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Serving vegetables first: A strategy to increase vegetable consumption in elementary school cafeterias

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ABSTRACT

Vegetable consumption in the United States is low despite the wealth of evidence that vegetables play an important role in reducing risk of various chronic diseases. Because eating patterns developed in childhood continue through adulthood, we need to form healthy eating habits in children. The objective of this study was to determine if offering vegetables before other meal components would increase the overall consumption of vegetables at school lunch. We served kindergarten through fifth-grade students a small portion (26–33 g) of a raw vegetable (red and yellow bell peppers) while they waited in line to receive the rest of their lunch meal. They then had the options to take more of the bell peppers, a different vegetable, or no vegetable from the lunch line. We measured the amount of each vegetable consumed by each child. Serving vegetables first greatly increased the number of students eating vegetables. On intervention days most of the vegetables consumed came from the vegetables-first portions. Total vegetable intake per student eating lunch was low because most students chose to not eat vegetables, but the intervention significantly increased this value. Serving vegetables first is a viable strategy to increase vegetable consumption in elementary schools. Long-term implementation of this strategy may have an important impact on healthy eating habits, vegetable consumption, and the health consequences of vegetable intake.

1. Introduction

Consuming fruits and vegetables is associated with decreased risk for chronic diseases such as cardiovascular disease (CVD), stroke, cancer, and obesity (Slavin & Lloyd, 2012). Although diet-related CVD and stroke are not prevalent in children, biomarkers for these diseases (high cholesterol and hypertension) are associated with childhood obesity (Kit et al., 2015). The What We Eat in America survey (2011–2012) reported that children and adolescents (2–19 years) ate only 0.93 daily cup (1 cup = 237 ml) equivalents of vegetables, representing about half to one third of the recommended number of servings (USDA, ARS,2014). Robinson-O'Brien, Burgess-Champoux, Haines, Hannan, and Neumark-Sztainer (2010) observed that low income children at four elementary schools consumed about 44% of their vegetables at school. Consumption of school meals was associated with higher frequency of fruit and vegetable intake among low income adolescents, and lower frequency among high income adolescents in Northern New England (Longacre et al., 2014). Eating habits developed in childhood continue for years afterward (Demory-Luce et al., 2004), calling for a push to increase vegetable consumption at a young age.

Serving low energy-dense foods before other meal components not only is a strategy for decreasing energy intake, but also can increase vegetable consumption as the low-energy dense food is often a salad or vegetable dish (Roe, Meengs, & Rolls, 2012; Rolls, Roe, & Meengs, 2004). Serving a large vegetable salad to adult women before the main course decreased overall energy intake by 12% and increased intake of salad by 23% (Rolls, Roe, & Meengs, 2004). Spill, Birch, Roe, and Rolls (2010) similarly increased the amount of vegetables consumed by preschool children at a supervised day care center by serving carrots as the first course of a

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lunch. Harnack et al. (2012) increased intake of fruits, but not vegetables, by serving both fruit and vegetables to preschool children first before other meal components. 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 serving vegetables first on vegetable consumption in these settings.

Behavioral economics strategies may be useful for increasing vegetable consumption because they take advantage of natural human behaviors to increase the number of people selecting and consuming healthier foods. These strategies essentially make the healthy choice the most convenient choice (Downs, Loewenstein, & Wisdom, 2009). Placing fruits and vegetables at natural cafeteria bottlenecks increased impulse buys of these foods instead of less healthy options (Just & Wansink, 2009). Placing small cups of carrots in front of students as they were waiting at their tables to enter the cafeteria line produced a dramatic increase in the number of children consuming carrots compared to serving carrots only on the cafeteria line (Redden et al., 2015).

The purpose of the current study was to determine if serving bell peppers to elementary school students before other meal components were available would increase the overall consumption of vegetables at the school lunch meal. We hypothesized that serving peppers first would increase the number of students eating peppers and the total amount of vegetables eaten.

2. Materials and methods

2.1. Subjects

Subjects were children in kindergarten through fifth grade at a public, urban elementary school in Richfield, Minnesota. The school had a population of about 800, the majority coming from low-income homes with the majority receiving free (53%) or reduced priced lunches (10%). Approximately 85% of the students ate the school lunch on a given day. These students came from diverse racial/ethnic backgrounds (30% white and 70% minority – 20% black, 39% Hispanic, 8% Asian, 1% American Indian). Only students eating school-provided lunch were included in data collection (n = 500–575). All study procedures were approved by the University of Minnesota Institutional Review Board. Informed consent was waived due to the nature of the research.

2.2. Vegetables

Red and yellow bell peppers were purchased from H. Brooks & Company, Inc. (New Brighton, MN) and cut into uniform rectangular strips. Frozen carrot 'coins' were purchased through the school district from its normal supplier (Lakeside Foods, Manitowoc, WI). Size of portions served on the lunch line was determined by the supervisor of food services for Richfield School District according to USDA guidelines (USDA, 2013). Both fresh colored bell pepper strips and frozen carrot coins were routinely part of the school's menu rotation.

The peppers and carrots were pre-portioned in (120 mL) paper soufflé cups (Solo Cup Company, Urbana, IL) and (120 mL) clear plastic portion containers (Dart Container Corporation, Mason MI), respectively. The number of pepper pieces in each cup available on the cafeteria line did not vary, although the thickness of the pieces differed considerably among the days (see Table 1). Three to four pepper pieces were placed in each of the cups served first. The volume of the carrot portion sizes stayed constant throughout the study, though the weight of a portion varied depending on the size and weight per piece of vegetable (see Table 1).

2.3. Experimental procedures

A within-subjects experimental design was used. We conducted the tests on one control day, followed by three intervention days, and then one follow-up control day. The follow-up control day was included to see if any carryover effects emerged (e.g., a habit), and to un-confound the control days from time. Test days occurred three weeks apart to coincide with the school district's pre-planned menu rotation. The same menu was offered on all days (i.e., the same choice options were available each day), but the students could change their selections of menu items over the five days. Meal items on the regular lunch line were presented in the following order: vegetables, fruit, hot side, and entrée. On all days, students had two vegetable options on the line (colored bell peppers and cooked carrots), each on its own tray from which they could elect to take as many serving cups as they would like. We also included carrots in our study design to allow us to subsequently test whether changes in pepper consumption affected the intake of other vegetables (i.e., cannibalization).

Students arrived at lunch for one of nine lunch periods. They were escorted to the lunch line by their teacher. Students were allowed to serve themselves vegetables and fruit from a buffet-type line, while a cafeteria employee served the hot side and entrée. On intervention days, all students were offered a portion (3–4 pieces) of the peppers in a 60 mL paper soufflé cup (Solo Cup Company, Urbana, IL) in the hallway prior to reaching the station where they entered their Personal Identification numbers (PIN). As we handed them the peppers, we said to each student individually: "These sweet peppers are for you to eat right now." If a student refused to take a cup, they were encouraged one more time to take a portion before being allowed to pass empty-handed if they still refused.

Most students then had a couple of minutes to eat their peppers while waiting in line to enter their PIN. They placed the served-first cup with any remaining vegetable (or empty) on their trays as they started through the lunch line. Students then walked through the lunch line as they typically did for lunch. On all days, students then sat down at a lunch table in the cafeteria with other students in the same class. When 5 min remained in the lunch period, trained members of the research team recorded each student's PIN and visually assessed and recorded how much remained in each of the vegetable cups (a count of pepper pieces in the served-first cups and/or in the cafeteria line portion cups, and the amount remaining [e.g. none, ¼, ½, ¾, or full] in the carrot cups). The reliability of such visual assessment has been demonstrated by Hanks, Wansink, and Just (2014).

2.4. Data analysis

The weight of peppers consumed by each individual student (identified by their PIN number) on each study day was first calculated. We subtracted the number of pieces left in a given cup from the starting number of pieces in a full portion, and then multiplied it by the mean weight of one piece of that vegetable. Each day the weight of one piece of pepper was determined by finding the mean weight of ten filled cups and dividing by the number of pieces in a cup.

The weight of carrots consumed for each individual student on each study day was calculated in a similar way. We subtracted the portion fraction remaining in the cup from 1, and then multiplied that by the mean weight of a serving of carrots. The mean weight of a serving of carrots was determined each day by determining the mean weight of 10 portions.

The weight consumed *per student eating school lunch* was calculated by dividing the total amount of a specific vegetable consumed across all students by the number of students eating the

Table 1
Mean weight (g) per portion of vegetables on the 5 testing days.

Portion size (volume of serving cup)	Control	Intervention 1	Intervention 2	Intervention 3	Follow-up
Pepper 60 mL	–	26[c]	29[b]	33[b]	–
Pepper 120 mL	17[d]	49	70	72	52
Carrots 120 mL	71[a]	71[a]	68	77	69

[a] No weight recorded: value is the average of the days when the mean weight per portion was recorded.
[b] 3 pepper pieces per 60 ml cup.
[c] 4 pepper pieces per 60 ml cup.
[d] 8 pepper pieces were always placed in the 120 ml cups. Dimensions of peppers were changed on intervention day 2 through follow-up to be twice as wide and half as long to reduce the ease with which a cup could be tipped and its contents spilled on the floor. Pepper pieces were much thinner on the control day and much thicker on intervention days 2 and 3, hence the differences in weight.

lunch provided by the school (whether they took vegetables or not). Because some portion cups and vegetable pieces dropped on the floor and would have been erroneously counted as eaten, the datum for each student without a full served-first cup remaining was adjusted to account for this using a factor based on the weight of vegetables collected from the floors.

Quantitative statistical analysis was performed primarily using SAS version 9.3 (SAS Institute Inc., Cary, NC), unless otherwise noted. We used logistic regression (PROC GLIMMIX) to determine whether the number of children eating the peppers on the days with vegetables first was larger than the number eating peppers on the control days. Whether or not a student ate any peppers was the dependent variable, while control/intervention was a fixed predictor and individual student PIN was a random predictor.

To determine if consumption increased as a result of serving vegetables first, mixed model analyses of variance were utilized. The dependent variables were the weight of peppers consumed from the cafeteria line, the weight of all peppers consumed, the weight of carrots consumed, and the weight of all vegetables (peppers plus carrots) consumed. The predictors were PIN (a random effect), and day (control, intervention days 1–3, follow-up). We used contrasts to compare the control days with the intervention days. These analyses were separately conducted using the data from all children consuming school lunch, and data from only those children consuming peppers on a specific day. We used contrasts to examine trends for increasing vegetable consumption over the 5 days for those children consuming peppers on a specific day.

3. Results

As reported in Table 2, the mean number of students *taking* peppers increased 669% from an average of 45 (8%) on the two control days without vegetables first to an average of 346 (65%) on the three days with vegetables first. (We computed these averages over the two control days and over the three days with vegetables first from column 3 in Table 2.) The mean number of students eating school lunch that ate *some* peppers increased 309% from an average of 34 on days without vegetables first to an average of 139 on days with vegetables first. (We computed these averages over the two control days and over the three days with vegetables first from column 5 in Table 2.)

Pepper intervention days resulted in greater consumption of peppers by weight (mean = 4.1 g per each child eating school lunch) compared to days when peppers were not served first (mean = 1.4 g). (These means have been computed across days from data in Table 3.) An average of 75% of the peppers consumed on the intervention days (4.1 g) came from the vegetables-first portions (3.1 g). Consumption of cooked carrots was higher on control and follow-up days than on intervention days (2.8 g vs. 1.3 g). Total consumption of vegetables was higher on intervention days than on control and follow up days (mean = 5.4 g vs. 4.0 g).

Among just those children consuming some peppers on a specific day, we did not observe a significant increase in pepper (or total vegetable) consumption from control to intervention days (see Table 4). Instead we observed significantly increasing linear trends in the consumption of peppers ($F = 51.3$, $p < 0.001$) and total vegetables ($F = 34.4$, $p < 0.0001$) over the 5 occasions (Table 4).

The mean weight of peppers consumed per person who took a portion of peppers from the cafeteria line was greater when peppers were not served first (24 g vs. 17 g; $F = 8.5$, $p = 0.004$). Thus serving peppers first diminished the amount of peppers subsequently eaten from the serving line.

4. Discussion

The increase in mean pepper consumption over the course of the three intervention days (Table 3) appears to be primarily due to an increase in the amount of peppers eaten by each person eating peppers (Table 4) because we observed no increase over these three days in the number of students taking or the number of students eating peppers (Table 2). This increase may have been due to

Table 2
Numbers of students eating school lunch and accepting peppers from any source.

Data collection day	Number of students eating school lunch	Number of students taking peppers	% of students taking peppers	Number of students eating any amount of peppers	% of students eating any amount of peppers	Number of students eating any amount of carrots	% of students eating any amount of carrots.
Control	532	37	7	34	6	34	6
Intervention 1	500	356	71	168	34	18	4
Intervention 2	511	346	68	123	24	25	5
Intervention 3	575	336	58	125	22	9	2
Follow-up	534	53	10	33	6	43	8
p value[a]				<0.0001		<0.0001	

[a] From the logistic regressions contrasting the number of students on control and follow-up versus the three combined intervention days.

Table 3
Mean weight (g) of vegetables consumed per student eating school lunch.

Condition	Peppers first	Peppers regular line	Total peppers	% of pepper intake from pepper-first portions	Cooked carrots	Total vegetables
Control	–	0.8	0.8	0	2.5	3.3
Intervention 1	1.3	1.9	3.2	41	1.4	4.6
Intervention 2	3.5	0.8	4.3	81	1.7	6.0
Intervention 3	4.4	0.5	4.9	90	0.8	5.7
Follow-up	–	2.0	2.0	0	3.0	5
F value[a]		3.2	64		15.4	4.9
p value[a]		0.07	<0.0001		<0.0001	0.03

[a] Contrasting control and follow-up vs. the three combined intervention days.

Table 4
Mean weight of peppers and total vegetables consumed per student eating peppers on each day of the study.

Study day	Total peppers	Total vegetables	Number of students eating peppers
Control	13.1	17.3	34
Intervention 1	9.6	11.2	168
Intervention 2	17.6	19.8	123
Intervention 3	22.7	23.7	125
Follow-up	32.7	36.8	33
F value[a]	1.23	2.6	
p value[a]	0.27	0.11	

[a] Contrasting control plus follow-up vs. combined interventions, using data from the analysis of variance using only those children consuming peppers on at least one of the five study days.

repeated exposure to the vegetable and/or to the formation of an eating-vegetables-first habit. Previous research has shown that children tasting small portions (~4 g) of vegetables without being required to eat all of them can increase their liking and subsequent intake of the tasted vegetables (Anzman-Frasca, Savage, Marini, Fisher, & Birch, 2012). This has been demonstrated specifically with red bell peppers (Wardle, Herrera, Cooke, & Gibson, 2003). This increase may also have been due to the increased size of the peppers from the first through the fourth days of the study (Table 1). Although the rectangular surface area dimensions of the pepper pieces remained constant throughout the study, the thickness of the flesh increased, increasing the weight per piece, and thus the weight per serving. This increase in portion size would be expected to increase consumption (Fisher, 2007; Fisher, Arreloa, Birch, & Rolls, 2007; Fisher & Kral, 2008; Fisher, Liu, Birch, & Rolls, 2007; Fisher, Rolls, & Birch, 2003; Miller et al., 2015).

Serving vegetables first when no other well-liked competing foods are available is likely essential to the effectiveness of this intervention. Harnack et al. (2012) showed that serving both fruit and vegetables first before other meal components increased intake of fruits but not vegetables, which may have reflected competition between fruits and vegetables. Their children may have chosen to eat more fruit, which was sweeter and more palatable, instead of increasing their intake of vegetables. Since high sugar and high fat foods are generally more liked than vegetables, they are chosen over vegetables time and time again. For example, serving raw baby carrots alongside M&M's® resulted in lower consumption of carrots by adults than if carrots were served first in isolation (Redden et al., 2015). Therefore, serving vegetables when other more palatable options are not available will be more effective at increasing vegetable consumption than interventions where competing foods are available alongside vegetables. The length of time the served-first vegetables were available without competing foods was potentially important for the success of this strategy. We had little control over this time. Some students waited in line for several minutes and had ample time to eat the served-first peppers. Others, especially those first in line, had no wait and thus no time without the presence of competing foods. Future work can explore the role played by waiting time in the effectiveness of this intervention.

Serving vegetables first is a feasible strategy for improving children's vegetable consumption. The serving-vegetables-first strategy requires relatively few resources to implement (cost of paper cups, time to portion vegetables, and time to serve). The strategy should be compatible, with only minor modifications, in most dining facilities. Many more students ate vegetables when served first, and while many of them ate only a bite, most continued doing so throughout the intervention period. With continued implementation of this strategy, eating vegetables first could become a habit, especially for vegetables that may be somewhat unfamiliar such that the child does not already have a strong opinion of them. Offering more choices of vegetables before other meal components are available might further increase consumption of vegetables (Bucher, Siegrist, & van der Horst, 2014).

Serving vegetables first will potentially increase vegetable waste. On the two control days relatively few of the portions taken went totally uneaten (8% and 38%; see Table 2), whereas on intervention days the majority of portions (53–64%) were uneaten. Our data suggest that consumption of vegetables served first may partly displace consumption of other vegetables served on the cafeteria line, thus serving vegetables first may be partly 'funded' by savings from vegetables served on the line. Many of the students in our study willingly took the offered vegetable, but did not eat it. Modifying the serve-first strategy so only those students that intend to eat the vegetables would take them, may minimize the waste.

Our study had several strengths. The school had a fairly large population of about 800; about 85% of the students ate the school lunch. Our population was also very diverse with many of our students coming from low-income homes across a variety of ethnicities. Having low income students was important because school may be one of the most reliable places those students are able to get vegetables (Longacre et al., 2014). We were able to track individual student's selection and consumption of vegetables, enabling the use of more powerful statistics.

Our study had weaknesses as well. The weight of a serving of a

specific vegetable varied within a day and among the test days. This was largely due to the natural variability in thickness of the peppers. This variation made it more difficult to observe differences in consumption between control and intervention days. Because we did not measure the amounts of non-vegetable menu items selected and eaten, we were unable to determine whether any increased vegetable intake impacted the choices or amounts of other foods eaten at the meal. Knowing this would be important for determining the overall impact of this intervention on calorie consumption. The varying lengths of time students waited in line was also a weakness. The first few students to enter the cafeteria at each lunch period had no or very little time to eat the served-first peppers.

5. Conclusions

Serving vegetables before other meal components were available increased the proportion of students taking and eating vegetables in an elementary school cafeteria. With continued implementation, this strategy may contribute to the formation of healthier eating habits.

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