

Plate Size and Children's Appetite: Effects of Larger Dishware on Self-Served Portions and Intake

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KEY WORDS

children, African American, eating, plate size, portion size, obesity, family-style meals

ABBREVIATIONS

BMI_z—BMI-for-age z-scores

NSLP—National School Lunch program

Dr DiSantis assisted in the conceptualization and design of the experiment, coordinated and supervised data collection, performed the statistical analyses for the secondary analyses, drafted the initial manuscript, and revised the manuscript; Dr Birch assisted in the conceptualization and design of the experiment and reviewed and revised the manuscript; Dr Davey performed the final statistical analyses for the main outcome and reviewed and revised the manuscript; Dr Serrano reviewed and revised the manuscript; Dr Zhang performed the initial statistical analyses for the main outcome and reviewed and revised the manuscript; Ms. Bruton assisted in data collection and reviewed and revised the manuscript; Dr Fisher conceptualized and designed the experiment, assisted in data collection, and reviewed and revised the manuscript; and all authors approved the final manuscript submitted.

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WHAT'S KNOWN ON THIS SUBJECT: Research has shown that dishware size influences self-served portion sizes and meal intake in adults. In children, larger bowls led children to request more food, but whether larger dishware affects children's self-served portions or intake at meals is not known.



WHAT THIS STUDY ADDS: We assessed the effect of increasing dishware size on self-served portions and intake in young children. Larger plates and bowls resulted in larger self-served portions, and indirectly promoted greater intake, emphasizing the importance of age-appropriate dishware.

abstract

FREE

OBJECTIVES: Dishware size is thought to influence eating behaviors, but effects on children's self-served portion sizes and intakes have not been studied. We aimed to evaluate whether larger dishware increased children's self-served portion sizes and intake during meals.

METHODS: A within-subjects experimental design was used to test the effects of dishware size (ie, plates and bowls) on children's self-served portion sizes and intakes in a naturalistic setting. Subjects were predominantly African American elementary school-aged children ($n = 42$) observed on repeated occasions during school lunch. Children served themselves an entree and side dishes using either child- or adult-size dishware, which represented a 100% increase in the surface area of plates and volume of bowls across conditions. Condition order was randomly assigned and counterbalanced across 2 first-grade classrooms. Entrées of amorphous and unit form were evaluated on separate days. Fruit and vegetable side dishes were evaluated at each meal. Fixed portions of milk and bread were provided at each meal.

RESULTS: Children served more energy (mean = 90.1 kcal, SE = 29.4 kcal) when using adult-size dishware. Adult-size dishware promoted energy intake indirectly, where every additional calorie served resulted in a 0.43-kcal increase in total energy intakes at lunch ($t = 7.72$, $P = .001$).

CONCLUSIONS: Children served themselves more with larger plates and bowls and consumed nearly 50% of the calories that they served. This provides new evidence that children's self-served portion sizes are influenced by size-related facets of their eating environments, which, in turn, may influence children's energy intake. *Pediatrics* 2013;131:1–8

Allowing young children to serve themselves at meals is thought to confer numerous developmental benefits, including social and motor skills as well as autonomy in eating.^{1–3} Encouraging children to serve themselves as part of family-style meals is widely endorsed by professional and government entities, including the American Academy of Pediatrics, the Institute of Medicine, and the US Department of Agriculture.^{4–9} Yet, there has been little research to evaluate children's self-served portion sizes at meals and the factors that influence children's serving behaviors.

Size-related visual cues of the eating environment are thought to influence serving behaviors by inflating consumption norms and/or interfering with the ability to accurately monitor the amount selected.^{10–12} Among adults, dishware size has been shown to influence self-served portion sizes and intake.^{12–14} Experimental studies have demonstrated that children eat more food when served larger portions^{3,15–17}; however, whether using larger dishware causes children to serve themselves more and to eat more food has not been studied. A study of preschoolers found that children requested twice as much cereal for a hypothetical snack when the size of the bowl used to serve the child was doubled from 16 oz to 32 oz.¹⁸ That study, however, did not assess effects on children's actual serving behaviors and intake. Investigation of the influence of dishware size on children's eating behaviors in naturalistic settings is needed to identify concrete ways that pediatricians and clinicians can target child nutrition and healthy eating.¹⁹

This research experimentally evaluated the effects of dishware size on young children's self-served portion sizes and energy intakes at school lunch. We hypothesized that children would serve themselves larger portion sizes and

consume greater energy at meals when larger dishware was provided. Children's self-served portion sizes of both unit (eg, pizza) and amorphous (eg, macaroni and cheese) entrees were evaluated, given evidence that the portion size of amorphous foods is more difficult to estimate than that of unit foods.^{20–22} A secondary aim was to identify characteristics of children who responded to larger dishware by serving more food. Child and family characteristics known to affect child dietary intake and/or obesity risk were assessed (child gender,²³ child weight status,²⁴ household food security²⁵).

METHODS

Subjects and Setting

Subjects were first-grade children in 2 classrooms of a privately-funded urban elementary school in Philadelphia, Pennsylvania, that participated the US Department of Agriculture National School Lunch program (NSLP). First graders were sampled because experimental studies of portion size, another size-related environmental cues, have consistently demonstrated effects on intake among children aged 4 to 5 years.^{26,27} While allowing children to serve themselves as part of family meals is encouraged beginning in toddlerhood,^{4,6–8} slightly older children were sampled to minimize potential motor skill development influences (ie, strength, dexterity) on serving behavior. Written parental consent was obtained for all participating children. Exclusion criteria for child participants were parental report of a chronic medical condition or medication use affecting food intake and/or reported allergies to foods on the experimental menu. Non-participating children were offered the same lunch as participating children, but data were not collected. All procedures and the protocol were approved by Temple University's institutional review board. Data were collected in 2010.

Design

A within-subjects experimental design with randomization at the level of the classroom was used where children served themselves using either child- or adult-size dishware (Table 1). In the child-size dishware condition, children served themselves entrées using 7.25 inch diameter plates (surface area = 41.26 inch²) and side dishes using 8-oz bowls. In the adult-size dishware condition, children served themselves using 10.25 inch diameter plates (surface area = 82.47 inch²) and 16-oz bowls, representing 100% increases in surface area/volume across dishware conditions. The menu was composed of foods offered at the school as part of the NSLP. Children self-served amorphous (pasta with meat sauce) and unit (chicken nuggets) entrées on separate days, whereas fruit (apple-sauce) and vegetable (mixed vegetables with butter) side dishes were self-served at all meals. Fixed portions of milk (1%, flavored) and bread were provided to children at each meal and did not vary by condition because they were not self-served. The size of the serving spoon, the serving bowl, and the amount of food offered were held constant across conditions. As shown in Table 1, children were seen once a week in a condition order that was counterbalanced across 2 classrooms. Two trials of each dishware condition (child-size versus adult-size) and entrée type (amorphous versus unit) were held for a total of 8 lunches. Children's self-served portions of each food, measured using weighed methods, and total energy served were the primary outcomes. Energy intake at the meal was a secondary outcome.

Measures and Procedures

Lunch Procedures

Children served themselves in a buffet-type line outside their classrooms during their normal scheduled lunch

TABLE 1 Experimental Condition Orders by Classroom

Study Week	Classroom A		Classroom B	
	Plate Size	Entrée Type	Plate Size	Entrée Type
1	Adult	Unit	Child	Unit
2	Adult	Amorphous	Child	Amorphous
3	Child	Amorphous	Adult	Amorphous
4	Child	Unit	Adult	Unit
	1-week washout		1-week washout	
5	Child	Unit	Adult	Unit
6	Child	Amorphous	Adult	Amorphous
7	Adult	Amorphous	Child	Amorphous
8	Adult	Unit	Child	Unit

time. This represented a departure from the typical school lunch procedures in which children typically select preportioned servings, reflecting NSLP guidelines for reimbursement.²⁸ To minimize any effects of the novelty of the self-serving procedure, an introductory session was performed to familiarize children with the procedure. The buffet table held 3 serving bowls containing the entrée, vegetable, and fruit; children served the food in this order in each condition. Serving bowls were filled for each child to the following weights: 825 g of penne pasta with meat sauce or ~324 g of chicken nuggets (18 pieces), 300 g of mixed vegetables with butter, and 300 g of applesauce. Available serving portions were approximately 3 to 5 times larger than those normally offered so as to minimize potential “ceiling” effects on children’s self-served portion size. To measure self-served portion size, each plate and bowl was discretely placed on a digital platform scale (12.4 × 12.4 inches; accuracy ± 3.0 g; Acculab, SVI-10A, Brooklyn, NY) while children served themselves; a remote readout was used to minimize children’s awareness that self-served portion sizes were being weighed. Each plate/bowl was removed from the platform scale after a stabilized weight to the nearest 0.1 g had been recorded. Children were told that they could make 1 trip through the buffet line, that they could serve themselves and eat as much or as little as they wanted, and

they were not allowed to share food with other children.

Children ate at their desks in their classrooms during a 15-minute timed meal. Research assistants were present to ensure that foods were not shared and to note any spilled or dropped foods. Following the meal, postweights were recorded for each food using the same digital platform scales. Self-served portion sizes were calculated as the difference in grams between pre- and post-lunch weights. Energy intake was calculated using nutritional information provided by the school’s food service vendor.

Experimental Menu

The experimental menu used foods offered as part of the NSLP at the participating school; the amount of food available to each child and the energy density of each food are provided in Table 2. Foods were selected, in consultation with school personnel, to be well-liked and regularly offered on the rotating menus. The amorphous entrée was penne pasta with meat sauce (Preferred Meal Systems, Inc, Berkeley, IL) and the unit entrée was chicken nuggets (Preferred Meal Systems, Inc). Entrées were not served on nonstudy days during the 8-week period. Mixed vegetables (Preferred Meal Systems, Inc) with unsalted butter (Shurfine, Western Family Foods, Inc, Portland, OR) and applesauce (United Commod-ity Group, Inc, Plymouth, MI) were the

vegetable and fruit side dishes. Fixed portions of flavored (strawberry or chocolate) 1% low-fat milk (236 mL) and bread (1 slice; 20–29 g) were served to all participating children. Lactose-free milk was offered to 2 participants who were identified by school staff and/or parents as lactose intolerant.

Parent Questionnaires

A demographic questionnaire was used to assess the participating parent’s education, race/ethnicity, employment status, and family income. The short form of the US Department of Agriculture Household Food Security Scale (6 items) was used to classify food security.^{29,30} With possible scores ranging from 0 to 6, a total score of 2 or above indicates household food insecurity. In a nationally representative sample of adults, this instrument had a 92% sensitivity and 99% specificity for identifying food insecurity.²⁹

Children’s Body Weight and Height

Child body weight and height were measured in light clothing without shoes³¹ during a morning physical education class in the last 2 weeks of the study. Digital portable scales (882-11321134, Seca, Hanover, MD) were used to obtain duplicate weight measurements to the nearest 0.1 kg and portable stadiometers (PE-AIM-101, Perspective, Portage, MI) were used to obtain duplicate height measurements to the nearest 0.1 cm. A third measurement was taken and the discrepant measure discarded, in cases in which the weight measurements varied by >0.05 kg or height measurements varied by >0.2 cm. BMI-for-age z-scores (BMIz) were calculated using national reference data.³²

Food-Liking Assessment

Liking of foods on the experimental menu was assessed by individual interview on a nonstudy day, just before

TABLE 2 Energy Density and Portion Sizes of NSLP Foods on the Experimental Menu

Experimental Menu	Menu Item	Energy Density, kcal/g	Standard NSLP Portion ^a		Experimental Serving Bowl Portions ^b	
			Weight, g	Energy, kcal	Weight, g	Energy, kcal
Amorphous entrée	Penne with meat sauce	1.59	225.1	357.9	825.0	1311.8
Unit entrée	Chicken nuggets	2.53	86.2	218.0	384.8 ^c	973.6
Vegetable side	Mixed vegetables ^d	1.05	73.5	79.3	300.0	315.0
Fruit side	Applesauce	1.05	113.4	120.0	300.0	315.0

^a Amount provided to each child at regular NSLP meals.

^b Amount available to each child in serving bowl at experimental meals.

^c Approximate weight; serving bowls contained 18 chicken nuggets; estimated 21.5 g/piece.

^d The NSLP serves mixed vegetables with butter; energy density reflects approximately 4 g of butter per 70 g vegetables.

lunch. Each child was shown 2 bites of each food, asked to smell each food, and then asked “Do you think this food tastes yummy, yucky, or just ok?” Cartoon drawings of faces depicting those levels of liking were used to facilitate responses.³³ This procedure was an adaptation of a tasting method developed for preschool-aged children.^{33,34}

Analyses

Generalized estimating equations³⁵ were used to evaluate effects of dishware size (child-size versus adult-size) on children’s self-served portions of unit and amorphous entrées (kcal), and vegetable and fruit side dishes (kcal), as well as total energy (kcal) served. All models were adjusted for entrée type (unit versus amorphous), child gender, child obesity status, food insecurity, and the child’s liking of the food. In models predicting total energy served/consumed, liking of the main entrée was included. Generalized estimating equation analyses were also used to evaluate effects of dishware size (child-size versus adult-size) on children’s energy intake (kcal) of unit and amorphous entrées, and vegetable and fruit side dishes, and total energy intake (kcal) at the meal. In addition to the covariates listed previously, these models were adjusted for self-served portion size (kcal). Linear regressions were used to identify predictors of increases in total self-served energy

(kcal) across dishware conditions. Data are presented as adjusted least-squared means unless otherwise indicated. Statistical analyses were performed using Stata version 11 statistical software (StataCorp, LP, College Station, TX) and SPSS version 19 (IBM, Armonk, NY).

RESULTS

Of 48 first-grade students in 2 participating classrooms, 43 were enrolled, with 5 parents refusing participation. Of the 43 child participants, 1 left the school and did not complete the study. Demographic information was obtained from 41 of the 42 participating parents and is presented in Table 3.

Effects of Dishware Size on Self-Served Portion Sizes

A main effect of dishware size on children’s total self-served energy was seen ($t = 3.07, P = .002$). On average, children served 90.1 kcal (SE = 29.4 kcal) more at lunch when using adult-size than child-size dishware to serve themselves (Fig 1). This effect was seen in approximately 80% of the children ($n = 34$). The type of entrée offered also influenced the amount of energy served, where children served themselves an average of 238.9 kcal (SE = 29.1 kcal) more at lunches at which the unit entrée was offered compared with lunches at which the amorphous entrée was offered ($t = 8.20, P = .001$).

Additionally, children served themselves an average of 104.2 kcal (SE = 30.9 kcal) more energy at the meal when they reported liking the entrée ($t = 3.38, P = .001$).

Main effects of dishware size on children’s self-served portion sizes were seen for individual foods (Fig 2). Main effects of dishware size ($t = 2.92, P < .01$) and entrée type ($t = 2.45, P < .01$) on self-served entrée portion size were observed, where children served themselves 57.6 kcal (SE = 19.7 kcal) more when using the adult-size dishware compared with child-size dishware and 54.5 kcal (SE = 22.2 kcal) more when the unit entrée was served, compared with the amorphous entrée. Children also served themselves, on average, 104.5 kcal (SE = 30.2 kcal) more of the entrée when they reported liking the entrée ($t = 3.46, P < .01$). A main effect of dishware size was observed for the fruit side, such that children served themselves 15.7 kcal (SE = 6.3 kcal) more fruit with the adult-size than with the child-size dishware ($t = 2.50, P < .05$). They also served themselves an average of 62.9 kcal

TABLE 3 Sample Characteristics ($n = 41$)^a

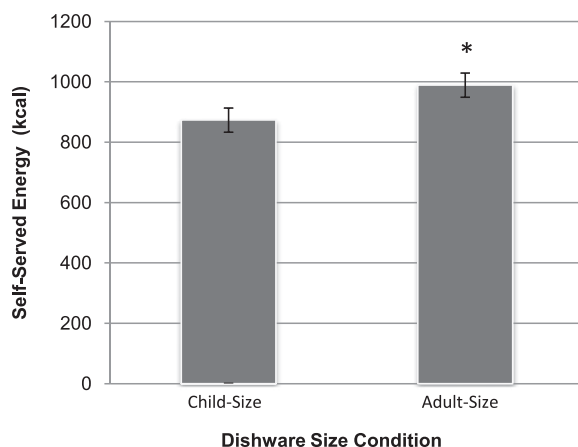
	<i>n</i> (%)
Household	
No. children in family	2.2 (1.3) ^b
Food insecure ^c	8 (20)
Parent/caregiver	
Employed	28 (68)
College educated	10 (24)
Married	14 (34)
Child	
African American, non-Hispanic	35 (88)
Mixed race/ethnicity	5 (12)
Female	25 (61)
Overweight or obese	19 (45)
NSLP participant ^d	40 (98)

^a Forty-two participants in final sample, but 1 participant did not have demographic questionnaires completed.

^b Mean (SD).

^c Food insecure refers to a household experiencing food insecurity in the past year as measured by the short form of the Household Food Security Scale.^{29,30}

^d Parent/Guardian reported that his or her child ate lunch in the NSLP 4 to 5 days per week. This includes children receiving free or discounted lunch, along with children paying full price.

**FIGURE 1**

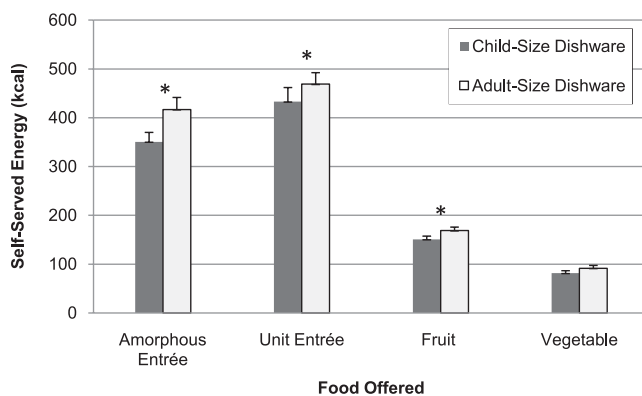
Mean total self-served energy at lunch by dishware size condition. Unadjusted generalized estimating equation models revealed main effects of dishware size on the amount of energy children served themselves from an entrée, fruit, and vegetable at school lunch ($t = 3.07$, $P < .01$). Children served 90.1 kcal (SE = 29.4 kcal) more at lunch when using adult-size than child-size dishware to serve themselves. * $P \leq 0.05$.

(SE = 23.0 kcal) more fruit when they reported liking the fruit side ($t = 2.73$, $P < .01$). For the vegetable side, only liking of the food had a main effect on self-served energy, such that children served themselves 42.3 kcal (SE = 14.6 kcal) in vegetables when they reported liking the vegetable ($t = 2.89$, $P < .01$).

Direct and Indirect Effects of Dishware Size on Energy Intake

Direct effects of dishware condition on children's energy intakes were evalu-

ated without and with adjustment for the amount of energy children served themselves. Unadjusted models showed no differences in children's total energy intakes at lunches across dishware conditions (587 ± 31 vs 593 ± 30 kcal, in child- and adult-size conditions, respectively; $P = \text{NS}$) as well as intake of individual foods. However, dishware size indirectly effected energy intake through children's self-served portion sizes. For every additional calorie that children

**FIGURE 2**

Self-served energy of each food by dishware size condition; mean self-served energy at lunch for individual foods by dishware size condition. Unadjusted generalized estimating equation models revealed main effects of dishware size on the amount of energy children served themselves from the entrée and fruit energy. Children served themselves 57.6 kcal (SE = 19.7 kcal) more of the entrée and 15.7 kcal (SE = 6.3 kcal) more of the fruit when using adult-size than child-size dishware ($t = 2.50$, $P < .05$). Dishware size had no effect on children's self-served vegetable portions. * $P \leq 0.05$.

served themselves, there was a 0.43-kcal observed increase in total meal energy intake ($t = 7.72$, $P < .01$). Similar associations were observed for the individual foods. Thus, children served themselves more food when using larger dishware and children who served themselves more energy, in turn, tended to consume more energy. In those models that adjusted for the amount of energy that children served themselves, however, adult-size dishware per se was associated with lower meal energy intakes than child-size dishware (50.8 kcal difference; $t = -3.69$, $P \leq .001$).

Characterizing Children Who Served Larger Portion Sizes When Using Adult-Size Dishware

BMIz, food insecurity, and child gender were evaluated as predictors of a child's response to dishware size, where response was measured by as change in total self-served energy (kcal) across child- to adult-size dishware conditions. Table 4 shows the results of a linear regression that included all the potential predictors and controlling for condition order. Food insecurity was a significant predictor ($P < .05$), where children from food insecure households ($n = 8$; 20%) showed greater increases (34.2% vs 17.7%) in total self-served energy (kcal) than children from food secure households ($n = 33$; 80%). BMIz and child gender, however, did not predict changes in children's total self-served energy (kcal) across conditions.

DISCUSSION

Current US dietary guidance (ie, *ChooseMyPlate*) uses dishware to convey messages about healthy eating.³⁶ This research is the first to experimentally evaluate the effects of dishware size on children's eating behaviors in a naturalistic setting. The fact that adult-size plates and bowls produced greater self-served portions

TABLE 4 Results of Linear Regression Assessing the Predictors of Response to Adult-Sized Dishware^a

Predictor	Standardized β	<i>P</i> value
Child BMIz	0.11	.50
Food insecurity	0.36	.04
Child gender	-0.06	.74

^a Defined as the change across dishware conditions in children's self-served energy (kcal) from the entrée and fruit/vegetable side dishes; controlling for condition order.

in young children at lunch provides new evidence of the influence of environmental eating cues on appetitive behavior among children. Dishware size effects on children's serving behavior were observed for unit and amorphous entrées and the fruit side dish, but interestingly not for the vegetable side dish. Because larger self-served portion sizes were associated with greater energy intake at the meal, the findings suggest that larger dishware sizes may indirectly promote energy intake at meals through greater self-served portion sizes.

Our findings advance previous research on dishware size among children¹⁸ by demonstrating effects on children's actual serving and eating behaviors. The mechanism(s) by which larger dishware promotes self-served portions among children are unclear. It is possible that larger dishware suggested inflated norms for consumption that translated into larger self-served portion sizes.¹⁰ It is also possible that the use of larger dishware may have altered children's visual perception of portion size. Recent experimental studies demonstrated that adults perceived a given portion to be smaller when the plate size and the amount of white space on the plate (ie, the gap between the food and the edge of the plate) were increased.¹² In the same vein, it is possible that children serve themselves more food because the larger dishware made portions appear smaller to the eye. Additional research is needed to systematically evaluate these propositions.

That greater energy intakes were seen with greater self-served portions is consistent with previous research showing that children will generally eat more when served larger portions.^{17,37} It is important to note, however, that when the amount that children served themselves was factored out of the analyses, larger dishware was actually associated with lower energy intake. Hence, larger dishware does not appear to directly promote consumption but rather results in larger self-served portions, which then may lead to greater intakes. These findings suggest the amount of food that ends up on the plate is a central determinant of the amount consumed for children. As such, dishware size may be an important part of behavioral interventions and clinical recommendations aimed at reducing intakes of energy-dense foods and promoting healthy appetites in children. Whether dishware size can be used to promote consumption of low-energy, nutrient-rich foods is less clear. Children served themselves more fruit with larger dishware, but did not serve more vegetables with larger dishware. Yet, effects of this and previous studies are relatively modest in absolute terms and appear to be linked to children's preferences for fruits and vegetables.³⁸ Thus, the present results suggest that dishware size should be used as an adjunct strategy to those directly aimed at increasing the acceptability and preference for low-energy, nutrient-dense foods.

Although the vast majority of children showed increases in self-served portions with adult-size dishware, individual differences were not clearly demarcated by age, gender, or weight. That child BMI did not identify children who served more when using larger dishware suggests that the effects are not limited to heavier children. Household food insecurity was related to the degree to which dishware size

influenced the amount of food that children served themselves. This finding could reflect food-insecure parents' encouragement of eating when food is available (eg, time of month when food assistance is received).³⁹ At the same time, the greater self-served portion sizes of children from food insecure households did not translate to greater intake.

The current findings are qualified by a number of limitations. Because the randomization of the condition orders occurred at the level of classroom, classroom and condition order effects are not separable. Although this research was conducted in a naturalistic setting, children were not typically allowed to serve themselves, but rather chose preportioned servings of the lunch item(s) offered as part of the NSLP.²⁸ Thus, the experimental procedures represented a departure from normal food-service procedures. An initial "practice" lunch session was used to familiarize children with procedures and reduce novel effects on serving behavior. Also, children likely varied in the extent to which they were allowed to serve themselves at home. Although the research did not specifically measure children's serving behaviors at home, the use of a within-subjects design where children served as their own controls minimizes the influence of this potential source of random bias. Finally, the extent to which the findings generalize to children of other ages, ethnicity/race, and socioeconomic background requires further inquiry.

In conclusion, this research demonstrates that children serve themselves larger portions and, in turn, may consume greater energy at meals when using larger dishware. These findings provide "proof of concept" for a role of dishware size in appetite regulation in children. Additional studies are needed to formally evaluate the utility

of smaller dishware for promoting age-appropriate child portion sizes at mealtimes in the home and other settings where young children routinely eat (eg, child care). Providing guidance to parents on child portion

sizes is challenged by the fact that education emphasizing metrics may not be viewed as helpful⁴⁰ and may be difficult to understand, particularly among individuals with lower levels of literacy and numeracy.^{41,42} Encourag-

ing parents to use smaller dishware may be a relatively straightforward and acceptable strategy that can be used by clinicians to promote age-appropriate child portion sizes across diverse populations.

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