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Change in Dietary Energy Density after Implementation of the Texas Public School Nutrition Policy

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Abstract

The consumption of energy-dense foods has been associated with rising obesity rates and the metabolic syndrome. Reducing dietary energy density (ED) is an important strategy to address obesity, but few studies have examined the effect of nutrition policies on children's ED. The study's objective was to assess the impact of the Texas Public School Nutrition Policy on children's ED by using a pre- and post-policy evaluation. Analysis of variance/covariance and nonparametric tests compared ED after the Texas policy change to intakes at baseline. Two years of lunch food records were collected from middle school students in Southeast Texas at three public middle schools: baseline (2001–2002) and one year after implementation of the Texas Policy (2005–2006). Students recorded the amount and source of foods consumed. The Texas Public School Nutrition Policy was designed to promote a healthy school environment by restricting 1) portion sizes of high fat and sugar snacks and sweetened beverages, 2) the fat content of foods, and 3) the serving of high fat vegetables like French fries. Energy Density (kcal/g): ED1 was the energy of foods only (no beverages) divided by the gram weight and has been previously associated with obesity and insulin resistance; ED2 included all food and beverages to give a complete assessment of all sources of calories. Following implementation of the Texas Policy, students' ED1 significantly decreased from 2.80 +/− 1.08 kcal/g to 2.17 +/− 0.78 kcal/g (P<0.0001). Similarly, ED2 significantly decreased from 1.38 +/− 0.76 kcal/g to 1.29 +/− 0.53 kcal/g (P<0.0001). In conclusion, the Texas Public School Nutrition Policy was associated with desirable reductions in ED, which suggests improved nutrient intake as a result of student school lunch consumption.

Keywords

Energy Density; School Nutrition; Policy; Children

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Introduction

Dietary energy density (ED) is defined as the amount of energy for a given weight of food (kcal/g) (1). The two main influences on ED include 1) water, which adds weight but not energy and thus decreases ED, and 2) fat, which has high energy content and raises ED (2). The World Health Organization recommended restricting children's intake of energy-dense food for obesity prevention (3). Likewise, the Expert Committee convened by the American Medical Association recommended that the consumption of low energy-dense foods was likely a useful strategy for pediatric weight management (4). A growing number of study findings have linked the consumption of energy-dense foods with obesity (5), the metabolic syndrome (6), and type 2 diabetes (7). Experimental feeding studies have reported that children who consumed higher energy-dense foods consumed more energy (8,9), and this effect was additive if portion size was also increased (8). Large scale epidemiological studies among children have reported positive correlations between dietary ED and daily energy intake (10,11). Some longitudinal, epidemiological studies among children have linked higher ED with higher fat mass (12,13). Similarly in large-scale cross-sectional epidemiological studies among adults, consumption of ED foods was positively associated with weight status (6,14) and the metabolic syndrome (6). Short- and long-term studies have also reported that consuming low ED foods was associated with weight loss or maintenance among adults (15–20).

Schools provide an ideal setting to implement and evaluate policy interventions because they are an important venue for targeting large numbers of youth. Previous research has shown that school environments influenced children's dietary behavior (21). States and school districts have enacted policies to improve school nutrition (22). For example, improvements in food consumption, i.e. greater milk, calcium and vitamin A and less sweetened beverages, were associated with a local school district policy on snack bars in middle schools (23).

The Texas Public School Nutrition Policy was an unfunded mandate designed to promote healthy school environments (24). The guidelines applied to all school food environments, including snack bars and vending. For middle schools, the policy restricted portion sizes of snacks and high fat foods, sales of sweetened beverages, and the fat content of all foods (24). Implementation of the policy was associated with greater lunch-time consumption of vegetables, milk, and several nutrients and lower consumption of sweetened beverages, snack chips, and percentage energy from fat (25). These findings suggested that improvements in ED were likely, since decreasing fat and increasing vegetable intakes were two important strategies to lower ED (26). To date, no studies have examined the effectiveness of school policy interventions to reduce children's dietary ED. This study seeks to fill this gap by reporting on the impact of the Texas Public School Nutrition Policy on the ED of lunch time meals consumed by middle school students in Houston, Texas. This study uses data from a previously published study (25). Specifically, the research objectives were to 1) examine the changes in ED after the policy, 2) determine whether socioeconomic status moderated the impact of the policy on ED, 3) identify changes in the contribution of individual food groups to energy intake after the policy was implemented, and 4) determine whether socioeconomic status moderated changes by individual food groups to energy intake.

Methods

The first year of the study (Y1) was conducted during the 2001–2002 school year and the schools were chosen and assessed as part of a convenience sample for an intervention study (27). The second year of the study (Y2) encompassed the 2005–2006 school year. The Texas Public School Nutrition Policy was implemented statewide in the fall of the 2004–2005 school year. For Y1 and Y2, school-level demographics were obtained from the school district. In Y2 only, individual-level demographics were obtained. Since students who qualify for the federal free/reduced lunch program must meet specific family income eligibility criteria (<185% of the federal poverty level) (28), this indicator provides a school-level measure of socioeconomic status based on income. Data were collected by research assistants at three middle schools in the same school district in Southeast Texas from September to May during both academic years, as previously described (25). Research assistants received a two-hour training on dietary data collection specifically for this study's instruments, which included survey logistics, sampling, and answering students' questions, and were observed monthly by the project manager. This research was approved by the Institutional Review Board of Baylor College of Medicine.

Briefly, all parents received study information and notified that their child could assent or refuse to provide data. Then, assented sixth through eighth grade students completed anonymous lunch food records immediately after lunch in the cafeteria, which has been shown to maximize accuracy of self-report (29). The lunch food records used were shown to be valid in a previous study (30). On each school day during the week, research assistants selected either one or two tables of students at each lunch period and asked students to complete a food record for lunch consumption only. Lunch tables were selected starting at one side of the cafeteria and then on subsequent days, tables closer to the opposite side of the cafeteria were selected until all tables had been sampled. This process was then repeated throughout the entire school year, September through May. Research staff did not collect data on refusals. Since records were anonymous, students could have completed more than one record during each school year. No individual demographic data were collected in Y1.

From the food records, data were entered into the Nutrition Data System (versions 4.2 and NDS-R-2005; Nutrient Coordinating Center, University of Minnesota, Minneapolis) to obtain average daily lunch intake of calories and the average gram weight of food at lunch. Because no standard definition of ED exists (1), the ED of students' lunch meals was defined by two calculation methods: 1) ED1 as the total energy (kilocalories, where 1 kcal = 4.184 kJ) of the lunch meal divided by the total weight (grams) of the lunch meal, excluding all beverages, and 2) ED2 as the total energy (kilocalories) of the lunch meal divided by the total weight (grams) of the lunch meal, including all foods and beverages (water included) as previously described (1). ED1 was calculated for comparative purposes and served as the primary outcome measure. ED1 or food energy density (without beverages), has been previously associated with obesity (5,16,18,31), and the Metabolic Syndrome (6). ED2 was a secondary outcome measure and calculated to provide useful information on the complete diet, including all food and all beverages such as water, fruit juices/drinks, and soft drinks. All analyses were performed for each ED definition separately.

Students' daily average lunch intake by food groups and the percentage of average daily intake by food groups were also calculated. Using the NDS food file output, the foods were classified into food group-specific categories based on the Nutrient Coordinating Center code and description. The percentage of daily lunch intake per food group were secondary outcomes and calculated as the food group-specific kilocalories (energy) divided by the total kilocalories (excluding beverages) and multiplied by 100%. Beverages were excluded from the calculation of food group-specific percentage of total energy since this calculation would most closely resemble ED1, which excluded beverages. ED1 was also the primary outcome measure of this study and has been associated with health outcomes (5,6,16,18,31).

Statistical Methods

Analysis of variance (ANOVA) was used to address the study objectives, using the Statistical Analysis Software (version 9.1.3, 2006, SAS Institute Inc, Cary, NC). Two-way ANOVAs, with year and school SES as factors, were used to identify differences in ED between academic years and school socioeconomic status (SES) (objective one). The inclusion of a study year by SES interaction served to assess whether SES moderated the effect of policy on ED (objective two). A significance level of 0.05 was used for these analyses.

Although a significant interaction indicated moderation by SES, the global statistic did not indicate specifically how the change between years was moderated by SES. Therefore, subsequent to significant interactions, tests of simple effects were performed to more specifically identify significant moderation. The tests of simple effects consisted of stratifying by SES and then examining differences between years. The academic years (2001–2002; 2005–2006) were considered independent student cohorts and the schools were classified as low, moderate, or high SES based on the percent of students who qualified for the federal free/reduced lunch program using school level data. To control for inflated Type I errors caused by multiple testing, the Bonferroni correction was used and the significance level was set to 0.0167.

Similarly, two-way ANOVAs, with year and school SES as factors, were used to identify differences between academic years for the food group-specific percentage of total energy (objective three). Analyses were performed for each food group separately. As above, the inclusion of a study year by SES interaction served to assess whether SES moderated the effect of policy on the food group-specific percentage of total energy (objective four). Since there were eight different food groups, a significance level of 0.00625 was used per the Bonferroni correction. For significant interactions, tests of simple effects were performed to more specifically identify significant moderation. The tests of simple effects consisted of stratifying by SES and then examining differences between years. The Bonferroni correction was used and the significance level was set to 0.002. Effect sizes were classified as small (d=0.25), medium (d=0.50) and large (d=0.80) as previously described by Cohen (32).

Results

School-level socio-demographic characteristics obtained from the school district are shown in Table 1, stratified by school SES. The low SES school had a higher proportion of Hispanic students while the high SES school had a higher proportion of non-Hispanic White students. In Y2, when individual-level socio-demographic data were assessed, the low SES school had a higher proportion of males (66%) than females (34%) while the moderate (52% female) and high (50% female) SES schools were more evenly split by gender.

In Y1, 2616 self-reported food records were collected while in Y2, 10,172 records were collected. The data collection occurred in the schools about 50% of the time. Changes in the school-level demographics of the three schools for Y1 and Y2 occurred. Enrollment increased from about 900 to 1100 students per school. The percent of students eligible for free/reduced price meals increased from 26 to 38%, 50 to 66%, and 68 to 75% in the high, moderate, and low SES schools respectively. The percentage of Hispanic students increased slightly (35 to 45%; 62 to 72%, 87 to 89%), while Non-Hispanic White students decreased slightly (61 to 48%, 29 to 18%, 11 to 9%).

Results from the two-way ANOVAs yielded significant year and SES main effects and significant year by SES interactions (P<0.001 for all) for both measures of ED (Table 2). Comparing the overall ED1 for the three schools before and after the policy, in Y1, foods consumed at school lunch had an ED of 2.80 +/− 1.08 kcal/g (n=2616), while in Y2, ED1 significantly declined to 2.17 +/− 0.78 kcal/g (n=10,172). Similarly, ED2 in Y1 was 1.38 +/− 0.76 kcal/g (n=2616) and significantly declined to 1.29 +/− 0.53 kcal/g (n=10,172). The significant year by SES interactions were of primary interest as they signified the reduction in ED was significantly moderated by SES, meaning that the change between Y1 and Y2 was

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different for at least one SES group. When stratified by SES (with $P \leq 0.0167$), significant reductions of ED1 occurred at all three schools. However, large reductions, based on standardized effect sizes, were observed for the moderate and high SES schools, whereas the low SES school exhibited a small reduction in ED1. In contrast to significant reductions observed in ED1 at all three schools, only the moderate and low SES schools had significant reductions of ED2, although these reductions were small.

Nearly all food group-specific percentages of total energy differed significantly by year (Y1 vs. Y2), school SES level, and the interaction of year by SES (Table 3, $P<0.00625$). Among all the food groups, the year main effect was significant except for grains. The significant year by SES interactions indicated that school SES moderated the change in percentage from total energy. No significant ($P<0.002$) changes in Y2 were observed in the percentage of 1) dessert for the high SES school, 2) grains and fat/oil for the moderate SES school, and 3) fruit, vegetables, and candy for the low SES school. With all schools combined, the percentage of energy for each food group changed from Y1 to Y2 for all food groups except grains. The following food groups increased: the National School Lunch Program (NSLP) mixed entrée, vegetables, fruit, and the NSLP dessert. The following food groups decreased: snack chips, fat/oil, and candy. Snack chips had the largest effect size (0.76) while the remaining food groups all had small or small to moderate effect sizes (0.04–0.36). The changes to percentage of total energy by food groups did vary by school SES, although most had small effect sizes. Exceptions included 1) a moderate decrease from snack chips at the high SES school; 2) a moderate increase in the NSLP mixed entrée and a large decrease for snack chips at the moderate SES school; and 3) a moderate decrease in fat/oil at the low SES school.

Discussion

Implementation of the Texas Public School Nutrition Policy was associated with desirable decreases in the lunchtime ED of middle school students, whether beverages were included or not. The overall reduction in ED1 (food only, no beverages) of 0.63 kcal/g was consistent with previous reports among adults who reduced their ED and achieved long-term weight loss and maintenance (16,18). Moreover, in Y2 (post-policy) mean ED1 declined to 2.17 kcal/g, which is closer to mean ED1 of 2.03 +/− 0.03 kcal/g (S.E.) for an entire day based on nationally representative data on nine to thirteen year old children from NHANES 1999–2004 (33). Significant reductions in ED1 were seen at all three schools, but were greatest for the high and moderate SES schools. Those students had the highest lunchtime ED1 values in Y1, with values well above comparable mean daily ED1 values for nine to thirteen year old US children (33) and instead were in the range of the highest ED1 tertile category for US adults. A caveat in these comparisons is that the students' ED1 values were from the lunch meal only rather than the entire day's dietary intake (5). Nevertheless, it is plausible that students from the high and moderate SES schools had more money to spend on snack foods or vending machine items in Y1, which resulted in higher lunchtime ED1. Since the Texas Public School Nutrition Policy restricted the purchase of these items in Y2, ED1 declined at all schools, but more substantially at the moderate and high SES schools. In support, the percentage of energy from snack chips significantly decreased from Y1 to Y2. These decreases had moderate or large effect sizes at the high and moderate SES schools, respectively, compared to the small effect size at the low SES school.

The Texas Public School Nutrition Policy was also associated with desirable changes to lunchtime ED2, which included all foods and beverages. These decreases in ED2 were significant only for the moderate and low SES schools. The baseline ED2 values were higher than comparable ED2 values (1.30+/− 0.031) from a nationally representative sample of secondary school students participating in the NSLP (34). However, the decrease in ED2 associated with the policy resulted in energy density values similar to ED2 values for secondary school students participating in the NSLP from that same study (34).

Changes in lunchtime ED were associated with greater percentages of energy from the following food groups: NSLP mixed entrée, NSLP dessert, vegetables, and fruit, although the effect sizes were small. Conversely, changes in ED were associated with decreased percentages of energy from snack chips, fat/oil, and candy, with the effect size for snack chips being the largest. These findings were consistent with the previously published findings, which reported associations with increased intake of NSLP foods and decreased snack bar and vending machine item intake (25). These findings were generally consistent with national recommendations to improve fruit and vegetable consumption and decrease intake of fats, added sugars, and salt (35). They are also consistent with previously published recommendations for changing the ED of diets for weight management, which included increasing water rich ingredients (i.e. fruits and vegetables), and reducing the amount of added fat to mixed dishes in addition to simply eating more fruits and vegetables (26). Changes in ED were also associated with greater consumption of foods prepared as part of the NSLP (mixed entrée and dessert). These are desirable changes since the NSLP mixed entrée and dessert are under the direct control of schools or school districts, rather than outside vendors.

The changes to the percentage of total energy by food groups differed by school SES with most changes having small effect sizes. Although for all three schools combined, the decrease in snack chips had the largest effect size, analyses stratified by school SES revealed that the policy was associated with high or moderate decreases, respectively, to snack chips at the moderate and high SES schools only. The decrease at the low SES school had a small effect size. Since the students from the moderate and high SES schools may have had greater disposable income and had substantially higher percentages of total energy due to snack chips at baseline, the policy may have been able to have a greater impact on their consumption of snack chips by limiting in-school purchases of those items.

This study has several limitations, as previously reported (25). First, there was no control group and individual students were not followed longitudinally; therefore, the changes in ED may simply reflect a secular trend or due in part to changing demographics at the schools. Second, the dietary intake data were by students' self report, although this method was previously validated against direct observation (30). Third, individual-level socio-demographic data on students were collected only in Y2, and no data on non-responders were collected. Fourth, it cannot be determine if students completed multiple assessments, although this bias was minimized by aggregating the data at the weekly level. Also the analyses did not account for potential bias from social clustering at lunch tables, nor the potential clustering effect by school due to only three schools enrolled in the study. While the schools varied by SES, their race/ethnicity makeup may not reflect other schools, limiting external generalizability. Fifth, no process evaluation was conducted to assess the degree of policy implementation at the schools. Finally, dietary intake was assessed only at lunchtime, which may not reflect consumption over a 24-hour period. It could be argued that decreasing students' lunchtime ED may lead to higher ED at home. However, a previous study (34) reported that among secondary school students, NSLP participants had higher ED2 at school than at home. This finding suggests that these students may not compensate for the lower ED2 at school by increasing ED2 outside of school. Further research is necessary to clarify that important issue.

Conclusions

This study is the first to report on a successful school nutrition policy intervention that significantly reduced students' lunchtime ED. The policy had different desirable effects to students' lunch intake, depending on school SES. Since consumption of higher ED foods has been linked to obesity and the metabolic syndrome, reducing ED on a population level is a necessary strategy. This report is important because the Texas Public School Nutrition Policy has wide scope and implications. The policy provides school nutrition guidelines for the entire state of Texas and serves as a model for other states and school districts to follow. Of particular note, since the Texas Public School Nutrition Policy was associated with a greater percentage of energy consumed from the NSLP entrée and dessert, dietetic professionals should provide guidance on optimizing the nutritional quality of these items. Moreover, this report lends support that school lunch policies should extend to all food environments, including snack bars and vending machines, since the items from those areas were most highly impacted and associated with lower lunchtime energy density. Further studies are needed to confirm these findings and determine their associations with overall daily ED, energy balance, and weight status.

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Table 1

Percentages for Participant Characteristics

	Low SES (%)		Moderate SES (%)		High SES (%)	
	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
Year 1 School Demographics[a]						
%Free/reduced Lunch	68	75	50	66	26	38
Ethnicity						
African-American	1	1	7	8	0	1
Hispanic	87	89	62	72	35	45
White	11	9	29	18	61	48
Other	1	1	2	3	4	6
Year 2 Individual Demographics						
Ethnicity						
African-American	n/a	2	n/a	10	n/a	3
Hispanic		93		77		60
White		2		9		31
Other		3		4		6
Gender	n/a		n/a		n/a	
Male		66		48		50
Female		34		52		50

[a] Individual-level demographics were available for year 2 only

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Table 2

Means (standard deviations) and results from two-way analyses of variance for energy density by academic year and socioeconomic status (SES)

Energy Density	Academic Year				ES[a]
	Year 2001–2002		Year 2005–2006		
	N	M (SD)	n	M (SD)	
ED1: Energy Density Without Beverages[b]					
High SES (26%)	978	3.12 (1.01)	3558	2.34 (0.87)	0.99
Moderate SES (50%)	937	2.97 (1.19)	3458	2.09 (0.72)	1.07
Low SES (68%)	701	2.15 (0.70)	3156	2.06 (0.69)	0.29
Total	2616	2.80 (1.08)	10172	2.17 (0.78)	0.87
ED2: Energy Density With Beverages[c]					
High SES (26%)	978	1.35 (0.83)	3558	1.31 (0.59)	0.04
Moderate SES (50%)	937	1.42 (0.85)	3458	1.26 (0.49)	0.22
Low SES (68%)	701	1.38 (0.50)	3156	1.29 (0.51)	0.15
Total	2616	1.38 (0.76)	10172	1.29 (0.53)	0.12

[a]Using Cohen's interpretation, the magnitude of the standardized effect sizes (ES) are small (0.25), moderate (0.50), and large (0.80)

[b]ED1:Significant Year $F(1,12782)=1029.67$, $P<0.0001$, SES $F(2,12782)=384.14$, $P<0.0001$, and Year by SES $F(2,12782)=166.38$, $P<0.0001$ effects; Simple effects yielded significant difference between years for all SES Schools ($P<0.0001$)

[c]ED2: Significant Year $F(1,12782)=55.29$, $P<0.0001$, and Year by SES $F(2,12782)=7.50$, $P=0.0006$ effects. Simple effects yielded significant difference between years for Moderate & Low SES Schools ($P<0.001$)

Table 3

Percentage of total energy by food group, year, and socioeconomic status (SES)

Food Group[a]	**Year 1**	**Year 2**	**ES[b]**
	M (SD)	**M (SD)**	
High SES	n=978	n=3558	
Meat/cheese/mixed entrée	27.4 (20.5)	34.8 (21.6)	0.35
Fruit	2.0 (6.0)	5.0 (9.4)	0.34
Vegetables	7.9 (11.5)	10.8 (13.7)	0.22
Grains	17.2 (14.4)	19.1 (13.4)	0.14
Dessert	9.2 (20.2)	10.8 (18.7)	0.09 ns
Candy	5.7 (16.1)	4.3 (9.2)	0.13
Fat/oil	13.6 (12.4)	10.7 (10.4)	0.26
Snack Chips	16.4 (28.3)	4.5 (13.1)	0.68
Moderate SES	n=937	n=3458	
Meat/cheese/mixed entrée	28.2 (19.4)	38.2 (19.4)	0.52
Fruit	3.8 (8.1)	7.9 (10.6)	0.41
Vegetables	4.6 (6.7)	8.5 (10.8)	0.39
Grains	21.1 (15.2)	19.8 (12.7)	0.10 ns
Dessert	5.4 (14.5)	9.2 (18.8)	0.21
Candy	6.9 (18.1)	4.0 (8.2)	0.27
Fat/oil	10.4 (10.0)	11.0 (9.4)	0.07 ns
Snack Chips	18.9 (30.9)	1.2 (7.3)	1.13
Low SES	n=701	n=3156	
Meat/cheese/mixed entrée	37.2 (16.9)	39.7 (19.1)	0.13
Fruit	7.4 (10.5)	6.6 (10.1)	0.08 ns
Vegetables	10.6 (11.3)	11.7 (13.8)	0.09 ns
Grains	22.9 (11.5)	19.9 (13.2)	0.23
Dessert	2.8 (7.8)	9.7 (20.1)	0.37
Candy	2.0 (6.9)	2.2 (5.8)	0.03 ns
Fat/oil	13.9 (10.0)	9.4 (8.4)	0.52
Snack Chips	2.3 (10.5)	0.9 (6.7)	0.19
Total	n=2616	n=10172	
Meat/cheese/mixed entrée	30.3 (19.6)	37.5 (20.2)	0.36
Fruit	4.1 (8.4)	6.5 (10.1)	0.25
Vegetables	7.5 (10.2)	10.3 (12.9)	0.23
Grains	20.1 (14.2)	19.6 (13.1)	0.04 ns
Dessert	6.1 (15.8)	9.9 (19.2)	0.21
Candy	5.1 (15.2)	3.5 (8.0)	0.16
Fat/oil	12.5 (11.1)	10.4 (9.5)	0.21
Snack Chips	13.5 (26.8)	2.3 (9.7)	0.76

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[a]Level of significance (*P*<0.00625) for global effects; All global main effects and interactions were significant except for the year main effect for Grains; all simple effects were significant (*P* <0.002), unless noted with ns (not significant)

[b]Using Cohen's interpretation, the magnitude of the standardized effect sizes are small (0.25), moderate (0.50), and large (0.80)