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Diet and Physical Activity Patterns of School-Aged Children

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ABSTRACT

Childhood provides an opportunity for establishing healthful lifestyle habits, yet little is known about diet and physical activity patterns of elementary school-aged children. A cohort of 35 boys and girls in grades 3 through 5 (mean age=9.5 years) was studied during the course of the 2004-2005 school year, providing seasonal assessments of diet and physical activity. Objectively measured data included height, weight, and pedometer step counts. Subjective data included seasonal 3-day diet diaries, a food frequency questionnaire, and a physical activity questionnaire. Participants were white, well-nourished, and within the healthy range for body mass index for age. Only three students (9%) were overweight and another three were "at risk" for overweight. Food intake patterns fell far below MyPyramid guidelines for average daily servings of fruits and vegetables. High intakes of saturated fat (average of 12% of calories) and sodium were noted, along with inadequate fiber intakes. Snacks, desserts, and entrees that contributed most to calorie and saturated fat intake were identified. Self-reported physical activity appears in line with recommendations, but step counts fall short, particularly for girls and during winter months. These findings identify targets for behavioral and environmental interventions to reduce childhood obesity risks. Additional research involving more diverse populations is warranted.

J Am Diet Assoc. 2009;109:145-151.

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Manuscript accepted: July 25, 2008.

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0002-8223/09/10901-0018$36.00/0

doi: 10.1016/j.jada.2008.10.012

Prevalence of childhood obesity has risen dramatically in the United States, and is recognized as an important public health threat. Since the 1970s, obesity prevalence has more than doubled among preschool-aged children and adolescents, and has more than tripled among children ages 6 to 11 years (1-3). Approximately 9 million children older than age 6 years are classified as overweight according to age- and sex-specific body mass index (BMI; calculated as kg/m^2) cut-points (1-3). Unfortunately, youth does not spare children from the physical, social, and emotional consequences of obesity, including diabetes, dyslipidemia, hypertension, and metabolic syndrome (1-3).

There are many contributors to childhood obesity, manifested by notable shifts in population demographics, lifestyle behaviors, and environments at home, in the community, and in schools. Multiple forces contribute to the imbalance between energy intake and energy expenditure that influences weight gain (4). The importance of establishing healthful nutritional practices in young children is underscored by the fact that eating habits are typically molded during early childhood (5). Only 2% of school-aged children meet all of the recommendations of the Food Guide Pyramid (6) and 16% do not meet any of the guidelines (7). Some 20% of children and adolescents meet the recommendation for fruit and vegetable intake and even fewer drink at least 3 cups of milk daily (8). Children also fall short of physical activity recommendations, with roughly one third of students active for at least 60 minutes per day at least 5 days a week (8). Moreover, 58% of students are exceeding the American Academy of Pediatrics (AAP) guidelines (9) by spending more than 2 hours a day watching television or playing computer/video games (8).

Efforts to address childhood obesity include public health goals to increase daily physical activity, decrease sedentary behaviors, and establish healthful eating habits (4). To inform effective interventions, a better understanding of the behaviors of school-aged children is needed, yet relatively little research includes elementary school students. Research examining this population comes predominantly from large surveys (10-12) using short-term, self-reported assessments methods that can contribute to measurement error and imprecise estimates of both diet and physical activity. While these data are useful for generating new research hypotheses, more comprehensive objective data are needed. Because >20% of US children who are either overweight or "at-risk" have achieved that status by the time they enter middle school (2,3,13), the elementary school years represent an appropriate time to introduce behavioral interventions

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(4). The purpose of this pilot study (KidSTEPS) is to use a combination of age-appropriate objective and self-reported assessment tools to describe the eating patterns and physical activity habits of elementary school-aged children.

METHODS

Children in grades 3 through 5 were recruited from two partnering elementary schools in a single suburb of Boston, MA. Fliers were distributed in school in September 2004 and eligibility required only parental consent. Parents contacted study personnel via e-mail and informed consent was obtained by telephone with follow-up mailings to obtain signed parental consent and student assent forms. Study protocols were approved by the Boston University Institutional Review Board. Enrollment occurred between September and November. Data collection was initiated upon enrollment and continued through June 2005. Study materials were user-friendly, low-burden, completed at home by children and their parents, and exchanged by mail. Stamped envelopes were provided for return of completed forms and small prize incentives (eg, keychains, t-shirts) were given as rewards.

Children were assessed in three seasons: fall (October/November), winter (January/February), and spring (May/June). Parents completed a brief demographic questionnaire at baseline. All other information was collected in each season, with the exception of the food frequency and physical activity questionnaires as noted here. Each season, students were given a personalized KidSTEPS diary that facilitated collection of information by integrating assessment forms into a single booklet.

Height (in inches) and weight (in pounds) were measured by certified school nurses using district-wide clinical protocols that comply with state regulations (14). Nurses used existing equipment in their schools that is calibrated annually (Detecto physician beam balance scales, Webb City, MO; and Seca wall-mounted stadiometers, Hanover, MD). Single measures were taken and recorded to the nearest one-quarter inch for height and one-half pound for weight. Anthropometric data were recorded by nurses in the KidSTEPS diary. BMI was computed (15) and BMI-for-age was plotted on sex-specific growth charts (16). Overweight was defined as BMI-for-age ≥95th percentile, and "at risk" was defined as values ≥85th percentile but <95th percentile (17).

Diet

A validated 152-item semi-quantitative youth food frequency questionnaire (FFQ) (18,19) was completed at home by children with their parents. FFQs were collected in fall and spring seasons to assess long-term intake patterns. Children reported how often they ate specific foods during the past year. Response categories ranged from "never/less than once per month" up to "5 or more times per day." Questionnaires were used to generate estimates of food group intake and to identify foods that were top contributors to key macronutrients in students' diets. Questionnaires were reviewed for completeness, open-ended responses were coded by trained research assistants according to standard procedures of Channing Laboratory (Boston, MA), and forms were optically scanned to produce electronic data sets. All questionnaires were sufficiently complete for analysis; none were excluded and no outliers were detected with respect to reported food group intake.

There are many contributors to childhood obesity, manifested by notable shifts in population demographics, lifestyle behaviors, and environments at home, in the community, and in schools.

Three-day food records were collected from participants in each of three seasons for the purpose of estimating daily nutrient intake. Children and their parents were instructed to record the child's food and beverage intake on 2 weekdays and 1 weekend day in the KidSTEPS diary. Days of the week specified for record-keeping were randomly assigned across cohort members and were guaranteed to be nonconsecutive. Portion sizes were estimated using household measures, food-specific portion size information from food packages, and serving size information obtained from the school foodservice manager. Completed diaries were returned by mail and reviewed by trained staff. Parents were contacted and probed for missing information, food preparation details, or missing portion details. The foodservice manager provided recipe, ingredient, and serving size details for school lunch items. Food records were coded by trained university-based research staff using the Nutrition Data System for Research (NDS-r version 5.0, database 35, 2004) developed by the Nutrition Coordinating Center at the University of Minnesota (20) to generate nutrient intake estimates exclusive of micronutrients from multivitamin/mineral supplements. Data files were reviewed by investigating the top 10% and bottom 10% of daily intake estimates for total calories and macronutrients to correct or verify any extreme nutrient outliers.

Physical Activity

Physical activity was assessed by self-report using a validated, youth seasonal activity questionnaire (21,22) completed in fall and spring seasons. Like the FFQ, this instrument was scanned by Channing Laboratory (Boston, MA) to generate a data set that was devoid of outliers. The questionnaire lists 18 physical activities, 8 inactive pursuits like reading and doing homework, and queries participation in team sports. This instrument minimizes the overestimation of highly seasonal activities by asking respondents to report their frequency of participation in each season of the previous year (23). Children also wore pedometers for 7 consecutive days in each season. A 7-day monitoring protocol was shown to provide reliable estimates of usual physical activity in children (24). Students entered daily pedometer counts into activity logs in the KidSTEPS diaries, with parental assistance as needed.

Analyses

Nutrient estimates represent an average of 9 days of food record data (3 days/season). Food group intake was derived from the spring FFQ to coincide with nutrient estimates from food records kept during the same time frame (the 2004-2005 school year). Foods that contributed the most to total energy and saturated fat intakes in the cohort were determined from FFQ data. Pedometer, anthropometric, demographic, and behavioral data (such as multivitamin/mineral supplement use) were keyed and verified using duplicate entry procedures. The Statistical Analysis System (SAS/STAT Software, version 8.2, 2001, SAS System for Windows, SAS Institute Inc, Cary, NC) was used to generate descriptive statistics and two-sample *t*-tests compared data across sexes.

RESULTS AND DISCUSSION

Demographics

Thirty-five children enrolled and completed baseline data collection. The cohort was almost exclusively white (n=34), with one minority participant who was Asian American. At the close of data collection, 32 children (91%) remained in the study, with reasons for drop-out related to burden of the diet assessment protocols. Children who dropped out of the study were no different from those who completed the study with respect to demographic characteristics, BMI, or baseline physical activity. Participants were between the ages of 8 and 10 years with a mean age of 9.5 years. Most students (n=15) were in the fourth grade. The study group was predominantly female (n=24) and most were within the healthy range for weight. In this sample, 26 students (82%) had a BMI-for-age in the desired range, three (9%) were at risk for overweight, and three others were overweight. About half of participants (n=17) took a multivitamin/mineral supplement, with only 10 reporting daily use.

Dietary Patterns

The dietary profiles of elementary school-aged children in this sample (Table 1) were relatively consistent with recommendations of the *Dietary Guidelines for Americans 2005* (25). Children consumed 54% of calories from carbohydrate, 15% from protein, and 33% from fat, on average. According to Institute of Medicine recommendations (26-30), diets appeared adequate in folic acid, iron, and vitamins C and D from food sources (exclusive of multivitamin/mineral supplements). However, diets fell short of target intakes for fiber and calcium with children meeting only 50% and 70% of the recommendations, respectively. Both boys and girls consumed more saturated fat and sodium in their diets than what is recommended by the Institute of Medicine (30,31). The difference in mean energy intake between sexes approached statistical significance, and boys consumed more fiber, iron, calcium, folic acid, and sodium than girls ($P<0.05$).

Average daily intakes of fruits and vegetables were markedly low; children consumed half or less of the amount recommended by the US Department of Agriculture's MyPyramid (32). In contrast, intake of milk, yogurt, and cheese approached recommended levels, yet only boys' average intakes met the guideline. While it is promising that children in this cohort were close to meeting the milk equivalent recommendation, it is important to promote consumption of these foods wisely. In this school-aged sample, milk was the biggest contributor to both total calories and saturated fat intake, suggesting that availability and promotion of low-fat and nonfat milk deserves extra effort. In fact, many items commonly offered in school cafeterias as either lunch entrees or snack foods were found to be important contributors to calorie and saturated fat intake in this cohort, namely ice cream treats; chips; macaroni and cheese; fried foods, including chicken nuggets; meatballs; and other entrees made with cheese. This observation was made previously in a high school population (33) and substantiates the need for healthier menu offerings in school foodservice beginning at the elementary level.

Sex differences in dietary intake in this cohort were relatively few. According to the Institute of Medicine guidelines, active boys and girls between the ages of 9 and 13 should consume 2,000 to 2,600 and 1,800 to 2,200 calories, respectively (30). Reported energy intakes in our cohort are slightly lower than these targets, but are not likely the result of substantial measurement error, given the 9 days of food records collected during the year. Nonetheless, our estimates of intake are comparable with the limited body of research among this age group showing that boys tend to consume more calories than girls (10) and children between the ages of 6 and 11 years eat, on average, 2,100 kcal/day, with 33% of calories from fat and 11.5% of calories from saturated fat (10). Research suggests that children's diets are also high in sodium (10,11). Finally, low fruit and vegetable intake in school-aged children may represent an important precursor to adolescent behavior, because only one in five high school students reportedly eats five or more servings of fruits and vegetables daily (8). Without diligent efforts, these undesirable food and nutrient intake patterns that begin as early as elementary school will likely persist throughout adolescence.

Physical Activity Patterns

According to self-reports from the activity questionnaires, elementary school-aged students in this cohort met the AAP guidelines for physical activity (34) by engaging in a mean of 1.8 hours of daily activity (Table 2). They accumulated, on average, almost 11,000 steps per day. Simultaneously, both boys and girls were spending an average of 4 hours per day engaging in inactive pursuits including television, video games, computer media, and recreational reading. While television viewing and video, computer, and handheld games were not distinguished from inactivity associated with pleasure reading and homework in this analysis, it is possible that the proportion that was screen time exceeded AAP recommendation of fewer than 2 hours per day (9).

While children in this sample appear reasonably active based on self-reported activity data, objectively measured pedometer counts fall short of public health recommendations for children. Whereas 10,000 steps per day is advocated as a target for health promotion among adults (35), the 2001-2002 President's Challenge Physical Activity and Fitness Awards Program (36) recommends that children accumulate more; specifically 11,000 steps (for

Table 1. Dietary intakes of elementary school-aged participants in KidSTEPS compared to recommended intake levels, with food sources of key macronutrients identified

	Recommended intake at the 2,000-calorie level[a]	Overall (n=32)	By Sex	
			Boys (n=8)	Girls (n=24)
Nutrients[b]		← mean±standard deviation →		
Energy (kcal)	2,000	1,766±325	1,949±401†	1,702±275
Carbohydrate (%)	45-65	54.0±5.0	54.6±5.9	53.8±4.8
Protein (%)	10-35	15.0±2.1	15.7±2.1	14.8±2.0
Total fat (%)	25-35	32.6±4.1	31.7±4.8	32.9±3.9
Saturated fat (%)	<10	11.9±1.9	12.2±2.4	11.8±1.7
Trans fat (g)	—	4.6±1.4	4.5±1.6	4.6±1.4
Cholesterol (mg)	<300	193±75	203±91	190±70
Fiber (g)	28	13.6±4.1	16.4±5.6*	12.6±3.0
Sodium (mg)	<2,300	2,627±549	3,009±673*	2,495±440
Calcium (mg)	1,300	900±314	1,165±339*	809±252
Iron (mg)	8	14.2±4.3	17.7±4.9*	12.9±3.4
Folic acid (DFE)[c]	300	382±136	472±184*	352±102
Food groups[d]				
Fruits (cups/day)	2	0.96±0.50	0.83±0.25	1.01±0.06
Vegetables (cups/day)	2.5	1.06±0.49	1.30±0.22	0.98±0.50
Milk equivalents[e] (cups/day)	3	2.42±1.18	3.06±1.15	2.21±1.13
Top contributors to calories and saturated fat in children's diets[d]				
Total calories	Milk, peanut butter sandwich, poultry, ice cream, beef, yogurt, cold cereal, spaghetti w/sauce, pasta, dark bread			
Calories from mixed dishes	Peanut butter sandwich, spaghetti w/ sauce, pizza, macaroni and cheese, turkey sandwich, tacos, bologna sandwich, cheeseburger, French toast, grilled cheese sandwich			
Calories from snack foods	Potato chips, corn chips, crackers, nuts, pretzels, popcorn, nachos, chicken noodle soup			
Calories from desserts and sweetened beverages	Ice cream, fruit punch, chocolate chip cookies, frozen yogurt, popsicles, chocolate, soda, cake, other candy, graham crackers			
Saturated fat	Milk, ice cream, beef, cheese, butter, poultry, peanut butter sandwich, macaroni and cheese, fried foods eaten away from home, meatballs			

[a]Recommended intake levels for energy and food groups were estimated for the average KidSTEPS participant who was 9.5 years old, based on the US Department of Agriculture Food Guide amount at the 2,000 calorie-level for a moderately-active to active boy or girl ages 9-13 (25); for micronutrients, Dietary Reference Intakes are shown for males and females ages 9-13 years (26-31). Recommended fiber intake is 14 g/1,000 kcal, representing 28 g/day at a 2,000-calorie intake level (30). There is no specific recommendation for *trans*-fat intake other than to keep intake as low as possible (25).
[b]Nutrient intake estimated from a series of 3-day food records collected in each of three seasons (fall, winter and spring), for a total of nine dietary records per child.
[c]DFE=dietary folate equivalent. 1 DFE=1 μg food folate (26).
[d]Derived from the Youth/Adolescent Questionnaire (18,19).
[e]Milk equivalents include milk, yogurt and cheese.
*$P<0.05$ for differences in intake between sexes.
†$P=0.05$.

girls) to 13,000 steps (for boys) at least 5 days a week. More recently, targets ranging from 12,000 up to 16,000 steps per day have been suggested for girls and boys, respectively (37,38). KidSTEPS participants were challenged to meet these goals, with boys logging an annual average of 12,839 steps and girls accumulating only 9,822 steps on average. In fact, boys logged considerably more steps than girls in each season. The sex discrepancy was least pronounced during the spring season, when both groups appeared to be the most active. In general, step counts were notably higher during the fall and spring seasons, whereas levels dropped to below recommended targets in the winter among both sexes. Sustaining physical activity during winter months and inclement weather requires special efforts and creative innovation.

The observation that boys were more active than girls is consistent with other research (39-42) and suggests the importance of targeting activity interventions differently to girls to achieve high rates of participation. In addition, research suggests that interventions should encourage specifically more vigorous physical activity. In fact, the majority of youth participate in moderate physical activity, whereas <3% engage in vigorous activity three or more times per week (39,43).

While the activity findings are promising, observations about the average time spent inactive warrant attention. Research suggests that physical activity declines throughout adolescence and is often replaced with less-active pursuits (44). Inactivity, particularly inactivity associated with television-watching and video or computer games, may be related to development of unhealthful eating and snacking patterns (45,46), including excess fat consump-

Table 2. Mean daily pedometer step counts and self-reported physical activity of elementary school-aged participants in KidSTEPS, compared to recommendations for physical activity

Season[a]	Recommended	Overall (n=32)	By Sex: Boys (n=8)	By Sex: Girls (n=24)
		← mean±standard deviation →		
Fall (steps/day)	13,000 for boys[b]	10,955±3,273	13,354±1,884**	10,124±3,262
Winter (steps/day)		9,236±2,554	11,495±2,416**	8,513±2,179
Spring (steps/day)	11,000 for girls[b]	11,625±3,600	13,795±3,676*	10,902±3,342
Annual average[c] (steps/day)		10,576±2,760	12,839±2,548**	9,822±2,432
Time spent in physical activity[d] (h/day)	≥1	1.80±0.91	1.97±1.05	1.75±0.99
Time spent in inactivity[e] (h/day)	<2[f]	4.05±1.92	4.45±1.24	3.93±2.09

[a]Average of pedometer step counts logged over 7 consecutive days per season.
[b]Recommendations for children, set by the 2001-2002 President's Challenge Physical Activity and Fitness Awards Program (36).
[c]Average of pedometer step counts logged over 7 consecutive days in each of three seasons (21 days total).
[d]Self-reported time spent in various physical activities and sports, from the Seasonal Youth/Adolescent Activity Questionnaire (21-23).
[e]Self-reported time spent doing inactive tasks like playing computer games, reading, or watching television; from the Seasonal Youth/Adolescent Activity Questionnaire (21-23).
[f]Recommendation is to limit "screen time" specifically to no more than 2 hours per day (9). This makes the comparison with the estimate of time spent in inactivity as defined by the Seasonal Youth/Adolescent Activity Questionnaire (21-23) less direct because reading is included in that tool's estimate of inactive time.
*$P<0.05$.
**$P<0.01$.

tion (47) and low fruit and vegetable intake (48). Because elementary school-aged children in this sample may already exceed AAP recommendations (9) for screen time, this trend may become problematic as adolescence approaches. In fact, some of the observed dietary traits may already reflect the unhealthful patterns that can develop with excess screen time.

The hypothesis that obesity risk behaviors cluster together is well-supported in the literature. In a recent study, nearly 80% of 11- to 15-year-olds had more than one risk factor related to poor diet and physical activity (49). Moreover, children who are the most sedentary are reportedly less likely to undertake physical activity and consume adequate servings of fruits and vegetables (50). Unhealthful dietary patterns appear to proliferate during the years between elementary and high school, with far fewer high school students consuming enough daily servings of fruits and vegetables (12). In a nationwide survey of >4,000 students, the proportion who fell short of physical activity guidelines increased dramatically by 28 percentage points between elementary and high school, with 63% of high school students not meeting the criteria for physical activity (12). While behavioral research demonstrates that unhealthful behaviors travel together, it also suggests that healthier behaviors are similarly correlated (51,52). This evidence underscores the need for integrated intervention strategies and environmental changes to effectively moderate obesity-related risk behaviors.

Limitations

This descriptive research is preliminary and is limited by the cohort's small sample size, unequal sex distribution with few male participants, and relative homogeneity with respect to demographic characteristics. Yet the combination of multiple self-reported, seasonal, and objective measures of diet and physical activity reduces measurement error and strengthens our behavioral assessments. It should be noted that for apparent differences between boys and girls that do not reach statistical significance, one explanation may be lack of analytical power given the small sample size. Self-selection bias is possible because children who participated may have had activity and dietary patterns that were different, and possibly healthier, than those who did not enroll. This source of bias may explain why most participants were within the healthy BMI range, which limits the generalizability of findings to overweight children. Nonetheless, areas for improvements in diet and physical activity were clearly identified even within this selective cohort, suggesting that substantial risk may remain undefined in the general population.

CONCLUSIONS

Elementary school–aged children have diet and physical activity patterns that warrant attention, additional study, and targeted intervention in order to impact childhood obesity risks. Food and nutrition professionals and educators should work to foster healthful eating behaviors in elementary schools and facilitate physical activity opportunities that effectively involve girls and students in general who are challenging to engage. Specific efforts to increase intakes of fruits, vegetables, dietary fiber, and calcium appear important, as are efforts to reduce consumption of saturated fat and sodium in home, school, and snack environments. Continued emphasis on the promotion of daily physical activity is appropriate, and creative strategies that sustain activity during winter months are needed.

This work was supported by funds from the Dudley Allen Sargent Research Fund, Sargent College of Health and Rehabilitation Sciences at Boston University.

The authors gratefully acknowledge the contributions of the school nurses, school administrators, teachers, parents, and children who participated in the KidSTEPS

project. Special thanks to Research Assistants Danielle Duggan, Katie Kirkpatrick, Annie Paquette, Eva Mallis, Helen Wei, and Mimi Borkan. Thanks to Winning Moves Games, Inc of Danvers, MA and the Barnes & Noble Bookstore at Boston University for the games and prizes donated as incentive gifts for study participants.

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