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Research report

Increasing portion sizes of fruits and vegetables in an elementary school lunch program can increase fruit and vegetable consumption ☆

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ABSTRACT

Increasing portion size can increase children's consumption of food. The goal of this study was to determine whether increasing the portion sizes of fruits and vegetables in an elementary school cafeteria environment would increase children's consumption of them. We measured each child's consumption of the fruit and vegetables served in a cafeteria line on a control day (normal cafeteria procedures) and on two intervention days. When we increased the portion size of 3 of the 4 fruits and vegetables by about 50%, children who took those foods increased their consumption of them. Although this was an effective strategy for increasing fruit and vegetable consumption among students who took those foods, many children chose not to take any fruits or vegetables. Further efforts are needed to increase children's selection and consumption of fruits and vegetables in an environment of competing foods of higher palatability.

Introduction

Consuming a diet plentiful in fruits and vegetables benefits health. Such benefits include reductions in relative risk for coronary artery disease (Bazzano et al., 2002; He, Nowson, Lucas, & MacGregor, 2007; Joshipura et al., 2001), stroke (He, Nowson, & MacGregor, 2006), and cancer (Riboli & Norat, 2003). Inclusion of fruits and vegetables in the diet has shown favorable effects on weight status (Ledoux, Hingle, & Baranowski, 2011; Rolls, Ello-Martin, & Tohill, 2004). Obesity remains an important health concern for children, especially in low income populations (Pan, May, Wethington, Dalenius, & Grummer-Strawn, 2013; Singh, Siahpush, & Kogan, 2010). Shifting consumption from high energy density foods to lower energy-dense and nutrient-rich foods, such as fruits and vegetables, could potentially reduce the risk of obesity (Ledikwe et al., 2006). Data from the National Health and Nutrition Examination Survey (NHANES) indicate a large majority of children do not meet the dietary recommendations for fruit and vegetable intake (Krebs-Smith, Guenther, Subar, Kirkpatrick, & Dodd, 2010). Determining new strategies to promote children's vegetable consumption is an important goal for their future health.

One of the most robust findings in eating consumption research is that the more food people have in front of them, the more of it they eat (Wansink, 2004). Increasing portion size has been shown to promote intake in children (Fisher, 2007; Fisher, Arreola, Birch, & Rolls, 2007; Fisher & Kral, 2008; Fisher, Liu, Birch, & Rolls, 2007; Fisher, Rolls, & Birch, 2003).

While most of these studies show children consuming more of a highly liked food when given a larger portion, mixed evidence exists that these effects also influence the consumption of less palatable food. Wansink and Kim (2005) observed that individuals consumed more of foods served in larger portions, even when they rated the foods as not tasting good, and even though they were not hungry. On the other hand Kral, Kabay, Roe, and Rolls (2010) increased portion sizes of applesauce, broccoli and carrots and found that consumption of only the applesauce increased with the increasing portions. Doubling the amounts of the broccoli and carrots did not significantly increase their consumption except when comparing children who said they preferred the broccoli or carrots over the other menu items in comparison to children who preferred these items least. Mathias et al. (2011) observed increases in

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children's consumption of broccoli with increases in the serving size of broccoli. Their broccoli was buttered and served with a side of salad dressing, which may have increased its palatability. Previous studies increasing portion sizes of fruit and vegetables for children have been conducted in laboratory settings only. Studies in more naturalistic cafeteria settings, where the physical and social environments are less controlled, and where children have greater autonomy, will be necessary to determine the impact of portion size on consumption in these settings.

The main objective of our study was to investigate whether increasing portion sizes of fruit and vegetable side dishes could increase consumption of these items by elementary school children participating in the National School Lunch Program. We hypothesized that increasing the portion size of a fruit or vegetable side dish by about 50% would increase consumption, and that the increase in fruit consumption would be greater than the increase in vegetable consumption.

Materials and methods

Overview

We conducted a pre-study measurement day to practice our data collection procedures and accustom the children to our presence and our activities in the cafeteria. On three subsequent days, spaced with approximately 1-month intervals, with identical cafeteria menus (same choice options each day; they could change their selections of menu items), we conducted a control day with the school's standard portion sizes and then two intervention days during which we increased the portion size of one vegetable (raw baby carrots) and two fruits (applesauce and fresh orange slices) by about 50%. A second vegetable (green beans) was served on control and intervention days at the standard portion size. At the time of our test, children at the school were required to take a minimum of 3 items from the cafeteria line, thus they could easily select a lunch containing no fruits or vegetables.

Participants

All children in Kindergarten through fifth grade who purchased lunch or received free lunch (n = 643–758 depending on the day) from an elementary school in the Richfield, Minnesota school district participated in this study from January through April 2011. These students came from diverse racial/ethnic backgrounds (30% white and 70% minority – 20% black, 39% Hispanic, 8% Asian, 1% American Indian) with the majority receiving free (53%) or reduced priced lunches (10%). The University of Minnesota Institutional Review board approved the waiver of informed consent and all procedures for this study.

Menu items

All menu items were purchased by the school district through their normal suppliers. Portion sizes for each menu item served on the control days were those typically served by the school using guidelines established by the United States Department of Agriculture (USDA) (U.S. Department of Agriculture Food and Nutrition Service, 2011).

To establish the pre-weight (serving size) for each type of fruit and vegetable, we weighed 10 servings of each fruit and vegetable individually and computed the average (Table 1). Carrot and orange data also included the number of carrots (orange wedges) in the cups – the number was the same for all cups on any particular day (Table 1). From the number of carrots and the average weight of a serving, the average weight per-carrot or per-orange wedge was also determined. The per-carrot weight was used when determining plate waste if the leftover carrots were covered with ranch dressing. The weight of a serving of oranges, carrots and beans varied within a day and among the test days. This was due to the natural variability in the size and shape of the products. Serving size of beans was set by volume; equal volumes of smaller pieces weigh more than the same volume of larger pieces. We served the vegetables and fruits in pre-portioned cups: applesauce in 5 oz Jcups (Dart®, Mason, MI) on control days or 8 oz Styrofoam squat cups (Dart, Mason, MI) on intervention days; oranges and carrots in 5 oz paper squat cups for control days and 8 oz cups for intervention days; green beans in 5 oz paper squat cups.

Procedure

Control days differed from intervention days only in the increased portion size of the carrots, oranges and applesauce.

After entering the cafeteria, students picked up a tray, took a carton of milk, and selected as many pre-portioned fruit and vegetables as they wished from the line. Cafeteria staff served the rest of the meal. Children were required to take at least 3 menu items from the 12 offered (Table 1). After collecting their lunch items the children could visit a condiment bar and serve themselves catsup and ranch dressing ad lib. Our research staff gave each child an index card with their unique personal identification number (PIN). When

Table 1
Lunch menu and amounts served for control and intervention days. Students self-served the milk and the pre-portioned fruits and vegetables. Cafeteria staff served standard-sized portions of the entrée and the noodles. Students had a choice of the three entrees and of the milk types. Children were required to select at least 3 items for their lunch.

Menu item	Control day	Increased portion intervention day 1	Increased portion intervention day 2
Milk (strawberry, chocolate, skim, 2%)	8 oz.	8 oz.	8 oz.
Entrée (chicken tenders, BBQ beef sandwich, peanut butter and jelly sandwich)	Standard	Standard	Standard
Buttery noodles	Standard	Standard	Standard
Orange wedges (1/8) orange (Sunkist® Sherman Oaks, CA)	4 wedges (67 g[a])	6 wedges (110 g[a])	6 wedges (117 g[a])
Carrots (Grimmway® Bakersfield, CA)	5 baby carrots (55 g)	8 baby carrots (93 g[b])	8 baby carrots (70 g[b])
Green beans (frozen, steamed) (Bybee® Pasco, WA)	51 g[c]	51 g[c]	69 g[c]
Applesauce (canned, unsweetened) (Nugget® Atlanta, GA)	115 g	174 g	180 g

[a] The average weight of the oranges does not include peel weight. One wedge equaled approximately 1/8 orange.
[b] Serving size of carrots was set by the count of carrots; smaller carrots on intervention day 2 weighed less than the larger carrots on intervention day 1.
[c] The portion size of the green beans did not change from control to intervention days. Portion size of beans was set by volume; equal volumes of smaller pieces on intervention day 2 weighed more than the same volume of larger pieces on the control day and on intervention day 1.

the students finished eating, our staff collected any fruit and vegetable waste (or empty containers) and placed them on top of that student's index card. We later weighed the uneaten fruit and vegetable waste and recorded the amount remaining for each student.

Data analysis

We determined the amount of each fruit and each vegetable eaten by each child by subtracting the uneaten amount from the average weight of a serving (Table 1). If a child had no cup(s) left on their tray we assumed they had not taken or eaten a fruit or vegetable.

We used SAS version 9.2 for all statistical analysis ($\alpha = 0.05$). To investigate whether or not the amounts consumed were different between test and control days we employed a mixed model analysis of variance (PROC MIXED) for each type of fruit and vegetable separately using only data for students who had consumed that particular fruit or vegetable at least once. The dependent variable was the amount of an individual fruit or vegetable consumed by students taking that specific item; explanatory variables were grade, student (a random variable nested in grade) and the condition (control or intervention day). (We did not include time of day as a separate factor because only one grade ate at each lunch time. Thus grade was completely confounded with lunch time.)

To compare the proportions of students taking individual fruits and vegetables on control and on particular intervention days, z scores for binomial proportions were computed.

Results

Augmenting portion size increased consumption of oranges, applesauce and carrots from 55 to 73% *for those students who took those foods* (Table 2). The average size of these increases ranged from 42 g for applesauce to 16 g for oranges to 13 g for carrots.

Few children selected any vegetable from the cafeteria line. Only 12–14% of children selected carrots, and 4–6% selected green beans (Table 3). Serving larger portions did not increase or decrease the proportion of students selecting the beans or the carrots. Increasing the portion size decreased the proportion of students taking applesauce, but increased the proportion of students taking oranges (Table 3). From 7 to 30% of students taking a fruit or vegetable consumed the entire portion. This percentage did not appear to generally decrease with the increased portion sizes (Table 4).

Because far more students selected the oranges and applesauce than the carrots, the consumption of those fruits per student consuming school lunch increased far more than the consumption of the carrots (a 10–11 g increase for each fruit compared to a 2 g increase in carrot consumption) (Table 5).

A legitimate concern about serving larger portions of fruits and vegetables is the increased amount of waste that could result. Waste more than doubled when serving larger portions of oranges, but increased only a moderate 18% when serving increased portions of applesauce (Table 6). The percent increase in waste from increasing the portion size was generally less than the percent increase in the portion size with the exception of the oranges (Table 6). The proportion of students who took oranges increased on the intervention days (52% and 50%) compared to the control day (35%). This increase in the number of students taking oranges explained the relatively large percent increase in orange waste from the control to intervention condition; each student taking oranges wasted about 67% of the amount served in both conditions. We did not consider the waste from preparing the fruits or vegetables that were not taken although that could be an important economic issue.

Table 3
Percent of all students eating school lunch who took the specific fruit or vegetable on control (n = 680) and intervention days 1 (n = 663) and day 2 (n = 684). P-values are from the test of binomial proportions comparing the control day to each of the intervention days.

Fruit/ Vegetable	Control day	Intervention day 1	P	Intervention day 2	P
Applesauce	46	36	<0.0001	36	<0.0001
Carrots	12	12	.93	14	.27
[a]Green beans	5	6	.41	4	.35
Oranges	35	52	<0.0001	50	<0.0001

[a] The portion size of the green beans did not change from control to intervention days.

Table 4
Number of students eating the entire serving of the fruit or vegetable/number of students taking the fruit or vegetable from the cafeteria line (% of those taking the item that ate the entire amount) for the control and each of the intervention days.

Fruit/Vegetable	Control day	Intervention day 1	Intervention day 2
Applesauce	29/298 (10%)	17/232 (7%)	19/239 (8%)
Carrots	6/80 (7%)	7/77 (9%)	13/92 (14%)
[a]Green beans	7/36 (19%)	11/42 (26%)	5/27 (18%)
Oranges	33/227 (14%)	89/300 (30%)	52/313 (17%)

[a] The portion size of the green beans did not change from control to intervention days.

Discussion

The palatability of the food and the ease of eating it may have influenced the size of the effect of increasing the portion size. Wansink and Kim (2005) showed that people ate 45% more popcorn when given a larger portion size of a better-liked popcorn, but ate only 34% more when the popcorn was relatively more disliked. If we use the percent choosing applesauce (46%) as a crude indicator of palatability, it was the most palatable fruit and vegetable option. Increasing the portion size of the applesauce had the largest effect (an increase of 42 g eaten by those taking the applesauce). Applesauce was a thick, sweet, liquid that could be rapidly eaten with a spoon. Oranges (35% chose these, and ate on average 16 g

Table 2
Mean consumption (least squared means) per student taking a specific fruit or vegetable at least once on control and intervention (INT) days. P-values are from the mixed model analyses of variance.

Fruit or vegetable	Control day (g)	Control SEM[a] (g)	INT day 1	INT day 2	INT days (g)	INT days SEM (g)	Change (g)	Percent change	p
Applesauce	77	3	110	127	119	3	42	55	<0.001
Oranges	22	1	45	32	38	2	16	73	<0.001
Carrots	20	2	30	36	33	3	13	65	0.02
[b]Green beans	22	3	22	26	24	4	2	9	0.36

[a] SEM is the standard error of the mean.
[b] The portion size of the green beans did not change from control to intervention days.

Table 5
Mean consumption *per student consuming school lunch* on control (n = 680) and intervention days 1 (n = 663) and day 2 (n = 684).[†]

Fruit/ Vegetable	Control day (g)	Intervention day 1 (g)	Intervention day 2 (g)	Mean difference in consumption (intervention days – control days)	Percent change [(mean of intervention days – mean control)/mean control)*100]
Applesauce	34	41	46	9.5	28
Carrots	2	3	5	2	100
[a]Green beans	1	1	1	0	0
Oranges	7	20	17	11.5	164

[a] The portion size of the green beans did not change from control to intervention days.
[†] Standard errors are not reported due to a very high proportion of zeros and a non-normal data distribution.

Table 6
Total weight of each product taken and the waste (amount taken minus amount eaten) on control and intervention days, plus comparisons of increases in the amounts served to increases in amounts wasted.

Fruit/ Vegetable	Control day (kg)		Intervention days (kg)		Increase in amount served from control to intervention %	Waste increase from control to intervention (kg)	Waste increase from control to intervention %
	Amount taken	Amount wasted	Amount taken	Amount wasted			
Applesauce	35.0	11.6	41.5	13.6	h8	2.1	18
Carrots	4.4	2.8	6.8	4.0	48	1.2	43
[a]Green beans	1.8	1.0	2.0	1.2	18	.1	11
Oranges	15.2	10.2	34.6	23.0	69	12.8	125

[a] The portion size of the green beans did not change from control to intervention days.

more) were less convenient and more time-consuming to eat because they needed to be removed from the peel. Carrots (12% chose these, and ate on average 13 g more) clearly took the longest time to chew. Future research on the relationship of ease of eating to consumption may prove useful. We did not record the number of times children consumed ranch dressing with their carrots. Its use was not uncommon, but we estimate that less than a fourth of students taking carrots ate them with ranch dressing.

The value of the intervention depended on the cost of the fruit/vegetable, the increase in consumption and the nutritional value of the food consumed. The average cost per gram of the fruits and vegetables we served was $0.006. The average increase in carrot consumption among all children eating school lunch was 2 g (Table 5); for this increase in carrot consumption, we paid about $8.00 per day or about $0.01 per child. The average increase in applesauce consumption per student eating school lunch was 10 g; for this increase we paid about $40.00 or about $0.06 per child. The average increase in orange consumption per student eating school lunch was about 12 g; for this increase we paid about $48.00 or about $0.07 per child. Because the carrots and the oranges were more nutrient dense than the applesauce, the value of increasing the portion size of those foods is likely higher than the value of increasing applesauce consumption.

In general our intervention provided a benefit to students who chose to take the fruits or vegetables by increasing their likelihood of meeting or exceeding USDA lunch meal recommendations. The 42 g per person increase in applesauce intake (Table 2) represented a 0.17 cup increase (one cup = .237 liter). The minimum per day lunch meal recommendation for fruit for these children is 0.5 cups (U.S. Department of Agriculture, Agricultural Research Service, 2013); children who took the increased portion size increased intake from .6 cups to about 1 cup, thus exceeding the meal minimum and approaching the U.S. Department of Agriculture, Agricultural Research Service (2013) recommendation of 1–1.5 cups of fruit/day. The 16 g increase in orange intake represents an increase from about .6 cups to 0.27 cups, or about one-half of the minimum recommended amount of fruit to be served with the lunch meal. The 13 g increase in consumption of carrots for those children taking carrots would have increased intake from .16 cups to 0.27 cups or to about one-third of the recommended 0.75 cups of vegetables at lunch.

Clearly the larger issue at the school we studied was the small proportion of students who took any vegetable. The school we studied routinely offered servings of two different vegetables and two different fruits, from which students could select an unlimited amount. This amount offered is well above the average amount offered nationally. According to the School Nutrition Dietary Assessment Study IV nationally representative data on what was offered and served in schools in 2009–2010 (Fox & Condon, 2012), the average elementary school lunch offered 29% of the daily recommended amounts of vegetables and 50% of the daily recommended amounts of fruits. However, Fox and Condon (2012) noted that children took (or were served) only 23% and 32% of the recommended amounts of vegetables and fruits respectively. Thus the failure of children to choose sufficient vegetables and fruits at lunch appears widespread. Based on our other activities at this school (Redden, Mann, Vickers, Mykerezi, & Reicks, 2015) we think that many students who liked the vegetables and were willing to eat them chose not to take them from the cafeteria line. Other more preferred foods were available in sufficient quantities that neither fruits nor vegetables needed to be consumed to achieve satiation. If students must be allowed to choose the foods they eat, efforts at this school need to be directed toward getting more children to select the vegetables. One example of such an effort at this same school using pictures in the trays to nudge selection of vegetables (Reicks, Redden, Mann, Mykerezi, & Vickers, 2012) increased the number of children taking carrots up from the 12% we observed in our study to 37%. A second effort, serving students the carrots first, increased the number of students eating at least some carrots up to 54% (Redden et al., 2015). More research is needed on strategies to increase children's selection and consumption of fruits and vegetables in a choice environment of competing foods of higher palatability.

Our study had several strengths. The school had a population of about 800; about 85% of the students ate the school lunch. Our population was also very diverse, with the majority of our students coming from low-income homes. Having low income students was important as fruits and vegetables at school may be one of the most reliable places they are able to get them. We had two intervention days, making it less likely that the intervention data would have been markedly influenced by a co-occurring event. We were able to track individual student's selection and consumption of fruits and

vegetables, enabling the use of more powerful statistics. Although many of our consumption measures were the only time a particular student took a fruit or vegetable, the percentages of children choosing fruits or vegetables on both the control and one intervention day were 57% for applesauce, 27% for beans; 21% for carrots, and 45% for oranges.

Another strength was that the school was a naturalistic setting allowing us to test the effectiveness of the approach despite some forces outside of our control. These included the following: children had the option of taking one of 3 entrées (although a very large majority appeared to select the chicken tenders); the choice of entrée may have influenced the choice of other menu items; the amount of the entrée eaten may have influenced the amount of fruits and vegetables eaten (Savage, Fisher, Marini, & Birch, 2012); the students who attended school were not completely the same each day (some were absent on some of the days); the weather differed (affecting whether they could go outside to play before or after); the other students in the nearby environment; the friendliness of the lunchroom staff; etc. We have used a randomized design to simultaneously balance out all of these sources of variation.

Our study had weaknesses as well. We were unable to differentiate trends in eating patterns due to the children's grade because grade was completely confounded by lunch session. We did not collect information on students' gender. We did not randomize intervention and control days, instead we conducted the control day first so intervention day activities would not influence the control day. As the study progressed, the students became older and the weather became warmer, both of which could have altered food intake. We did not request any information regarding a child's fruit and vegetable consumption at home. If we were able to have that data for individual students, we would have been able to determine if students who were choosing fruit and vegetables at school were also eating more of them at home. The weight of a serving of a specific fruit or vegetable varied within a day and among the test days. This was due to the natural variability in the size and shape of the products. This variation made it more difficult to observe differences in consumption due to portion size. Because we did not measure the amounts of other menu items selected and eaten, we were unable to determine whether any increased fruit and vegetable intake impacted the choices or amounts of other foods eaten at the meal. Knowing this would be important for determining the impact of this intervention on calorie consumption.

Conclusions

Children consumed more fruits and vegetables in an elementary school cafeteria when the portion sizes of these foods were increased by about 50%. Although this was an effective strategy for increasing fruit and vegetable consumption among students who took those foods, many children chose not to take any fruits or vegetables. Further efforts are needed to increase children's selection and consumption of fruits and vegetables in an environment of competing foods of higher palatability.

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