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Reductions in Entrée Energy Density Increase Children's Vegetable Intake and Reduce Energy Intake

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The energy density (ED; kcal/g) of an entrée influences children's energy intake (EI), but the effect of simultaneously changing both ED and portion size of an entrée on preschool children's EI is unknown. In this within-subject crossover study, 3- to 5-year-old children (30 boys, 31 girls) in a daycare facility were served a test lunch once/week for 4 weeks. The amount and type of vegetables and cheeses incorporated into the sauce of a pasta entrée were manipulated to create two versions that varied in ED by 25% (1.6 or 1.2 kcal/g). Across the weeks, each version of the entrée was served to the children in each of two portion sizes (400 or 300 g). Lunch, consumed *ad libitum*, also included carrots, applesauce, and milk. Decreasing ED of the entrée by 25% significantly ($P < 0.0001$) reduced children's EI of the entrée by 25% (63.1 ± 8.3 kcal) and EI at lunch by 17% (60.7 ± 8.9 kcal). Increasing the proportion of vegetables in the pasta entrée increased children's vegetable intake at lunch by half of a serving of vegetables ($P < 0.01$). Decreasing portion size of the entrée by 25% did not significantly affect children's total food intake or EI at lunch. Therefore, reducing the ED of a lunch entrée resulted in a reduction in children's EI from the entrée and from the meal in both portion size conditions. Decreasing ED by incorporating more vegetables into recipes is an effective way of reducing children's EI while increasing their vegetable intake.

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INTRODUCTION

The American Medical Association recently issued recommendations on the prevention of child overweight and obesity, including such changes in eating behavior as limiting the consumption of energy-dense foods and consuming diets with recommended amounts of fruits and vegetables (1). Reducing the energy density (ED; kcal/g) of foods has been shown to be an effective strategy for moderating energy intake (EI) in adults because adults tend to consume a consistent weight of food even when it is reduced in ED (2,3). Previous research has also shown that preschool children (4) tend to consume a consistent weight of an entrée when it is reduced in ED. However, the portion size of an entrée has also been shown to influence preschool children's food intake at a meal (5–7). In one study (6), when the size of a reference entrée portion was doubled, preschool-aged children ate 25% more energy from the entrée and 15% more energy at the meal. Previous studies on adults (8,9) and school-aged children (10) have shown that ED and portion size have independent and additive effects on EI, indicating that large portions of energy-dense foods are particularly problematic

for maintaining energy balance. This study tests how the effects of ED and portion size combine to influence preschool children's EI at a meal.

Dietary ED can be reduced by decreasing the proportion of fat or by increasing the proportion of water-rich ingredients, such as vegetables, in recipes. Decreasing the ED of an entrée by reducing its fat content has been shown to moderate preschool children's EI at a meal (4). Although increasing the proportion of vegetables in an entrée has been shown to reduce EI in adults (2), this has not been tested in children. Such a strategy also has the potential to increase vegetable intake and to improve diet quality if it can be achieved without affecting palatability. Therefore, an aim of this study was to determine the effect on EI of reducing ED not only by reducing the proportion of fat in an entrée but also by incorporating extra vegetables while maintaining palatability. The effect of varying the portion size of entrées differing in ED was also determined. Another aim was to assess the influence of children's physical characteristics and mothers' child-feeding practices on the relationships between ED and portion size of the entrée and intake.

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METHODS AND PROCEDURES

Design

A within-subject crossover design was used to test the effects of varying the ED and portion size of a lunch entrée on young children's meal intake in a preschool setting. All children received breakfast and lunch 1 day per week for 6 weeks. A standard breakfast of cereal, milk, and fruit was served to ensure a consistent level of hunger across lunch sessions. A single lunch menu, varying only in the ED and portion size of the main entrée, was used throughout the experiment. Four experimental conditions spaced a week apart were used: larger portion (400 g) of higher-ED (1.6 kcal/g) entrée, smaller portion (300 g) of higher-ED entrée, larger portion (400 g) of lower-ED (1.2 kcal/g) entrée, and smaller portion (300 g) of lower-ED entrée. The order of presentation for the four conditions was counterbalanced across children. Children in different conditions could be seated next to each other at lunch because the higher-ED and lower-ED versions of the entrée looked similar and the portions of the entrée were arranged to appear similar on the plate. The week before data collection was used to familiarize children with experimental menu and procedures. In this case, they were served 300 g portions of pasta with an intermediate ED (1.4 kcal/g). The sixth and final week of the study was used as a make-up week for children who were absent during the study. On the make-up day, all children were served the test meal. Children who were making up for an absence were served the condition that they missed during the study, and their intakes were recorded. All remaining children received 300 g of pasta of either ED.

The number of children to be included in this study was based on previous research in a similar population and using similar foods. We considered a clinically significant difference in lunch EI to be 50 kcal between any two conditions. This amount is ~15% of typical lunch intakes in this population. A power analysis showed that a sample size of 46 children would allow detection of this difference at a significance level of 0.05 and power of 80%.

Participants

Children were recruited by letters given to all parents at the child care facility with children who would be at least 3 years of age at the start of the study. Parents provided written consent for both their own participation and the participation of their child, and all procedures were reviewed and approved by the Pennsylvania State University Office for Research Protections.

Seventy-five preschool children in full-day daycare participated in the study. Twelve children were excluded from the analyses because they failed to meet the predefined minimum consumption criteria: these children ate <25 g of the entrée on three or more occasions. Two children were excluded because of absenteeism. The final group of 61 children (30 boys and 31 girls) had a mean (\pm s.e.) age of 4.4 ± 0.1 years (range: 3.1–5.6 years) and a mean sex- and age-specific percentile for BMI of 62.5 ± 3.3 (range: 3.2–97.8). Twelve children had BMI percentiles >85 and one child had a BMI percentile >95. Boys and girls did not differ significantly from each other in mean age, body weight, height, or BMI percentile (Table 1). Of the 51 children whose parents provided demographic information, 63% were non-Hispanic white, 31% were Asian, and 6% were black or African American, and 87% of mothers and 83% of fathers reported having at least a 4-year university degree. The majority of parents, 83% of mothers and 90% of fathers, reported being employed. Most of the families (66%) reported earning a combined income of >\$50,000 per year.

Measures and procedures

Lunch procedures. Children's food intake was measured during each of the four test lunches. Children in each of five classrooms at the day-care center were served lunch at their regularly scheduled time and ate at tables of three to six children and one adult, which is standard practice at the center. Teachers were instructed not to encourage children to eat and not to discuss food. Food and drink spillage and any comments

Table 1 Characteristics of children (mean \pm s.e.; range)

Characteristic	Boys	Girls
Age (years)	4.5 \pm 0.1 (3.1–5.6) <i>n</i> = 30	4.3 \pm 0.1 (3.1–5.5) <i>n</i> = 31
Body weight (kg)	18.1 \pm 0.5 (13.7–25.4) <i>n</i> = 29	17.8 \pm 0.5 (13.9–24.6) <i>n</i> = 29
Height (cm)	106.2 \pm 1.1 (97.1–120.1) <i>n</i> = 28	105.0 \pm 1.2 (92.0–117.6) <i>n</i> = 29
Sex- and age-specific percentile for BMI	59.0 \pm 4.9 (3.2–94.9) <i>n</i> = 28	65.9 \pm 4.3 (3.8–97.8) <i>n</i> = 29

made by children or teachers pertaining to food were recorded by trained observers. Conversations about food-related topics were redirected to minimize the influence of teachers' and peers' comments on children's lunch intake. When children finished lunch, dropped and spilled foods were returned to the proper dish and lunch items were cleared. Food weights were recorded to the nearest 0.1 g using digital scales (Mettler-Toledo PR5001 and XS4001S; Mettler-Toledo, Columbus, OH). Children's consumption of all foods was determined by subtracting post- from pre-meal weights, and manufacturers' nutrition information was used to calculate ED and EI.

Experimental menu

The experimental entrée served to all children during the study was pasta with cheese and a tomato-based vegetable sauce (Table 2). Two entrées were formulated to differ in ED; the higher-ED entrée had 1.6 kcal/g and the lower-ED entrée was reduced in ED by 25% (1.2 kcal/g). The ED of the entrée was reduced by increasing the amount of pureed broccoli and cauliflower (thus increasing water content), and decreasing the amount of cheese and substituting low-fat cheeses (thus decreasing fat content). The higher-ED entrée had 35% of energy as fat, 48% as carbohydrate, and 17% as protein; the lower-ED entrée had 28% energy as fat, 54% as carbohydrate, and 18% as protein. The larger portion (400 g) of the entrée was chosen so as not to limit the intake of the children. This portion is larger than the 90th percentiles for pasta, macaroni and cheese, and spaghetti with sauce consumption data for 2- to 5-year-old children from the Continuing Survey of Food Intakes by Individuals (11). The smaller portion (300 g) was chosen so that it was 25% smaller than the larger portion. The 400-g portion provided 640 kcal (higher-ED) or 480 kcal (lower-ED), and the 300-g portion provided 480 kcal (higher-ED) or 360 kcal (lower-ED). Other foods served during lunch were 2% milk (297 ml; University Creamery, State College, PA), four carrot sticks (22–32 g; Foodhold U.S.A., Landover, MD), and unsweetened applesauce (150 g; Knouse Foods, Peach Glen, PA). All lunch items were consumed *ad libitum*.

Other measures

Preference assessments and portion size comparisons. The two versions of the pasta were formulated to be similar in palatability. Children's preferences for the two pastas were assessed at the end of the study to evaluate whether one version was consistently preferred over the other. Prior to individual preference assessments, the meaning of three cartoon faces ("yummy," "just ok," and "yucky") was explained to all children in the classroom in an interactive demonstration. Similar protocols with cartoon faces have been used in other studies of preschool-aged children (12), and preference data have been shown to predict

Table 2 Nutrition information for two versions of the pasta entrée (300 g portion)^a

Ingredients	Weight (g)	Energy (kcal)	Fat (g)	Carbohydrate (g)	Protein (g)
Higher-ED version (1.6 kcal/g)					
Pasta					
Cooked macaroni ^b	102.5	145.7	0.7	28.4	4.9
Vegetables					
Pureed broccoli ^c	5.9	2.1	0	0.3	0.1
Pureed cauliflower ^d	4.2	1.0	0	0.2	0.1
Cheese					
Mozzarella and parmesan ^e	46.4	149.0	9.9	1.7	9.9
Parmesan ^e	4.6	18.6	1.4	0	1.9
Sauce					
Spaghetti sauce ^f	147.6	147.6	4.3	23.4	2.5
Heavy whipping cream ^g	4.6	15.5	1.6	0	0
Uncooked total	315.8	479.5	17.9	54.0	19.4
Cooked total ^h	300.0				
Lower-ED version (1.2 kcal/g)					
Pasta					
Cooked macaroni ^b	101.5	144.0	0.7	28.1	4.8
Vegetables					
Pureed broccoli ^c	17.6	6.2	0	0.8	0.2
Pureed cauliflower ^d	12.5	2.9	0	0.4	0.3
Cheese					
Mozzarella and parmesan ^e	22.9	73.7	4.9	0.8	4.9
2% Mozzarella ^e	7.6	19.1	1.1	0.3	2.2
Parmesan ^e	3.1	12.2	0.9	0	1.2
Sauce					
Spaghetti sauce ^f	57.3	57.3	2.4	9.1	1.0
Light whipping cream ^g	4.6	9.1	0.8	0.3	0
Puréed tomatoes ⁱ	65.7	26.1	0	5.7	1.0
Light tomato basil sauce ^j	22.9	11.0	0	2.2	0.4
Uncooked total	315.7	358.7	10.8	47.7	16.0
Cooked total ^h	299.9				

ED, energy density.

^aThe other two entrées had the same proportion of ingredients scaled to 400g. ^bAmerican Italian Pasta, Kansas City, MO. ^cBirds Eye Food, Rochester, NY. ^dHanover Foods, Hanover, PA. ^eKraft Foods North America, Glenview, IL. ^fCampbell Soup, Camden, NJ. ^gFoodhold U.S.A., Landover, MD. ^hCooked total is the weight of food after water loss due to cooking. ⁱDel Monte Foods, San Francisco, CA. ^jUnilever, Englewood, NJ.

preschool children's intake (13,14). During each preference assessment, the child was seated at a table with two samples of the entrée. Three cartoon faces were set in front of the child. The child was told "Please take a bite of one of the pastas. Do you think it tastes yummy, just ok, or yucky? Now, take a bite of the other pasta. Do you think it tastes yummy, just ok, or yucky?" If the same category was chosen for both samples, the child was then asked, "Do you think that one of the pastas tastes better than the other or do they both taste the same?" Next, the child was simultaneously shown two plated portions (400 and 300g) of the entrée and was asked, "Does one of these plates have more pasta than the other or do they have the same amount of pasta?" The child's responses were recorded.

Children's body weight and height. Body weight and height measurements for the majority of children were obtained within 2 weeks

of the final test day. Body weight was measured to the nearest 0.1 kg using a portable digital scale (Seca Onda 843; Seca North America East, Hanover, MD). Height was measured in duplicate to the nearest 0.1 cm using a portable stadiometer (Seca 214; Seca North America East, Hanover, MD). If the two measurements varied by >0.2 cm, then a third measurement was taken. Body weight and mean height of each child were used to calculate their sex- and age-specific percentile for BMI using a program from the Centers for Disease Control and Prevention (15).

Parental questionnaires. Parents were asked to complete two questionnaires: the Child Feeding Questionnaire and a demographic questionnaire. The Child Feeding Questionnaire is composed of 75 questions that assess parental feeding strategies and opinions about body weight. The psychometric characteristics of this instrument are

described elsewhere (16). For the purposes of this study, only four of the seven subscales were used in the analysis: the scores for the mother's restriction of her child's food intake, her exertion of pressure on her child to eat, her level of monitoring her child's eating, and her level of responsibility in child-feeding. Fifty-one mothers completed the Child Feeding Questionnaire. The demographic questionnaire consists of 16 questions that assess the background and the health status of the child, and either parent could complete this questionnaire. Fifty-one parents completed this questionnaire.

Analyses

Data were analyzed using a mixed linear model with repeated measures in the SAS System for Windows (version 9.1, 2003; SAS Institute, Cary, NC). Results were considered significant at $P < 0.05$ and will be reported as mean \pm s.e. The main outcomes for the study were weight and energy of pasta consumed, weight of vegetable consumed, and total weight and energy of lunch consumed. The fixed-factor effects for the model were ED and portion size, and the interaction of these two factors was tested for significance before assessment of the main effects of the factors. If no interaction was found, then analyses were done with only the main effects. The influences on the main outcomes of child's sex were tested, and data were combined for subsequent analyses if there was no significant effect of subject sex. Children who ate $>95\%$ (285 g) of the entrée during both of the smaller portion conditions were classified as "plate cleaners"; three children met this criterion. Study outcomes were analyzed both with and without data from these children in order to assess their effect on the results.

t-Tests were used to determine whether boys and girls differed in terms of age, body weight, height, and BMI percentile. Covariate analyses tested whether continuous subject characteristics, such as age, body weight, height, and BMI percentile, and maternal scores for child-feeding related to eating behavior (restriction, pressure, monitoring, and responsibility) affected the relationships between the experimental variables and the main outcomes of the study. Multivariate analysis of variance was used to determine whether children responded to the change in the portion size and ED of the pasta by adjusting the proportion of the individual foods and milk they consumed. It was also used to determine whether the proportions of macronutrients consumed at lunch changed in response to the modifications to the pasta recipe. Regression analyses, using ED of the entrée, portion size of the entrée, child characteristics (age, sex, and BMI percentile), and the maternal scores for child-feeding related to eating behavior (restriction, pressure, monitoring, and responsibility), were done to assess which factors best predicted food and EI at lunch. Adjusted R -square (R^2) values are reported.

RESULTS

Entrée intake

Analyses indicated no difference in intake by sex of the child, so data were combined for subsequent analyses. ED and portion size did not interact to affect children's entrée intake. EI from the entrée was significantly affected by the ED of the pasta ($P < 0.0001$; **Figure 1a**) but not the portion size of the pasta (**Figure 1b**). Children consumed a mean of 251.1 ± 11.0 kcal from the higher-ED entrée and 187.6 ± 9.6 kcal from the lower-ED entrée across portion sizes. Thus, decreasing the ED of the pasta by 25% resulted in a 25% (63.1 ± 8.3 kcal) decrease in energy consumed from the entrée. The weight of pasta consumed was not significantly affected by either the ED (**Figure 2a**) or the portion size (**Figure 2b**) of the entrée. Excluding three children who were recognized as "plate cleaners" from the analyses did not affect the main outcomes, and therefore, these children were included in all of the reported analyses.

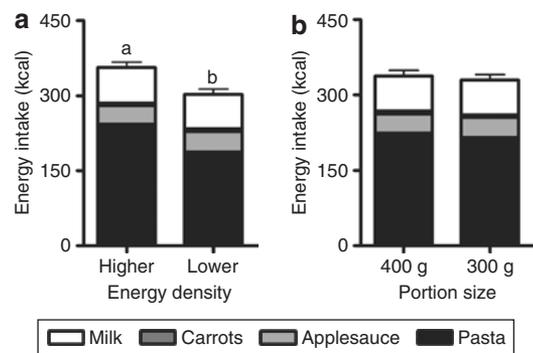


Figure 1 Preschool children's energy intake from foods (mean \pm s.e.) for (a) the two energy densities (EDs) (1.6 and 1.2 kcal/g) with the two portion sizes (400 and 300 g) averaged and (b) the two portion sizes with the two energy densities averaged. Means with different letters are significantly different ($P < 0.0001$). Compared to when served the higher-ED entrée, children consumed significantly less energy from both the pasta dish and the meal when served the lower-ED entrée. Portion size did not significantly affect children's energy intake.

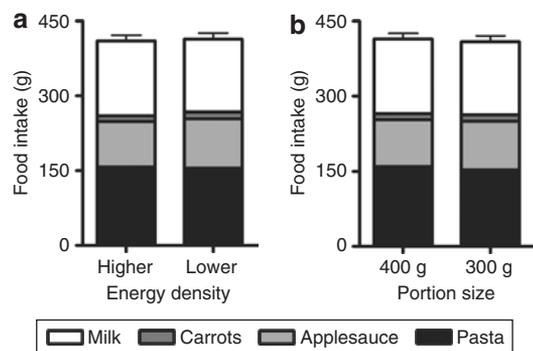


Figure 2 Preschool children's food intake (mean \pm s.e.) for (a) the two energy densities (1.6 and 1.2 kcal/g) with the two portion sizes (400 and 300 g) averaged and (b) the two portion sizes with the two energy densities averaged. Neither energy density nor portion size affected the weight of food children consumed.

Vegetable intake

Subject sex was unrelated to the amount of vegetable consumed, so data were combined for subsequent analyses. Changing the portion size of the entrée did not have a significant effect on the amount of vegetable consumed during lunch. Changing the ED of the entrée by increasing the amount of pureed vegetables (broccoli and cauliflower) significantly increased vegetable consumption ($P < 0.0001$). When served the lower-ED version of the pasta, children's mean consumption of broccoli and cauliflower increased by more than half of a serving of vegetables (serving = three tablespoons cooked vegetables (17)). Children consumed a mean of 5.3 ± 0.2 g of pureed broccoli and cauliflower from the two higher-ED versions of the entrée and a mean of 15.6 ± 0.8 g of pureed vegetables from the two lower-ED versions of the entrée. When the tomato content of the pasta sauce and the carrots served as a side dish were included in children's vegetable intake during lunch, results remained significant ($P < 0.01$).

Table 3 Children's food intakes and energy intakes (mean \pm s.e.) at lunch

Lunch component	400 g of pasta with 1.6 kcal/g	300 g of pasta with 1.6 kcal/g	400 g of pasta with 1.2 kcal/g	300 g of pasta with 1.2 kcal/g
Pasta				
Weight (g)	158.6 \pm 10.3	155.9 \pm 9.2	161.0 \pm 12.1	150.0 \pm 10.4
Energy (kcal)	253.2 \pm 16.5	248.9 \pm 14.7	194.2 \pm 14.6	180.9 \pm 12.5
Applesauce				
Weight (g)	89.0 \pm 7.2	94.0 \pm 6.6	96.7 \pm 6.3	100.5 \pm 7.0
Energy (kcal)	36.5 \pm 3.0	38.5 \pm 2.7	39.6 \pm 2.6	41.2 \pm 2.9
Carrots				
Weight (g)	11.0 \pm 1.5	11.9 \pm 1.5	13.6 \pm 1.6	12.5 \pm 1.6
Energy (kcal)	4.9 \pm 0.7	5.3 \pm 0.7	6.1 \pm 0.7	5.6 \pm 0.7
Milk				
Weight (g)	146.8 \pm 12.9	152.4 \pm 13.0	151.3 \pm 12.5	141.0 \pm 12.3
Energy (kcal)	69.2 \pm 6.1	71.9 \pm 6.1	71.3 \pm 5.9	66.5 \pm 5.8
Total				
Weight (g)	403.0 \pm 15.8	414.0 \pm 16.2	422.6 \pm 17.3	403.8 \pm 17.0
Energy (kcal)	362.7 \pm 16.1	364.5 \pm 14.9	311.2 \pm 14.7	294.1 \pm 13.6

Lunch intake

Children did not compensate for the decrease in EI from the lower-ED pasta by increasing their intake of the other foods offered during lunch, so the ED of the entrée had a significant effect on lunch EI ($P < 0.0001$). Decreasing the ED of the pasta by 25% resulted in a 17% decrease in energy consumption during the meal (Table 3). Mean lunch EI (363.6 \pm 11.0 kcal) for the higher-ED conditions differed from mean lunch EI (302.6 \pm 10.0 kcal) for the lower-ED conditions by 60.7 \pm 8.9 kcal. There were no effects of ED or portion size on the weight of food consumed during lunch. The effect of subject sex on the total weight of food consumed at lunch had a trend for significance ($P = 0.0511$); girls consumed 383.5 \pm 11.7 g and boys consumed 439.5 \pm 11.0 g.

Multivariate analysis of variance demonstrated that there was no overall effect of portion size or ED on the proportion of total meal weight that was consumed from each lunch item. Multivariate analysis of variance also showed a significant effect of ED on the proportion of energy consumed from fat, carbohydrate, and protein during lunch ($P < 0.0001$), which can be explained by the differences in the macronutrient composition of the manipulated entrée. In the higher-ED conditions, children ate a mean of 30.2% energy from fat, 53.1% energy from carbohydrate, and 16.7% energy from protein. In the lower-ED conditions, they consumed an average of 23.1% energy from fat, 59.6% energy from carbohydrate, and 17.3% energy from protein.

Regression analyses revealed that the significant predictors of the weight of lunch consumed were the mother's score for pressuring her child to eat, the child's age, and the child's sex ($R^2 = 0.15$; $P < 0.0001$). The significant predictors of the amount of energy consumed at lunch were the ED of the pasta, the child's age, and the mother's score for pressuring her child to eat ($R^2 = 0.17$; $P < 0.0001$). Intake was greater when

the higher-ED entrée was served, when the maternal score for pressuring was lower, and in boys.

Participant characteristics

Of the 52 children who participated in preference assessments, 37 children (71%) rated the lower-ED pasta as "yummy," 10 children (19%) rated it as "just ok," and five children (10%) rated it as "yucky." Thirty-four children (65%) rated the higher-ED pasta as "yummy," 14 children (27%) rated it as "just ok," and four children (8%) rated it as "yucky." Twenty-eight children (54%) rated the taste of both versions of the pasta as the same, 13 children (25%) rated the lower-ED pasta more favorably than the higher-ED pasta, and 11 children (21%) rated the higher-ED pasta more favorably than the lower-ED pasta. The children's preferences for the pasta entrées did not significantly affect the weight of pasta that they consumed. Of the 51 children who participated in the portion size comparisons for the entrée, 27 children (53%) thought that there was no size difference between the 300 and 400 g portions, three children (6%) thought the 300 g portion was >400 g portion, and 21 children (41%) correctly identified the 400 g portion as >300 g portion. The children's ability to recognize the 400 g portion as >300 g portion did not significantly affect the weight of pasta that they consumed.

There were no effects of the children's characteristics (age, body weight, height, BMI percentile, and maternal child-feeding scores) on the relationships between the experimental variables and food intake and EI.

DISCUSSION

Decreasing the ED of an entrée by 25% led to a 25% (63 kcal) reduction in children's EI from the entrée and a 17% (61 kcal) reduction in EI at the meal. However, decreasing the portion size of the entrée by 25% did not significantly affect children's

food or EIs. The reduction in the ED of the pasta was achieved by increasing the vegetable content and decreasing the fat content without detrimentally affecting taste; 79% of the children who participated in the assessment reported that the lower-ED entrée tasted the same or better than the higher-ED entrée. Because the lower-ED entrée had a larger proportion of pureed vegetables, children consumed a significantly greater amount of vegetables when it was served. Children consumed about a half of a serving more of vegetables at lunch when they were served the lower-ED version of the pasta.

The effects of ED on *ad libitum* EI are similar to those seen in experimental studies conducted in adults (2,18–20) and children (4,10). Studies carried out with adult participants have shown that decreasing the ED of foods leads to a reduction in EI at a single meal (8), throughout a single day (20), and over the course of multiple days (2,9,18,19). Adults tend to consume a fairly consistent weight of foods even when the foods are reduced in ED. The effects of changing the ED of an entrée on preschool children's *ad libitum* EI have been tested in two studies (4,21). In the more recent of the two studies, Leahy *et al.* (4) served two versions of an entrée that was varied in ED to preschool children. Just as in the adult studies, children consumed similar amounts of each version of the entrée, so the ED of the entrée affected their EI. Compared to when served the higher-ED version of the entrée, children consumed 25% less energy from the entrée and 18% less energy from the lunch when served the lower-ED version. The results of this study revealed that children's EIs were reduced in the lower-ED conditions because they consumed a consistent weight of pasta across conditions, findings in agreement with existing literature on the effects of ED on *ad libitum* EI among adults.

The findings on the effect of portion size on *ad libitum* EI differ from those conducted with adults (22–28) and preschool children (5–7) in which increasing the portion size of foods led to an increase in food intake. The disparity in the results could be due to several methodological differences between studies. First, the portion size reduction in this study was 25%, but the reduction was 50% in most of the studies in which portion size affected preschool children's EI (5–7). In one study (5) in which three portions (225, 338, and 450 g) of macaroni and cheese were served to children, significant differences in intake were only found between the large and small portions. The 33% change (medium portion vs. small portion) and 25% change (large portion vs. medium portion) in portion size did not lead to significant differences in intake. Thus, it is likely that the magnitude of the change in portion size affects children's food intake. Second, both of the portion sizes served in this study were large. The reduced portion size, 300 g, was larger than what is considered an age-appropriate amount (11) for the younger children in this study; across both portion sizes, children consumed a mean of 156 g, or about half of the smaller portion size. A third difference between studies is the type of food served. In all of the previous research on the effects of portion size on preschool children's intake, macaroni and cheese was served. Additionally, in one study in which all foods served to adults over 11 days were changed in portion

size, there was a significant effect of portion size on intake for all categories of foods except fruit served as a snack and vegetables (28). It is possible that children's responses to portion size could be food-specific. Studies in which a larger range of portions are served to children are needed to assess whether there is a dose-related response to portion size. In addition, studies are needed in which a wide variety of foods are varied in portion size to assess whether portion size effects are specific to the type of food served.

In previous studies of ED in children (4,10,21), the ED of entrées was decreased through fat reductions. This study is the first to decrease the ED of the test entrée for children by combining the strategies of decreasing fat content and increasing vegetable content. This increase in vegetable content led to a significant increase in children's vegetable consumption when they were served the lower-ED entrée; the average amount of vegetable consumed from the lower-ED entrée was more than half of a serving of cooked vegetables (17). Increasing the vegetable content of the lower-ED entrée led to a 10% increase in vegetable intake (broccoli, cauliflower, tomato sauce, and carrots) during lunch.

The practical implications of children's increased vegetable intake in this study warrant further exploration. Increasing children's consumption of vegetables is vital considering many American children are not meeting dietary recommendations for these foods (29). Data from the National Health and Nutrition Examination Survey (1999–2000) show that only ~48% of 2- to 3-year-old children consume the combined recommended amounts for fruits and vegetables. Only ~5% of boys and 10% of girls 4–8 years of age consume the combined recommended amounts for fruits and vegetables. Furthermore, interventions designed to prevent obesity and promote healthy eating in 0- to 5-year-old children have not proven to be as successful as anticipated (30). From a practical perspective, incorporating vegetables into a mixed dish is a relatively easy and inexpensive way to increase children's vegetable intake. While it is important for parents to model healthy eating behaviors by consuming a variety of fruits and vegetables so that their children are exposed to and develop a liking for these foods (31–33), adding vegetables to foods could have a significant impact on children's energy and nutrient intakes.

This study had limitations, including the use of a convenience sample and the use of a single meal. Because the study population was mostly non-Hispanic white or Asian and parents were highly educated, the findings of the study should not be generalized to all preschool children. Research in a more diverse group of children is needed to extend the findings of this study.

This study is the first to show that decreasing the ED of an entrée by increasing vegetables and reducing fat decreased children's *ad libitum* EI, while also increasing their vegetable intake. Although reducing the portion size of the entrée did not affect children's EI, decreasing the ED of the entrée led to a 25% reduction in EI from the entrée and a 17% reduction in EI at lunch. The results of this study demonstrate that reducing the ED of an entrée by decreasing fat and increasing vegetable

content can simultaneously lead to a reduction in EI and an increase in vegetable intake for preschool children.

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DISCLOSURE

The authors declared no conflict of interest.

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