

Eating vegetables first: the use of portion size to increase vegetable intake in preschool children¹⁻³

Maureen K Spill, Leann L Birch, Liane S Roe, and Barbara J Rolls

ABSTRACT

Background: Serving larger portions of low-energy-dense vegetables at a meal could have beneficial effects on children's food and energy intakes.

Objective: We investigated whether increasing the portion size of vegetables served at the start of a meal leads to increased vegetable consumption and decreased meal energy intake in children.

Design: In a crossover design, 3- to 5-y-old children in a daycare center were served a test lunch once a week for 4 wk ($n = 51$). In 3 of the meals, a first course of raw carrots varied in portion size (30, 60, or 90 g), and no first course was served in the control meal. Children consumed the first course ad libitum over 10 min and then were served a main course of pasta, broccoli, applesauce, and milk, which was also consumed ad libitum.

Results: Total vegetable consumption at the meal increased as the portion size of carrots increased ($P < 0.0001$). Doubling the portion size of the first course increased carrot consumption by 47%, or 12 ± 2 g ($P < 0.0001$). Tripling the portion size of carrots, however, did not lead to a further increase in intake ($P = 0.61$). Meal energy intake was not significantly affected by the amount of carrots served in the first course. The effect of portion size on intake was not significantly influenced by the children's age or body weight status.

Conclusion: Increasing the portion size of a vegetable served as a first course can be an effective strategy for increasing vegetable consumption in preschool children. *Am J Clin Nutr* 2010;91:1237-43.

INTRODUCTION

Strategies that will increase vegetable intake in children clearly need to be identified. Although it has been established that fruit and vegetables are an important dietary component for many reasons, including the vital micronutrients they provide and their role in disease prevention (1-3), nationally representative data show that less than half of American children meet their daily recommended intake of fruit and vegetables (4). One strategy that has the potential to increase fruit and vegetable intake in children is to serve larger portions at meals. In adults, increasing the portion size of pasta, sandwiches, and snack foods has been shown to significantly increase intake of these foods (5-7). In children, several studies have shown that portion size can affect the intake of many foods (8-11), but the effects of portion size have been less consistent than in adults. The aim of the current study was to determine whether increasing the portion size of

a vegetable served as a first course at lunch influences vegetable intake in preschool children.

The effect on intake of varying the portion size of nutrient-dense foods such as vegetables has been investigated in several studies. One study in adults found that increasing the portion size of all foods served over 11 d led to increased intake in all food categories except fruit (as a side dish) and vegetables (12). In children, a recent study varied the portion size of the fruit and vegetable side dishes, whereas the entrée portion was kept constant (13). The results showed that when the portion size of the fruit was doubled, intake increased, yet when the portion size of 2 vegetables was doubled there was no significant change in intake. Thus, larger portions did not influence vegetable intake when competing foods were available. It is not known whether serving larger portions of vegetables at the start of a meal in the absence of competing foods affects vegetable intake.

Increased consumption of vegetables at the start of a meal could affect the type or amount of food eaten during the rest of the meal. In adults, adding a first course of vegetables has been shown to reduce meal energy intake. In one study, salads differing in portion size and energy content were served to women as a compulsory first course (14). The results showed that consumption of a low-energy-dense salad decreased energy intake in the subsequent course and over the entire meal. No data in either adults or children indicate whether providing different portions of vegetables as a first course to be consumed ad libitum will affect vegetable or energy intake at the meal. The purpose of the present study was to determine the effects of serving preschool children different portions of a vegetable as a first course at lunch on vegetable consumption and energy intake at the meal.

¹ From the Departments of Nutritional Sciences (MKS, LSR, and BJR) and Human Development and Family Studies (LLB) and the Center for Childhood Obesity Research (LLB), The Pennsylvania State University, University Park, PA.

² Supported by the National Institute of Diabetes and Digestive and Kidney Diseases (R01 DK082580) and the Robert Wood Johnson Foundation.

³ Address correspondence to BJ Rolls, The Pennsylvania State University, 226 Henderson Building, University Park, PA 16802-6501. E-mail: bjr4@psu.edu.

Received December 23, 2009. Accepted for publication February 17, 2010.

First published online March 10, 2010; doi: 10.3945/ajcn.2009.29139.

SUBJECTS AND METHODS

Experimental design

A within-subject crossover design was used to test the effect of varying the amount of carrots served to preschool-aged children as a lunch first course on food and energy intake. On 1 d per week for 4 wk, children in a daycare setting were provided with a test lunch. Across the weeks, the portion size of carrots served in the first course was varied (30, 60, or 90 g), and during 1 wk no first course was provided. The foods and beverages served in the main course were not varied in portion size. On test days, a standard breakfast was served \approx 3 h before lunch to maintain a similar level of hunger before lunch. All foods and beverages were consumed ad libitum. During the week before the study, 1 d was used to acquaint the children and teachers with the test meal procedures; no data were collected on this day.

Participant recruitment

Recruitment began in April 2008 by distributing letters to parents who had children aged 3–6 y enrolled in daycare at the Bennett Family Center at the University Park campus of The Pennsylvania State University. Children were enrolled from 5 classrooms; the order of the experimental conditions across study weeks was assigned to classrooms by using a Latin square design. Parents and guardians provided informed written consent for both their own participation and that of their child. The Pennsylvania State University Office for Research Protections reviewed and approved all procedures.

A power analysis was performed to determine the number of children needed in the study, based on previous research in a similar population of children with similar foods (11). The minimal clinically relevant difference in meal energy intake was assumed to be 40 kcal, which is \approx 10–15% of typical meal intakes in this population (11). It was estimated that a sample of 44 children would allow the detection of this difference with $>$ 80% power with a 2-sided test with a significance level of 0.05.

Test foods and meal procedures

The foods and amounts served at the test meal, which was served once per week for 4 wk, are shown in **Table 1**. Raw carrots were chosen for the first course vegetable because they are popular among preschool children (15, 16). The smallest portion size of carrots (30 g) was selected based on the mean carrot intake per eating occasion for children in this age group (15); this amount was doubled and tripled to determine the larger 2 portion sizes. The 60-g portion is equivalent to a 0.5-cup (118 mL) serving, which represents one-third of the recommended daily vegetable intake for most children aged 3–5 y (17). The carrots were served with low-fat dip because studies in older children have shown that the preparation method influences the acceptability of vegetables and that children particularly prefer vegetables served with dip or cooked with butter (18). The remaining items served at the test meal (pasta, broccoli, applesauce, and milk) were also familiar to the children in the daycare center. The portion sizes of these foods were based on consumption data from previous research with children in this age group (11, 19, 20). Cooked broccoli was served as the vegetable

TABLE 1

Food and beverage items served to 51 children at a test lunch in which the portion size of carrots in the first course varied

Meal component	Amount served	Energy density
	g	kcal/g
First course		
Carrot sticks	0, 30, 60, or 90 ¹	0.40
Ranch dip ²	30	0.67
Main course		
Macaroni and cheese ³	400	2.00
Steamed broccoli ⁴	60	0.28
Unsweetened applesauce ⁵	150	0.43
Milk, 2% fat ⁶	240	0.50

¹ Portion size varied across the experimental conditions.

² The HV Foods Products Co, Oakland, CA; prepared with reduced-fat buttermilk, skim milk, and fat-free sour cream.

³ Nestle USA Inc, Solon, OH; prepared with butter and vegetable oil.

⁴ Birds Eye Foods Inc, Rochester, NY.

⁵ Knouse Foods Inc, Peach Glen, PA.

⁶ Schneider Valley Farms, Williamsport, PA.

component of the main course in all test meals to comply with the National School Lunch Program (21); this also allowed the examination of the effects of the vegetable first course on vegetable intake in the main course.

Lunch was served to all children in the participating classrooms at the regularly scheduled time and was eaten at tables with 3 to 6 children and 1 adult, which is the standard practice at this facility. Once children were seated at their tables, they were served the first course of carrots. Ten minutes after serving the first course, the remaining carrots and dip were removed and the main course of the lunch was served. A 10-min interval for the first course was selected based on teacher recommendations and the amount of time allotted for the lunch meal. In the condition with no first course, children were served the main course on being seated. Incidents of food and drink spillage were recorded by researchers. Teachers were instructed to redirect conversations pertaining to food to nonfood-related topics to minimize the influence on lunch intake. When children finished their lunch, spilled or dropped food was returned to the correct dish, and any spilled milk was recovered with paper towels. Uneaten items were removed, and weights were recorded to the nearest 0.1 g with digital scales (Mettler Toledo model XS4001S, Mettler-Toledo Inc, Columbus, OH). Consumption of the foods and milk was determined by subtracting postmeal weights from premeal weights. Information from food manufacturers and from a standard food-composition database (22) was used to calculate energy content.

Food acceptability assessment

Within 2 wk of completing all test meals, the children's acceptability of the experimental foods was assessed by using a procedure developed by Birch et al (16, 23, 24). Children were instructed on the use of 3 cartoon faces to indicate whether they thought a food was "yummy," "okay," or "yucky." After instruction, each child was presented with a sample of carrots and dip. The child was asked to taste the carrots and indicate their acceptability by pointing to the appropriate face. The carrots and dip were then removed, and the child was presented with a sample

of pasta. The child was again asked to taste the food and point to the face that corresponded to their degree of acceptability.

Demographic and anthropometric measures

Parents were asked to complete a questionnaire, which consisted of 19 questions about family demographics and the health status of their child. Body weight and height measurements of the children were taken within 2 wk of the final test meal. Body weight was measured in duplicate with a portable digital scale (Seca Onda model 843; Seca Corporation, Hanover, MD). If the 2 measurements differed by >0.1 kg, a third measurement was taken and the measurements were averaged. Height was measured to the nearest 0.1 cm in duplicate with a portable stadiometer (model 214; Seca Corporation). If the 2 measurements varied by >0.2 cm, a third measurement was taken and the measurements were averaged. The children's height, weight, and age were used to calculate their sex-specific body mass index-for-age percentile and z score for body mass index-for-age by using a software program from the Centers for Disease Control and Prevention (25).

Statistical analysis

Data were analyzed by using a mixed linear model with repeated measures (SAS version 9.1; SAS Institute, Cary, NC). The fixed factors in the model were carrot portion size (0, 30, 60, or 90 g) and session number; subjects were treated as a random factor. The factors of children's food acceptability ratings and sex were also investigated. The main outcome measures were weight and energy intake of carrots and all other foods as well as total vegetable intake and total food and energy intake at the meal. Total vegetable consumption at the meal (carrots + broccoli) was assessed to investigate the effect of vegetable intake in the first course on this outcome.

Children who consumed all of the carrots ($\geq 95\%$ of the weight served) at any meal were identified, and data were analyzed both with and without these children to determine whether they influenced the results. The effect of individual children who were influential on the main study outcomes was assessed by using the procedure of Littell et al (26).

Differences between girls and boys in age, body weight, height, BMI percentile, and BMI z score were analyzed by using t tests. Analysis of covariance was used to assess the influence of continuous variables (age, body weight, height, BMI percentile, and BMI z score) on the relation between carrot portion size and

the main study outcomes. Data are reported as means \pm SEMs, and the results were considered significant at $P < 0.05$. The Tukey-Kramer method was used to adjust significance levels to account for multiple comparisons.

RESULTS

Subject characteristics

A total of 51 children were enrolled, and all of them completed the study; participant characteristics are shown in **Table 2**. Study participants had a mean age of 4.4 ± 0.1 y and a mean sex-specific BMI-for-age percentile of 63.5 ± 3.7 ; 24% of the children were overweight ($n = 6$) or obese ($n = 5$). Mean age, body weight, height, and BMI percentile did not differ significantly between the boys and girls. Of the 51 children in the study, 46 parents provided demographic information for their children. Of these 46 children, 28 (61%) were white, 14 (30%) were Asian, 3 (7%) were black or African American, and 1 (2%) was American Indian or Alaska Native. Parents of the children had above-average educational levels and household incomes; 90% of mothers and 85% of fathers had a college degree, and 79% of households had an annual income $> \$50,000$.

Vegetable intake

Intake of carrots in the first course was significantly affected by the portion of carrots served ($P < 0.0001$; **Figure 1**). Doubling the portion size from 30 to 60 g led to a significant increase in carrot consumption by 47%, or 12 ± 2 g. Tripling the portion size from 30 to 90 g led to a significant increase in carrot consumption by 54%, or 14 ± 3 g. There was no significant difference in carrot consumption as carrot portion size was increased from 60 to 90 g ($P = 0.61$).

Total vegetable consumption at the meal (carrots + broccoli) increased as the portion of carrots was increased ($P < 0.0001$; **Figure 1**). Broccoli consumption was not affected by serving carrots as a first course, regardless of their portion size. When no first course was served, the mean vegetable consumption was 20.5 ± 2.6 g, or about one-third of a 0.5-cup serving. Vegetable consumption more than doubled to 44.4 ± 3.2 g when 30 g of carrots were served as a first course. When the carrot portion size increased to 60 g, vegetable consumption nearly tripled to an average intake of 58.2 ± 4.3 g compared with having no first course. This amount is equivalent to approximately a 0.5-cup serving, or one-third of the recommended daily vegetable intake for most children in this age group (17).

TABLE 2

Characteristics of children participating in a study that tested the effects of increasing the portion size of a vegetable served as a first course on meal intake¹

Characteristic	Boys ($n = 22$)		Girls ($n = 29$)	
	Mean \pm SEM	Range	Mean \pm SEM	Range
Age (y)	4.3 ± 0.2	3.1–5.8	4.5 ± 0.2	3.2–6.1
Weight (kg)	18.8 ± 0.8	13.8–24.6	17.9 ± 0.6	14.0–24.8
Height (cm)	106.4 ± 1.8	94.9–121.9	105.5 ± 1.4	94.7–119.7
BMI z score ²	0.6 ± 0.3	–1.3–2.3	0.4 ± 0.1	–1.1–1.7
Sex-specific BMI-for-age percentile ²	64.8 ± 6.8	10.5–99.0	62.6 ± 4.4	14.3–96.0

¹ There were no significant differences (t test) between boys and girls for any characteristic.

² Calculated from height, weight, and age (25).

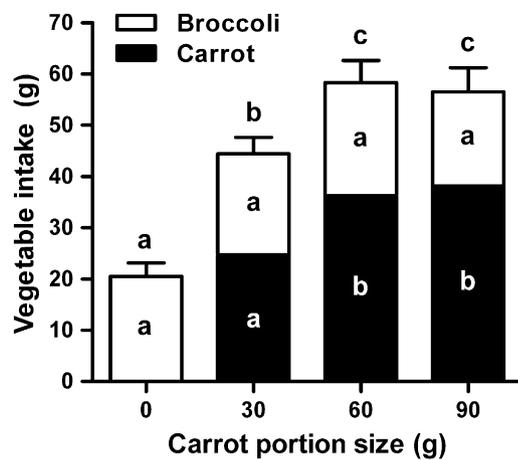


FIGURE 1. Mean (\pm SEM) weight of vegetables consumed at lunch by 51 preschool children who were served various portion sizes of carrots as a first course and 60 g broccoli in the main course. Values for the same meal component with different superscript letters are significantly different, $P < 0.0001$ (mixed linear model with repeated measures with a Tukey-Kramer adjustment for multiple comparisons).

Approximately 60%, or 31 of the 51 children tested, consumed $\geq 95\%$ of the carrots in the smallest portion size condition, and $\approx 20\%$, or 11 children, consumed $\geq 95\%$ of the carrots in the middle condition. Only one child consumed $\geq 95\%$ of the carrots in the largest condition. When the 31 children who consumed all of the carrots in the smallest condition were removed from the analysis, the portion size effect on carrot consumption was no longer significant. When the 11 children who consumed all the

carrots in both the smallest and middle condition were removed from the analysis, the portion size effect on carrot consumption remained significant ($P = 0.001$). With these 11 children removed, the average carrot consumption in the middle and largest conditions was significantly greater than the average carrot consumption in the smallest condition; in the 30-, 60-, and 90-g conditions, the average carrot intake was 23.3 ± 1.4 g, 29.8 ± 2.5 g, and 31.8 ± 2.9 g, respectively.

Although increasing the portion size of carrots led to an increase in carrot consumption, the larger portions were also associated with an increase in the amount of uneaten carrots ($P < 0.0001$). Of the 30 g portion, a mean of 5.3 ± 1.1 g carrot was uneaten. In the 60 g condition, the mean amount uneaten was 23.8 ± 2.6 g, and in the 90 g portion, this value was 51.9 ± 3.2 g.

Meal food intake

Food and beverage intake at the entire meal (first course + main course) is shown in **Table 3**. Providing a vegetable first course led to an increase in the weight of food consumed at the meal compared with having no first course ($P = 0.003$). Intake of the individual main course food items did not differ across the 4 conditions. Milk intake was greater in the 30 g carrot condition ($P = 0.0004$), which was attributable to increased milk consumption in one classroom at one meal. Although there was an increase in carrot intake with an increase in portion size, the amount of dip consumed did not differ significantly as the portion size of carrots was varied. In each condition, 30 g dip was served, and the mean intakes were 6.1 ± 0.8 , 7.7 ± 1.0 , and 7.1 ± 0.8 g in the 30-, 60-, and 90-g conditions, respectively.

TABLE 3

Food and energy intakes of 51 children at the test lunch in which the portion size of carrots in the first course varied¹

Meal component	Portion size of carrots			
	0 g	30 g	60 g	90 g
Carrots				
Weight (g)	—	24.7 ± 1.1^a	36.2 ± 2.6^b	38.1 ± 3.2^b
Energy (kcal)	—	8.7 ± 0.4^a	12.8 ± 0.9^b	13.5 ± 1.1^b
Dip				
Weight (g)	—	6.1 ± 0.8	7.7 ± 1.0	7.1 ± 0.8
Energy (kcal)	—	4.1 ± 0.6	5.2 ± 0.6	4.8 ± 0.5
Macaroni and cheese				
Weight (g)	123.0 ± 11.1	114.1 ± 11.7	132.2 ± 11.2	123.3 ± 11.8
Energy (kcal)	246.6 ± 22.2	228.9 ± 23.5	265.1 ± 22.5	247.2 ± 23.7
Broccoli				
Weight (g)	20.5 ± 2.6	19.7 ± 2.9	22.1 ± 2.9	18.4 ± 2.6
Energy (kcal)	5.8 ± 0.7	5.6 ± 0.8	6.2 ± 0.8	5.2 ± 0.7
Applesauce				
Weight (g)	99.4 ± 7.4	99.9 ± 7.2	99.2 ± 7.1	103.6 ± 7.4
Energy (kcal)	42.8 ± 3.2	43.0 ± 3.1	42.7 ± 3.0	44.6 ± 3.2
Milk				
Weight (g)	122.7 ± 11.4^a	151.7 ± 11.4^b	106.1 ± 12.0^a	118.0 ± 11.6^a
Energy (kcal)	61.4 ± 5.7^a	75.8 ± 5.7^b	53.0 ± 6.0^a	59.0 ± 5.8^a
Total meal				
Weight (g)	365.6 ± 15.9^a	416.1 ± 18.3^b	403.4 ± 17.6^b	408.5 ± 18.5^b
Energy (kcal)	356.6 ± 21.7	366.1 ± 24.6	385.0 ± 22.2	374.3 ± 24.5

¹ All values are means \pm SEMs. Values in the same row with different superscript letters are significantly different, $P < 0.003$ (mixed linear model with repeated measures with a Tukey-Kramer adjustment for multiple comparisons).

Meal energy intake

Despite an increase in vegetable consumption when carrots were served as a first course, there was no significant difference in total meal energy intake across the 4 conditions (Table 3). Energy intake of individual meal components did not differ, with the exception of milk ($P = 0.004$), which was greater in the smallest carrot condition than in the other conditions. The average meal energy density was 1.18 ± 0.05 kcal/g when no carrots were served, which decreased to a mean of 1.07 ± 0.03 kcal/g when any portion of carrots was served ($P < 0.0001$). The average energy intake from the dip was <6 kcal in all conditions and did not change significantly across conditions.

Influence of subject characteristics

Acceptability ratings for the carrots and pasta were collected for 46 of the 51 children. Of these, 42 children (91%) rated the carrots and dip as acceptable ("yummy" or "okay"), and 43 children (93%) rated the pasta as acceptable. Ratings of acceptability of the carrots did not significantly influence the effect of portion size on carrot intake ($P = 0.51$ for interaction). There were no significant differences between boys and girls in total lunch food intake (284 ± 8 compared with 267 ± 9 g; $P = 0.18$) or energy intake (366 ± 15 compared with 374 ± 17 kcal; $P = 0.70$). Analysis of covariance showed that the effect of carrot portion size on lunch energy intake was not influenced by the children's age, height, weight, BMI z score, or age- and sex-specific BMI percentiles (all $P > 0.36$).

DISCUSSION

The findings of this study showed that increasing the portion size of a vegetable served as a first course led to increased vegetable intake in preschool children. Children consumed 47% more carrots when the portion size was doubled from 30 to 60 g. This greater intake of vegetables at the start of the meal did not affect the amount of vegetables consumed at the main course, which led to a significantly greater vegetable intake at the meal. The increase in vegetable intake from one-third of a serving to one serving at a single meal was substantial, particularly considering that most children consume less than half of the daily recommended amount of fruit and vegetables (4). The results of this study suggest that increasing the portion of a vegetable served at the start of meal is a useful strategy to increase vegetable intake in preschool children.

The effect of serving additional vegetables at a meal on vegetable intake may be influenced by factors such as the timing of serving the vegetables and the characteristics of the other available foods. In a recent study, Kral et al (13) doubled the portion sizes of 2 vegetable side dishes and 1 fruit side dish at a meal and tested its effect on intake of 5- to 6-y-old children. The results differed from those of the present study in that doubling the portion of vegetables did not affect vegetable consumption, whereas doubling the portion of fruit did lead to increased fruit consumption. This suggests that, in the present study, serving vegetables at the start of a meal in the absence of competing foods was an important factor in promoting vegetable intake. In addition, the finding that increased vegetable intake in the first course did not affect vegetable consumption in the main course may be attributable to sensory differences between the vegetables

served in the 2 courses. Providing a variety of foods has been shown to increase intake in 8- to 12-y-old children (27, 28) as well as in adults (29). Serving vegetables with different sensory characteristics may reduce the effect of sensory-specific satiety, the phenomenon in which foods with similar sensory properties decline in perceived pleasantness as they are consumed (30, 31). The results of the present study suggest that vegetable consumption at a meal can be enhanced by serving vegetables alone at the start of the meal and ensuring that they have contrasting sensory properties to vegetables served later in the meal.

There are several possible explanations for the finding that the increase in portion size did not continue to affect vegetable intake across the entire range of portions. The time available in the daycare center for consuming the first course may have been a limitation. It is possible that if more time had been provided, a greater amount of carrots would have been consumed when large portions were served. Another factor that may have limited the consumption of large portions of vegetables is the preparation technique. For example, serving vegetables that are cooked or cut into bite-size pieces may reduce the amount of chewing and the time required for consumption, which could lead to increased intake. Although in the present study the carrots were well liked, previous research has shown that enhancing the palatability of vegetables by cooking them with butter increases intake in older children (18), and this may also apply in young children. The variability in the results of portion size studies in children indicates that all of these factors require further attention.

Although it is important to increase vegetable consumption in children, a concern regarding serving additional vegetables is that such strategies may also lead to greater amounts of uneaten food. It is unrealistic to expect childcare providers to serve large portions if much of it will be discarded. The amount of uneaten food may be reduced by implementing some of the strategies previously mentioned, such as increasing consumption time or varying the preparation technique to make the vegetables more palatable and easier to consume. Another approach to reduce uneaten food may be to serve vegetables "family-style," whereby children serve their own portion from a large serving bowl. This approach, however, may limit the beneficial effect of serving large portions of vegetables on vegetable intake. Orlet Fisher et al (32) found that when children served themselves an entrée, they consumed 25% less than when they were served a large portion. Further research is needed to determine optimal vegetable portion sizes so that consumption is maximized while the amount of uneaten food is minimized and also to understand how serving vegetables "family-style" influences vegetable intake in children.

The results of the present study did not support the hypothesis that consuming vegetables as a first course would affect energy intake at the meal. A few studies have shown that young children have some ability to compensate for food consumed in the first course of a meal by reducing energy consumed in the subsequent course (30, 33, 34). In those studies, however, the first course consisted of a fixed amount of food that the children were asked to consume in full; thus, the items tested were highly palatable foods such as pudding and muffins that were relatively high in energy density. None of the studies in children have examined the effect of serving a low-energy-dense food as a first course. In adults, research has shown that consuming 150 g to >500 g of a low energy-dense first course (salad, soup, or fruit) decreased intake of the higher-energy-dense main course and reduced meal

energy intake (14, 35, 36). In the present study, intake of the low-energy-dense first course was a much smaller amount than the amount consumed in previous studies in children and adults. It seems probable that this amount of food was insufficient to displace intake from the main course. It remains possible that consumption of a larger amount of vegetables as a first course by children might lead to a reduction in energy intake at the meal.

The use of portion size as a strategy to increase vegetable intake was found to be effective in preschool children who varied in individual characteristics such as body weight and age. Children with a body weight status across a wide range of BMI percentiles responded to the increase in portion size. This finding agrees with the conclusion of a recent review by Fisher and Kral (37), which states that there is insufficient evidence to suggest a relation between portion size effects and body weight status in children. The influence of children's age on the response to portion size has been found to be less consistent between studies. In one study, when the entrée portion size was doubled, intake increased in 5-y-old children, yet there was no effect on intake in 3-y-old children (8). In other studies (11, 38), as well as in the present study, there was no significant influence of age on the relation of portion size to intake of 3- to 5-y-old children. A larger sample of children with a wider range of individual characteristics should be tested to further examine the influence of these individual characteristics on the response to portion size changes.

A strength of the present study was the paradigm used to test portion size effects on intake of a 2-course meal in young children. Several previous studies testing a manipulated first course in children used a protocol in which a fixed amount of a first course was provided before an ad libitum main course (30, 33, 34). By having both the first and main courses consumed ad libitum, we were able to measure portion size effects on both intake of the manipulated course and the subsequent course. An additional strength of the study was the ecologic validity achieved by testing the children in their natural lunchtime environment with their peers and by serving foods typically consumed by the children. A limitation of the study was the use of a convenience sample from a single childcare center on a university campus. Parents of the children had above-average education levels and household incomes. A more diverse sample population should be assessed to generalize the results to a broader population. In addition, the study examined a single meal. Further studies are required to explore the effects of vegetable portion size on intake over a longer period of time.

The present study showed that increasing the portion size of vegetables served at the start of a meal, in the absence of competing foods, can lead to increased vegetable consumption in preschool children. Childcare providers can promote vegetable consumption in young children by serving large portions of vegetables at the start of a meal. The results strengthen those of previous studies showing that portion size can influence intake in children and that this effect can be used in a beneficial way to increase the intake of vegetables in children.

We thank the students and staff of the Laboratory for the Study of Human Ingestive Behavior, the Center for Childhood Obesity Research, and the Bennett Family Center at The Pennsylvania State University.

The authors' responsibilities were as follows—MKS: design of the experiment, collection and analysis of the data, and writing of the manuscript; LSR: analysis of the data and writing of the manuscript; and LLB and BJR: design

of the experiment and writing of the manuscript. None of the authors had a personal or financial conflict of interest.

REFERENCES

- Steinmetz KA, Potter JD. Vegetables, fruit, and cancer prevention: a review. *J Am Diet Assoc* 1996;96:1027–39.
- Hu FB. Plant-based foods and prevention of cardiovascular disease: an overview. *Am J Clin Nutr* 2003;78(suppl):544S–51S.
- Riboli E, Norat T. Epidemiologic evidence of the protective effect of fruit and vegetables on cancer risk. *Am J Clin Nutr* 2003;78(suppl):559S–69S.
- Guenther PM, Dodd KW, Reedy J, Krebs-Smith SM. Most Americans eat much less than recommended amounts of fruits and vegetables. *J Am Diet Assoc* 2006;106:1371–9.
- Rolls BJ, Morris EL, Roe LS. Portion size of food affects energy intake in normal-weight and overweight men and women. *Am J Clin Nutr* 2002;76:1207–13.
- Rolls BJ, Roe LS, Meengs JS, Wall DE. Increasing the portion size of a sandwich increases energy intake. *J Am Diet Assoc* 2004;104:367–72.
- Rolls BJ, Roe LS, Kral TV, Meengs JS, Wall DE. Increasing the portion size of a packaged snack increases energy intake in men and women. *Appetite* 2004;42:63–9.
- Rolls BJ, Engell D, Birch LL. Serving portion size influences 5-year-old but not 3-year old children's food intakes. *J Am Diet Assoc* 2000;100:232–4.
- Fisher JO, Arreola A, Birch LL, Rolls BJ. Portion size effects on daily energy intake in low-income Hispanic and African American children and their mothers. *Am J Clin Nutr* 2007;86:1709–16.
- Fisher JO, Liu Y, Birch LL, Rolls BJ. Effects of portion size and energy density on young children's intake at a meal. *Am J Clin Nutr* 2007;86:174–9.
- Leahy KE, Birch LL, Fisher JO, Rolls BJ. Reductions in entrée energy density increase children's vegetable intake and reduce energy intake. *Obesity (Silver Spring)* 2008;16:1559–65.
- Rolls BJ, Roe LS, Meengs JS. The effect of large portion sizes on energy intake is sustained for 11 days. *Obesity (Silver Spring)* 2007;15:1535–43.
- Kral TVE, Kabay AC, Roe LS, Rolls BJ. Effects of doubling the portion size of fruit and vegetable side dishes on children's intake at a meal. *Obesity (Silver Spring)* (Epub ahead of print 13 August 2009).
- Rolls BJ, Roe LS, Meengs JS. Salad and satiety: energy density and portion size of a first course salad affect energy intake at lunch. *J Am Diet Assoc* 2004;104:1570–6.
- Smiciklas-Wright H, Mitchell DC, Mickle SJ, Goldman JD, Cook A. Foods commonly eaten in the United States, 1989–1991 and 1994–1996: are the portion sizes changing? *J Am Diet Assoc* 2003;103:41–7.
- Birch LL. The relationship between children's food preferences and those of their parents. *J Nutr Educ* 1980;12:14–8.
- US Department of Agriculture. MyPyramid for preschoolers, version current 2009. Available from: <http://www.mypyramid.gov/preschoolers/index.html> (cited 22 December 2009).
- Nicklas TA, Baranowski T, Baranowski JC, Cullen K, Rittenberry L, Olvera N. Family and child-care provider influences on preschool children's fruit, juice, and vegetable consumption. *Nutr Rev* 2001;59:224–35.
- Leahy KE, Birch LL, Rolls BJ. Reducing the energy density of an entrée decreases children's energy intake at lunch. *J Am Diet Assoc* 2008;108:41–8.
- Leahy KE, Birch LL, Rolls BJ. Reducing the energy density of multiple meals decreases the energy intake of preschool-age children. *Am J Clin Nutr* 2008;88:1459–68.
- US Department of Agriculture, Food and Nutrition Service. Nutrition standards and menu planning approaches for lunches and requirements for afterschool snacks. Code of Federal Regulations. 7 CFR 210.10 Washington, DC: GPO, 2009. Available from: http://www.fns.usda.gov/cnd/governance/regulations/7cfr210_09.pdf (cited 22 December 2009).
- US Department of Agriculture, Agricultural Research Service. USDA nutrient database for standard reference, release 22. 2009;Nutrient Data Laboratory Home Page. Available from: <http://www.ars.usda.gov/ba/bhnrc/ndl> (cited 22 December 2009).
- Birch LL. Dimensions of preschool children's food preferences. *J Nutr Educ* 1979;11:91–5.

24. Birch LL. Preschool children's food preferences and consumption patterns. *J Nutr Educ* 1979;11:189-92.
25. Centers for Disease Control and Prevention. A SAS program for the CDC growth charts. Version current. Available from: <http://www.cdc.gov/nccdphp/dnpao/growthcharts/resources/sas.htm> (cited 22 December 2009).
26. Littell RC, Milliken GA, Stroup WW, Wolfinger RD, Schabenberger O. SAS for mixed models. 2nd ed. Cary, NC: SAS Institute Inc, 2006.
27. Epstein LH, Robinson JL, Temple JL, Roemmich JN, Marusewski AL, Nadbrzuch RL. Variety influences habituation of motivated behavior for food and energy intake in children. *Am J Clin Nutr* 2009;89:746-54.
28. Temple JL, Giacomelli AM, Roemmich JN, Epstein LH. Dietary variety impairs habituation in children. *Health Psychol* 2008;27:S10-9.
29. Rolls BJ, Rowe EA, Rolls ET, Kingston B, Megson A, Gunary R. Variety in a meal enhances food intake in man. *Physiol Behav* 1981;26:215-21.
30. Birch LL, Deysher M. Caloric compensation and sensory specific satiety: evidence for self-regulation of food intake by young children. *Appetite* 1986;7:323-31.
31. Rolls BJ, Rolls ET, Rowe EA, Sweeney K. Sensory specific satiety in man. *Physiol Behav* 1981;27:137-42.
32. Orlet Fisher J, Rolls BJ, Birch LL. Children's bite size and intake of an entrée are greater with large portions than with age-appropriate or self-selected portions. *Am J Clin Nutr* 2003;77:1164-70.
33. Birch LL, Deysher M. Conditioned and unconditioned caloric compensation: evidence for self-regulation of food intake in young children. *Learn Motiv* 1985;16:341-55.
34. Cecil JE, Palmer CN, Wrieden W, et al. Energy intakes of children after preloads: adjustment, not compensation. *Am J Clin Nutr* 2005;82:302-8.
35. Flood JE, Rolls BJ. Soup preloads in a variety of forms reduce meal energy intake. *Appetite* 2007;49:626-34.
36. Flood-Obbagy JE, Rolls BJ. The effect of fruit in different forms on energy intake and satiety at a meal. *Appetite* 2009;52:416-22.
37. Fisher JO, Kral TV. Super-size me: portion size effects on young children's eating. *Physiol Behav* 2008;94:39-47.
38. Fisher JO. Effects of age on children's intake of large and self-selected food portions. *Obesity (Silver Spring)* 2007;15:403-12.