	Nutr/PA, 1.7. Strategies for overcoming barriers to healthful eating
What Does 200 Calories feel like? How much energy a calorie represents, energy expenditure in different activities	Small groups engage in different intensity activities (e.g., jump rope, walking) to compare energy expenditure. Create 3-D graph of daily classroom energy expenditure in 15-minute increments using colored chips (light, moderate, vigorous); compare weekend vs. school day. Identify how to increase expenditure in school.	Nutr/PA, 1.6. How to assess personal physical activity Nutr/PA, 4.2. How much energy is expended during exercise/activity Science, SPS1. Scientific inquiry & critical thinking skills Science, SPS4. Science skills for information, communication & media literacy
Build-a-Meal: Making food choices & substitutions	Using a calorie counter, build a 2000 calorie meal; identify substitutions and where to obtain within school environment (e.g., skim vs. 1% milk; soda vs. water). Track class-level changes in calories if everyone were to make one substitution per day.	Nutr/PA, 1.4. Benefits of decreasing fat intake Nutr/PA, 1.5. Benefit of moderating sugar intake
Student Research Investigations: Develop a researchable question; collect data; summarize and present data	Student small groups develop a hypothesis or research question about built environment influences on diet or activity; collect data through surveys, observations, or other methods; summarize data; present data in visual (poster) format; present to others.	Science, SPS1-Scientific Inquiry & critical thinking skills Science, SPS3- Personal, Social & Technical perspectives Science, SPS4-Science skills for information, communication & media literacy Math, DSP:7:2. Analyze patterns, trends or distributions Math, DSP:7:3. Organizes and displays data

* This study was conducted while the USDA's food guide was MyPyramid. The curriculum has since been updated to use MyPlate.