Digital photography assessment of 1,750 elementary and middle school student lunch meals demonstrates improved nutrition with increased exposure to hands-on cooking and gardening classes

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ORIGINAL ARTICLE

Digital photography assessment of 1,750 elementary and middle school student lunch meals demonstrates improved nutrition with increased exposure to hands-on cooking and gardening classes

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Abstract To investigate a scalable version of a global nutrition education model by a novel assessment of the impact of hands-on cooking and gardening classes, Edible Schoolyard (ESY), on the eating patterns of elementary and middle school students. Lunches ($n = 1{,}750$) by students ($n = 479$) including 8,750 food components in an urban charter school in New Orleans, Louisiana, were analyzed over one week using a validated digital photography protocol. Univariate analyses and multivariate logistic regression according to school class were performed. Compared to less ESY exposed grades, eighth graders consumed less saturated fat (2.4 vs. 2.8 g, $p < 0.0274$), less total fat (11.9 vs. 13.5 g, $p = 0.0324$), and more fruits (100 vs. 68 %, $p = 0.0047$). After controlling for caloric intake, this class was nearly twice as likely to consume less than 1,000.0 mg sodium per meal compared to other grades (OR = 1.94, 95 % CI 1.0137–3.7140, $p = 0.045$), however, eighth graders failed to meet the 650.0 mg sodium target of the Healthy, Hunger-Free Kids Act of 2010. We report lower sodium and fat but higher fruit consumption in students with greater exposure to hands-on nutrition education. This is the first known application of an accurate digital photography protocol to demonstrate dietary improvements of elementary and middle school students with increased exposure to a hands-on cooking, gardening, and nutrition education curriculum. This study suggests that such a curriculum is thus scalable through schools for improving child health.

Keywords Childhood obesity · Culinary medicine · Nutrition education

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Introduction

The global obesity epidemic and its toll of associated chronic diseases pose an alarming problem among American children. Nearly 1 in 5 children aged 2–19 are obese [1] and 9 of the 10 states with the highest childhood obesity rates are located in the southern United States [2, 3]. The negative health effects of childhood obesity have been well documented, including increased rates of diabetes and prediabetes, cardiac risk factors, and sleep apnea, as well as social and psychological problems. Childhood obesity is strongly linked with adult obesity and long-term health problems such as heart disease, diabetes, cancer, and osteoarthritis [4]. Despite the rapid worsening of this problem, there has been a shortage of successful long-term weight loss interventions [5]. Most programs combat childhood obesity center on adoption of healthy eating habits and increasing physical activity. The Center for Disease Control (CDC) identifies the school system as integral to combating childhood obesity since schools promote a safe and supportive environment to foster healthy behaviors and also provide a significant amount of physical exercise and nutrition for a large number of students [6].

Since the National School Lunch Program (NSLP) was founded by the federal government in 1946 to provide low-cost or free school lunch meals to low-income students, the program has grown steadily in size and scope. In the 2011 fiscal year, 31.8 million American children received lunch through the NSLP at a cost of $11.1 billion per year and now it provides breakfast, snacks, and meals during summer [7, 8]. Given the size and number of meals served per year, the NSLP has been a significant contributor to the health of children.

The USDA conducted the National Evaluation of School Lunch programs in 1980, which validated that students participating in the program had better nutrition status than controls, but only minor changes in the contents of meals were made [9]. In 1992, the USDA released the School Nutrition Dietary Assessment Study (SNDA-I), which found that less than 1 % of schools were meeting the USDA guidelines for healthy diets, with reimbursable lunches having a significantly higher percentage of fats than recommended [10]. As a result, the USDA created strict nutrient standards for reimbursable meals and required ongoing evaluation every 5 years. The SNDA-III, published in 2005, found significant improvement in school lunches, especially in regards to fat content. As a result of this study, and acknowledging the agency's importance in combating both the obesity epidemic and the rising increase in childhood hunger, the USDA published new guidelines for the NSLP in early 2012 [11]. These changes amounted to the most drastic overhaul to the NSLP since its founding. Not only was the content of meals changed, with mandated daily servings of fruits and vegetables, daily minimums for meat or meat alternatives, a switch to whole grains by 2014, only fat-free milk and elimination of trans fats, but also the Healthy, Hunger-Free Kids Act allowed for limits on "competitive foods" such as vending machines in schools, establishing consistent nutrition throughout the entire school for the first time [12, 13].

While studies have shown that the content of NSLP lunches has considerably healthier nutrition status compared with lunches brought from home, concerns have been raised that students do not always eat the healthier choices in their meals [14]. A 2011 study of middle school students found that despite having the healthier options present, few students actually met the nutritional guidelines, especially for green vegetables, whole grains, and fruit [15]. Recent child plate waste studies have documented high waste rates, especially for vegetables and fruits, to be 61 and 38 % wasted, respectively [16], though these studies fail to adequately characterize key macronutrient metrics including sodium and fat intake [17].

The Edible Schoolyard (ESY) is an emerging international program to help address this disparity through its School Lunch Initiative, a public–private partnership that integrates gardening education and cooking instruction [18, 19]. A 2010 study found that the School Lunch Initiative was successful in increasing elementary and middle school student fruit and vegetable intake and nutrition knowledge [20], though the study was not subjected to a peer-review process.

FirstLine Charter school network in New Orleans partnered with ESY in 2006 after the destruction wrought by Hurricane Katrina. FirstLine operates five open-admission charter schools across the city enrolling nearly 2,400 students. All five have gardens and two of the schools have teaching kitchens. Ninety-six percent of the participating students are African American and nearly all are eligible for free or reduced price meals through the NSLP [21]. The site at Samuel Green Charter School is the largest and is modeled after the original ESY, with a one-third acre garden and a state-of-the-art teaching kitchen on campus. Gardening and cooking have been integrated into the school's curriculum over the past 6 years with school programs seeking to involve both parents and the wider community in sustainable agriculture and healthy eating.

In an effort to determine the effectiveness of ESY programming, we implemented a validated digital photography protocol for studying proportions of students' food consumption according to lunch components (protein, fruit, starch, vegetable and dairy) and macronutrients (calories, sodium, trans fat, saturated fat and total fat) [22, 23]. This study sought to use a validated digital photography protocol for the novel application to test an integrated healthy cooking, gardening, and nutrition education in a school-based curriculum program that is thus scalable globally.

Methods

This cross-sectional study assesses consumption of lunch meals ($n = 1{,}750$) by 479 elementary and middle school students in an inner-city school in New Orleans, Louisiana, over 1 week. We also sought to analyze the consistency of serving sizes provided by the food vendor for three classes over five study days. Documentation of consumption was achieved using the digital photography protocol comparing pre- and post-lunch student plates validated by Williamson et al. 2004 in a similar elementary student population. Two cameras were secured at standard angles of 45 degrees, in relation to the metal cart tray at an elevation of 15 inches above the trays. One researcher operated each of the two cameras simultaneously as elementary and middle school students placed their trays before and after lunch consumption on the cart trays using IDs on clothespins, attached to each plate for tracking students in a de-identified

Fig. 1 The before photo for student 1,668 from the stage one photographic data

fashion (Fig. 1). Variance from standard serving sizes was calculated from the photographic data as well as mean and standard deviations of serving sizes. The digital photography protocol was applied for all students in the school over five lunch periods.

The photographic data were coded using the system developed by Williamson et al. 2004. For each student's meal, two researchers marked the photos corresponding to post-lunch consumption periods as percentages in 10 % increments of the pre-lunch consumption plates. The menus were obtained from cafeteria staff with the food names from the Sodexo distributor, which were then referenced to the distributor's online nutrition calculator, the Sodexo nutrition calculator [24], to generate the amount of macronutrients in their respective units including calories, sodium, trans fat, saturated fat, and total fat. Each class was followed for 1 week, with over 80 % of the meals during the study period being variations of the sample menu included in Appendix 1. The percentage of food consumed by one student for one serving of each menu item was multiplied by the nutrient breakdown for one serving from this calculator. This tool was chosen due to the reliability of the distributor accurately chronicling the nutrient profile for each of their foods as standard products, including lists with the set names on the menus obtained from the cafeteria.

Univariate analyses with multivariate logistic regression according to school class were performed with appropriate test statistics and adjustment for known covariates using STATA 12.0 (StataCorp LP, College Station, TX, USA). A p value <0.05 was considered statistically significant. This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the Tulane University Institutional Review Board (IRB). The IRB approved de-identified data collection on elementary and middle school students' plate waste with waived informed consent.

Results

The photographic data (Table 1) showed that while students are served the caloric requirements of 550.0–650.0 calories per meal, the students consistently fail to consume the amount suggested by national guidelines, with an average consumption of 358.0 calories per lunch. The students did meet guidelines of consuming meals that consist of 0.0 % of trans fat (5-day average 0.0 %). The students also met guidelines for consuming meals that contain less than 650.0 mg of sodium (5-day average 544.0 mg). The students consumed an average of 15.1 g of total fat, 38.0 g of carbohydrates and 4.1 g of dietary fiber per meal as well as an average of 68.0 % daily vitamin A, 53.0 % daily vitamin C, 11.0 % daily iron and 21.0 % daily calcium.

The variability of serving sizes of meals was assessed to determine the food vendor's compliance with federal serving sizes (Tables 2 and 3). 10.1 % of meals served had a greater than 10.0 % variance from the reference entree. However, the average meal size was 98.9 % of the ideal serving. When shepherd's pie and turkey tacos were removed from the data set (due to the 0.0 % variability in those meal sizes) 18.6 % of entrees varied by more than 10.0 % from the reference meal. The variability of side dishes was even more significant—the amount of side dishes that showed greater than 20.0 % variance from the reference serving was 65.0 % for oranges, 47.0 % for steamed carrots, 22.0 % for baked sweet potato, 39.0 % for peas, 33.0 % for squash, and 21.0 % for steamed green beans.

The digital photography protocol was applied for the entire school for 8,750 food components (protein, fruit, starch, vegetable, and dairy) among 479 students (n = 1,750 lunch meals). The highest mean caloric intake by grade was the second graders (431.0 g, SE = 16.7 g), followed by the seventh graders (374.0 g, SE = 11.2 g), fifth graders (363.0 g, SE = 14.6 g), eighth graders (359 g, SE = 12.4 g), and the remaining classes. Compared to the other grades with less ESY exposure, eighth graders consumed half the mean sodium (390.1 mg vs. 822.6 mg, $p < 0.0001$) (Fig. 2), lower saturated fat (2.4 g vs. 2.8 g, $p < 0.0274$), and lower total fat (11.9 g vs. 13.5 g, $p = 0.0324$). Eighth graders consumed significantly more fruit by percentage of the fruit they selected compared to other grades (100.0 % vs. 68.0 %, $p = 0.0047$), though there was no significant difference in vegetable intake between eighth graders and other classes with less ESY exposure (30.0 % consumption vs. 29.0 %, $p = 0.5685$). Even after controlling for caloric intake, eighth graders compared to other grades were nearly twice as likely to consume less than 1,000.0 mg sodium per meal (OR = 1.94, 95 % CI 1.0137–3.7140, $p = 0.045$) and nearly twice as likely to consume less than 13 g of total

Table 1 Macronutrients consumed in stage one

	Monday	Tuesday	Wednesday	Thursday	Friday	Average
Calories	335.0	487.0	347.0	381.0	239.0	358.0
Total fat (g)	7.0	27.8	17.2	16.4	7.1	15.1
Sat fat (g)	2.5	7.0	9.0	6.3	2.3	5.4
Trans fat (g)	0.0	0.0	0.0	0.7	0.0	0.1
Cholesterol (mg)	21.0	85.0	56.2	53.0	44.3	52.0
Sodium (mg)	453.0	468.0	611.0	596.6	588.9	544.0
Total carbs (g)	54.0	31.7	33.1	39.8	32.5	38.0
Dietary fiber (g)	4.6	3.6	4.0	5.8	3.3	4.1
Sugars (g)	24.4	13.9	15.1	16.7	13.6	17.5
Protein (g)	14.7	26.4	15.8	18.6	22.7	18.8
Vitamin A (%)	50.2	144.0	41.7	66.9	39.0	68.0
Vitamin C (%)	92.0	16.7	24.3	52.5	81.2	53.0
Calcium (%)	9.8	23.5	32.8	21.2	17.8	21.0
Iron (%)	9.3	14.0	12.1	11.3	9.4	11.0

Table 2 Percent variance ≥20 % of the reference serving size

	Steamed carrots	Orange slices	Baked sweet potato	Peas	Steamed corn	Squash	Steamed green beans
Percentage varied	47.0	65.0	22.0	39.0	26.0	33.0	21.0
Mean	109.5	130.6	85.0	86.3	88.8	89.2	90.8
Standard Deviation	23.7	62.8	31.3	30.6	25.1	20.6	20.2

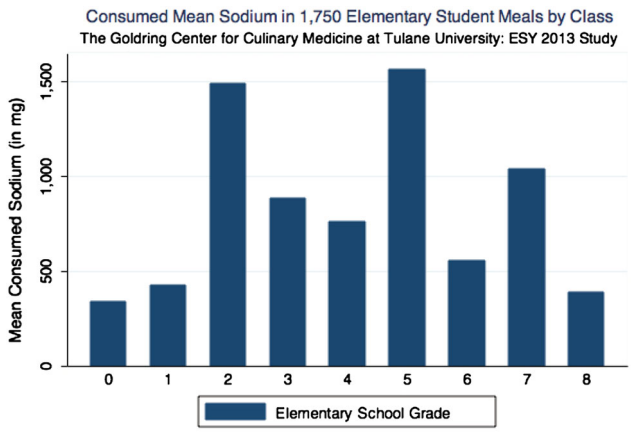

Fig. 2 Consumed mean sodium (in mg) according to elementary and middle school grade for stage two

fat per meal (OR = 1.67, 95 % CI 1.1212–2.4817, $p = 0.012$). There was no significantly greater likelihood for eighth graders to meet the Healthy, Hunger-Free Kids Act of 2010 target of less than 650 mg of sodium. Fifth graders, in contrast, were half as likely to consume under 1,000 mg sodium (OR = 0.49, 95 % CI 0.2767–0.8818, $p = 0.017$) and 65 % less likely to consume less than 13 g of total fat (OR = 0.35, 95 % CI 0.2219–0.5433, $p < 0.001$).

Discussion

This is the first known application of a validated digital photography protocol to demonstrate the dietary improvements of elementary and middle school students with increased exposure to a hands-on cooking, gardening, and nutrition education curriculum in a school setting. We demonstrate that lower sodium and total fat consumption along with higher fruit consumption are associated with increased exposure to ESY nutrition education. Despite the largely consistent linear trends in these macronutrient consumption proportions by grade, there are spikes in sodium and fat with drops in fruit consumption among second and fifth graders. These findings are particularly important because they may indicate a previously poorly considered confounder in plate waste studies, namely biologic growth spurts. Students in these grades may consume more calorie-dense meals with less discriminant

choice for healthier lunch options that may mask the impact of the ESY curriculum.

Our analysis also showed that there is prominent serving size variability in elementary and middle school student meals. The serving sizes for three of the five main entrees and all of the side dishes varied significantly from the standard serving size at least 18 % of the time. The serving size of entrees varied by more than 10 % from the reference meal and 18.6 % of the time, the side dishes showed even greater variability; for example, one of every two students received a serving of carrots that was either less than 90 % or more than 110 % of the reference. Our findings not only suggest areas of improvement for food providers meeting contract guidelines, but also suggest a critical area for consideration during plate waste studies to account for variability in amount of food in meals served.

The generalizability of the results may be diminished due to study limitations, including single-site design, lack of randomization of ESY versus no ESY exposure, inconsistent application of ESY exposure to the students and less effective ESY curriculum features persisting. An additional limitation is the possible Hawthorne effect of students seeking to improve their diets; based on their knowledge their eating habits are being monitored. Possible future studies may include a variation of the digital photography protocol using standard angles for a hidden camera either at the site of plate disposal or on study staff.

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Conflict of interest The authors have no conflicts of interest.

Ethical disclosures This study was conducted with IRB-approval and in accordance with the guidelines in the World Medical Association (2000) Declaration of Helsinki, the Guidelines on the Practice of Ethics Committees involved in Medical Research Involving Human Subjects, and the Guidelines for the Ethical Conduct of Medical Research Involving Children.

Appendix

See Table 3.

Appendix 1 Sample menu representing > 80 % of student meals

Nutrients	Day 1	Day 2	Day 3	Day 4	Day 5
Main dish (choose 1)	Turkey spaghetti, chicken salad, garlic breadstick	Baked chicken thighs, tuna salad, cornbread	Turkey and cheese sandwich, tuna salad, garlic breadstick	Cheese pizza, tuna salad, cornbread	Smothered chicken, tuna salad, garlic breadstick
Side dish (choose 4)	Frozen carrots, frozen peas, fresh apples, grapes	Steamed corn, baked beans, fresh pear, plum	Floret broccoli, carrot sticks, fresh apple, fresh orange	Vegetable medley, romaine salad, fresh pear, fresh banana	Sweet potato, green beans, fresh orange, plum
Milk (choose 1)	Assorted milk	Assorted milk	Assorted milk	Assorted milk	Assorted milk

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