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THE EFFECT OF VARYING THE PORTION SIZE AND ENERGY DENSITY OF FOODS AND MILK ON PRESCHOOL CHILDREN’S INTAKE

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by

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ABSTRACT

Serving larger portion sizes and energy-dense foods and beverages has robust effects on preschool children’s intake, and these factors are often implicated as the primary drivers in the obesity epidemic. Experimental studies have shown that variations in portion size and energy density (ED) have substantial, independent effects on children’s energy intake. The available data demonstrate that continuing to serve large portions has effects that persist for up to 24-hours in children, and for ED, the effects continue for up to 2 days. Since children are exposed to large portions of higher-ED foods, it is essential to investigate how these factors combine to influence preschool children’s intake, but the studies that have been conducted report inconsistent results. Furthermore, in these studies the main dish at the meal was the only item varied by portion size and ED, which does not represent the current eating environment in which other foods and beverages also vary in these properties. For this dissertation, two studies were designed to test the effect of varying both the portion size and ED of an entire meal (Study 1) and of milk (Study 2) on preschool children’s intake. Investigation of these effects will aid in the development of strategies to counter these environmental food cues and moderate energy intake.

In Study 1, the effect of varying the portion size and ED of a meal of commonly consumed foods on children’s intake was evaluated. In a crossover design, lunch was served in 3 childcare centers once a week for 6 weeks to 120 children aged 3-5 years (14% overweight or obese). For the 6 meals, all items were served at 3 levels of portion size (100, 150, or 200%) and 2 levels of ED (100 or 142%). Lunch items were either lower- or higher-ED commercially available versions of chicken, macaroni and cheese,
vegetable, applesauce, ketchup, and milk. Children’s ratings of the foods showed that the lower-ED and higher-ED items were equally well liked. Varying the ED of food and milk did not affect the total weight consumed across meals; however, serving larger portions significantly increased the weight eaten at both the lower- and higher-ED meals (P<0.0001). Meal energy intake was found to be independently affected by ED and portion size (both P<0.0001). Increasing meal ED by 42% led to a 40% increase in energy intake and doubling portions led to a 24% increase. These effects combined to increase intake by 177±12 kcal or 80% in the meal with the higher ED and largest portions compared to the lower-ED meal with the smallest portions. Large portions of high-ED foods are likely to contribute to childhood obesity by promoting the overconsumption of energy. Since the differences in ED did not affect ratings of liking, these results suggest that preschool children could be offered lower-ED versions of commonly consumed foods in order to moderate energy intake.

In Study 2, the extent that changes in milk portion size and ED affected children’s intake of both milk and the accompanying foods was investigated with a 2-by-2 crossover design. Experimental meals were served once a week for 4 weeks in childcare classrooms and were consumed ad libitum by 125 children aged 3-5 y (8% overweight or obese). Across the 4 meals, unflavored milk was varied in portion size (9 fl. oz. or 6 fl.oz. [recommended]) and ED (3.25% full-fat [0.61 kcal/g] or 1% low-fat [0.42 kcal/g; recommended]). The foods served at the meal (chicken, pasta, broccoli, and bananas) were not varied. The results showed that serving the larger portion of milk increased milk energy intake by 20±3 kcal (27%; P<0.0001) compared to serving the smaller portion, but had no significant effect on food intake or meal energy intake. Serving higher-ED
milk increased milk energy intake by 31±2 kcal (44%) and decreased food energy intake by 26±6 kcal (10%) compared to serving lower-ED milk (both P<0.0001). Thus, across all children, the change in milk ED did not influence total energy intake at the meal. The effects of milk portion size and ED were not influenced by most child characteristics, such as age, body size, and parent-reported eating behaviors; however, the effect of milk ED on intake did differ significantly by sex. For boys, serving higher-ED milk decreased food energy intake by 43±8 kcal (16%; P<0.0001) and did not affect total energy intake compared to serving lower-ED milk. For girls, consuming more energy from the higher-ED milk did not lead to a significant compensatory reduction in food energy intake and an additional 24±10 kcal (7%; P=0.03) was consumed over the entire meal. This suggests that boys, but not girls, adjusted their food energy intake in response to changes in ED of milk consumed with lunch. These results showed that serving larger portions of milk could promote milk intake without affecting total energy intake at a meal, but the effects of milk ED on total energy intake at a meal vary between children.

The results of the two present studies indicate that the intake of preschool children is influenced by variations in both portion size and ED. When larger portions are served, children increase both the weight consumed and energy intake. However, when similar portions are served, they consume a consistent weight of a meal or milk even when ED is varied; therefore, when ED is increased children consume significantly more energy from the food or beverage. When the portion size and ED of all foods at a meal are manipulated, preschool children’s intake is substantially influenced; however, if only one item is manipulated, such as milk, some children may adjust intake to account for changes in these factors. For most children, however, strategies that moderate the portion
size of food would be effective at reducing energy intake. Choosing lower-ED commercially available products, such as lower-fat milk, grilled chicken strips, and unsweetened applesauce that are similar in acceptability to the higher-ED versions is an effective and easy strategy for caregivers to adopt. Overall, the results of the present research indicate that the combination of large portions and higher-ED foods has a substantial effect on ad libitum energy intake, which indicates that policy makers and food producers should consider these factors when developing recommendations and products.
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<table>
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<th>Abbreviation</th>
<th>Definition</th>
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<tr>
<td>ED</td>
<td>Energy density; kcal/g</td>
</tr>
<tr>
<td>kcal</td>
<td>Kilocalories</td>
</tr>
<tr>
<td>g</td>
<td>Grams</td>
</tr>
<tr>
<td>CACFP</td>
<td>Child and Adult Care Food Program</td>
</tr>
<tr>
<td>y.o.</td>
<td>Years old</td>
</tr>
<tr>
<td>BMI</td>
<td>Body mass index</td>
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<tr>
<td>fl. oz.</td>
<td>Fluid ounces</td>
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CHAPTER 1

INTRODUCTION
With approximately one third of U.S. children classified as overweight or obese (body mass index (BMI)-for-age ≥ 85th percentile) (1), it is essential to identify factors that promote overconsumption of energy and weight gain. Childhood obesity is associated with both immediate and future health complications, including cardiovascular disease, type 2 diabetes mellitus, hypertension, some cancers, and obesity in adulthood (2-5). This disease also leads to extensive costs for both the individual and public (6); thus, factors that promote obesity need to be identified and counteracting strategies need to be developed. As a multifactorial disease, obesity is influenced by genetics, physiology, culture, behavior, and the environment (7); however, behavioral and environmental factors affect a large proportion of the population.

In an environment filled with large portions of energy-dense foods and beverages, it can be challenging to regulate energy intake and avoid weight gain (8-10). Portions that exceed the standard serving sizes by to two- or eight-fold have become the norm throughout the food environment, including grocery stores, restaurants, cookbooks, and homes (11-15). Consequently, the portions consumed by children have significantly increased in the U.S. from the mid 1970’s to the mid 2000’s (16,17); for example, the average portion size of pizza has increased by 176 kcal (18). Furthermore, the availability and consumption of larger portions is a strong predictor of children’s energy intake, and is associated with increased body weight and adiposity suggesting that larger portions may affect children’s regulation of energy intake (19-22).

Foods and beverages typically consumed by children also vary widely in energy density (ED; kcal/g). Diets higher in ED have been shown to be positively correlated with children’s energy intake, body fat, body weight, and weight gain in several
population-based epidemiological and longitudinal studies (23-28). By the age of 2
years, a significant portion of daily energy intake comes from foods that are high in ED,
such as cereals, grain-based desserts, and processed meats (29). Since these higher-ED
foods are highly palatable, inexpensive, and dominate the choices in the food
environment, it is difficult for parents and children to make healthy choices.

To counter these pervasive environmental cues, several organizations, including
The American Medical Association and The Expert Committee on the Assessment,
Prevention, and Treatment of Child and Adolescent Overweight and Obesity, have
released recommendations aimed at moderating energy intake and prevent childhood
obesity (30-35). These recommendations include serving age-appropriate portions and
limiting children’s intake of energy-dense foods (34-36). Even though these
recommendations are promoted to the public, there is limited evidence to support them,
only a few studies have investigated how changes in portion size or ED of commonly
consumed meals or milk affects preschool children’s intake.

**Can children regulate their energy intake?**

When provided a variety of healthy foods, infants have been shown to self-select a
balanced diet, suggesting that they have an innate ability to self-regulate (37,38). This
notion has been further investigated using satiety or preloading paradigms, which measure
how well individuals compensate for variations in the energy content of a first course (i.e.,
preload) by measuring intake at a subsequent meal (**Table 1.1**; 39-44). Using this
paradigm, young children have been shown to adjust intake at a subsequent meal in
response to variations in the energy content of a compulsory preload (39-54). Children, on
average, compensate for the additional energy consumed from a higher-energy preload by reducing their energy intake from the subsequent main course compared to when a lower-energy preload is served. Thus, a consistent amount of energy is consumed at the eating occasion regardless of the ED of the preload (40,43,45,52). This response, however, varies widely across children with some over-compensating by under-eating at the subsequent meal, while others under-compensate and over-eat at the subsequent meal (41,42,51,53,55-59).

**Does compensation accuracy differ between individuals?**

The degree of compensation for variations in the ED of preloads may differ by anthropometric and demographic factors, such as child’s age, body size, and sex (Table 1.1; 42-44,50,53,58-60). Children who are younger or who have less adiposity, as measured by skinfolds, tend to have a more accurate compensatory responses to preloads that vary in ED compared to their counterparts (42,44,53,58,60). Preloads, however, are not adjusted for the size of the child, and thus when a child is younger, the preload represents a larger portion of children’s energy needs which tends to be easier to detect and respond to with appropriate compensatory responses (50,58,60). Irrespective of age and body size, males have been shown to be more precise at compensating for a preload at a subsequent meal compared to females in both childhood and adulthood (43,53,61,62). For example, compared to perfect compensation of 100%, male children compensated for 109.7% of the additional energy provided by a higher-energy beverage preload compared to lower-calorie preload; whereas, girls compensated for 65.9% of the additional energy (43). Understanding these differences in compensation could lead to the identification of
children who are at risk for overconsumption; in addition, examining how child or parent behaviors are related to this response would aid in the development of targeted strategies to moderate energy intake.

Parent-reported child appetitive traits and parent behaviors have also been shown to relate to a child’s regulation of intake in a laboratory setting (Table 1.1; 41,42,53,60). Children with higher satiety responsiveness or lower enjoyment of food tend to be more accurate at compensating for differences in preload energy content (41). This suggests that children who rely more on their internal hunger and fullness cues and less on external food cues may be better able to regulate their intake. Eating-related behaviors and beliefs that a parent communicates to the child may also influence this response; maternal concern for child overweight and use of more controlling feeding practices are associated with weaker compensatory response in children (42,53). Furthermore, parental eating behaviors could also influence children’s intake through modeling (63-65). One study demonstrated that parents with higher disinhibition or restraint had children with lower compensation (53). These results suggest that children’s regulation of energy intake may not only be affected by anthropometric and demographic factors, such as age, adiposity, and sex (42-44,50,53,58,60), but may also be related to environmental factors (41,42,53,60).

Understanding the mechanisms behind these differences in compensation could lead to targeted strategies to reduce overeating; however, it is unknown if these differences are seen in a typical meal context where beverages are served with the meal.

Even though some children may be able to compensate for preloads that vary in energy content, this response may not be seen when the varied food or beverage is served simultaneously with other foods. Highly palatable foods, such as sugar-sweetened
beverages, juice, or pudding, are typically served in preloading studies (39,40,46,49), but are not typically served before meals, and may not elicit the same response as less palatable foods, such as unflavored milk. For example, one study demonstrated that serving low-fat milk with breakfast led to higher satiety and lower energy intake at lunch in 10- to 12-year-old boys compared to apple juice that had a similar ED (66). In addition, children are often offered or served all meal components at once and are allowed to freely consume the foods. In these situations, variations in the portion size and ED of foods and beverages may override regulatory mechanisms leading to overconsumption compared to when the manipulated item is served before a meal, like a preload. Recent experimental studies have investigated these effects by varying the energy content of foods by manipulating portion size and ED (67-69), and allowing children to consume the foods and beverages *ad libitum* at a meal.

**Does portion size influence children’s intake?**

Experimental studies conducted in both laboratory and childcare settings have demonstrated that serving larger portions of main dishes, snacks, or multi-component meals leads to higher energy intake in children (Table 1.2; 68,70-78). For example, doubling the portion size of macaroni and cheese led to a 25% increase in energy intake from the manipulated dish and a 15% increase in total energy intake at the meal (68,79). The effect of serving larger portions on intake has been shown to persist for up to 24 hours (72), and also deters consumption of other foods at a meal. Increasing the portion size of a palatable main dish has been shown to lead to lower intake of un-manipulated fruit and vegetable side dishes offered with the meal (73). However, there is the potential that the
substantial and consistent effects of large portions on intake could be used beneficially to promote intake of other foods, such as snacks or side dishes.

Studies investigating the effect of serving larger portions of other foods, such as snacks, have reported inconsistent results on preschool children’s intake (72,77). Two studies have investigated the effect of serving larger portions of snack (72,77), but only one of these studies reported the effect of portion size on snack intake (77). Looney and colleagues demonstrated that doubling the portion of either pudding or applesauce significantly increased energy intake of that item by 15 kcal, on average (77). This suggests larger portions promote intake of both a palatable snack, and a lower-ED, nutrient-dense fruit.

Dietary recommendations frequently group fruit and vegetables together; however, portion size may have differential effects on these food groups due to differences in palatability. When the portions of a main dish and milk are held constant, increasing the portion size of fruit and vegetable side dishes consistently increases fruit intake, but not vegetable intake (80,81). On the other hand, when vegetables are served alone as a first course, serving larger portions consistently leads to increased intake (82,83). These results suggest that serving larger portions may be a beneficial strategy to increase children’s intake of nutrient-dense foods; yet, more research is needed to determine how competition with other foods, such as main dishes, influences the effectiveness of this recommendation.

Most research has investigated the effects of portion size by manipulating main and side dishes separately, even though children are exposed to large portions of entire meals. Three studies have investigated the effect of increasing the portion sizes of most or
all items in a meal on intake (75,76,84), and two of these studies have shown that larger portions lead to higher energy intake (75,76). Even though children’s intake increases when served larger portions of meals, but there is limited information about how larger meal portions affect intake of the individual meal components. One study reported children’s intake of the individual foods, but only in terms of energy (76). As portion size increased, children increased the amount of energy consumed from macaroni and cheese and cookies, but not corn or applesauce (76). However, since corn, applesauce, and milk have a low energy density (<0.80 kcal/g), larger portions could have affected the weight or amount consumed of these items without affecting energy intake. Since children are frequently exposed to variations in the portion size of meals, it is important to understand how children’s intake of different meal components is affected, which may lead to the development of strategies that moderate energy intake, promote intake of nutrient-dense foods, and fit into children’s typical childcare center meal patterns.

**Do the effects of portion size differ between individuals?**

The response to larger portions of foods may also differ by child characteristics, specifically the age of the child (Table 1.2; 70,74). Studies have noted that children 2 years and younger have consumed consistent amount of foods and beverages (85) and show good within-meal energy regulation (29). Beyond 2 years, however, this ability seems to deteriorate and children become responsive to environmental food cues, such as portion size (67,71,74,86). Only two studies, however, have reported age differences in the response to larger portions (70,74). Younger preschool children’s (3- and 4-years-old) intake was not affected when portion size was increased, while older (5- and 6-years-old)
children consumed more energy when served the larger compared to smaller portion (70,74). Yet, in a study designed to assess developmental differences, no differences were found between three distinct age groups of children (2-3 years old, 5-6 year olds, and 8-9 year olds) in their response to increases in portion size of a main dish (71). Furthermore, several other studies have not replicated these effects, which may be due to differences in methodology. For example, the two studies that reported a significant effect of age on children’s response to portion size served portions based on the age of the child (67,74); thus younger children received smaller portions than the older children. Whereas, other studies have served the same portion sizes to all participating children (72,73,76), which better reflects childcare nutrition recommendations that 3- to 5-year-olds should be served the same amount of food (87).

Since large portions lead to higher intake, it is of interest to determine whether children’s susceptibility or responsiveness to increases in portion size is related to weight status and risk for obesity. Two studies have found a relationship between children’s weight status and intake response to larger portion sizes. Children who were classified as overweight or obese (sex-specific BMI-for-age >85th percentile) showed greater increases in intake when served larger portions of an entrée or broccoli compared to children who were normal weight (Table 1.2; 73,80). Most other studies looked for this relationship; however, it is not consistently found (71,72,76). Compared to the studies that report null results, the studies that show a relationship between weight status and portion size responsiveness tend to have larger proportion of children who are overweight or obese (73,80). Overall, both older and heavier children may increase their intake to a greater extent compared to other children; however, identifying either child appetitive traits or
parenting practices that explain the relationship between portion size responsiveness and obesity would allow identification of specific behaviors to target in childhood obesity interventions.

Certain child behaviors, as measured by the Child Eating Behaviour Questionnaire (Table 1.2; 41,88), have also been shown to be related to differences in response to larger portions (76). Children with lower scores for satiety responsiveness or higher scores for food responsiveness increased their intake to a greater extent when served larger portions of a meal compared to their counterparts (76). Satiety responsiveness is the degree to which a child chooses to initiate or end a meal based on their fullness, and food responsiveness captures maladaptive eating behaviors, such as eating in response to external food cues (41). Mooreville and colleagues were the first to report that appetitive traits (i.e., satiety responsiveness and food responsiveness) relate to children response to larger portion sizes (76). This may be primarily due to a number of studies not including this questionnaire in their protocols (68,70,72,73,75,77). More importantly, these results indicate that measures of child eating behaviors may be essential in characterizing those susceptible to large portions, and that future research including other behavioral measures, such as parenting practices, may provide additional insight into between-child variations in the response to portion size.

Even though some child characteristics may affect the relationship between portion size and intake (70,73,74,76,80), most studies report that the majority of children eat more when served more food (68,71,72,77,82,83,89). This suggests preventing overconsumption through portion size reduction would affect a wide-range of children, but intervening on specific characteristics and behaviors may be needed to help children at
the highest risk. Furthermore, serving less of everything may not be the best message for parents and their children (90,91); thus, messages about portion size may need to be combined with strategies concerning other properties of food to effectively moderate energy intake.

**Does energy density influence children’s intake?**

Energy density (ED) is the amount of energy in a given weight of food, and is determined by the macronutrient and water content. It is usually calculated as kilocalories per gram (kcal/g), and ranges from 0 kcal/g to 9 kcal/g. Of the macronutrients, fat has the largest influence on the ED of a food as it contributes 9 kcal/g, whereas carbohydrates and protein have 4 kcal/g. As the largest component of many foods, water has the greatest influence on overall ED, since it contributes weight and volume without supplying any energy (0 kcal/g). Fiber plays a minor role in the ED of food by supplying 1.5-2.5 kcal/g.

ED has a robust effect on children’s energy intake, but modest changes usually do not affect acceptability or the amount of food consumed (Table 1.3; 69,92-94). Children consume a similar weight of food when served similar portions of foods at separate eating occasions (69,92-94). Thus, changing ED consistently leads to a direct effect on energy intake; for example, a 27% decrease in ED led preschool children reduce the energy consumed from the manipulated foods by 27% (92). Furthermore, the effect of ED on preschool children’s intake has been shown to persist over two days (92), and is robust amongst the majority of children studied. This suggests that modifying the ED of commercially available foods could have a substantial, wide-spread impact on energy intake. ED can also effectively be changed by altering the amount of ingredients, such as
fat, sugar, fruits, or vegetables without affecting acceptability (69,92-94). However, since
the portion sizes of food often simultaneously vary with ED, research is needed to
determine how these effects combine to develop effective strategies to manage body weight.

**Do the effects of portion size and energy density combine to influence children’s intake?**

Since children are exposed to foods that vary both in portion size and ED, it is important to understand how these factors work together to affect energy intake. However, the two experimental studies that simultaneously varied portion size and ED of a main dish reported inconsistent findings (Table 1.4; 94,95). One study demonstrated that increases in portion size and ED of a main dish had independent effects that combined to lead to higher energy intake (94). The other study that used a similar design found that although increasing the ED of the entree reduced children’s amount of energy consumed from the entree and at the meal, decreasing portion size did not affect children’s intake (95). In this study, the reference (100%) portion may have been too large for preschool children, which may explain the lack of a portion size effect and the plateau in intake. Even though portion size and ED have robust effects in studies that only manipulate one factor (68-70,92), it is unclear whether portion size and ED combine to influence children’s intake at a meal (94,95). Further research is warranted since the combination of these factors may have substantial effects on intake, which could inform recommendations and lead to powerful strategies to moderate energy intake.
Does the portion size and energy density of beverages affect children’s intake?

The effect of variations in the portion size and ED of beverages is of particular interest since a substantial proportion of children’s (2 to 11 year olds) daily energy intake comes from caloric beverages, such as milk (96-100). However, the effect on energy intake of varying these beverage factors has received limited investigation. Larger portions of juice have been shown to lead to a greater increase in intake compared to serving larger portions of water (101). This suggests that differences in palatability may affect children’s response to portion size; however, the children’s liking of the beverages was not reported in this study (101).

The effects of serving palatable, flavored milk has been of great public health interest, since chocolate milk promotes milk and calcium intake but may also lead to excessive energy intake (Table 1.5; 102-104). Studies have shown the extra energy consumed from higher-ED reduced-fat chocolate milk (0.76 kcal/g) leads to higher milk and energy intake at a meal compared to meals that include lower-ED options, such as plain, reduced-fat milk (0.59 kcal/g) or chocolate milk sweetened with aspartame (0.60 kcal/g) (102-104). However, serving the higher-ED, highly palatable chocolate milk with a meal may overwhelm children’s regulation of intake in response to variations in ED, leading to increased energy intake. Thus, these results cannot be generalized to higher-ED, unflavored milk, which is frequently served in childcare centers.

Even though the Child and Adult Care Food Program and the American Academy of Pediatrics recommend serving lower-ED milk to children 2 years and older in order to moderate energy and fat intake (87), it is unknown whether implementing these guidelines will lead to lower energy intake at meals. Since milk contributes a large portion of energy
to children’s diets, simply changing the type of milk served could lead to a substantial change in energy intake (99,100). In addition, epidemiological studies suggest that serving lower-ED instead of higher-ED milk leads to reduced energy intake (Table 1.5; 105-109), but this assumption has not been evaluated in a controlled experimental setting. Although milk is commonly served in preschools and the type and amount served is highly regulated, it is unknown if implementing these recommendations has an effect on children’ intake at meals.

Summary

When investigated individually, portion size and ED have consistent, robust effects on children’s energy intake (68,70,92,93); it is unclear, however, how these effects combine to influence intake (94,95). Most studies manipulate a single item, such as a main dish or side dish (67,80,82), which does not represent the current eating environment where children are challenged with a variety of foods that vary simultaneously in portion size and ED. Furthermore, even though milk is an important part of children’s diets (99,100), little is known about how changing the portion size or ED affects children’s intake. Overall, several organizations provide recommendations on the appropriate amounts and types of foods served to children (32,33,87,110,111); however, further research is needed to determine whether serving smaller portions or lower-ED foods and beverages will lead to reductions in energy intake.
Study 1: Aims and hypotheses for Double Trouble: Portion size and energy density combine to increase preschool children’s lunch intake

Several studies have shown that changing the portion size or ED affects preschool children’s energy intake (67-69,72,92,93). Increasing portions leads to higher intake (67,68,72), and serving larger portions of a higher-ED dish, such as macaroni and cheese, can lead to excess energy intake (69,92-94). In comparison, children tend to consume a consistent weight of food when served similar portions of foods that vary in ED, but varying ED of foods substantially influences children’s energy intake (69,92,93). Although children are served foods and beverages that vary in both portion size and ED, there has been limited research investigating how these effects combine (94,95). In the two studies that investigated the combined effects, only the main dish at the meal was manipulated and the results on intake were inconsistent (94,95). Since children are exposed to multiple foods that vary in portion size and ED simultaneously, the primary aim of this study was to test the effect of varying the portions and ED of an entire meal on preschool children’s \textit{ad libitum} energy intake. The meal that was chosen for this study included foods that are typically served in local childcare centers and are available in lower-ED and higher-ED versions. Meal portion sizes were based on children’s intake from previous studies and nutrition recommendations for childcare centers (87).

**Aim 1.** To investigate the independent and combined effects of ED and portion size on preschool children’s intake at a meal composed of foods typically served to this population.
- **Hypothesis 1a.** Children will consume more food and energy when served larger portions of the meal.

- **Hypothesis 1b.** On average, children’s intake by weight of the lower-ED and higher-ED meals will not differ; therefore, children will consume more energy at the higher-ED meal than the lower-ED meal.

- **Hypothesis 1c.** Increasing the portion size and ED of the meal will have differential effects on the intake of the six individual foods at the meal.

**Aim 2.** To investigate the effect of child characteristics (such as weight status, age, and liking for the foods) and parenting practices on the relationship between portion size or ED and intake.

- **Hypothesis 2a.** Children who are older or have an overweight or obese weight status will consume more by weight and energy when served larger portions or higher-ED meals compared to children who are younger or have lower weight status.

- **Hypothesis 2b.** Children who have low satiety responsiveness and high food responsiveness, as measured by the Child Eating Behaviour Questionnaire, will consume more by weight and energy when higher-ED meals or larger portions are served compared to their counterparts (41,88).

- **Hypothesis 2c.** Children with parents who report frequently using restrictive, monitoring, or pressuring feeding practices, as reported on the Child Feeding Questionnaire, will consume more by weight and energy when higher-ED meals or larger portions are served compared to their counterparts (112,113).
Study 2: Aims and hypotheses for Does milk matter: Is children’s intake affected by the type of amount of milk served at a meal?

Varying the portion size and ED of foods has been shown to have robust effects on children’s energy intake (68-70,72,92,93), but there has been little research on how these factors affect intake of beverages (101-104), including unflavored milk. Studies of satiety suggest that children compensate for variations in energy consumed from preloads by reducing intake at a subsequent meal (39,43,52,114). In contrast, when beverages are served with a meal, increases in beverage ED lead to higher energy intake (102-104). However, limited research has been conducted using unflavored milk, which is a large component of children’s daily intake (99,100). The aim of the present study was to test the effects of varying the portion size and ED of milk on preschool children’s intake of milk and of a meal served simultaneously. Commonly consumed types of milk (low-fat [1% fat] and whole [3.25% fat] milk) in typical portions (6 fl. oz. [recommended] and 9 fl. oz.) were served along with a meal that included foods typically served in the childcare centers (87).

**Aim 1.** To determine the effect of varying milk portion size and ED on preschool children’s energy intake at lunch. The study will evaluate the effect of varying the portion size of lower-ED and higher-ED milk on intake of milk, food, and the total meal by weight and energy.

- **Hypothesis 1a.** When served a larger portion of milk, children will increase energy consumed from milk and the total meal compared to when the meal includes a
smaller portion size of milk. Intake of food served with the milk will not vary between conditions.

- **Hypothesis 1b.** When served the higher-ED milk, children will increase energy consumed from milk and the total meal compared to when the meal includes the lower-ED milk. Intake of food served with the milk will not vary.

**Aim 2.** To investigate the effect of child characteristics (such as weight status, age, parent-reported behaviors, familiarity and liking of the milk) or parenting practices on the relationship between milk portion size and ED on and milk, food, and total meal intake.

- **Hypothesis 2a.** Younger or normal-weight children will decrease their food intake when larger portions or higher-ED milk is served with the meal; whereas, older or heavier children will not show this compensatory reduction in food intake. This will lead to no change in total intake at the meal.

- **Hypothesis 2b.** Compared to their counterparts, children who have high satiety responsiveness or low food responsiveness, as measured by the Child Eating Behaviour Questionnaire, will decrease their food intake when larger portions or higher-ED milk is served with the meal. This will lead to no change in total intake at the meal (41,88).

- **Hypothesis 2c.** Compared to their counterparts, children with parents who report infrequently using restrictive feeding behaviors, as reported on the Child Feeding Questionnaire, will decrease their food intake when larger portions or higher-ED milk is served with the meal. This will lead to no change in total intake at the meal (112,113).
Table 1.1: Experimental studies examining the effect of varying the energy density of a preload on children’s subsequent intake

<table>
<thead>
<tr>
<th>Investigators and subjects</th>
<th>Design and duration of the study</th>
<th>Manipulations of portion size (PS) and energy density (ED)</th>
<th>Effects of preload on intake (means)</th>
<th>Effect of subject characteristics on response to preload (means)</th>
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</thead>
<tbody>
<tr>
<td>Anderson, Saravts, Schacher, Zlotkin, Leiter, Appetite, 1989 (55)</td>
<td>Within-subjects, crossover 2 sessions within 1 week Lunch served 90 minutes after preload</td>
<td>Preload: Ice slurry of Kool-Aid with carbohydrate polycose (high ED) or aspartame (low ED) – carbohydrate manipulation Standard Lunch: sandwiches, milk, celery, apple, orange, cookies, condiments</td>
<td>No effect on lunch intake</td>
<td>Tested individual characteristics did not affect the relationship between preload ED and intake</td>
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<td>Experiment 1 20 – 9 to 10 y.o. boys and girls</td>
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<td>Anderson, Saravts, Schacher, Zlotkin, Leiter, Appetite, 1989 (55)</td>
<td>Within-subjects, crossover 2 sessions within 1 week Lunch served 90 minutes after preload</td>
<td>Preload: Kool-Aid fruit drink with sucrose (high ED) or aspartame (low ED) – carbohydrate manipulation Standard Lunch: sandwiches, milk, celery, apple, orange, cookies, condiments</td>
<td>No effect on lunch intake</td>
<td>Tested individual characteristics did not affect the relationship between preload ED and intake</td>
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<td>Experiment 2 20 – 9 to 10 y.o. boys and girls</td>
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<td>Bellissimo, Pencharz, Thomas, Anderson, Pediatr Res, 2007 (56)</td>
<td>Within-subjects, 2x2 crossover 4 days 2 levels of ED (low, high), 2 levels of TV (with and without) Lunch served 30 minutes after preload</td>
<td>Preload: Preload with Splenda sucralose (low ED) or glucose (high ED) – carbohydrate manipulation Lunch: Pizza</td>
<td>In the no TV condition, glucose suppressed food intake compared with sucralose, COMPX&lt;sub&gt;b&lt;/sub&gt; was 112% in no TV condition and 66% in TV condition</td>
<td>Tested individual characteristics did not affect the relationship between preload ED and intake</td>
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<td>Birch, Deysher, Learning and Motivation, 1985 (39)</td>
<td><strong>Experiment 1</strong>&lt;br&gt;18 – 3 to 5 y.o. boys and girls</td>
<td>- Within subjects&lt;br&gt;2 days per week for 6 weeks&lt;br&gt;Pairs of conditioning trials with ED (low or high) were paired with flavor (chocolate or vanilla)&lt;br&gt;Pairs of extinction trials included intermediate preload (90kcal/100g) served in both flavors&lt;br&gt;Snack served 20 to 40 minutes after preload</td>
<td>- Preload: Pudding either low ED (42kcal/100g) or high ED (156 kcal/100g) – carbohydrate manipulation&lt;br&gt;Snack: Variety of cookies and chips</td>
<td>- In the first pair of trials, 14 of 18 children showed some self-regulation; thus, snack intake was greater after low-ED preload than high-ED&lt;br&gt;In the second pair of trials, 16 of 18 children showed some self-regulation; thus, snack intake was greater after low-ED preload than high-ED&lt;br&gt;Over all trials, children, on average, consumed more of the snack after the low-ED preload than high-ED preload</td>
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<td>Birch, Deysher, Learning and Motivation, 1985 (39)</td>
<td><strong>Experiment 2</strong>&lt;br&gt;10 – 3 to 5 y.o. boys and girls</td>
<td>- Within subjects&lt;br&gt;2 days per week for 6 weeks&lt;br&gt;Pairs of conditioning trials with ED (low or high) were paired with flavor (chocolate or vanilla)&lt;br&gt;Pairs of extinction trials included intermediate preload (90kcal/100g) served in both flavors&lt;br&gt;Snack served 20 to 40 minutes after preload</td>
<td>- Preload: Pudding either low ED (42kcal/100g) or high ED (156 kcal/100g) – carbohydrate manipulation&lt;br&gt;Snack: Variety of cookies and chips</td>
<td>- In the first pair of trials, 8 of 10 children showed some self-regulation; thus, snack intake was greater after low-ED preload than high-ED&lt;br&gt;In the second pair of trials, 8 of 10 children showed some self-regulation; thus, snack intake was greater after low-ED preload than high-ED&lt;br&gt;Over all trials, children, on average, consumed more of the snack after the low-ED preload than high-ED preload</td>
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<td>Birch, Deysher, Appetite, 1986 (114)</td>
<td>Within subjects, crossover 1 lunch session per week for 2 weeks Lunch served 20 minutes after preload</td>
<td>Preload: Pudding either high ED (132kcal) or low ED (32kcal) - carbohydrate manipulation Standard Lunch: sandwiches, carrots, oranges, grapes</td>
<td>Total lunch consumption was nearly identical in the low-ED and high-ED conditions (269, 260 kcal)</td>
<td>Tested individual characteristics did not affect the relationship between preload ED and intake</td>
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<tr>
<td>21 – 2.5 to 5 y.o. boys and girls</td>
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<td>20 of 21 children ate less lunch following high-ED preload than low-ED preload</td>
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<td>Birch, McPhee, Steinberg, Shoba, Krehbiel, Learning and Motivation, 1987 (46)</td>
<td>Between subjects 5 snack trials, 3 pairs of conditioning trials, 2 pairs extinction trials over 6 weeks Each trial included preload followed by a snack 10 minutes between preload and snack</td>
<td>Preload: High or low ED yogurt either low-ED (60kcal/100g) or high-ED (145/100g) (distinctly flavored) – carbohydrate manipulation Standard snack included a variety of snack foods Each pair of conditioning trials included 1 day of low-ED yogurt and 1 day of high-ED with were both paired with a different flavor Elimination trials included both flavors in an intermediate ED (95kcal/100g)</td>
<td>Internal cues: snack intake after low-ED and high-ED preload did not differ after 1st conditioning trials Snack intake greater following low-ED preload than high-ED preload after 2nd and 3rd conditioning trials External cues: children showed no responsiveness to ED</td>
<td>Tested individual characteristics did not affect the relationship between preload ED and intake</td>
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<tr>
<td>Birch, McPhee, Sullivan, Physiol &amp; Behav, 1989 (40)</td>
<td>Within-subjects (preload type), between subjects (time delay) crossover 2 snacks per week for 2 weeks Snacks served 0, 30, or 60 minutes after preload</td>
<td>Preload: Fruit flavored drink (150ml) with sucrose (0.44kcal/ml), aspartame (0.017kcal/ml), aspartame plus low glucose maltodextrin (0.44kcal/ml), or water control (0 kcal/ml) – carbohydrate manipulation Standard snacks: 7 sweet and savory snack items</td>
<td>The higher ED preloads led to reduction in snack intake compared to water and aspartame. The effects similar at different time delays. Aspartame suppressed intake relative to water, but less than other drinks. Effect most clear at 30 minute time delay.</td>
<td>Tested individual characteristics did not affect the relationship between preload ED and intake</td>
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<td>Birch, McPhee, Steinberg, Sullivan, 1990 (47)</td>
<td>Within-subject, crossover, 2 conditions 4 days per week for 2 weeks Snack served 20 to 30 minutes after preload</td>
<td>Preload: Drinks either high ED (155kcal/150ml) or low ED (&lt;5kcal/150ml) – carbohydrate manipulation Snack: changed for each day ~420 kcal</td>
<td>Children ate more of snack following the low-ED than the high-ED drink, and this difference increased with repeated exposure</td>
<td>Tested individual characteristics did not affect the relationship between preload ED and intake</td>
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<tr>
<td>Birch, Johnson, Jones, Peters, Am J Clin Nutr, 1993 (48)</td>
<td>Within-subject, crossover, 2 conditions 2 days per week for 5 weeks</td>
<td>Fat manipulated item: served 1 manipulated item during 1st 3 meals of the day, either contained dietary fat (high ED) or substitute (low ED; olestra) Normal menu served for the other items at meals</td>
<td>Children did not compensate for fat substitute on day 1 and daily energy intake was less compared to fat condition No differences in condition on day 2</td>
<td>Tested individual characteristics did not affect the relationship between preload ED and intake</td>
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<td>Birch, McPhee, Bryant, Johnson, Appetite, 1993 (49)</td>
<td>Within-subjects crossover 4 conditions 1 day per week for 4 weeks Lunch consumed 2 hours after preload</td>
<td>Preload: Ice cream with 0 (177kcal/113g), 12 (228kcal/113g), or 18 (275kcal/113g) g of fat and 4 g protein with baseline/control preload of juice and cereal (80kcal/109g) – fat manipulation Standard Lunch: variety of lunch foods</td>
<td>Children consumed less energy at lunch following the ice cream preloads, but compensation was incomplete and energy intake was higher after high ED preloads</td>
<td>Tested individual characteristics did not affect the relationship between preload ED and intake</td>
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<td>Branton, Akhavan, Gladanac, Pollard, Welch, Rossiter, Bellissimo, Appetite, 2014 (50)</td>
<td>Within-subjects, 2X2 crossover 4 days 2 levels of ED (low, high), 2 levels of pre-meal video game (with and without) Lunch served 30 minutes after preload</td>
<td>Preload: Preload with sucralose (low ED) or glucose (high ED) – carbohydrate manipulation Standard lunch: Pizza</td>
<td>Glucose preload suppressed food intake by 170 kcal compared to sucralose preload</td>
<td>Bodyweight was related to response to preload. For larger boys, preload dose was smaller relative to body weight and consumed more kcal at lunch</td>
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<td>Carnell, Wardle, Appetite, 2007 (41)</td>
<td>Within-subject crossover 2 ED conditions 4 sessions within 1 week lunch served 30 minutes after preload</td>
<td>Preload: Drink low ED and high ED served in either same flavor (disguised) or different flavors (undisguised) – carbohydrate manipulation Standard lunch: chicken, cheese, bread, crackers, cookies, grapes, vegetable</td>
<td>Children showed some compensation ability for preload energy Disguised COMPX&lt;sup&gt;b&lt;/sup&gt; means: 80.1% for girls and 58.1% for boys – no sig. differences Undisguised COMPX means: 62.0% for girls and 40.0% for boys – no sig. differences</td>
<td>Higher satiety responsiveness associated with better caloric compensation Higher enjoyment of food associated with poorer caloric compensation</td>
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<td>Carnell, Pryor, Mais, Warkentin, Benson, Cheng, Physiol &amp; Behav, 2016 (57) 70 - 4 to 5 y.o. boys and girls</td>
<td>Within-subjects, crossover 1 day per week for 5 weeks lunch served 30 minutes after preload</td>
<td>Preload: Orange flavored drink either low ED or high ED (carbohydrate manipulation) or no preload or water or milkshake Standard lunch: chicken, cheese, bread, crackers, cookies, grapes, vegetable</td>
<td>Lunch intake did not differ between the preloading conditions</td>
<td>Tested individual characteristics did not affect the relationship between preload ED and intake</td>
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<td>Cecil, Joanne et al. Am J Clin Nutr, 2005 (42) 74 – 6 to 9 y.o boys and girls</td>
<td>Within-subjects, crossover 3 conditions Lunch served 90 minutes after preload</td>
<td>Preload: No energy or orange drink wither low ED or high-ED (carbohydrate manipulation) plus muffin Standard lunch: self-selected test meal</td>
<td>Children adjusted for preload by decreasing lunch intake after high ED compared to low ED preload (21%) and less after both preloads compared to water. COMPXb for no vs. high preload = 35% COMPXb for no vs. low preload = 51% Compensation was incomplete and total energy intake was higher after high ED preload Found high inter-individual variation and low intra-individual variation</td>
<td>Younger children better at adjusting than older children (COMPXb for low and high 40% vs. 32%) Maternal concern with overweight correlated with higher tendency to under- or over-compensate</td>
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<td>Faith, Keller, Johnson, Pietrobelli, Matz, Must, Jorge, Cooperberg, Heymsfield, Am J Clin Nutr, 2004 (51)</td>
<td>Within-subjects, crossover 2 conditions Lunch served 25 minutes after preload</td>
<td>Preload: Fruit drink either low ED (3kcal/173g) or high ED (150kcal/173g) – carbohydrate manipulation Standard lunch: macaroni and cheese, beans, cheese, crackers, grapes, carrots, milk</td>
<td>Children consumed more total energy after low ED preload than high ED (535 kcal, 383 kcal, COMPXb = 103.6%) Large individual variation in COMPXb scores</td>
<td>Tested individual characteristics did not affect the relationship between preload ED and intake</td>
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<td>32 – 3 to 7 y.o. boys and girls (sibling pairs)</td>
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<td>Faith, Pietrobelli, Heo, Johnson, Keller, Heymsfield, Allison, Inter J of Obes, 2012 (43)</td>
<td>Within subjects, crossover, 2 preload conditions Lunch offered 25 minutes after preload</td>
<td>Preload: Kool-Aid fruit drinks either low-ED (3 kcal/173g) or high-ED (159kcal/173g) – carbohydrate manipulation Standard Lunch: macaroni and cheese, string beans, string cheese, graham crackers, grapes, carrots, whole milk COMPX score generated</td>
<td>Lunch intake was greater following low-ED preload compared to high-ED (381, 256 kcal) COMPXb score of 86.2±119.2%</td>
<td>COMPX scores were lower for girls than boys (66%, 110%) COMX scores lower for non-European American than European American children (60%, 100%)</td>
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<td>138 - 4 to 7 y.o. (69 pairs of twins, boys and girls)</td>
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<tr>
<td>Johnson, McPhee, Birch, Physiol &amp; Behav, 1991 (52)</td>
<td>Within-subjects, crossover 8 pairs of conditioning trials, 2 days per week for 8 weeks ad libitum meal intake collected after final conditioning trials Snack served 15 minutes after preload</td>
<td>Preload: Yogurt either low in fat and ED (110kcal/serving) or high in fat and ED (220kcal/serving) – fat manipulation Standard snack: hotdogs, crackers, cheese, applesauce, Fig Newtons</td>
<td>Children consumed more following the low-ED preload than the high ED after conditioning</td>
<td>Tested individual characteristics did not affect the relationship between preload ED and intake</td>
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<td>Experiment 1</td>
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<td>12 – 2 to 5 y.o. boys and girls</td>
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<tr>
<td>Investigators and subjects</td>
<td>Design and duration of the study</td>
<td>Manipulations of portion size (PS) and energy density (ED)</td>
<td>Effects of preload on intake (means)</td>
<td>Effect of subject characteristics on response to preload (means)</td>
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<tr>
<td>Johnson, McPhee, Birch, Physiol &amp; Behav, 1991 (52)</td>
<td>Within-subjects, crossover 8 pairs of conditioning trials, 2 days per week for 8 weeks</td>
<td>Preload: Yogurt either low in fat and ED (110kcal/serving) or high in fat and ED (220kcal/serving) – fat manipulation</td>
<td>Children consumed more following the low-ED preload than the high ED after conditioning</td>
<td>Tested individual characteristics did not affect the relationship between preload ED and intake</td>
</tr>
<tr>
<td>Experiment 2</td>
<td>ad libitum meal intake collected after final conditioning trials</td>
<td>Standard snack: hotdogs, crackers, cheese, applesauce, Fig Newton’s</td>
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<tr>
<td>9 – 2 to 3 y.o. boys and girls</td>
<td>Snack served 15 minutes after preload</td>
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<tr>
<td>Johnson, Birch, Pediatrics, 1994 (53)</td>
<td>Within subjects, crossover, 2 preload conditions</td>
<td>Preload: Kool-Aid fruit drinks either low-ED (3kcal/163g) or (150kcal/163g) – carbohydrate manipulation</td>
<td>Limited evidence of self-regulation with COMPXb score of 46.2±5.7%</td>
<td>Boys had a higher COMPX score than girls (57%, 36%)</td>
</tr>
<tr>
<td>77 – 3 to 5 y.o. boys and girls</td>
<td>Standard Meal: turkey hotdogs, buns, American cheese, unsweetened applesauce, carrot sticks, Fig Newtons, 2% milk</td>
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<td>Children with lowest COMPX scores [undercompensators] had greater adiposity [skinfolds] than those with highest COMX scores</td>
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<td>More controlling child feeding practices related to lower COMPX</td>
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<td>Parents with higher disinhibition had children with lower COMPX scores</td>
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<td></td>
<td>Mothers with higher restraint had girls with lower COMPX scores. This was a trending effect.</td>
</tr>
<tr>
<td>Investigators and subjects</td>
<td>Design and duration of the study</td>
<td>Manipulations of portion size (PS) and energy density (ED)</td>
<td>Effects of preload on intake (means)</td>
<td>Effect of subject characteristics on response to preload</td>
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<tr>
<td>Johnson, Pediatrics, 2000 (60) 25 – 4 to 5 y.o. boys and girls</td>
<td>Within-subject COMPX measured before and after intervention on total of 4 test days Lunch served 35 minutes after preload Intervention to help children identify internal hunger and satiety cues</td>
<td>Preload: Juice drink either high (150kcal/163g) or low ED (3kcal/163g) Standard lunch: hotdogs, buns, cheese, applesauce, carrots, Fig Newtons, milk</td>
<td>At baseline, limited evidence of compensation (COMPX$^b$ 24.3%) with large variability After intervention, mean compensation improved (COMPX 65.1%) and variability decreased</td>
<td>At baseline, higher adiposity in girls (trend) showed less evidence compensation At baseline, mothers with high disinhibition or high dietary restraint had daughters less likely to compensate accurately</td>
</tr>
<tr>
<td>Johnson, Taylor-Holloway, Am J Clin Nutr, 2006 (58) 262 - 5 to 12 y.o. boys and girls</td>
<td>Within-subjects, crossover, 2 preload conditions Lunch offered 30 minutes after preload</td>
<td>Preload: fruit-flavored drinks either high (150kcal/163 g) or low ED (3kcal/163 g) – carbohydrate manipulation Standard lunch: of macaroni and cheese, broccoli, carrots, grapes, cheese sticks, graham crackers, 2% milk</td>
<td>Limited evidence of self-regulation with COMPX$^b$ score of 48.6±6.4%</td>
<td>Older children had lower mean COMPX$^b$ scores (R2=2%; P&lt;0.05)</td>
</tr>
<tr>
<td>Kane, Wright, Fariza, Hetherington, Appetite, 2011 (59) 11 – 1 to 10 y.o. boys and girls who were formally or currently tube or supplement fed</td>
<td>Within subject, crossover 2 conditions</td>
<td>Preload: Drink either high ED (121kcal/200ml) or low ED (0.3kcal/200ml) Lunch: Multi-item Lunch served 20 minutes after preload</td>
<td>Median COMPX$^b$ = 70%, but there was a wide range (~73%-178%)</td>
<td>Boys tended to compensate more accurately than girls (99%, 30%, medians)</td>
</tr>
<tr>
<td>Investigators and subjects</td>
<td>Design and duration of the study</td>
<td>Manipulations of portion size (PS) and energy density (ED)</td>
<td>Effects of preload on intake (means)</td>
<td>Effect of subject characteristics on response to preload (means)</td>
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<tr>
<td>Kral, Allison, Birch, Stallings, Moore, Faith, Am J Clin Nutr, 2012 (44)</td>
<td>Within-subject, crossover 2 conditions</td>
<td>Preload: Pudding either low ED (0.57kcal/g) or high ED (0.97kcal/g) or no preload</td>
<td>As preload ED increased, children decreased dinner intake</td>
<td>Overweight/obese siblings undercompensated and overate with high ED preload (COMPX^b -48.8%)</td>
</tr>
<tr>
<td>94 – 5 to 12 y.o. boys and girls (47 same-sex sibling pairs)</td>
<td>Dinner served 25 minutes after preload</td>
<td>5-8 y.o. served 100g, 9-12 y.o. served 140 g of pudding Standard dinner: pasta, broccoli, applesauce, milk</td>
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<td>Normal-weight siblings showed accurate compensation (COMPX^b 101.3%)</td>
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<td>Older normal-weight siblings overcompensated and underate</td>
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<td></td>
<td></td>
<td>Younger overweight/obese siblings undercompensated and overate</td>
</tr>
<tr>
<td>Zandstra, Mathey, Graaf, van Staveran, Eur J Clin Nutr, 2000 (54)</td>
<td>Within-subjects, crossover 5 conditions</td>
<td>Preloads: 200 g of strawberry yogurts either low fat, low carbohydrate, low ED (167kcal/500g), high fat, medium ED (478kcal/500g), high carbohydrate, medium ED (478kcal/500g), high fat, high carbohydrate, high ED (717kcal/500g), or no yogurt Standard lunch: break, sandwich fillings, fruits, drinks</td>
<td>Children ate significantly less after the high-ED yogurt Other analyses revealed that compensation was due to carbohydrate not fat content COMPX^b (no preload compared to each of the conditions) ranged from 21% to 34%</td>
<td>Tested individual characteristics did not affect the relationship between preload ED and intake</td>
</tr>
<tr>
<td>30 – 4 to 6 y.o. boys and girls</td>
<td>Lunch meal served 90 minutes after preload</td>
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</table>

^a y.o. = years old  
^b COMPX Score = [(Meal\textsubscript{low} – Meal\textsubscript{high})/(Preload\textsubscript{high} – Preload\textsubscript{low})] X 100  
Perfect COMPX Score = 100%  
Lower COMPX scores = undercompensation and overeating, Higher COMPX scores = overcompensation and undereating
Table 1.2: Experimental studies examining the effect of portion size on children’s intake

<table>
<thead>
<tr>
<th>Investigators and subjects</th>
<th>Design and duration of the study</th>
<th>Manipulations of portion size (PS) and energy density (ED)</th>
<th>Effects of PS and ED on intake (means)</th>
<th>Effect of subject characteristics on relationship between PS or ED and intake</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fisher, Rolls, Birch, Am J Clin Nutr, 2003 (68)</td>
<td>Within-subjects, crossover with 3 conditions</td>
<td>Macaroni and cheese served in different PS (age-appropriate 100% reference or 200%) and self-selected condition</td>
<td>Macaroni and cheese intake increased with increasing PS (mean intakes 1578, 1922 KJ)</td>
<td>Children who had higher intakes in the eating in the absence of hunger had greater increases in entrée intake as PS increased</td>
</tr>
<tr>
<td>30 – 3 to 5 y.o.² boys and girls</td>
<td>Lunch 1 day/week for 12 weeks</td>
<td>Portions of side dishes did not vary across conditions</td>
<td>Total meal intake increased with increasing PS (mean intakes: 2275, 2603 KJ)</td>
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<td></td>
<td>Each PS was served during a series of 4 lunches followed by 2 self-served lunches</td>
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</tr>
<tr>
<td>Fisher, Arreola, Birch, Rolls, Am J Clin Nutr, 2007 (72)</td>
<td>Within-subjects, crossover with 2 conditions</td>
<td>Three main dishes (lunch macaroni and cheese, snack apple juice &amp; graham crackers, dinner chicken nuggets, breakfast cereal) served in different PS (100%, 200%)</td>
<td>Energy intake from manipulated foods increased with increasing PS (777, 957 kcal)</td>
<td>Tested individual characteristics did not affect the relationship between PS and intake</td>
</tr>
<tr>
<td>59 – 5 y.o. boys and girls</td>
<td>2 24-hour periods separated by ≥ 2 weeks</td>
<td>Portions of side dishes did not vary across conditions</td>
<td>Total intake for the day increased with increasing PS (1500, 1639 kcal)</td>
<td></td>
</tr>
<tr>
<td>Fisher, Obesity, 2007 (71)</td>
<td>Within-subjects, crossover with 3 conditions</td>
<td>Macaroni and cheese served in different PS (age-appropriate 100% reference or 200%) and self-selected condition</td>
<td>Energy intake from manipulated foods increased with increasing PS (251, 278 kcal)</td>
<td>Tested individual characteristics, including age, did not affect the relationship between PS and intake</td>
</tr>
<tr>
<td>25 – 2 to 3 y.o.</td>
<td>Dinner 1 day/week for 3 weeks</td>
<td>Portions of side dishes did not vary across conditions</td>
<td>Total intake for the day increased with increasing PS (484, 541 kcal)</td>
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<td>25 – 5 to 6 y.o.</td>
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<tr>
<td>25 – 8 to 9 y.o., boys and girls included in each group</td>
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<tr>
<td>Investigators and subjects</td>
<td>Design and duration of the study</td>
<td>Manipulations of portion size (PS) and energy density (ED)</td>
<td>Effects of PS and ED on intake (means)</td>
<td>Effect of subject characteristics on relationship between PS or ED and intake</td>
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<tr>
<td>Fisher, Birch, Zhang, Grusak, Hughes, Int J Obes, 2013 (115) 60 – 4 to 6 y.o. boys and girls</td>
<td>2X2 within-subjects-crossover Dinner 1 day/week for 4 weeks</td>
<td>Macaroni and cheese was served in a dish containing different PS (100% [275 g], 200% [550 g]). Children were allowed to served themselves from the dish using 2 sizes of spoons (teaspoon, tablespoon) Portions of side dishes did not vary across conditions</td>
<td>Amount served of macaroni and cheese increased with increasing PS (65.6. 91.9 g) PS was not directly related to intake Children who selected more of the macaroni and cheese ate more of the entrée and consumed more energy at meal</td>
<td>Tested individual characteristics did not affect the relationship between PS and intake</td>
</tr>
<tr>
<td>Huss, Laurentz, Fisher, McCabe, Kranz, Appetite, 2013 (84) 23 – 2 to 5 y.o. boys and girls</td>
<td>2X2 within-subjects, crossover Lunch served 2 days/week for 12 weeks</td>
<td>Two lunches were served in different PS (age-appropriate 100% reference or 200%). Timing of dessert was also varied (with lunch, after lunch) Lunch 1 included fish, rice, orange, mixed vegetable Lunch 2 included ravioli &amp; meat sauce, mixed fruit, mixed vegetable</td>
<td>Total lunch energy intake was not affected by PS</td>
<td>Tested individual characteristics did not affect the relationship between PS and intake</td>
</tr>
<tr>
<td>Kral, Kabay, Roe, Rolls, Obesity, 2010 (80) 43 – 5 to 6 y.o. boys and girls</td>
<td>Within-subject, crossover with 2 conditions Dinner served 1 day/week for 2 weeks</td>
<td>Broccoli, carrot, and applesauce side dishes served in different PS (100% [75g], 200% [150 g]) Portion of main dish and beverage did not vary across conditions</td>
<td>Total energy intake of applesauce increased with increasing PS (add. 15 kcal) Energy intake in vegetables and total meal did not differ by PS</td>
<td>Children who were overweight consumed more broccoli with larger PS (25.1, 39.9 g) Children who ranked broccoli as most preferred food increased broccoli intake with increasing PS (additional 27.2 kcal)</td>
</tr>
<tr>
<td>Investigators and subjects</td>
<td>Design and duration of the study</td>
<td>Manipulations of portion size (PS) and energy density (ED)</td>
<td>Effects of PS and ED on intake (means)</td>
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<tr>
<td>Kral, Remiker, Strutz, Moore, Obesity, 2014 (75) 94 – 8 to 10 y.o. boys and girls</td>
<td>Within-subject, crossover with 3 conditions Dinner served 1 day/week for 3 weeks</td>
<td>Dinner served in different PS (100%, 150%, 200%) Dinner included chicken nuggets, hash browns, ketchup, green beans, brownies, fruit punch</td>
<td>Total meal intake increased with increasing PS (mean intakes: 921, 1046, 1041 kcal)</td>
<td>Tested individual characteristics did not affect the relationship between PS and intake</td>
</tr>
<tr>
<td>Looney, Raynor, J Am Diet Assoc, 2011 (77) 17 – 2 to 5 y.o. boys and girls</td>
<td>2X2 within-subjects, crossover Snack served 1 day/week for 4 weeks</td>
<td>2 types of afternoon snack (applesauce [0.43 kcal/g] and pudding [1.19 kcal/g] was served in different PS (150, 300 g))</td>
<td>Snack intake increased with increasing PS (84, 99 kcal), but did not differ between applesauce and pudding</td>
<td>Tested individual characteristics did not affect the relationship between PS or snack type and intake</td>
</tr>
<tr>
<td>Mathias, Rolls, Birch, Kral, Hanna, Davey, Fisher, J Acad Nutr Diet, 2012 (81) 30 – 4 to 6 y.o. boys and girls</td>
<td>2X2 within-subjects, crossover Dinner served 1 day/week for 5 weeks</td>
<td>Peaches were served in different PS (100% [75 g], 200% [150 g]) and broccoli served in different PS (100% [75 g], 200% [150 g]) Portion of main dish and beverage did not vary across conditions</td>
<td>Fruit intake increased with increasing PS (59, 101 g) Vegetable intake increased with increasing PS (32, 44 g) Total energy intake was not affected by increasing PS</td>
<td>Children who rated the fruit or vegetable as “yummy” had larger increases in intake when PS increased compared to children who rated the items as “just okay” or “yucky”</td>
</tr>
<tr>
<td>Mooreville, Davey, Orloski, Hannah, Mathias, Birch, Kral, Zakeri, Fisher, Obesity, 2015 (76) 100 – 5 to 6 y.o. boys and girls</td>
<td>Within-subjects, crossover with 4 conditions Dinner served 1 day/week for 4 weeks</td>
<td>Dinner was served in different PS (100%, 150%, 200%, 250%) Dinner included macaroni and cheese, corn, applesauce, cookies Portion of milk did not vary across conditions</td>
<td>Total energy intake increased with increasing PS (479, 531, 540, 585 kcal) along with energy intake from macaroni and cheese (262, 299, 282, 317 kcal) and cookies (88, 109, 126, 140)</td>
<td>Children with lower satiety responsiveness scores or higher food responsiveness scores showed greater increases in total energy intake with increasing PS</td>
</tr>
<tr>
<td>Investigators and subjects</td>
<td>Design and duration of the study</td>
<td>Manipulations of portion size (PS) and energy density (ED)</td>
<td>Effects of PS and ED on intake (means)</td>
<td>Effect of subject characteristics on relationship between PS or ED and intake</td>
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<tr>
<td>Ramsay, J Sch Health, 2013 (78) 114-121 – 5 y.o. boys and girls</td>
<td>Quasi-experimental with 2 conditions Lunch served 1 day/week for 4 weeks</td>
<td>Children were served a proportioned amount (non-choice; 4 nuggets) or allowed to choose portion (choice; 2, 3, or 4, nuggets) Portions of other foods did not vary across conditions</td>
<td>Chicken nugget intake was higher on non-choice day compared to choice Total intake was not affected by condition</td>
<td>Demographic and anthropometric measures not collected</td>
</tr>
<tr>
<td>Rolls, Engell, Birch, J Am Diet Assoc, 2000 (70) 32 – 3 to 5 y.o. boys and girls</td>
<td>Within-subjects, crossover with 2 conditions Lunch served 1 day/week for 3 weeks</td>
<td>Macaroni and cheese served in different PS for 3-year-olds (250, 263, 376 g) and 5-year-olds (225, 338, 450 g) Portions of side dishes did not vary across conditions</td>
<td>Macaroni and cheese intake increased with increasing PS for 5-year-old children (76.7, 100.7, 122.7 g), but not 3-year-old children (44.8, 54.6, 38.6 g) Total energy intake increased with increasing PS for 5-year-old children (186, 227, 258 kcal), but not 3-year-olds (140, 155, 146 kcal)</td>
<td>Age affected the relationship between PS and intake</td>
</tr>
<tr>
<td>Savage, Fisher, Marini, Birch, Am J Clin Nutr, 2012 (73) 17 – 3 to 5 y.o. boys and girls</td>
<td>Within-subjects with 5 conditions</td>
<td>Macaroni and cheese was served in different PS (100, 160, 220, 280, 340 g) Portions of side dishes did not vary across conditions</td>
<td>Macaroni and cheese increased with increasing PS (145, 233, 261, 302, 356, 388 kcal) Intake of other foods at the meal decreased as PS increased Total energy intake increased with increasing PS (315, 401, 418, 435, 499, 506 kcal)</td>
<td>Children who were overweight shown greater increased in macaroni and cheese and total energy intake as PS increased compared to normal weight children</td>
</tr>
<tr>
<td>Investigators and subjects</td>
<td>Design and duration of the study</td>
<td>Manipulations of portion size (PS) and energy density (ED)</td>
<td>Effects of PS and ED on intake (means)</td>
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<tr>
<td>Spill, Birch, Roe, Rolls, Am J Clin Nutr, 2010 (82)</td>
<td>Within-subject, crossover with 4 conditions Lunch 1 day/week for 4 weeks</td>
<td>First course carrots were served in different PS (0, 30, 60, 90 g) Portion of meal did not vary across conditions</td>
<td>Carrot intake increased with increasing PS (8.7, 12.8, 13.5 kcal) Total energy intake was not affected by increasing PS</td>
<td>Tested individual characteristics did not affect the relationship between PS and intake</td>
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<tr>
<td>51 – 3 to 5 y.o. boys and girls</td>
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<tr>
<td>Spill, Birch, Roe, Rolls Appetite, 2011 (83)</td>
<td>Within-subject, crossover with 4 conditions Lunch 1 day/week for 4 weeks</td>
<td>First course tomato soup was served in different PS (0, 150, 225, 300 g) Portion of meal did not vary across conditions</td>
<td>Soup intake increased with increasing PS (39.8, 44.8, 48.8 kcal) Total energy intake was not affected by increasing PS</td>
<td>Tested individual characteristics did not affect the relationship between PS and intake</td>
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<td>72 – 3 to 5 y.o. boys and girls</td>
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<tr>
<td>Smith, Appetite, 2013 (74)</td>
<td>Within-subjects, crossover with 3 conditions</td>
<td>Main dish served in different portions (age-appropriate 100% reference, 70% or 130%) Dish with rice (50%), veg (25%), and protein (25%) Portion of side soup did not vary across conditions Children could ask for seconds</td>
<td>Main dish intake increased with increasing PS for 6-year-olds (252, 325, and 441 g), 4-year-olds only increased intake between 70% and 100% PS (179, 256, 183 g)</td>
<td>Age affected the relationship between PS and intake</td>
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<tr>
<td>172 – 4- and 6- y.o. boys and girls</td>
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* y.o. = years old
Table 1.3: Experimental studies examining the effect of energy density on children’s intake

<table>
<thead>
<tr>
<th>Investigators and subjects</th>
<th>Design and duration of the study</th>
<th>Manipulations of portion size (PS) and energy density (ED)</th>
<th>Effects of PS and ED on intake (means)</th>
<th>Effect of subject characteristics on relationship between PS or ED and intake</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leahy, Birch, Rolls, Am J Clin Nutr, 2008 (92) 29 – 3 to 5 y.o.* boys and girls</td>
<td>Within-subjects, crossover with 2 conditions  Meals served 2 days/week with 12 days between conditions</td>
<td>2 days of breakfast, lunch, and afternoon snack were served in differed ED (0.94, 1.13 kcal/g including food and beverages)  Dinner and evening snack did not vary across conditions</td>
<td>Energy intake from manipulated foods increased with increasing ED (1296, 1727 kcal)  Total energy intake over 2 days increased with increasing ED (2350, 2739 kcal)</td>
<td>Tested individual characteristics did not affect the relationship between ED and intake</td>
</tr>
<tr>
<td>Leahy, J Am Diet Assoc, 2008 (69) 77 – 2 to 5 y.o. boys and girls</td>
<td>Within-subjects, crossover with w conditions  Lunch served 1 day/week for 6 weeks</td>
<td>Macaroni and cheese served at different ED (1.4, 2.0 kcal/g)  Side dishes did not vary across conditions</td>
<td>Energy intake from macaroni and cheese increased with increasing ED (217, 288 kcal)  Total energy intake increased with increasing ED (320, 392 kcal)</td>
<td>Tested individual characteristics did not affect the relationship between ED and intake</td>
</tr>
<tr>
<td>Spill, Birch, Roe, Rolls, Am J Clin Nutr, 2011 (93) 40 – 3 to 5 y.o. children</td>
<td>Within-subjects, crossover  Meal served 1 day/week for 3 weeks</td>
<td>Main dishes at breakfast, lunch, dinner, and evening snack served at different ED (100%, 85%, 75%)  Foods that were varied included zucchini bread, pasta &amp; red sauce, and chicken noodle casserole  Other foods served throughout the day did not vary across conditions</td>
<td>Energy intake from manipulated foods decreased with decreasing ED (695, 722, 665 kcal)  Total energy intake decreased with decreasing ED (1023, 1015, 889)</td>
<td>Tested individual characteristics did not affect the relationship between ED and intake</td>
</tr>
</tbody>
</table>

*a y.o. = years old
## Table 1.4: Experimental studies examining the combined effects of portion size and energy density on children’s intake

<table>
<thead>
<tr>
<th>Investigator and subjects</th>
<th>Design and duration of the study</th>
<th>Manipulations of portion size (PS) and energy density (ED)</th>
<th>Effects of PS and ED on intake (means)</th>
<th>Effect of subject characteristics on relationship between PS or ED and intake</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fisher, Liu, Birch, Rolls, Am J Clin Nutr, 2007 (94)</td>
<td>2X2 within-subjects, crossover Dinner 1 day/week for 4 weeks</td>
<td>Macaroni and cheese was served in different PS (250, 500 g) and ED (1.3, 1.8 kcal/g) Side dishes did not vary across conditions</td>
<td>Main dish intake increased with increasing PS (249, 332 kcal) and increasing ED (249, 332 kcal) Total energy intake increased with increasing PS (478, 548 kcal) and increasing ED (471, 554 kcal) Effects of PS and ED were independent and combined to increase total energy intake by 153 kcal (34%)</td>
<td>Tested individual characteristics did not affect the relationship between PS or ED and intake</td>
</tr>
<tr>
<td>Leahy, Birch, Fisher, Rolls, Obesity, 2008 (95)</td>
<td>2X2 within-subjects, crossover Lunch 1 day/week for 4 weeks</td>
<td>Macaroni and cheese was served in different PS (400, 300 g) and in different ED (1.6, 1.2 kcal/g) Side dishes did not vary across conditions</td>
<td>Main dish intake decreased with decreasing ED (251, 188 kcal), but not PS Total energy intake decreased with decreasing ED (364, 303 kcal), but not PS</td>
<td>Tested individual characteristics did not affect the relationship between PS or ED and intake</td>
</tr>
</tbody>
</table>

*y.o. = years old
Table 1.5: Experimental studies examining the effects of portion size or energy density on children’s beverage intake

<table>
<thead>
<tr>
<th>Investigators and subjects</th>
<th>Design and duration of the study</th>
<th>Manipulations of portion size (PS) and energy density (ED)</th>
<th>Effects of PS and ED on intake (means)</th>
<th>Effect of subject characteristics on relationship between PS or ED and intake</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kral, Remiker, Strutz, Moore, Obesity, 2014 (75)</td>
<td>Within-subject, crossover with 3 conditions</td>
<td>Dinner served in different PS (100%, 150%, 200%)</td>
<td>Fruit punch intake increased with increasing PS (83, 99, 112 kcal)</td>
<td>Tested individual characteristics did not affect the relationship between PS and intake</td>
</tr>
<tr>
<td>94 – 8 to 10 y.o. boys and girls</td>
<td>Dinner served 1 day/week for 3 weeks</td>
<td>Dinner included chicken nuggets, hash browns, ketchup, green beans, brownies, fruit punch</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leahy, Birch, Rolls, Am J Clin Nutr, 2008 (95)</td>
<td>Within-subjects, crossover with 2 conditions</td>
<td>2 days of breakfast, lunch, and afternoon snack were served in differed ED (0.94, 1.13 kcal/g including food and beverages)</td>
<td>Energy intake from manipulated beverages increased with increasing ED (334,462)</td>
<td>Tested individual characteristics did not affect the relationship between ED and intake</td>
</tr>
<tr>
<td>29 – 3 to 5 y.o. boys and girls</td>
<td>Meals served 2 days/week with 12 days between conditions</td>
<td>Dinner and evening snack did not vary across conditions</td>
<td>Total energy intake from beverages over 2 days increased with increasing ED (536, 686 kcal)</td>
<td></td>
</tr>
<tr>
<td>Norton, Poole, Raynor, Appetite, 2015 (101)</td>
<td>2X2 within-subjects, crossover</td>
<td>2 types of beverages (water, juice) in different PS (180, 360 g)</td>
<td>There was a significant interaction of type and PS on beverage intake with beverage intake highest in the large PS of juice condition. Beverage intake varied by type (water: 111 g, juice: 185 g) and PS (121, 174 g)</td>
<td>Tested individual characteristics did not affect the relationship between PS or beverage type and intake</td>
</tr>
<tr>
<td>26 -- to 5 y.o. children</td>
<td>Afternoon snack served 1 day/week for 4 weeks</td>
<td>Other snack foods did not vary by condition</td>
<td>There was a significant interaction of type and PS on food intake with intake highest in large PS of water condition. Total snack intake varied by beverage type (water: 105, kcal juice: 175.4 kcal)</td>
<td></td>
</tr>
<tr>
<td>Investigators and subjects</td>
<td>Design and duration of the study</td>
<td>Manipulations of portion size (PS) and energy density (ED)</td>
<td>Effects of PS and ED on intake (means)</td>
<td>Effect of subject characteristics on relationship between PS or ED and intake</td>
</tr>
<tr>
<td>---------------------------</td>
<td>---------------------------------</td>
<td>----------------------------------------------------------</td>
<td>---------------------------------------</td>
<td>----------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| Wilson, Appetite, 1991 (102)  
40 – 1.67 to 4.67 y.o. boys and girls | Within-subjects, crossover with 2 milk conditions (varied in ED and flavor)  
Milk served with lunch  
4 days per week for 8 weeks | Milk: 4 oz. (could ask for more) of plain milk (18.1 kcal/oz) or sucrose-sweetened chocolate milk (23.7 kcal/oz)  
Lunch: 4 different menus served on different days | Children consumed more energy from chocolate milk than plain milk (161, 74 kcal)  
Children consumed more energy at lunch when served sucrose-sweetened chocolate milk than plain milk (372, 288 kcal) | Tested individual characteristics did not affect the relationship between milk type (ED) and intake |
| Wilson, Appetite, 1994 (103)  
24 – 1.5 – 5.5 y.o. boys and girls | Within-subjects, crossover  
Milk served with lunch  
2 days per week for 12 weeks | Milk: 8 oz. of plain milk (18.1 kcal/oz), chocolate sucrose-sweetened milk (29.4 kcal/oz), and chocolate aspartame-sweetened milk (18.6 kcal/oz) | Milk type did not affect total energy intake at the meal (plain: 260 kcal, sucrose: 260 kcal, aspartame: 267 kcal) | Tested individual characteristics did not affect the relationship between milk type (ED) and intake |
| Wilson, Physiol & Behav, 2000 (104)  
135 – 1.5 to 5.5 y.o. boys and girls | Within-subjects, crossover with 3 milk conditions (varied in ED)  
Milk served with lunch  
2 days per week for 12 weeks | Milk: 4 oz. (could ask for more) of plain milk (18.1 kcal/oz), sucrose-sweetened chocolate milk (29.4 kcal/oz), or aspartame-sweetened chocolate milk (18.6 kcal/oz)  
Lunch: 4 different menus served on different days | Children consumed more energy from the sugar-sweetened chocolate milk (143 kcal) than the plain (55 kcal) or aspartame-sweetened chocolate milk (89 kcal)  
Children consumed more energy from the aspartame-sweetened chocolate milk (89 kcal) than plain milk (55 kcal)  
Consumed significantly more energy from the meal when sucrose-sweetened chocolate milk (371 kcal) was served than the plain (306 kcal) or aspartame-sweetened milk (315 kcal) | Tested individual characteristics did not affect the relationship between milk type (ED) and intake |

*a y.o. = years old
References


40. Birch LL, McPhee L, Sullivan S. Children's food intake following drinks sweetened with sucrose or aspartame: time course effects. Physiol Behav. 1989;45(2):387-395.


73. Savage JS, Fisher JO, Marini M, Birch LL. Serving smaller age-appropriate entree portions to children aged 3-5 y increases fruit and vegetable intake and reduces energy density and energy intake at lunch. *Am J Clin Nutr*. 2012;95(2):335-341.


CHAPTER 2

Study 1:

DOUBLE TROUBLE: PORTION SIZE AND ENERGY DENSITY

COMBINE TO INCREASE PRESCHOOL CHILDREN’S LUNCH INTAKE

Reprinted from Physiology & Behavior, 162, Kling SMR, Roe LS, Keller KL, Rolls BJ,

Double trouble: Portion size and energy density combine to increase preschool

children’s lunch intake, 18-26, 2016, with permission from Elsevier.
Introduction

Both the portion size and energy density (ED) of foods have robust effects on energy intake, and these two factors are often implicated as primary drivers of the obesity epidemic. In preschool children, serving larger portions has been consistently shown to increase energy intake (1-5). Less is known about the effects of ED on children’s eating behavior, but the available data suggest that variations in ED have potent effects on energy intake (6-8), and higher-ED diets are associated with increased weight gain and weight status (9, 10). Although children are often exposed to multiple foods that are both large in portion size and high in ED, the potential of these properties acting together to influence consumption is not understood. To determine the combined effects of portion size and ED on energy intake, we systematically varied all the foods in a typical meal served in children’s usual preschool environment.

Studies in adults have shown that portion size and ED have strong, independent effects that combine to increase energy consumption, but it is unclear whether young children respond similarly. Only two studies have examined the combined effects of portion size and ED at a meal in children (11, 12). One study found that both portion size and ED affected energy intake independently and that the effects combined (11), but another study found that only ED affected energy intake (12). In addition, these studies modified only the main dish, which does not represent children’s current eating environment where multiple foods within a meal vary in both portion size and ED. To date, no research has tested whether children adjust their consumption in response to such variations in an entire meal. Most research has focused on how variations in portion size and ED affect intake of components of a meal such as main or side dishes,
and few studies have examined these effects when all foods at a meal are varied (5, 7, 13). When children are served an entire meal of large portions of high-ED foods, they might adjust their intake by eating a smaller proportion of all items or by altering their food selection and eating less of the higher-ED options. If such self-regulation does not occur, however, the powerful effects of portion size and ED have the potential to substantially increase energy intake, especially when everything in a meal is changed simultaneously. Given the prevalence of large portions of high-ED foods (14, 15), it is essential to determine how these factors combine to influence food selection and energy intake in children.

Identifying children at risk for overeating when served large portions and higher-ED foods could lead to the development of targeted recommendations, and thus recent studies have focused on relating individual characteristics to variations in children’s responses to these factors. The findings, however, have not led to clear and consistent predictors. In some studies, the response to larger portion sizes has been shown to be related to child age, weight status, or two sub-scales on the Child Eating Behaviour Questionnaire: satiety responsiveness and food responsiveness (1, 4, 5, 16, 17). In several other studies, however, these characteristics did not influence the relationship between portion size and intake (2, 3, 6-8, 11, 12, 18, 19). Furthermore, there has been limited research on the influence of individual characteristics on the effects of ED. Since children are exposed to foods that differ in both portion size and ED, it is important to test the effect of individual characteristics when these factors are varied simultaneously.

The primary aim of this study was to examine the independent and combined effects on children’s intake of changing the portion size and ED of all components of a
meal. Using a 3-by-2 crossover design, we systematically varied the portion size and ED of commonly consumed items in a meal served in childcare centers. We hypothesized that increasing the portion size and ED of a meal would have independent effects that combine to increase children’s energy intake (20, 21). To investigate whether the effects on intake varied across child characteristics or might differ for individual foods, we tested a larger sample of children than has been previously tested (1-8, 11-13, 16, 18, 19). Determining how typical variations in the portion size and ED of a meal influence preschool children’s energy intake is essential in order to understand the environmental factors that affect children's food intake and to develop practical strategies to counter these effects.

**Methods**

**Experimental design**

A within-subjects crossover design was used to evaluate the effect on intake of increasing the ED and portion size of all foods and milk served to preschool children at lunch. On 1 day a week for 6 weeks, the experimental meal was served to children in their classrooms at 3 childcare centers. Across the 6 meals, all foods and milk were served at 3 levels of portion size (100%, 150%, or 200% of reference amounts) and 2 levels of energy density (100% or 142%) and were consumed ad libitum ([Photograph 1](#)). The order of the six conditions was counterbalanced across classrooms using Latin squares, and classrooms were randomly assigned one of the condition sequences using a random number generator. Since the children were only served one experimental meal
per week, they never saw the different meals together. The children’s height, weight, and liking of the study foods were assessed after the final experimental meal.

Photograph 1: All foods at the experimental meals were served at 3 levels of portion size (100%, 150%, or 200%) and 2 levels of energy density (100% or 142%). Children were served one experimental meal per week for 6 weeks; thus, they never saw the different meals together.

Participant recruitment

Children were recruited by giving letters to parents with 3- to 6-year-old children enrolled at three childcare centers near University Park, PA. Parents provided written consent for the participation of their child in the study as well as their own participation in completing questionnaires. Children with a parentally reported allergy or intolerance to the foods or milk being served were not eligible to participate in the study. Neither parents nor children were informed about the purpose of the study. All procedures were reviewed and approved by The Pennsylvania State University Office for Research Protections.
A power analysis was conducted to determine the number of children needed for the study, based on previous research in a similar population with a similar meal. A clinically significant difference in energy intake was considered to be 48 kcal, which is approximately 15% of typical lunch intake in this population. A power analysis showed that a sample size of 58 children would allow detection of this difference at a significance level of 0.05 and power of 80%. To explore the effect of individual characteristics on the primary outcomes, we enrolled 131 children, which is larger than the sample sizes of previous controlled studies of portion size or ED (1-3, 5-8).

**Experimental menu and meal procedures**

*Experimental menu.* The experimental meal consisted of chicken (grilled breast or breaded nuggets), macaroni and cheese, a green vegetable (broccoli or peas), applesauce, ketchup, and milk. This menu was chosen because the foods and milk naturally vary in energy density (ED), are commercially available, and are commonly consumed by preschool children. Across meals, all foods and milk were served at 3 levels of portion size (100%, 150%, or 200%) and 2 levels ED (100% or 142%) (Photograph 1). In the 100% (reference) portion size condition, the amounts of each food and beverage served were based on preschool children’s intake in previous studies (7, 12, 19) and met the minimum recommendations from the Child and Adult Care Food Program (22). The larger portions of each food and milk were chosen to be 150% and 200% the size of the reference portion. As described in Table 2.1, ED was modified primarily by using products and recipes that differed in fat and sugar content. The 42% increase in ED was matched across all items served at the meal; this increase was based on the ED
difference between the two types of milk. In addition to milk, children were provided 237 mL of water that was not varied in portion size or ED. The lower-ED meal had 38% of energy as carbohydrates, 34% as protein, and 27% as fat; the higher-ED meal had 41% of energy as carbohydrates, 21% as protein, and 38% as fat.
Table 2.1: Items served in the experimental meals of lower and higher energy density; amounts of weight and energy served are shown for the 100% portion size conditions.

<table>
<thead>
<tr>
<th>Lower-energy-dense meal</th>
<th>100% portion size</th>
<th>Higher-energy-dense meal</th>
<th>100% portion size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower-energy-dense items</td>
<td>ED (kcal/g)</td>
<td>Weight (g)</td>
<td>Energy (kcal)</td>
</tr>
<tr>
<td>Grilled chicken strips(^1,2)</td>
<td>1.19</td>
<td>100</td>
<td>119</td>
</tr>
<tr>
<td>Macaroni and cheese(^4)</td>
<td>1.50</td>
<td>100</td>
<td>150</td>
</tr>
<tr>
<td>Broccoli with butter and flavoring(^6)</td>
<td>0.57</td>
<td>75</td>
<td>43</td>
</tr>
<tr>
<td>Reduced-sugar applesauce(^8)</td>
<td>0.50</td>
<td>100</td>
<td>50</td>
</tr>
<tr>
<td>Reduced-sugar ketchup(^10)</td>
<td>0.82</td>
<td>20</td>
<td>16</td>
</tr>
<tr>
<td>Low-fat milk (1%)(^12)</td>
<td>0.42</td>
<td>183</td>
<td>77</td>
</tr>
<tr>
<td>Total food served</td>
<td>0.96</td>
<td>395</td>
<td>378</td>
</tr>
<tr>
<td>Total food &amp; milk served</td>
<td>0.79</td>
<td>578</td>
<td>455</td>
</tr>
</tbody>
</table>

\(^1\)Fully Cooked Chicken Breast Strips, Tyson Foods Inc., Springdale, AR.
\(^2\)Chicken strips and nuggets were cut into similar bite-sized pieces.
\(^3\)Gluten Free Breaded Chicken Breast Nuggets, Bell & Evans, Fredericksburg, PA.
\(^4\)Stouffer’s Macaroni and Cheese, Nestle U.S.A. Inc., Solon OH.
\(^6\)Petite Broccoli Florets, Hanover Foods Corporation, Hanover, PA; Unsalted Whipped Butter, Land O’Lakes Inc., Arden Hills, MN; Crisco Pure Canola Oil, The J.M. Smucker Company, Orrville, OH.
\(^7\)Petite Broccoli Florets, Hanover Foods Corporation, Hanover, PA; Unsalted Whipped Butter, Land O’Lakes Inc., Arden Hills, MN; Molly McBudder Butter Flavor Sprinkles, B&G Foods Inc., Parsippany, NJ.
7 Sweet Peas, Foodhold U.S.A LLC, Landover, MD; Molly McButter Butter Flavor Sprinkles, B&G Foods Inc., Parsippany, NJ.
8 Lucky Leaf Premium Blend Applesauce, Knouse Foods Inc., Peach Glen, PA; Lucky Leaf Unsweetened Applesauce, Knouse Foods Inc., Peach Glen, PA.
9 Lucky Leaf Premium Blend Applesauce, Knouse Foods Inc., Peach Glen, PA.
10 Tomato Ketchup, H.J. Heinz Co. L.P., Pittsburgh, PA; Reduced Sugar Ketchup with Sucralose, H.J. Heinz Co. L.P., Pittsburgh, PA.
11 Tomato Ketchup, H.J. Heinz Co. L.P., Pittsburgh, PA.
12 Giant Food Stores Milk, Foodhold U.S.A LLC, Landover, MD.
13 ED, energy density.
Meal procedures. Children consumed the experimental meals ad libitum in their usual classrooms in the childcare centers and at their regularly scheduled lunchtime. Children ate at tables with the same group of three to six children and one adult, which is standard practice at the childcare centers. Foods and beverages were pre-portioned into dishware and then set at each child’s place at the table before the children were seated. Before the first experimental meal, researchers explained to the children that they could eat as much or as little as they wanted, but could not request more of any food or beverage. During each meal, adults, including teachers and undergraduate research assistants who did not know the purpose of the study, were instructed to redirect conversations about food-related topics to minimize peer influence on children’s lunch intake. After all children had finished lunch, researchers returned any dropped and spilled foods to the correct plate or bowl and recovered any spilled beverage with paper towels. To determine the amount consumed, all foods and beverages were weighed before and after the meal in a separate room out of the children’s view. Food weights were recorded to the nearest 0.1 g using digital scales (Mettler-Toledo PR5001 and XS4001S; Mettler-Toledo, Columbus, OH). Energy and nutrient intakes were calculated using information from food manufacturers and a standard food composition database (23). Children in the classrooms who did not participate in the study sat at tables out of the view of participating children and were served the childcare center’s scheduled lunch menu.

Assessments

Food liking assessments. Liking for the experimental foods and milk was assessed during an individual session with each child using a 5-point cartoon face scale based on
a 3-point version used in previous research (24-26). The child was seated at a table with
the 5 cartoon faces and was instructed on using them to indicate whether a food was
“super yummy,” “yummy,” “just okay,” “yucky,” or “super yucky.” After instruction,
samples of each food and beverage were presented to the child one at a time; the
condiment (ketchup) was not assessed since it was a minor component of the meal and is
not usually consumed alone. The order of presenting the samples of the five items was
randomized and within each item the low-ED and high-ED versions were also presented
in a random order. The children were asked to taste the food or milk and indicate their
liking for it by pointing to the appropriate cartoon face. Children’s liking for the foods
and milk was assessed within 2 weeks after the final experimental meal. Food liking
assessments were completed by 93 (78%) of the children. The remaining children were
absent or declined to participate, but did not differ from the other children on the main
outcomes.

*Body weight and height.* Body weight was measured to the nearest 0.1 kg using a
portable digital scale (Seca Onda model 843; Seca Corporation, Hanover, MD). Height
was measured in duplicate to the nearest 0.1 cm using a portable stadiometer (model
214; Seca Corporation, Hanover, MD). Body weight and height were used to calculate
body size parameters (sex- and age-specific BMI percentiles and z-scores) using a
software program based on nationally representative data (27). Children with sex-
specific BMI-for-age percentiles ≥85th or <95th percentile were classified as overweight
and those with percentiles ≥95th were classified as obese. Estimated daily energy
requirements were calculated using equations for children ages 3 through 5 years with
light activity levels (28). Children’s weight and height were assessed within 2 weeks after the final test meal. One hundred and five children (88%) completed the assessments for height and weight; the remaining children were absent or declined to participate,

*Parental questionnaires.* Parents were asked to complete three questionnaires about parent and child characteristics and behaviors related to the eating environment. The 35-item Child Eating Behaviour Questionnaire (CEBQ) evaluates 8 subscales that relate to eating styles and behaviors of the child (29, 30). Example items include “My child is always asking for food” from the 5-item food responsiveness subscale, and “My child gets full before his/her meal is finished” from the 5-item satiety responsiveness subscale. The 31-item Child Feeding Questionnaire (CFQ) assesses 7 subscales that measure perceived weight concerns and feeding practices (31, 32). An example from the 3-item monitoring subscale is “How much do you keep track of sweets (candy, ice cream, cake, pies, pastries) that your child eats?” For these CFQ and CEBQ subscales, the parent rated each item on a 5-point frequency scale (1=never, 5=always); for analyses, a mean score was calculated across all the items in a given subscale. The 16-item demographic questionnaire assesses family demographics and child health. Parents of 106 children (88%) completed the three questionnaires.

**Statistical analysis**

Data analyses were conducted using a mixed linear model with repeated measures (SAS version 9.4; SAS Institute, Inc., Cary, NC) for the outcomes of total
meal intake and intake of the individual foods and milk, both by weight (g) and energy (kcal). Fixed factors in the model were meal portion size (100%, 150%, or 200%), meal ED (100% or 142%), study week, and classroom. All interactions were tested and then removed from the model if not significant. Subjects were treated as a random factor. For outcomes with significant effects, the Tukey-Kramer method was used to adjust significance levels for multiple pairwise comparisons between means. Children who were absent for 3 or more conditions (n=11) were excluded from analyses. The procedure described by Littell et al. was used to identify children whose intakes were influential on the main outcomes on the basis of extreme values for the restricted likelihood distance (33); no intakes were found to meet the pre-determined criteria.

Analysis of covariance was used to assess the influence of continuous subject characteristics (age, body weight, height, BMI percentiles, BMI z-score, CFQ subscales, and CEBQ subscales) on the relationship between ED, portion size, and total meal intake; the children’s sex was also tested as a factor in the models. All subject characteristics were tested simultaneously in the final models. Children’s ratings of liking for each food were tested as a categorical factor in the model for intake of that food. Ordinal repeated measures logistic regression was used to compare the lower-ED and higher-ED meals as well as individual meal items for differences in the distribution of children’s liking ratings; results are reported as odds ratios with 95% confidence levels. T-tests were used to evaluate differences between boys and girls in age, body weight, height, BMI percentile, and BMI z-score. Data are reported as means ± standard errors, and results were considered significant at P<0.05.
Results

Subject characteristics

A total of 131 children from 11 classrooms at the 3 childcare centers were enrolled in the study from May 2013 to July 2014. Eleven children were excluded from the analysis because they were absent for 3 or more of the 6 experimental meals. Thus, intake data were analyzed for 120 children (61 boys and 59 girls). The children had a mean age of 4.4 ± 0.1 years and a mean BMI-for-age percentile of 56.8 ± 2.6 (Table 2.2). Fifteen children (14%) were classified as overweight or obese. The sample of children was 69% white, 21% Asian, 3% black or African American, and 7% of mixed or another race; 4% were of Hispanic or Latino origin. Based on the 106 parents (88%) who provided family information, household incomes and education levels were above average: 69% of households had an annual income of above $50,000 and 92% of mothers and 90% of fathers had a Bachelor’s degree or higher.
Table 2.2: Characteristics of 120 preschool children participating in a study that tested the effects of increasing portion size and energy density of a meal on lunch intake

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Boys (n=61)</th>
<th>Girls (n=59)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Mean ± SEM</td>
</tr>
<tr>
<td>Age (y)</td>
<td>56</td>
<td>4.4±0.1</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>52</td>
<td>18.2±0.5b</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>53</td>
<td>106.5±1.0</td>
</tr>
<tr>
<td>BMI-for-age percentile</td>
<td>51</td>
<td>55.6±4.1</td>
</tr>
<tr>
<td>BMI z-score</td>
<td>51</td>
<td>0.17±0.15a</td>
</tr>
<tr>
<td>Daily energy requirements (kcal)²</td>
<td>52</td>
<td>1163±13b</td>
</tr>
<tr>
<td>Food responsiveness score³</td>
<td>53</td>
<td>2.5±0.1</td>
</tr>
<tr>
<td>Enjoyment of food score³</td>
<td>53</td>
<td>3.6±0.1</td>
</tr>
<tr>
<td>Monitoring score⁴</td>
<td>53</td>
<td>4.0±0.1</td>
</tr>
</tbody>
</table>

¹ Boys and girls were compared with the use of a *t* test. Significant difference between boys and girls according to a *t* test, ^a^P < 0.01, ^b^P < 0.05

²Daily energy requirements were estimated using equations for children ages 3 through 5 years with light activity levels (28)

³Subscale on the Child Eating Behaviour Questionnaire (29, 30)

⁴Subscale on the Child Feeding Questionnaire (31, 32)
Food and energy intakes

Weight of food and milk. There was a significant effect of portion size (P<0.0001) but not ED (P=0.22) on the weight of the meal consumed (Figure 2.1A). Compared to the 100% portion size conditions, meal intake was 21% (60 ± 7 g) greater in the 150% portion size conditions and 26% (74 ± 7 g) greater in the 200% portion size conditions (both P<0.0001). Mean intakes in the 150% and 200% conditions did not differ significantly from each other (P=0.19). A similar weight of food and milk was consumed at the lower-ED and higher-ED meals (328 ± 11 vs. 321 ± 10 g; P=0.22).

The effects of portion size and ED on intake differed for each of the individual foods and milk served at the meal. Portion size had significant effects on the intake of macaroni and cheese, applesauce, milk, and ketchup (all P<0.02; Table 2.3), but had no effects on intake of chicken or vegetables (both P>0.53). For example, doubling the meal portion size increased intake of macaroni and cheese by 31%, applesauce by 64%, and ketchup by 49%. Energy density had significant effects on the weight consumed of chicken and macaroni and cheese (P<0.0001; Table 2.3), but had no significant effects on intake of the other foods or milk (all P>0.06). Compared to the lower-ED standard macaroni and cheese, children consumed 21% less of the macaroni and cheese with added fat; compared to the lower-ED grilled chicken, children consumed 53% more of the breaded chicken.
Figure 2.1: Mean (±SEM) food and milk intakes (g and kcal) at lunch by meal portion size and energy density (ED) in 120 preschool children. **Figure 2.1A:** There was a significant effect of portion size (P<0.0001) but not energy density (P=0.22) on total meal intake by weight. Across the lower- and higher-ED meals, intake was significantly greater when children were served the 150% and 200% portion size conditions compared to the 100% condition. **Figure 2.1B:** There were significant and independent effects of portion size and energy density (both P<0.0001) on total meal energy intake. Across the lower- and higher-ED meals, energy intake was significantly greater when children were served the 150% and 200% portion size conditions compared to the 100% condition (both P<0.0001). Across portion size conditions, increasing meal ED by 42% led to an increase in energy intake at the meal (P<0.0001). The effects of portion size and energy density combined to increase meal energy intake by 79% or 175 ± 12 kcal when the children were served the higher-ED meal with the largest portions compared to the lower-ED meal with the smallest portions.
Table 2.3: The effects of increasing meal portion size and energy density on the weight, energy, energy density, and macronutrients consumed from a meal served to 120 preschool children

<table>
<thead>
<tr>
<th></th>
<th>Lower-energy-dense meal</th>
<th></th>
<th>Higher-energy-dense meal</th>
<th></th>
<th>Significant effects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100% Portion Size</td>
<td>150% Portion Size</td>
<td>200% Portion Size</td>
<td>100% Portion Size</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(n=106)</td>
<td>(n=107)</td>
<td>(n=110)</td>
<td>(n=114)</td>
<td></td>
</tr>
<tr>
<td>Total meal intake (g)</td>
<td>280±11</td>
<td>357±14</td>
<td>360±14</td>
<td>283±10</td>
<td>331±13</td>
</tr>
<tr>
<td>Chicken (g)</td>
<td>40±3</td>
<td>39±3</td>
<td>37±3</td>
<td>56±3</td>
<td>56±4</td>
</tr>
<tr>
<td>Macaroni and cheese (g)</td>
<td>58±4</td>
<td>78±5</td>
<td>78±6</td>
<td>49±4</td>
<td>57±5</td>
</tr>
<tr>
<td>Vegetable (g)</td>
<td>20±2</td>
<td>22±3</td>
<td>18±3</td>
<td>18±2</td>
<td>18±2</td>
</tr>
<tr>
<td>Applesauce (g)</td>
<td>71±3</td>
<td>97±5</td>
<td>119±7</td>
<td>70±3</td>
<td>98±5</td>
</tr>
<tr>
<td>Ketchup (g)</td>
<td>7±1</td>
<td>9±1</td>
<td>10±1</td>
<td>7±1</td>
<td>10±1</td>
</tr>
<tr>
<td>Milk (g)</td>
<td>84±7</td>
<td>110±9</td>
<td>98±8</td>
<td>82±7</td>
<td>92±8</td>
</tr>
<tr>
<td>Total meal energy intake (kcal)</td>
<td>222±9</td>
<td>279±11</td>
<td>279±12</td>
<td>321±12</td>
<td>366±14</td>
</tr>
<tr>
<td>Chicken (kcal)</td>
<td>48±4</td>
<td>47±4</td>
<td>44±4</td>
<td>95±5</td>
<td>95±7</td>
</tr>
<tr>
<td>Macaroni and cheese (kcal)</td>
<td>86±6</td>
<td>117±8</td>
<td>116±9</td>
<td>102±8</td>
<td>119±10</td>
</tr>
<tr>
<td>Green vegetable (kcal)</td>
<td>12±1</td>
<td>12±2</td>
<td>11±2</td>
<td>15±2</td>
<td>15±2</td>
</tr>
<tr>
<td>Applesauce (kcal)</td>
<td>36±2</td>
<td>49±3</td>
<td>60±3</td>
<td>50±2</td>
<td>70±4</td>
</tr>
<tr>
<td>Ketchup (kcal)</td>
<td>6±1</td>
<td>8±1</td>
<td>8±1</td>
<td>9±1</td>
<td>12±1</td>
</tr>
<tr>
<td>Milk (kcal)</td>
<td>35±3</td>
<td>46±4</td>
<td>41±4</td>
<td>50±4</td>
<td>56±5</td>
</tr>
<tr>
<td>Meal energy intake (% total energy requirements)</td>
<td>20.8±0.9</td>
<td>25.4±1.0</td>
<td>25.7±1.1</td>
<td>29.6±1.1</td>
<td>33.5±1.3</td>
</tr>
<tr>
<td>Water intake (g)</td>
<td>53±6</td>
<td>42±5</td>
<td>48±5</td>
<td>51±6</td>
<td>46±5</td>
</tr>
<tr>
<td>Energy density of food (kcal/g)</td>
<td>0.95±0.02</td>
<td>0.94±0.02</td>
<td>0.92±0.02</td>
<td>1.34±0.02</td>
<td>1.30±0.02</td>
</tr>
<tr>
<td>Energy density of food and milk (kcal/g)</td>
<td>0.81±0.02</td>
<td>0.80±0.02</td>
<td>0.79±0.02</td>
<td>1.15±0.02</td>
<td>1.13±0.02</td>
</tr>
<tr>
<td>Carbohydrates (g)</td>
<td>24.2±0.9</td>
<td>32.2±1.3</td>
<td>34.1±1.4</td>
<td>33.5±1.1</td>
<td>40.3±1.4</td>
</tr>
<tr>
<td>Sugar (g)</td>
<td>12.9±0.5</td>
<td>17.3±0.7</td>
<td>18.6±0.8</td>
<td>17.7±0.6</td>
<td>22.8±0.9</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>17.1±0.9</td>
<td>19.2±0.9</td>
<td>18.0±1.0</td>
<td>16.3±0.6</td>
<td>17.1±0.8</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>6.6±0.3</td>
<td>8.4±0.4</td>
<td>8.1±0.5</td>
<td>13.6±0.7</td>
<td>15.1±0.8</td>
</tr>
</tbody>
</table>

1All values are mean ± SEM
Mixed linear models were used to test the effects of portion size and energy density on all outcomes except for percent energy consumed from carbohydrates, protein, and fat which were analyzed using multivariate analysis of variance.

PS, There was a significant, independent effect of portion size (all P<0.02) on the outcome.

ED, There was a significant, independent effect of energy density (all P<0.01) on the outcome.

PS, ED, There was a significant, independent effects of portion size (all P<0.03) and energy density (all P<0.009) on the outcome.

PS*ED, Portion size and energy density significantly interacted to affect energy consumed from ketchup (P=0.02).

Daily energy requirements were estimated using equations for children ages 3 through 5 years with light activity levels (28).
Energy intake. The portion size and energy density of the meals had significant and independent effects on preschool children’s energy intakes at lunch (Figure 2.1B; both P<0.0001). Compared to the 100% portion size conditions, meal energy intake increased by 18% (49 ± 7 kcal) and 24% (66 ± 8 kcal) when children were served the 150% and 200% portion conditions, respectively (both P<0.0001). Meal energy intake at the 150% and 200% conditions did not differ (P=0.09). Increasing meal ED by 42% led to a 103 ± 7 kcal or 40% increase in energy intake at the meal (P<0.0001). The effects of portion size and energy density combined to increase meal energy intake by 79% or 175 ± 12 kcal when the children were served the higher-ED meal with the largest portions compared with the lower-ED meal with the smallest portions (Table 2.3). Children consumed 20.8 ±0.9% of their estimated daily energy requirements from the smallest portion of the lower-ED meal compared to 35.9 ± 1.4% of their requirements from the largest portion of the higher-ED meal.

The effects of portion size and ED on energy intake differed for each of the individual foods and milk (Table 2.3). Serving larger portions led to increased energy intake from macaroni and cheese, applesauce, milk, and ketchup (all P<0.03), but had no effect on the amount of energy consumed from chicken or vegetables (both P>0.44). For example, doubling the meal portion size increased energy intake from macaroni and cheese by 31% and applesauce by 63%. Varying the ED of the foods and milk significantly affected the amount of energy consumed from all of these items (all P<0.02). The increased energy intake from the largest portion of the higher-ED meal compared to the smallest portion of the lower-ED meal (175 kcal) was primarily attributable to greater energy intake from the breaded chicken nuggets (60 ± 9 kcal; 34%
of the increase), macaroni and cheese with added fat (42 ± 5 kcal; 24%), and sugar-
sweetened applesauce (46 ± 4 kcal; 26%).

*Energy density.* The ED of the food and milk consumed at the meal did not differ by
meal portion size (P=0.57), but it was significantly affected by the meal ED served
(P<0.0001). ED of food and milk averaged 0.80 ± 0.01 kcal/g at the lower-ED meals and
1.14 ± 0.02 kcal/g at the higher-ED meals (Table 2.3). Thus, when the ED of the foods
and milk served was increased by 42%, the ED consumed at the meal increased by 42%.
This indicates that children did not shift their overall ED of the meal by changing their
selection or intake of the individual items to adjust for increases in meal ED.

*Macronutrient intake and composition.* The portion size and energy density of the meals
had significant and independent effects on preschool children’s intake of carbohydrate,
sugar, and fat (all P<0.0001; Table 2.3), but only portion size significantly affected
protein intake (P=0.01). Compared to the 100% portion size conditions, carbohydrate
intake (including sugar) increased by 36%, sugar increased by 42%, fat increased by
19%, and protein increased by 7% when children were served the 200% conditions (all
P<0.0001). Increasing meal ED led to a 32% increase in carbohydrate intake (including
sugar), a 35% increase in sugar intake and a 94% increase in fat intake (all P<0.0001),
but did not affect protein intake (P=0.07).
**Food liking ratings**

Figure 2.2 shows the distribution of food liking ratings for the 93 children who completed this assessment. When all the items were considered together, ordinal logistic regression indicated that there was no significant difference in the distribution of liking ratings between the lower-ED and higher-ED meals (P=0.15); the odds ratio was not significantly different from 1.0 (mean 1.22 [95% confidence interval 0.93-1.60]). Likewise, there were no significant differences in the distribution of liking ratings between the lower-ED and higher-ED versions of the individual foods and milk (all P>0.05). Thus, even though children’s intake of the chicken and macaroni and cheese differed by ED, their liking ratings did not. All the foods and milk were well-liked; children chose “super yummy” or “yummy” ratings in 73% of the assessments for both versions of chicken, 70% for macaroni and cheese, 70% for vegetables, 83% for applesauce, and 76% for milk. Applesauce was the most likely to be rated as “super yummy” and vegetables were the least likely (P=0.02). The children’s liking ratings of the foods did not influence the effects of portion size and ED on intake of the individual foods.
Figure 2.2: Frequency distribution of liking ratings (faces from left to right represent “super yucky,” “yucky,” “just okay,” “yummy,” and “super yummy”) for the lower- and higher-energy dense versions of a meal consisting of chicken, macaroni and cheese, green vegetable, applesauce, and milk. There was no significant difference in distribution of the ratings between the two versions of the meal, according to ordinal repeated measures logistic regression (p=0.15). ED, energy density.
Influence of subject characteristics

Analysis of covariance showed that the relationship between the portion size or ED and meal intake by weight and energy was not influenced by children’s sex, age, height, body weight, BMI-for-age percentile, or BMI z-score. In addition, the relationship between the portion size or ED and meal intake by weight and energy did not differ between the children who completed the liking assessments, participated in the anthropometric measurements, or had parents complete the questionnaires and the children who did not. Most of the subscales of the Child Eating Behaviour Questionnaire (CEBQ), including satiety responsiveness, and the Child Feeding Questionnaire (CFQ) did not influence the relationship between the experimental variables and meal intake; however, a few of the subscales did affect these relationships as described below.

Parental ratings of the children’s food responsiveness (a 5-item subscale on the CEBQ) significantly affected the relationship between portion size and meal intake by weight (Figure 2.3; P<0.01). Children who were rated as being more responsive to external food cues had larger increases in intake when served the 150% and 200% portions of the meal than children who were less responsive. When portion sizes were doubled, children with a food responsiveness score of 1 (frequency of responsive behavior = never) increased their meal intake by a non-significant mean of 29 grams, whereas children with a score of 4 (frequency = often) increased their intake by 124 grams. Thus, although most children had increased intake when served larger portions, children whose parents rated them as the most responsive to food showed an even stronger portion size effect. In addition, ratings of use of parental monitoring on the CFQ significantly affected the relationship between portion size and meal intake;
children with the least parental monitoring did not have increased intake when served the 200% portion compared to the 100% and 150% portions (Appendix L; P<0.02). For the relationship between meal ED and intake, only ratings of child enjoyment of food on the CEBQ significantly affected the relationship (Appendix L; P<0.01); children with highest scores ate more of the lower-ED meal than the higher-ED meal.

Figure 2.3: Effect of parental ratings of child food responsiveness on the relationship between meal portion size and weight of the meal consumed. Scores on the food responsiveness scale indicate the mean frequency of 5 responsive behaviors and range from 1 (never) to 5 (always). Analysis of covariance showed that the slopes of the regression lines for the 150% and 200% portion conditions were significantly greater than the slope for the 100% condition (both P<0.01). Thus, children who were rated as being more responsive to food had larger increases in intake when served the 150% and 200% portions of the meal (compared to the 100% condition) than children who were less responsive.
Discussion

Variations in the portion size and ED of all foods served at a meal in childcare centers had substantial effects on energy intake of preschool children. The weight consumed of the meal was affected by portion size but not by ED; in contrast, energy intake was independently affected by both properties. When meal portion size and ED were increased simultaneously, the two factors combined to increase children’s meal intake by 175 kcal or 79%. Both the lower-ED and higher-ED meals were well accepted, as indicated by the children’s ratings of liking and the consumption of a similar weight of the same portions. These results show that changes in meal portion size and ED have potent effects on children’s energy intake and demonstrate that reductions in ED and portion size can moderate these effects without a loss of acceptability.

The combined effects of portion size and ED on intake of multiple items at a meal have not previously been investigated in preschool children. Two studies varied both these factors in a single dish served to children and found inconsistent effects on consumption (11,12). One study found independent effects of doubling the portion of the main dish while also increasing its ED (11), and the other found no effect of a 25% change in the portion of the main dish but a significant effect of changing the ED (12). The lack of a portion size effect in the latter study may have been due to the modest difference that was tested or because even the smallest portion was overly large for the children (34). The results of the present study indicate that when all foods in a meal are varied, children show little evidence of compensatory adjustment to changes in portion size and ED, and these food properties have independent effects that combine to affect
energy intake. This is of concern because children are often exposed to large portions of multiple higher-ED foods at a meal; in the longer term, such exposure has the potential to promote overconsumption and lead to excess weight gain.

Strategies to moderate the energy intake of preschool children need to address both meal portion size and ED, since these two powerful factors combine to increase intake. The existing data, however, suggest that reducing ED may be the more effective strategy. The present study found that a 42% increase in ED of all foods increased energy intake by 40%. Likewise, within the range of ED tested, researchers generally find that a given percentage change in ED leads to an equivalent percentage change in energy intake of the varied foods (6-8, 35-37). For example, a 27% decrease in the ED of multiple meals served to preschool children reduced energy consumption at those meals by 25%, which was sustained over 2 days (7). In contrast, the relationship between portion size and intake is curvilinear (34, 38); thus, changes in portion size have proportionally smaller effects on intake than changes in ED. A 100% increase in portion size increases intake by substantially less than 100%, ranging from 21% to 53% in controlled studies (39) and averaging 24% in the present study. These results suggest that reducing the ED of foods and beverages would lead to more robust reductions in energy intake than similar percentage reductions in portion size, which may be more noticeable and difficult to implement and maintain (40-43).

Interventions to modify portion size and ED should take into account the individual meal components, which can have differential effects on both energy intake and diet quality. In particular, alterations in main dishes should be a primary target of these strategies, since they usually contribute the largest proportion of meal energy (1, 5,
16, 40, 44). Side dishes, however, also play a role (8, 17, 45-47). In this study, larger portions of applesauce promoted energy intake, but if equally palatable, lower-ED versions were served instead of higher-ED, sweetened versions, fruit intake and nutrient density of the diet could be improved with smaller increases in energy consumption. In the present study, serving larger portions of vegetables did not increase vegetable intake or energy intake. Since vegetables were the least likely food to be rated as “yummy” or “super yummy”, increasing the palatability or preference for the vegetables might improve intake (34, 47). Within a complex meal, serving larger portions of fruit and vegetables can be an effective strategy to increase intake; however, consideration needs to be given to the portions of main dishes, the other options in the meal, and the palatability of the foods (47).

Most of the children’s characteristics, including sex, age, body size, and satiety responsiveness, did not influence the effects of portion size and ED on intake, in contrast to some findings from previous studies (1, 4, 5, 16, 17). This disparity may be due to differences in study design; for example, in studies that found an effect of age, the portion sizes were tailored to different age groups (1, 4), whereas in the present study, the same portions were served to all children. Differences in the distribution of child characteristics may also explain their differential influence across studies. In particular, studies that reported an influence of weight status or satiety responsiveness on the portion size effect had a larger proportion of children who were overweight or obese or of lower-socioeconomic status than the sample in the current study (5, 16, 17). However, similar to a previous study (5), we found that children with higher scores for food responsiveness increased their intake of large portions to a greater extent than children
with lower scores. The comparable findings across studies suggest that responsiveness to food cues may predict the degree of susceptibility to portion size. The present study suggested that low parental monitoring may lead children to be less responsive to very large portions; however, this effect was not consistent in the two larger portion conditions (150% and 200%) and thus the practical implication of this effect is not clear. In addition, individual characteristics have not been found to substantially influence the effect of ED on intake, but future research should explore how children’s enjoyment of food influences their intake of foods that vary in ED (6-8). Despite differences in response, most of the children tested were susceptible to the effects of both portion size and ED, which indicates that recommendations focusing on these factors should be widely disseminated.

A strength of the present study is the large sample of children whose eating behavior was assessed. Previous studies investigating the effects of portion size or ED with a crossover design have included an average of 55 children (1-8, 11-13, 16, 18, 19), and only one study of 172 children (4) had a sample size larger than the present study (120 children). A further strength was that the lunch was served in the children’s usual environment, and included popular, commonly consumed foods that had typical variations in portion size and ED. In addition, the lower-ED and higher-ED versions of the meals were similar in palatability. Thus, the setting and the meal were generalizable to a wide range of children. However, the meal was pre-plated instead of served family style, a typical practice of childcare centers. To further assess the generalizability of the findings, the effects of portion size and ED should be investigated using family style meals. In addition, intake was measured at a single meal and the effect of meal portion
size and ED on later intake was not investigated. Future research should be conducted for longer periods of time on different populations to extend these findings and determine if children adjust for variations in meal portion size and ED at later meals. Previous research suggests the effects of portion size persist up to 24 hours and those of ED up to 2 days (3, 7), but the combination of these factors has not been investigated beyond a single meal in children.

Varying the portion size and ED of multiple items at a meal had a greater effect on energy intake than previously found in studies that manipulated only one of these factors or one food; these changes in all foods led children to consume a sizeable proportion (about 36%) of their estimated daily energy needs at a single meal. This demonstrates that strategically changing portion size and ED of a variety of foods and beverages should be a focus of obesity prevention initiatives at both individual and public levels. In particular, reducing the ED of foods and beverages should be a priority in developing strategies, since modest changes in ED have a large impact on intake and are unlikely to be noticed by most children or adults (6-8, 20, 21, 17).

There are several effective strategies to reduce the ED of meals while maintaining palatability; for example, recipes can be modified by reducing the fat or sugar content or adding water-rich ingredients, including fruits and vegetables (6-8, 37). Another option is choosing palatable lower-ED, commercially available products (such as the unbreaded, grilled chicken pieces and reduced-sugar applesauce used in this study), which may be a more practical strategy for caregivers. With acceptable recipes and products, strategies to reduce ED can be implemented in homes, restaurants, and childcare settings, and can be strategically combined with the beneficial effects of
reductions in portion size, for example by serving larger portions of lower-ED foods with smaller portions of higher-ED foods (48). These strategies to moderate the effects of portion size and ED are practical and effective in reducing energy intake; however, caregivers need clear guidance and acceptable products to implement such strategies and counter these pervasive environmental influences.
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CHAPTER 3

Study 2:

DOES MILK MATTER: IS CHILDREN’S INTAKE AFFECTED BY THE TYPE OR AMOUNT OF MILK SERVED AT A MEAL?

Reprinted from Appetite, 105, Kling SMR, Roe LS, Sanchez CE, Rolls BJ, Does milk matter: Is children’s intake affected by the type or amount of milk served at a meal?, 509-518, 2016 with permission from Elsevier.
Introduction

As an important component of children’s diets, milk provides essential nutrients and is a substantial contributor to the daily energy intake of 2- to 18-year-olds (1,2). One study reported that 2- to 18- year-old children consumed 7% of their daily energy from milk (1). Higher consumption of most types of fluid milk in childhood (3 to 10 years of age) has been found to protect against excess adiposity and obesity later in adolescence (3-5). However, other population-level studies suggest that children who consume higher-energy-dense milk (2% fat or greater) may be at risk for excess energy intake compared to those who consume lower-energy-dense milk (6-10). In response, various organizations, including the Child and Adult Care Feeding Program and the American Academy of Pediatrics, encourage milk consumption, but recommend that children two years and older consume lower-energy-dense milk (skim [0% fat] and low-fat [1% fat] milk) in age-appropriate portions (11-15). Even though these recommendations are widely adopted and milk is a large part of children’s diets, little is known about how changing milk energy density (ED) or portion size influences intake at a meal. To test this, we systematically varied the milk served with a typical meal in preschool children’s usual childcare environment.

Studies have shown that both the ED and portion size of foods can influence preschool children’s energy intake at a meal (16-19), but it is unclear whether variations in milk have a similar effect. Previous controlled studies have focused on chocolate milk because of its increased energy and sugar content; results showed that serving higher-ED chocolate milk substantially increased both milk intake and total energy intake at a meal compared to lower-ED unflavored milk (20-22). Chocolate milk, however, is highly
palatable and is not typically served in childcare centers; whereas, unflavored milk is offered on a daily basis and is available in lower-ED and higher-ED versions that are similar in palatability (23). In a previous study, we found that increasing the ED and portion size of all items in a meal (including unflavored milk) increased the amount of energy consumed from both food and milk (23). Varying the ED and portion size of just the milk at a meal, however, has not been studied and thus the effects on meal energy intake are not known. Examining how the ED and portion size of milk influences intake will further our understanding of how simple changes to foods and beverages can improve children’s diets.

In studies of satiety, preschool children have been shown to compensate for variations in the ED of solid or liquid preloads by adjusting energy intake at a subsequent meal (24-26). Moreover, one study found that serving low-fat milk with breakfast decreased lunch intake compared to serving juice with a similar ED. (27). This suggests that milk may have a greater effect on satiety than that of other beverages of similar ED (27,28). Adjustments of intake in response to changes in food properties can also differ between individuals; for example, males have been shown to be more accurate at compensating for the energy content of liquid preloads than females in both childhood and adulthood (29-32). These preloading studies suggest that preschool children can adjust their intake at a subsequent meal when the properties of a single item are varied; however, the results may not generalize to a satiation paradigm that represents a typical eating context where beverages are served simultaneously with a meal rather than as a preload. In studies of satiety, the delay between the preload and subsequent meal allows sensory and nutrient signals to influence fullness and subsequent intake; whereas, within a meal the sensory
properties may have a larger influence than nutrient signals (33). Thus, the compensatory responses seen in studies of satiety may not be observed in studies of satiation. Since children are frequently served milk with their meals, investigating how increasing milk ED or portion size influences intake within a meal would help determine whether this puts children at risk for overconsumption of energy.

The primary aim of this study was to examine the effects of varying the ED and portion size of unflavored milk served with a meal on preschool children’s milk and food intake. Using a 2-by-2 crossover design, we systematically varied the ED and portion size of milk served with lunch in childcare centers. We hypothesized that increasing the portion size and ED of milk would increase children’s milk intake as well as meal energy intake, consistent with previous research showing that increasing the portion size or ED of a single item at a meal led to higher energy intake (16,18,34). To investigate whether the effects on intake varied by sex, age, or other child characteristics, we tested a larger sample than in previous studies of the effects of beverage portion size or ED on children’s intake (20-22,35-37). Determining how variations in the portion size and ED of nutrient-dense milk affect preschool children’s eating behavior will increase the understanding of environmental factors that influence intake, aiding in the development of practical strategies to counter these effects.

Methods

Experimental design

A within-subjects crossover design was used to evaluate the effect of increasing the ED and portion size of milk on preschool children’s lunch intake. On 1 day a week
for 4 weeks, the experimental meal was served to children in their classrooms at 4 childcare centers. Across the 4 meals, the milk was varied in ED (100% [1%-fat milk] or 142% [3.25%-fat milk]) and portion size (100% or 150%). The 100% milk is also referred to as low-fat or semi-skimmed milk and the 142% milk is also referred to as whole or full-cream milk. The milk was served with an unvaried meal of common foods and children could eat as much or as little of the milk and foods as they wanted. The order of the 4 conditions was counterbalanced across classrooms using Latin squares, and classrooms were randomly assigned one of the condition sequences. Since the children were only served 1 experimental meal per week, they never saw the different milks together. The children’s height, weight, and liking and preference of the lower-ED and higher-ED types of milk were assessed after the final experimental meal.

Participants

Children were recruited by distributing letters to parents with 3- to 6-year-old children enrolled at 4 childcare centers near University Park, PA: the Bennett Family Center, Daybridge Child Development Center, Child Care Center at Hort Woods, and Step by Step School for Early Learning. Parents provided written consent for the participation of their child in the study as well as their own participation in completing questionnaires. Children with an allergy or intolerance to the foods or milk being served were not eligible to participate. Neither parents nor children were informed about the purpose of the study. All procedures were reviewed and approved by The Pennsylvania State University Office for Research Protections. This trial is registered at
ClinicalTrials.gov (Registration Number: NCT02755558) and follows the Consolidated Standards of Reporting Trials (CONSORT) guidelines.

A power analysis was conducted to determine the number of children needed for the study, based on previous research in a similar population with similar foods (19,23,36). A 7.5% (15 kcal) difference in meal energy intake as a result of varying the properties of one item (milk) was considered the minimum difference to be detected. A 15 kcal difference is equivalent to 36 g of the lower-ED milk or 25 g of the higher-ED milk. A power analysis showed that a sample size of 60 children would allow detection of this difference at a significance level of 0.05 and power of 80%. To explore the effect of individual characteristics on the primary outcome, a larger sample size was enrolled.

**Experimental menu and meal procedures**

*Experimental menu.* The experimental meals consisted of the milk and unvaried portions of macaroni and cheese, chicken, broccoli, and bananas, as described in Table 1. Across the meals, the milk was served at 2 levels of ED (lower-ED [0.42 kcal/g; 1% fat] and higher-ED [0.61 kcal/g; 3.25% fat]) and 2 levels of portion size (100% [183 g; 6 fl. oz.] and 150% [275 g; 9 fl. oz.]). The foods in the meal were frequently served by the participating childcare centers and were well-accepted by preschool children in previous studies (19,23,36,38). The participating childcare centers usually serve lower-ED, 1% fat milk. All milks and foods were commercially available. The milk met the minimum serving size requirements of the Child and Adult Care Food Program (12), which are to serve 3- to 5-year-old children at least 6 fl. oz. of milk. Both the 100% and 150% portions of non-compulsory milk were served chilled in the same small, clear plastic container.
with a straw to encourage consumption. To reduce the novelty of the milk container, one week prior to the start of the study, children were served 229 g of reduced-fat milk (2% fat; 0.50 kcal/g) in the container along with the lunch provided by the childcare center. The reduced-fat milk (2%) in a 125% portion size was served to prevent exposure to the experimental manipulations. The portions of the foods in the test meal were based on preschool children’s intake in previous studies (16,19,23,38). The foods in the test meal provided approximately 41% of energy as carbohydrates, 24% as protein, and 35% as fat. The lower-ED milk provided 47% of energy as carbohydrates, 32% as protein, and 21% as fat; the higher-ED milk provided 31% of energy as carbohydrates, 21% as protein, and 48% as fat.
Table 3.1: Amounts of items and composition of meals served to 125 preschool children

<table>
<thead>
<tr>
<th></th>
<th>Lower-energy-dense milk</th>
<th></th>
<th>Higher-energy-dense milk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(100%)</td>
<td>(142%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>100%</td>
<td>150%</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>Milk portion size</td>
<td>Milk portion size</td>
<td>Milk portion size</td>
</tr>
<tr>
<td></td>
<td>(6 fl. oz.)</td>
<td>(9 fl. oz.)</td>
<td>(6 fl. oz.)</td>
</tr>
<tr>
<td></td>
<td>g</td>
<td>kcal</td>
<td>g</td>
</tr>
<tr>
<td>Milk³</td>
<td>183</td>
<td>77</td>
<td>275</td>
</tr>
<tr>
<td>Food</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Macaroni and cheese (1.49 kcal/g)⁴</td>
<td>150</td>
<td>202</td>
<td>150</td>
</tr>
<tr>
<td>Chicken nuggets (1.68 kcal/g)⁵</td>
<td>120</td>
<td>223</td>
<td>120</td>
</tr>
<tr>
<td>Broccoli (0.57 kcal/g)⁶</td>
<td>80</td>
<td>46</td>
<td>80</td>
</tr>
<tr>
<td>Bananas (0.89 kcal/g)⁷</td>
<td>80</td>
<td>71</td>
<td>80</td>
</tr>
<tr>
<td><strong>Total meal</strong></td>
<td><strong>613</strong></td>
<td><strong>619</strong></td>
<td><strong>705</strong></td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>64.8</td>
<td>259</td>
<td>69.5</td>
</tr>
<tr>
<td>Protein</td>
<td>39.0</td>
<td>156</td>
<td>42.1</td>
</tr>
<tr>
<td>Fat</td>
<td>22.7</td>
<td>204</td>
<td>23.5</td>
</tr>
</tbody>
</table>

¹1% fat; 0.42 kcal/g  
²3.25% fat; 0.61 kcal/g  
³Giant Food Stores Milk, Foodhold U.S.A LLC, Landover, MD, USA.  
⁴Stouffer’s Macaroni and Cheese, Nestle U.S.A. Inc., Solon OH, USA.  
⁵Gluten Free Breaded Chicken Breast Nuggets, Bell & Evans, Fredericksburg, PA, USA.  
⁷Chiquita Brands LLC, Charlotte, NC, USA.
Meal procedures. Children were served the meal in their classrooms in the childcare centers and at their regularly scheduled lunchtime, and consumed as much or as little as they wanted of the milk and foods. Children ate at tables with three to six children and one adult, which is standard practice at the childcare centers; the adults were teachers who did not know the purpose of the study. The foods and milk were pre-portioned into dishware and set at each child’s place at the table just before the children were seated, which differed from the usual family-style service at the childcare centers. Before the first experimental meal, researchers explained to the children that they could eat as much or as little as they wanted, but could not request more of any food or milk. During each meal, adults at the tables were instructed to redirect conversations about food-related topics to minimize peer influence on children’s intake. After all children had finished lunch, researchers returned any dropped foods to the correct plate or bowl and recovered any spilled milk with paper towels. To determine the amount consumed, all foods and the milk were weighed before and after the meal in a separate room out of the children’s view. Weights of food and milk were recorded to the nearest 0.1 g using digital scales (Mettler-Toledo PR5001 and XS4001S; Mettler-Toledo, Columbus, OH). Energy and macronutrient intakes were calculated using information from food manufacturers and a standard food composition database (39). Children who did not participate in the study sat at tables out of participating children’s view and were served the scheduled lunch menu of the childcare center.
Assessments

Food liking and preference assessments. Liking and preference for the milks was assessed during an individual session with each child using a 5-point cartoon face scale (Figure 3.1) based on a 3-point version used in previous research (40). The child was seated at a table with the 5 cartoon faces and was instructed on using them to indicate whether a food was “super yummy,” “yummy,” “just okay,” “yucky,” or “super yucky.” After instruction, samples of the two types of milk were presented to the child one at a time; foods served in the test meal were not assessed since the foods were not varied across experimental conditions. The order of presenting the samples of the two milks was randomly assigned. The child was asked to taste the milk and indicate his or her liking for it by pointing to the appropriate cartoon face. After the child rated both milks, the child was asked to “point to the milk you like the very best” to indicate his or her preference between the two types of milk (40). Children’s liking for the milks was assessed within 2 weeks after the final experimental meal. Food liking assessments were completed by 107 (86%) of the children; the remaining children were absent or declined to participate.

Figure 3.1. Five-point cartoon face scale used to rate liking for the milks (faces from left to right represent “super yucky,” “yucky,” “just okay,” “yummy,” and “super yummy”).
Body weight and height. Body weight was measured to the nearest 0.1 kg using a portable digital scale (Seca Onda model 843; Seca Corporation, Hanover, MD). Height was measured in duplicate to the nearest 0.1 cm using a portable stadiometer (model 214; Seca Corporation, Hanover, MD). Body weight and height were used to calculate body size parameters (sex-specific BMI-for age-percentiles and z-scores) using a software program based on nationally representative data (41). Children’s weight and height were assessed within 2 weeks after the final test meal. One hundred and fifteen children (92%) completed the assessments for height and weight; the remaining children were absent or declined to participate.

Parental questionnaires. Parents were asked to complete 4 questionnaires about parent and child characteristics and behaviors related to the eating environment. The 35-item Child Eating Behaviour Questionnaire (CEBQ) evaluates 8 subscales that relate to eating styles and behaviors of the child (42). The 31-item Child Feeding Questionnaire (CFQ) assesses 7 subscales that measure feeding practices and perceived weight concerns (43). For these CFQ and CEBQ subscales, the parent rated each item on a 5-point scale; for analyses, a mean score was calculated across all the items in a given subscale. The 56-item food frequency questionnaire assessed the availability and frequency of parent and child consumption of various beverages at home. The 16-item demographic questionnaire assessed family demographics and child health. Parents of 113 children (90%) completed the 4 questionnaires.
**Statistical analysis**

Data analyses were conducted using a mixed linear model with repeated measures in SAS statistical software (SAS Institute, Inc., Cary, NC). The primary outcomes evaluated by the model were intake of milk by weight (g) and energy (kcal), intake of food at the meal by weight (g) and energy (kcal), and total meal intake (food + milk) by weight (g) and energy (kcal). The fixed factors in the model were milk portion size (100% and 150%), milk ED (100% and 142%), study week, and classroom. The interaction between portion size and ED was tested and then removed from the model if not significant. Participants were treated as a random factor. For outcomes with significant effects, the Tukey-Kramer method was used to adjust significance levels for multiple pairwise comparisons between means. It was pre-determined that children’s data would be excluded if at 2 or more of the 4 experimental meals they were absent or consumed less than 20 g of milk (approximately 10% of the smallest portion). In addition, using the procedure described by Littell et al., the data were examined for individual children whose intake was influential on the main outcomes in the mixed model, but no children met the criteria (44).

Analysis of covariance with a mixed linear model was used to assess the influence of continuous participant characteristics, (age, body weight, height, BMI-for-age percentile, BMI z-score, CFQ subscales, CEBQ subscales, and milk availability and consumption at home) on the relationship between the experimental factors and intake. Categorical subject characteristics (sex and ratings of liking for the milk) were tested as factors in the models. All participant characteristics were tested in one model, and then removed from the model if not significant. Ordinal repeated measures logistic regression
was used to compare the lower-ED and higher-ED milks for differences in the
distribution of children’s liking ratings (from “super yummy” to “super yucky”); results
are reported as odds ratios with 95% confidence levels. T-tests were used to evaluate
differences between boys and girls in age, body weight, height, BMI percentile, and BMI
z-score. A chi-square test was used to determine whether there were differences in the
proportion of boys and girls who consumed all of their milk. Data are reported as means
± standard errors, and results were considered significant at P<0.05.

Results

Subject characteristics

A total of 143 children from 10 classrooms at the 4 childcare centers were
enrolled in the study. Eight children (6%) were excluded from the analysis because they
were absent for 2 or more of the 4 experimental meals. An additional 10 children (7%)
were excluded from the analysis because of failure to meet the predetermined criterion of
minimum milk intake (less than 20 g at 2 or more of the 4 experimental meals). Thus,
intake data were analyzed for 125 children (67 boys and 58 girls; Table 2). The children
had a mean (± SEM) age of 4.2 ± 0.1 years (range: 3.1-6.0 years) and mean sex- and age-
specific percentile for BMI of 53.6 ± 2.4 (range: 0.0-97.8). Eight children (8%) were
classified as overweight or obese (45). The sample of children was 75% white, 15%
Asian, 3% black or African American, and 7% of mixed or another race; 8% were of
Hispanic or Latino origin. Based on the 112 parents (90%) who provided family
information, household incomes and education levels were above average: 72% of
households had an annual income above $50,000 and 92% of mothers and 86% of fathers
had a Bachelor’s degree or higher. According to parental report, 8% of children consumed only 0%-fat milk at home on a daily basis, 16% consumed 1%-fat milk, 25% consumed 2%-fat milk, 12% consumed 3.25%-fat milk, and 19% consumed multiple types of milk. Lastly, 20% of children did not consume these types of milk at home.
Table 3.2: Characteristics of 125 preschool children in a study of the effects of varying milk energy density and portion size on meal intake

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Boys (n=67)</th>
<th></th>
<th>Girls (n=58)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Mean ± SEM</td>
<td>Range</td>
<td>n</td>
</tr>
<tr>
<td>Age (y)</td>
<td>67</td>
<td>4.2±0.1</td>
<td>3.1–6.0</td>
<td>57</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>57</td>
<td>17.9±0.3</td>
<td>13.4–22.8</td>
<td>58</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>57</td>
<td>106.0±0.8</td>
<td>92.5–118.3</td>
<td>58</td>
</tr>
<tr>
<td>BMI z-score</td>
<td>57</td>
<td>0.12±0.13</td>
<td>-2.52–2.02</td>
<td>57</td>
</tr>
<tr>
<td>BMI-for-age percentile</td>
<td>57</td>
<td>54.8±3.6</td>
<td>0.6–97.8</td>
<td>57</td>
</tr>
</tbody>
</table>

¹The mean for girls was not significantly different from the mean for boys for any of the variables according to a T-test (all P>0.33)
²Body weight and height were used to calculate body size parameters (BMI z-scores and sex-specific BMI-for age-percentiles) using a software program based on nationally representative data (40).
**Intakes by weight and energy**

*Milk intake by weight and energy.* There was an effect of milk portion size ($F_{(1,256)}=60.77, P<0.0001$) but not ED ($F_{(1,296)}=0.16, P=0.69$) on the weight of milk consumed ([Figure 3.2A](#)). Compared to the 100% milk portion conditions, milk intake was $38 \pm 5 \text{ g} (1.25 \pm 0.2 \text{ fl. oz.}; 26\%)$ greater in the 150% conditions ($F_{(1,256)}=60.77, P<0.0001$; Table 3). A similar weight was consumed of the lower-ED and higher-ED milk ($F_{(1,296)}=0.16, P=0.69$). Since portion size but not ED affected the weight of milk consumed, there were independent effects of milk portion size ($F_{(1,348)}=64.55, P<0.0001$) and ED ($F_{(1,348)}=158.94, P<0.0001$) on energy consumed from milk ([Figure 3.2B](#)). Compared to the 100% milk portion conditions, energy intake from milk was $20 \pm 3 \text{ kcal} (27\%)$ greater when children were served the 150% conditions ($F_{(1,348)}=64.55, P<0.0001$). A 42% increase in milk ED led to a $31 \pm 2 \text{ kcal}$ or 44% increase in energy consumed from milk ($F_{(1,348)}=158.94, P<0.0001$). The effects of milk portion size and ED combined to increase energy intake from milk by $49 \pm 4 \text{ kcal}$ or 63% ($t(348)=-14.81, P<0.0001$) when children were served the 150% portion of the higher-ED milk compared with the 100% portion of the lower-ED milk.
**Figure 3.2:** Mean (±SEM) milk intake (g and kcal) at lunch by milk portion size and energy density (ED) in 125 preschool children. **Figure 3.2A:** There was a significant effect of portion size (P<0.0001) but not energy density (P=0.69) on milk intake by weight. Across the lower-ED and higher-ED milks, intake was significantly greater when children were served the 150% portion size conditions compared to the 100% conditions (P<0.0001). **Figure 3.2B:** There were significant and independent effects of portion size and energy density (both P<0.0001) on milk energy intake. Across the lower-ED and higher-ED milks, milk energy intake was significantly greater when children were served the 150% portion size conditions compared to the 100% conditions. Across portion size conditions, serving the higher-ED milk led to an increase in energy intake from milk (P<0.0001). The effects of portion size and energy density combined to increase meal energy intake by 63% or 49 ± 4 kcal when the children were served the higher-ED meal with the largest portions compared to the lower-ED meal with the smallest portions.
Table 3.3: Intake of 125 preschool children in a study of the effects of varying milk energy density and portion size on meal intake

<table>
<thead>
<tr>
<th></th>
<th>Lower-energy-dense milk</th>
<th></th>
<th>Higher-energy-dense milk</th>
<th></th>
<th>Significant effects$^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100% Portion Size (n=120)</td>
<td>150% Portion Size (n=118)</td>
<td>100% Portion Size (n=116)</td>
<td>150% Portion Size (n=119)</td>
<td></td>
</tr>
<tr>
<td>Total meal intake (g)</td>
<td>349±8</td>
<td>388±10</td>
<td>333±8</td>
<td>358±10</td>
<td>PS, ED$^3$</td>
</tr>
<tr>
<td>Milk (g)</td>
<td>149±4</td>
<td>187±8</td>
<td>147±4</td>
<td>185±7</td>
<td>PS$^4$</td>
</tr>
<tr>
<td>Food intake (g)</td>
<td>200±6</td>
<td>200±7</td>
<td>186±7</td>
<td>173±7</td>
<td>ED$^5$</td>
</tr>
<tr>
<td>Chicken (g)</td>
<td>50±4</td>
<td>47±4</td>
<td>44±4</td>
<td>41±3</td>
<td></td>
</tr>
<tr>
<td>Macaroni and cheese</td>
<td>82±5</td>
<td>84±5</td>
<td>76±5</td>
<td>75±5</td>
<td></td>
</tr>
<tr>
<td>Broccoli (g)</td>
<td>22±2</td>
<td>23±2</td>
<td>24±3</td>
<td>22±3</td>
<td></td>
</tr>
<tr>
<td>Bananas (g)</td>
<td>46±3</td>
<td>47±3</td>
<td>43±3</td>
<td>34±3</td>
<td></td>
</tr>
<tr>
<td>Total meal energy intake (kcal)</td>
<td>322±8</td>
<td>337±10</td>
<td>328±9</td>
<td>337±10</td>
<td>--$^6$</td>
</tr>
<tr>
<td>Milk (kcal)</td>
<td>63±2</td>
<td>79±3</td>
<td>90±3</td>
<td>113±4</td>
<td>PS, ED</td>
</tr>
<tr>
<td>Food intake (kcal)</td>
<td>260±8</td>
<td>259±9</td>
<td>238±9</td>
<td>224±9</td>
<td>ED</td>
</tr>
<tr>
<td>Chicken (kcal)</td>
<td>84±6</td>
<td>79±6</td>
<td>74±6</td>
<td>69±6</td>
<td></td>
</tr>
<tr>
<td>Macaroni and cheese</td>
<td>122±8</td>
<td>125±8</td>
<td>113±8</td>
<td>112±8</td>
<td></td>
</tr>
<tr>
<td>Broccoli (kcal)</td>
<td>13±1</td>
<td>13±1</td>
<td>13±2</td>
<td>13±1</td>
<td></td>
</tr>
<tr>
<td>Banana (kcal)</td>
<td>41±3</td>
<td>41±3</td>
<td>38±3</td>
<td>31±3</td>
<td></td>
</tr>
<tr>
<td>Energy density of food (kcal/g)</td>
<td>1.31±0.02</td>
<td>1.29±0.02</td>
<td>1.29±0.02</td>
<td>1.30±0.02</td>
<td>--</td>
</tr>
<tr>
<td>Energy density of food and milk (kcal/g)</td>
<td>0.92±0.01</td>
<td>0.88±0.02</td>
<td>0.98±0.01</td>
<td>0.94±0.01</td>
<td>PS, ED</td>
</tr>
<tr>
<td>Carbohydrate intake (g)</td>
<td>36.4±1.0</td>
<td>38.5±1.1</td>
<td>33.8±1.1</td>
<td>33.2±1.0</td>
<td>ED</td>
</tr>
<tr>
<td>Protein intake (g)</td>
<td>20.2±0.6</td>
<td>21.2±0.7</td>
<td>18.3±0.6</td>
<td>18.8±0.6</td>
<td>ED</td>
</tr>
<tr>
<td>Fat intake (g)</td>
<td>11.5±0.4</td>
<td>11.9±0.4</td>
<td>14.0±0.4</td>
<td>15.0±0.5</td>
<td>PS, ED</td>
</tr>
</tbody>
</table>

$^1$All values are mean ± SEM

$^2$Mixed linear models were used to test the effects of milk portion size and energy density on all outcomes. Results were considered significant at P<0.05.
PS, ED, There were significant independent effects of milk portion size (all $P<0.04$) and energy density (all $P<0.003$) on the outcome.

PS, There was a significant independent effect of milk portion size (all $P<0.0001$) on the outcome.

ED, There was a significant independent effect of milk energy density (all $P<0.0001$) on the outcome.

--, There were no significant effects of milk portion size or energy density on the outcome.
Food intake by weight and energy. There was an effect of milk ED ($F_{(1,323)}=19.92$, $P<0.0001$) but not milk portion size ($F_{(1,323)}=3.16$, $P=0.07$) on the weight of food consumed from the test meal. A similar weight of food was consumed when the children were served the 100% and 150% portions of milk ($F_{(1,323)}=3.16$, $P=0.07$, Table 3). None of children consumed all of the food at any meal (i.e., within 20 g of the amount served). Across all children, serving higher-ED milk led to a $19 \pm 5$ g or 9% reduction in the weight of food consumed compared to when the lower-ED milk was served ($F_{(1,323)}=19.92$, $P<0.0001$). Correspondingly, there was an effect of milk ED ($F_{(1,323)}=22.93$, $P<0.0001$) but not portion size ($F_{(1,322)}=2.74$, $P=0.10$) on energy consumed from food (Figure 3.3A). When the 100% and 150% portions were served, a comparable amount of energy was consumed from food ($F_{(1,322)}=2.74$, $P=0.10$). Serving higher-ED milk led to a $26\pm6$ kcal or 10% reduction in energy intake from food compared to serving lower-ED milk ($F_{(1,323)}=22.93$, $P<0.0001$).

Total meal intake by weight and energy. There was an effect of both milk portion size ($F_{(1,343)}=24.44$, $P<0.0001$) and ED ($F_{(1,343)}=11.41$, $P=0.0008$) on total meal intake by weight. Compared to the 100% milk portion conditions, total meal intake (food + milk) was 9% (30 $\pm$ 7 g) greater in the 150% conditions ($F_{(1,343)}=24.44$, $P<0.0001$; Table 3). Serving higher-ED milk led to a $21\pm6$ g or 6% reduction in total intake by weight compared to when lower-ED milk was served ($F_{(1,343)}=11.41$, $P=0.0008$). However, there was no effect of milk portion size ($F_{(1,314)}=2.88$, $P=0.10$) or ED ($F_{(1,315)}=0.44$, $P=0.51$) on total energy intake at the meal (Figure 3.3B). Total energy intake did not differ between the meals with 100% and 150% milk portion sizes ($F_{(1,314)}=2.88$, $P=0.10$) or meals with
the lower-ED and higher-ED milks ($F_{(1,315)}=0.44$, $P=0.51$). Therefore, across all children, varying milk portion size or ED did not affect total energy intake at a meal.
**Figure 3.3**: Mean (±SEM) food energy intake and total meal energy intake at lunch by milk portion size and energy density (ED) in 125 preschool children. **Figure 3.3A**: There was a significant effect of energy density (P<0.0001) but not portion size (P=0.10) on food energy intake. Across portion size conditions, increasing milk ED led to a 26±6 kcal or 10% reduction in energy consumed from food (P<0.0001). The data were analyzed with a mixed linear model with repeated measures and a Tukey-Kramer adjustment for multiple pairwise comparisons of the means. **Figure 3.3B**: There was no significant effect of milk portion size (P=0.10) or ED (P=0.51) on total energy intake at the meal.
Meal macronutrient intake and energy density. Serving higher-ED milk led to 2.9 ± 0.3 g increase in fat intake ($F_{(1,308)}=120.67$, $P<0.0001$), while carbohydrate intake decreased by 3.8 ± 0.8 g ($F_{(1,329)}=30.33$, $P<0.0001$) and protein intake decreased by 2.0 ± 0.4 g ($F_{(1,327)}=26.20$, $P<0.0001$), compared to serving lower-ED milk. Increasing milk portion size only affected fat intake, which was 0.6 ± 0.3 g higher in the 150% portion conditions than 100% conditions ($F_{(1,332)}=5.20$, $P=0.02$). The ED of the total meal was increased by serving the higher-ED milk ($F_{(1,347)}=34.50$, $P<0.0001$; Table 3), but was decreased by serving the larger portion of milk ($F_{(1,346)}=18.33$, $P<0.0001$).

Milk liking and preference ratings

The results of the liking and preference assessments indicate that the children rated the two types of milk similarly. There was no difference in the distribution of liking ratings between the lower-ED and higher-ED milk; the odds ratio was not different from 1 ($P=0.32; 1.30; 95\%$ confidence interval $0.78 – 2.18$). Both types of milk were well-liked; children chose “super yummy” or “yummy” ratings in 79% of the assessments of both the lower-ED and higher-ED milk. There was no difference between boys and girls in the distribution of liking ratings of the milk ($P=0.85;$ odds ratio $0.18; 95\%$ confidence interval $0.68 – 1.38$). The children’s liking ratings of the milk did not influence the effects of milk portion size and ED on intake of milk, food, or total meal by weight or energy (all $P\geq0.26$).

Results were similar for children’s reported preference for the milk. There was no difference in the distribution of the preference rankings between the lower-ED and higher-ED milk ($P=0.69;$ odds ratio $0.85; 95\%$ confidence interval $0.39 – 1.87$). The
lower-ED milk was preferred by 52% of children and the higher-ED milk by 48% of children. There was no difference between boys and girls in the distribution of preference rankings (P=0.53; odds ratio 0.18; 95% confidence interval 0.59 – 1.31). In addition, the children’s preference rankings of the milk did not influence the effects of milk portion size and ED on intake of milk, food, or the total meal by weight or energy (all P≥0.18).

**Influence of subject characteristics**

As shown in Table 4, the children’s sex differentially influenced the effect of milk ED on the weight and energy consumed from food (F(1,323)=12.03, P=0.0006; F(1,324)=15.86; P<0.0001) and the total meal (F(1,344)=5.98, P=0.02; F(1,315)=8.66, P=0.004). When the higher-ED milk was served rather than the lower-ED milk, boys showed a compensatory reduction in food intake of 43 ± 8 kcal (16%; F(1,186)=41.46, P<0.0001), whereas for girls, food intake was not affected by milk ED (F(1,159)=0.74, P=0.39). Thus, when the energy content of the milk was included, boys’ total energy intake at the meal did not differ by milk ED (F(1,186)=3.34, P=0.07), similar to the finding for the entire sample; for girls, however, serving higher-ED milk led to a modest increase in meal energy intake of 24 ± 10 kcal (7%; F(1,158)=5.31, P=0.03). There was no influence of the children’s sex on the relationship between milk portion size and intake of food or the total meal by weight or energy (all P>0.20).
Table 3.4. Intake by sex, energy density, and portion size in a study of the effects of varying milk energy density and portion size on the weight and energy consumed from a meal served to 125 preschool children

<table>
<thead>
<tr>
<th></th>
<th>Boys (n=67)</th>
<th>Girls (n=58)</th>
<th>Significance of interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lower-energy-dense milk</td>
<td>Higher-energy-dense milk</td>
<td>Lower-energy-dense milk</td>
</tr>
<tr>
<td></td>
<td>100% Portion Size</td>
<td>150% Portion Size</td>
<td>100% Portion Size</td>
</tr>
<tr>
<td>Total meal intake (g)</td>
<td>352±11</td>
<td>384±14</td>
<td>322±12</td>
</tr>
<tr>
<td>Milk intake (g)</td>
<td>156±6</td>
<td>183±10</td>
<td>155±5</td>
</tr>
<tr>
<td>Food intake (g)</td>
<td>197±9</td>
<td>201±10</td>
<td>167±10</td>
</tr>
<tr>
<td>Total meal energy intake (kcal)</td>
<td>320±13</td>
<td>338±14</td>
<td>312±14</td>
</tr>
<tr>
<td>Milk energy intake (kcal)</td>
<td>65±2</td>
<td>77±4</td>
<td>94±3</td>
</tr>
<tr>
<td>Food energy intake (kcal)</td>
<td>255±12</td>
<td>261±14</td>
<td>218±13</td>
</tr>
</tbody>
</table>

¹All values are mean ± SEM

²NS, non-significant (P<0.05)
Analysis of covariance showed that the relationship between the experimental factors (portion size and ED) and outcomes (milk intake, food intake, and total meal intake all by weight and energy) was not influenced by children’s age, height, weight, sex-specific BMI-for-age percentile, BMI z-score, the 8 subscales of the Child Eating Behaviour Questionnaire (CEBQ), the 7 subscales of the Child Feeding Questionnaire (CFQ), and milk intake and availability at home as assessed by a food frequency questionnaire. In addition, the relationship between the portion size or ED and the outcomes (milk intake, food intake, and total meal intake all by weight and energy) did not differ between the children who completed the liking assessments, participated in anthropometric measurements, or had parents who submitted the questionnaires and the children who did not.

Discussion

Variations in the energy density and portion size of milk had significant effects on preschool children’s milk intake at a meal. Energy intake from milk was independently affected by both milk portion size and ED; when these two properties were increased simultaneously, they combined to increase milk intake by 49 ± 4 kcal or 63%. Serving meals with higher-ED milk decreased overall food intake compared to serving lower-ED milk, and total meal energy intake was not influenced by either milk ED or portion size across all children. However, this response varied by sex; for boys, serving higher-ED milk decreased food energy intake, but did not affect total energy intake compared to serving lower-ED milk. In contrast, for girls, higher-ED milk did not lead to a compensatory reduction in food intake and additional energy was consumed at the meal.
Both the lower-ED and higher-ED types of milk were well accepted, as indicated by children’s ratings of liking and the consumption of a similar weight of milk when served the same portions. These results show that larger portions of milk can be served to increase intake of this nutrient-dense beverage, but the influence of milk ED on intake differs between boys and girls.

Both ED and portion size have robust effects on children’s food intake (16,18,19); however, the few studies that investigated the combination of these factors focused on foods, not beverages, and reported inconsistent effects on intake (16,23,34,38). Two studies found that the effects of increasing the ED and doubling the portion of a main dish or meal were independent and thus combined to influence intake (23,34). In comparison, the other study found a significant effect of varying ED but no effect of decreasing the portion of the main dish by 25% (38). The non-significant portion size effect in the latter study may have been due to the modest difference between the portions or because the smallest portion was overly large for the children (38). In the present study, increasing milk ED and portion size had robust, independent effects that combined to increase the amount of energy consumed from milk. These results along with previous research indicate that ED and portion size can have consistent and substantial effects on children’s intake, which is of concern since large portions of energy-dense foods and beverages are readily available and could lead to overconsumption and weight gain.

Young children have been found to respond to variations in ED of a preload by altering their intake at a subsequent meal (24-26). A similar response was seen in the present study; children consumed less food when higher-ED milk was included with the meal than when lower-ED milk was served. This suggests that higher-ED milk promotes
greater satiety than lower-ED milk. Even though the higher-ED and lower-ED milks were not rated differently in liking and preference, the children may have responded to differences in sensory properties such as viscosity or creaminess (46,47), which have been shown to influence satiety and fullness (33,48,49). Sensory characteristics may play a more critical role in studies of satiation, such as the present one, than in studies of satiety (33). Alternatively, the differential response to the lower-ED and higher-ED types of milk may be explained by other mechanisms, such as differences in gastric distension and associated physiological responses of appetite-regulating hormones (50). For example, a recent study showed that both the energy density and viscosity of a dairy-based shake influenced gastric emptying (33). The present study is the first to demonstrate that children adjust their intake to account for variations in milk ED within a meal; thus, determining the mechanisms behind this response, such as sensory properties, warrants future research.

Previous research has demonstrated that children’s adjustment of energy intake in response to differences in the ED of a food or beverage can vary by individual characteristics. Some studies suggest that such compensation diminishes from 5 to 12 years of age (26,51) and is reduced in children with higher body weight or adiposity (31,52-54). The accuracy of children’s compensatory response has also been related to child eating behaviors such as satiety responsiveness as well as parental practices such as controlling feeding and use of food as reward (26,42,55). The present study, in comparison, found no influence of child age, weight, BMI, child eating behaviors, or parental practices on the effect of milk ED on intake of milk, food, or the entire meal. Discrepancies in the results of these studies may be primarily due to research design and
sample characteristics; for example, previous studies used a preloading paradigm in which the varied item was served before the test meal (26,31,42,51-54), whereas in the present study, the varied milk and test meal were served simultaneously. One characteristic that has been found to influence the adjustment of food intake both in the present study and in some previous preloading studies in children and adults is the sex of the individual (29-32). Compared to females, males tend to have a more accurate compensatory response to variations in the ED of foods or beverages (29-32), as was found in the present study. Even though multiple studies have reported that males are better than females at adjusting intake for variations in ED, the mechanisms driving this effect have not been elucidated.

The weaker intake regulation of girls compared to boys in response to ED changes may be related to differential parental behaviors or social expectations. One study found that preschool daughters of mothers with restrained or disinhibited eating patterns showed poorer compensation for preload energy than did sons of the same mothers (31). This finding indicates that eating behaviors modeled by parents may influence children’s compensatory response, and suggests a potential explanation for the sex difference found in the present study. Other behaviors that are not captured by food-specific questionnaires may also explain differences in eating patterns. For example, young girls tend to be compliant to rules and have higher self-control (56,57), and thus may be more likely to stay focused on the meal and sit at a table longer than boys. Such characteristics could lead girls to regulate intake more on the basis of environmental feedback (e.g., praise for quietly sitting and eating) than on internal cues of hunger and fullness. Further investigation of the sex differences in intake regulation of preschool children could lead
to the identification of specific parent or child behaviors that could be addressed in efforts
to prevent childhood obesity.

In contrast to the effect of ED, increasing the portion size of milk by 50% did not lead
to a large enough increase in milk energy intake to substantially influence food or total
energy intake at a meal. Therefore, caregivers in childcare centers have the option of
serving larger portions of milk to promote intake of this important component of
children’s diets without leading to excess energy intake; however, lower-ED types of
milk, such as low-fat (1% milk), should be offered since girls have been shown to
consume more total energy from a meal when offered higher-ED milk. This practice
could help children meet the daily recommendation for milk intake (2,58); if a child
receives milk three times a day, as is typical in childcare centers, the effect of increasing
the portion size of milk from 6 to 9 fl. oz. could increase dairy intake by more than one-
half serving per day. Since milk is a major component of children’s diets, the additional
energy consumed from larger portions of milk might accumulate over time and promote a
positive energy balance and weight gain, and this possibility should be tested in future
research. However, serving milk in larger portions promotes intake of this nutrient-dense
beverage at a single eating occasion.

A strength of the present study is the large sample of children whose eating behavior
was assessed. Only one of the previous studies investigating the effects of beverage
portion size or ED with a crossover design included a sample of the same magnitude as
the present study (20-22,37). A further strength was that the lunch was served in the
children’s usual environment, and the variations in milk ED and portion size represented
what is commonly served to children. Thus, the setting and the meal were generalizable
to a wide range of children. However, the meal was pre-plated instead of served family style, as was usual in the child care centers, which may have influenced intake (59). In addition, intake was measured at a single meal and the effect of milk ED and portion size on intake later in the day was not investigated. Epidemiological research suggests that over the longer term, larger portions and higher-ED types of milk could promote energy intake (8-10,28) but experimental studies in children have not systematically investigated this beyond a single meal. Future research should be conducted for longer periods of time with more diverse populations and different types of milk to determine how variations in milk ED and portion size influence short- and long-term intake.

Since milk is a substantial and important component of preschool children’s diet (1,2), evidence-based recommendations about the type and amount of milk that preschool children should be offered are of considerable interest. The results of the present study support current advice that lower-ED, 1%-fat milk should be served in preschool settings (12). While we found that children, on average, compensated for the additional energy consumed from higher-ED milk, some children, especially girls, consumed more total energy at the meal when served the higher-ED milk rather than lower-ED milk. The findings also showed that providing larger portions of milk promoted intake of this nutrient-dense beverage without affecting energy intake at the meal. This strategy can be easily adapted by caregivers to help children meet recommendations for dairy intake. Further understanding of how the portion size and ED of the milk offered to children influence their long-term intake will help to ensure that the type and amount offered of this nutrient-rich beverage is optimal for children’s diets.
References


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CHAPTER 4

CONCLUSIONS
Summary of Findings

The objective of the studies described in this dissertation was to further investigate the independent and combined effects of portion size and energy density (ED; kcal/g) on preschool children’s intake of a meal and milk. Secondarily, the two studies also examined how individual characteristics influence children’s response to changes in the portion size or ED of foods and milk. These studies extend the existing research by investigating how these environmental factors influence children’s consumption of a commonly consumed meal and milk.

Study 1

Study 1 examined the effect of increasing the portion size and ED of a multiple-component meal on preschool children’s intake. All items at the meal were served at 3 levels of portion size (100%, 150%, or 200%) and 2 levels of ED (100% or 142%). The meal included lower-ED or higher-ED versions of chicken, macaroni and cheese, vegetables (broccoli or peas), applesauce, ketchup, and milk; all foods were consumed ad libitum. Serving larger portions significantly increased meal intake by weight and energy. Varying ED did not affect the total weight of food consumed, but total energy intake increased when the higher-ED meal was served compared to the lower-ED meal. Since the effects of portion size and ED were independent, these factors combined to increase intake by a substantial 175 ± 12 kcal or 79% at the higher-ED meal with the largest portions compared to the lower-ED meal with the smallest portions. Thus, varying the portion size and ED of an entire meal substantially influenced children’s intake.
The effects of portion size and ED on intake differed between the individual foods at the meal. Increasing meal portion size led to higher intake of pasta, applesauce, ketchup, and milk, but had no effect on intake of chicken or vegetables. Children ate equivalent weights of the lower- and higher-ED versions of vegetables, applesauce, milk, and ketchup; but, intake of chicken and macaroni and cheese differed significantly by ED. However, more energy was consumed from the higher-ED versions than the lower-ED versions of all the individual foods. These results indicate that the effect of changing the portion size or ED of an entire meal influences intake of each of the menu items differently.

Individual characteristics also affected the relationship between portion size or ED on total meal intake. Children who were reported to be more responsive to food or more frequently monitored consumed more when the larger portions of the meal were served compared to children who had lower scores on these subscales. In addition, children who enjoyed food and eating more consumed a greater amount of the lower-ED meal than the higher-ED meal. These results suggest that child eating behaviors or parental feeding practices could influence children’s response to variations in portion size or ED.

**Study 2**

Study 2 investigated the effect of changing the portion size and ED of milk on preschool children’s intake at a lunch meal. Milk was served at 2 levels of portion size (100% or 150%) and 2 levels of ED (100% or 142%). The foods in the meal were not varied. Serving the larger portion of milk increased the weight and energy consumed
from milk compared to serving the smaller portion. Milk intake by weight did not differ between the two types of milk, but children consumed more energy from the higher-ED milk than the lower-ED. The effects of increasing the portion size and ED of milk combined to increase milk intake from $63 \pm 2$ kcal to $113 \pm 4$ kcal or by 63% ($49 \pm 4$ kcal). Milk portion size had no effect on food intake or total meal intake, but serving higher-ED milk decreased food energy intake compared to serving lower-ED milk. Thus, across all children, the change in milk ED did not influence total energy intake at the meal. Varying the milk portion size and ED had substantial effects on milk intake, but had limited influence on total intake at the meal.

The effects of milk portion size and ED were not influenced by most child characteristics; however, the effect of milk ED on intake did differ significantly by sex. For boys, serving higher-ED milk decreased food energy intake and did not affect total energy intake compared to serving lower-ED milk. For girls, consuming more energy from the higher-ED milk did not lead to a significant compensatory reduction in food energy intake and an additional energy was consumed over the entire meal. Therefore, boys, but not girls, adjusted their food intake in response to changes in ED of milk consumed with the meal.

The results of these two studies support the prior research showing that variations in the portion size and energy density of foods and beverages have robust independent effects that combine to influence preschool children’s eating behavior. Both Study 1 and 2 demonstrated that increasing portion size and ED promotes higher energy intake from the manipulated item, but the context of the rest of the meal may determine whether these factors influence total energy intake at a single meal. This research has several
implications related to how children’s responses to these factors differ between individual foods and by child characteristics. Even though some child characteristics related to children’s response, most children were susceptible to both portion size and ED indicating that portion size and ED should be used strategically when developing dietary guidance and food products for children.

**Does portion size influence children’s intake?**

Multiple studies have shown that increasing the portion sizes of most or all items of the meal promotes substantial increases in energy intake (1,2). This was confirmed in Study 1 where doubling the portion size of the meal increased energy intake by 26% (74 ± 7 grams or 66 ± 8 kcal). This result indicates that serving overly large portions of multiple foods at a meal leads to higher energy intake in preschool children (1,2), but increasing portion size may not affect intake of all items similarly (1,3,4). Doubling portion size of the entire meal increased children’s intake of macaroni and cheese, applesauce, and ketchup, but did not affect chicken and vegetable intake in Study 1. The between-food differences in the portion size effect may not only be due to the properties of the foods, but also to how the studied portions relate to the curvilinear response pattern observed in portion size studies (5,6).

The portion size effect is characterized by curvilinear trajectory in which intake increases as portions become larger, but the propensity to consume diminishes as portions become too large. For Study 1, we evaluated the intake trajectory for the entire meal and for the individual foods at the meal using Random Coefficient Models as described by Roe and colleagues (5). In both analyses, intake was characterized by a quadratic curve as
shown in Appendix S. Total weight consumed in the meal was influenced by total weight served (i.e., portion size, P<0.0003), but not by meal ED. There was no random variation in the trajectory of intake in response to larger portions indicating that the portion size effect did not differ between individual children in the study. The portion size response trajectory, however, differed between the foods and milk (P<0.0001). Children increased their intake the least in response to larger portions of vegetables (slope mean = 0.10) and the most in response to portion size applesauce (slope mean = 0.59). Thus, the effect of increases in portion size on intake of individual foods at a meal conforms to a curvilinear trajectory, which can be used to explain differences in the magnitude of the portion size effect.

Differences in the portion size effect on intake between studies or types of foods may be partially due to where the selected portions fall on the curvilinear intake trajectory. At the lower end of the curve, intake increases substantially as portion size increase, which leads to a large effect of portion size on intake. This was observed with the applesauce in Study 1 (Appendix S). When intake falls onto this steeper part of the response curve, it suggests that the participants would have continued to eat more if they were served larger portions. As portion size continues to increase, however, the intake trajectory becomes relatively flat, which was seen with vegetable intake in Study 1 (Appendix S) and other studies that do not report an effect of portion size (3,7,8). This indicates that the portions served are too large for the tested population and intake is approaching a maximum level. If portions continue to get larger, intake may begin to decline, as seen with milk intake in Study 1 (Appendix S). This may be because the reference (100%) portions are at different points along the trajectory curve. The results of
Study 1 indicate that even within the same experiment, the effect of doubling portions has differential effects on intake of the individual foods in the meal. The response curve provides a theoretical underpinning for how individuals will respond to increases in portion size; however, other factors including the relative palatability of the items at the meal also affect the response to larger portions.

The relative palatability of each of the items at the meal may also influence the effect of larger portions on children’s intake of the individual foods within a meal (5). When served larger portions of an entire meal, adults were the most responsive to the food they ranked as the most palatable at the meal (5). In the context of Study 1, children increased their intake of applesauce and macaroni and cheese to the greatest extent, which suggests that these foods could have been more preferred than other foods, such as chicken and vegetables, which were not affected by portion size. Another study suggests similar effects: increasing the portion size of most items at a meal increased intake of macaroni and cheese and cookies, but not applesauce or corn (1). In this study, the high palatability of the cookies may have outcompeted the applesauce, and thus intake of cookies, not applesauce, increased with larger portion sizes (1). In contrast, in Study 1, applesauce intake increased when larger portions were served, and this food was the most liked food at the meal with 83% of the children rating it as “yummy” or “super yummy.” These data suggest that the other foods available at the meal could have substantial influence on the effectiveness of increasing the portion size of lower-ED, nutrient-dense foods to promote intake.

The size of the other foods offered at the meal could also affect how children respond to larger portions of some foods or beverages (3,4,9,10). For example, milk
intake was higher when the 50% larger portions were served in both studies, but the
effect was smaller when milk was served with large portions of everything else at the
meal (16 ± 5 grams; Study 1) compared to a standard meal (38 ± 5 g; Study 2) even
though the amount of milk served was the same in both studies. Similarly, increasing the
portion size of milk has been shown to be more effective when the portions of other foods
remain constant (11-13) rather than also increasing in portion size. Thus, serving larger
portions of lower-ED foods may be an effective strategy when the portion sizes of other
foods at the meal are not overly large.

Serving larger portion sizes could be used as a strategy to promote intake of
nutrient-dense foods, such as fruits, vegetables, and milk; however, this strategy may
need to be paired with other recommendations to be successful at increasing intake.
Providing larger portions of one of these target foods, vegetables, as a first course with no
competing foods has been shown to promote vegetable intake (14,15). Since providing
large portions of everything may promote intake of fruit but not vegetables (1),
moderating the portions of main dishes and higher-ED foods at the meal and increasing
the portion size of the lower-ED foods, such as fruit and vegetables, may promote intake
of nutrient-dense options at the meal and moderate intake (3,4). Another option to
promote intake of these foods is to serve palatable, preferred side dishes with less
preferred main dishes, but the effect of this strategy on children’s response to larger
portions has not been tested (16). Furthermore, some children may be less susceptible to
larger portions, and thus modifying the amounts served of various foods may not
effectively alter intake in some populations.
Do the effects of portion size differ between individuals?

In both studies, the effect of meal portion size on intake was not found to be influenced by most of the individual characteristics tested, including age and body size. This is in contrast to four previous studies which found child age or anthropometric measures of body size affected the relationship between portion size and intake (3,9,17,18). This could be due to differences in study design and population. Studies that have reported an effect of child age on relationship between portion size and intake adjusted the amount of food served according to age (9,17). Thus, younger children received smaller portions than older children; whereas, in other studies, including Studies 1 and 2, all children receive the same portions (1,3,4,18,19). Studies that have found a significant effect on child body size or weight status on the relationship between portion size and intake have included a larger proportion of overweight and/or obese children. Also, these studies also dichotomized children by weight status (e.g., healthy/normal weight vs. overweight or obese) (3,18), but this was not done in the present study, since there was no significant findings with the continuous version of BMI-for-age percentile or BMI z-scores. To determine the effect of age or body size on children’s response to large portions, future research should examine the effects of the differences in study design in a single population and oversample children who are considered overweight or obese.

The present study, however, did identify one parent-reported child eating behavior and one parent feeding practice that affected the relationship between portion size and intake. In Study 1, children who were reported to be more responsive to food consumed more when the larger portions of the meal were served compared to children who were
rated as less responsive to food (20,21). This aligns with a finding from a previous study that showed that children with high scores on a food responsiveness subscale increased their intake to the greater extent when meal portion size increased than children with lower scores (1). This suggests that children who tend to overeat in response to food cues had a stronger response to increases in portion size of a meal served in the childcare center compared to their counterparts; however, most children increased their intake when served larger portions. Similarly, children whose parents frequently monitored their intake consumed more of the meal when served the largest portion size than children who were less frequently monitored (22,23). Thus, excessive parental monitoring of a child’s food intake could be related to increased responsiveness to environmental cues, such as very large portions, and overeating. Overall, child food responsiveness and parental monitoring have some influence on child eating behavior in a childcare setting suggesting that these behaviors could be useful targets for interventions. However, most of research shows that portion size has a robust effect on the intake of the majority of children (1,2,9,10,24,25); therefore, focusing on how to alter food portions rather than these child characteristics may have a more substantial impact on children’s diets.

**Does energy density influence children’s intake?**

Studies 1 and 2 found that serving higher-ED versions of a meal or milk increases the amount of energy consumed from that item compared to serving lower-ED versions, which corresponds with previous research (11,12,26-28). Moreover, the acceptability did not differ between the lower-ED and higher-ED items as demonstrated by children’s liking ratings and consumption of similar weights of the lower-ED and higher-ED meals
and milk in both studies. Thus, changes in ED have a directly proportional effect on energy intake (26-28); for example, increasing ED by 42% increases energy intake by 40%. These results indicate that reductions in the ED of foods and beverages could lead to reduction in energy intake without affecting acceptability. If well-liked foods are readily available, caregivers could easily substitute lower-ED products for higher-ED versions to moderate children’s intake.

Both studies, however, found that children may not respond similarly to all lower-ED and higher-ED versions of foods and beverages even though they are liked similarly (26-28). The liking measures used in these studies (29-31), however, may not have fully captured differences between the foods. In particular, as evidenced by intake, children may have perceived differences in sensory properties between the higher-ED and lower-ED versions of chicken and macaroni and cheese served in Study 1. These differences in sensory properties may have led the children to consume more of the higher-ED chicken and lower-ED macaroni and cheese. In Study 2, boys’ response differed between the two types of milk, in that they reduced food intake when the higher-ED milk instead of the lower-ED milk was served. Even though children’s liking and preference ratings of the milk did not differ, it is plausible that the compensatory response to milk ED could have been driven by differences in other sensory properties that were not detected by the included measures. This emphasizes the need for administration and development of additional measures to determine how changing the ED of foods influences children’s acceptance and response to these foods.

In addition to differences in sensory properties, the role or size of the item in the context of the meal may affect children’s adjustment to differences in ED. Study 2
showed that if the ED of one item at a meal is varied, children can adjust for the difference in energy content; whereas, children did not show any adjustment when all items at the meal, including milk, were manipulated (Study 1). Similarly, previous studies have shown that increasing the ED of a main dish, which is the largest proportion of the meal, increases total energy intake (26,28). Altering only the milk at a meal may allow children to regulate their intake in response to variations in the energy content; whereas, serving a higher-ED main dish may present too challenging of a situation and regulatory mechanisms may be overridden. Since milk is a smaller proportion of the meal and low in ED, the change in total energy intake between the meals that included either type of milk may have been too small to detect by statistical analyses and a larger sample size may be needed. Even if children are able to adjust intake to account for variations in ED of a single item at the meal, the ability to regulate in response to higher-ED foods and beverages may not persist long-term and the small increases in energy intake may accumulate over time.

Reducing the ED of foods, such as main dishes, and meals is a potential strategy to moderate children’s energy intake without decreasing the weight or volume consumed or the acceptability of the food (26-28). Currently, there are a variety of commercial foods and beverages available that vary in widely in ED, but are still acceptable to children. Thus, substituting lower-ED foods and beverages for higher-ED versions, such as grilled chicken strips for breaded chicken nuggets and low-fat milk for whole-fat milk, is an effective and easy strategy for caregivers to decrease the ED of children’s meals and diets. In addition, other methods can be used to reduce the ED of foods, including removing added fat and sugar or increasing water or water-rich foods, such as fruits and
vegetables, without significantly influencing acceptability (32). For example, popular
dishes such as macaroni and cheese and zucchini bread can be altered to have a lower
ED, but not be any less appealing to children (27,28). These changes lead to reductions in
energy intake, and may also improve fruit and vegetable intake if these items are used to
reduce the ED of a recipe. Using a combination of these approaches, such as reducing fat
content while increasing vegetable content, can effectively reduce ED and energy intake,
and reducing the ED of a variety of foods has the potential to have a large impact on
children’s intake. For caregivers to implement these strategies, however, manufacturers
need to decrease the ED of popular foods and policy makers need to provide resources
and education.

Do the effects of energy density differ between individuals?

In both studies, the effects of meal ED on meal intake were not found to be
influenced by most of the individual characteristics tested, including age and body size;
however, two child characteristics were identified that affected the relationship between
ED and intake. In Study 1, child food enjoyment was found to influence the effect of ED
on intake (20,21). On average, children ate a similar amount of the lower- and higher-ED
meals, but children who enjoyed food and eating more consumed a greater amount of the
lower-ED meal. When parents rated their child as always enjoying food (score = 5),
children consumed 47 additional grams of the lower-ED meal than the higher-ED meal.
This suggests that the children who experience meal times positively may be exposed to a
greater variety of food, which could lead to more opportunities to become familiar with
and like lower-ED foods. In this study, however, children still consumed more energy at
the higher-ED meal than the lower-ED meal; thus the increase in intake of the lower-ED meal that children with high food enjoyment showed was not enough to make the energy intakes similar across the ED conditions.

In Study 2, the ability to adjust food intake to account for differences in milk ED differed by sex, and this relationship has been reported in both adults and children in previous studies (33-36). Compared to males, females were less accurate at adjusting their intake to account for additional energy consumed from the higher-ED milk. This effect was not influenced by milk intake, or other child characteristics (including age and size, type of milk available and consumed at home, liking and preference ratings, child eating behaviors) or parent feeding practices. The limitations of using parent-report measures of child behavior and intake at home to relate to eating behavior in a different context could be responsible for the lack of these effects. Alternatively, other factors, such as parent eating behaviors, influencing children’s eating behavior and ability to adjust in response to differences in ED could be at play.

Girls may be more likely to internalize modeled behaviors or social expectations that influence eating behaviors and intake regulation than boys (37). For example, mothers with more restrained eating patterns had preschool-aged daughters with a lower ability to compensate for preload energy compared to sons of the same mother (35). This study suggests that parent eating behaviors should also be considered when measuring child behaviors, since modeling can have a strong influence a child (38-40). Young females also tend to be compliant to the rules set by adults, which may make them more likely to stay focused on the meal and sit at a table longer than meals (41,42). This willing stance could lead girls to ignore their hunger and fullness cues and focus on
environmental feedback (e.g., appeasing adult by eating quietly at the table), which may lead to dysregulation of energy intake. Identifying the social mechanism behind the sex difference in the adjustment of intake in response to differences in milk ED could lead to strategies targeting behaviors and practices that may promote better regulation of energy intake in all children.

**Do the effects of portion size and energy density combine to influence children’s intake?**

Portion size and ED have robust, independent effects that combine to influence preschool children’s energy intake. This effect has been demonstrated in three studies will similar methodologies, but different food components were altered. The previous study by Fisher and colleagues showed that effects of varying the portion size and ED of macaroni and cheese combined to substantially increase children’s energy intake at a lunch meal including manipulated side dishes and milk (43). Doubling meal portions and increasing ED by 42% led children to consume an additional 175 kcal (79% increase) at a single meal in Study 1. The foods that contributed the most to the increase in energy intake were chicken, macaroni and cheese, and applesauce. Study 2 showed similar effects; serving a 50% larger portion and 42% higher-ED milk increased milk intake by 49±4 kcal or 63%. These findings suggest that children could be at risk for overconsumption and potentially weight gain, since the current environment is filled with large portions of higher-ED foods and beverages. Furthermore, caregivers and children need strategies that incorporate guidance about both portion size and ED to counter the effects of these pervasive food cues.
Several organizations recommend moderating portion size and ED of foods and beverages to prevent or treat childhood obesity (44-48). However, there is limited guidance on how to use the beneficial effects of these two factors to strategically improve children’s intake. In 2010, the Dietary Guidelines recommended to “make half your plate fruits and vegetables,” since higher-ED foods have disproportionate effect on energy intake (44); however, increasing the portion size of lower-ED foods without altering the portions of other higher-ED foods may not affect energy intake (3,4,14,15). Thus, adjusting the proportions of lower- and higher-ED foods should be the focus of recommendations (49). To reduce the ED of meals and the overall diet, caregivers could serve larger portions of low-energy-dense foods, such as fruit and vegetables, while reducing the amount served of high-energy-dense foods (49). Along with potentially reducing energy intake, adopting this strategy could also promote intake of fruit and vegetables which would be a beneficial dietary change for most children (50,51). In the current environment, however, large portions of higher-ED foods are palatable, inexpensive, and widely available making it difficult to choose appropriate amounts of lower-ED foods indicating; thus, substantial changes are needed to make these strategies easy and attractive to consumers.

**Strengths, limitations, and future directions**

The two studies described in this dissertation systematically investigated the effects of portion size and ED by using commonly consumed foods, which is the primary strength of these studies. Both studies included meals that are typically served in childcare centers and contain products that are readily available to parents and
caregivers. Furthermore, children were served in their usual eating environment to promote typical eating behavior. An additional strength of the study was the inclusion of a larger sample size than has been previously included in previous studies using similar methodologies to investigate the effect of individual characteristics on the relationship between portion size or ED and intake. However, since the present studies included relatively homogeneous samples, were short term, and included pre-plated meals which is not typical practice at the childcare centers, further research is needed to increase the generalizability of these studies and to further explore the effects of larger portions and higher-ED foods on children’s intake.

To increase the generalizability of these studies, a more diverse sample in terms of race, ethnicity, socioeconomic status, parent education, and weight status should be tested in future studies. Of particular importance is weight status, since both epidemiological and experimental studies have shown that obesity or higher weight status is associated with consumption of large portions and higher-ED foods (52-61). For studies investigating the effects of weight status on these outcomes, a large proportion (35-50%) of children with overweight and obesity is required (3,62); whereas, only 15 children (14%) were classified as overweight or obese in Study 1 and 8 children (8%) in Study 2. To better characterize relationships, future research should consider including children with a wider range of ages, oversampling children of higher weight status, and testing how age-adjusted portion sizes influence children’s response.

Allowing children to serve themselves has been proposed as a strategy to control portions and promote self-regulation, and its effects on children’s response to larger portions and higher-ED foods should be evaluated (63-65). Previous research has
suggested that this recommendation may improve diet quality and decrease energy intake (18,25,62,66). For example, children who were overweight decreased entrée and meal energy intake when allowed to serve themselves compared to being served a pre-plated main dish (18,62). This suggests that allowing children to self-serve could help them to resist the effects of portion size and ED on intake. Although it is recommended that children self-serve all components of a meal from a shared dish, these studies allowed children to self-serve only the main dish from their own serving dish. Compared to serving children pre-plated meals, allowing children to self-serve may provide them a chance to resist the effects of larger portions and higher-ED foods, and should be evaluated in future research since this is a typical practice of childcare centers.

Varying the portion size and ED of foods affects intake in the majority of individuals. Even though there may be differences between children, strategically modifying the portion size and ED of foods has the potential to significantly improve most children’s diets and nutrient intakes while moderating energy intake. However, the effects of varying portion size and ED have not been investigated long-term or beyond 24 hours or 2 days, respectively. Several studies have suggested that adjustments in energy intake in response to these factors may appear over multiple meals or over several days (10,11,67-72). The results of the studies suggest that children may make associations between foods and post-ingestive effects (10,11,67-72). However, these studies took place in controlled eating environments and children were only learning about a single food (21,36,68,73-75). Additionally, it has been suggested that biological systems may take up to 3 to 4 days to detect and respond to changes in energy intake to maintain energy balance (76). Future research should
investigate whether the effects of portion size and ED persist to determine if modifications in the portion size and ED of children’s diets will improve long-term energy intake and risk for obesity.

In regards to the current state of the literature, portion size receives much more focus than ED. This is reflected in both original research and review articles. (1-4,6,8-10,14,15,17-19,24-28,77-88). This may be due to the ease of conducting studies investigating the effects of portion size compared to ED. Portions are much easier to manipulate, since the weight of food or beverage served is just increased or decreased. In comparison, the nutrient composition of a food or beverage has to be altered to affect ED. There are also many other considerations when manipulating ED, including palatability and acceptability of the foods along with macronutrient composition. With few studies systematically evaluating the effects of ED on children’s intake, there is an obvious need to test these effects in a wider variety of foods with a greater range in ED, and in different meal and environmental contexts. To further improve children’s diets, we need to determine how much we can overtly and covertly change the ED of foods and beverages without affecting children’s desire to eat them.

**Final Conclusions**

Portion size and ED have robust, independent effects that combine to influence children’s energy intake, and most children are susceptible to these effects. Even if children can regulate intake in response to ED variations in a single food, the current food environment is filled large portions of a variety of higher-ED foods that likely promote excess energy intake. This indicates that recommendations to moderate energy
intake and prevent obesity should include strategies that address both of these pervasive factors. For example, since increasing portion size of nutrient-dense, low-ED foods promotes intake of these foods, larger portions of lower-ED foods should be served along with smaller portions of higher-ED foods. Caregivers can also replace higher-ED foods with similar, equally acceptable lower-ED versions. To effectively implement these recommendations, however, caregivers need clear guidance and food producers need to make products that make healthy choices easy and attractive.
References


APPENDIX A

RECRUITMENT LETTER

STUDY 1
Dear Parents:

The Step By Step Learning Center and Child Care and the Researchers with the Laboratory for the Study of Human Ingestive Behavior at Penn State are collaborating on a new project. The title of our new project is “Perceptions of Different Tastes at a Single Meal – Preschool Study.” We are seeking a group of children ages 3 – 5 and their parent to participate in a research study. If you are a parent of a child in this age group and are interested in having you and your child participate, please continue reading this letter and the attached Parent Informed Consent form. Parental consent is required for all children under the age of 18. All children at the center are eligible for inclusion in this research study.

The objective of this study is to understand the effects of changes in portion sizes of commonly consumed foods in kids.

At 6 different lunch times (beginning roughly first week of June), we will provide lunch. Your child will have lunch in one of the classrooms with other kids enrolled in the study. Children will participate in the following activities:

**Lunch**
- Lunch will be served to children by the Laboratory of Human Ingestive Behavior. It will consist of foods typically served at the daycare center: Grilled chicken breast, chicken nuggets, steamed broccoli, green peas, applesauce, macaroni and cheese, milk, and water. Not all foods will be served on the same day. This will vary slightly from their usual lunch as a bottle of spring water will be offered as the beverage.

**The Tasting Game**
- “The Tasting Game” is used to assess children’s food preferences for menu items and involves interviewing children individually. At the end of the study, children taste a food that is served during the study and tell us about their preferences for the food.

**Height and weight**
- These measurements will be taken once by a trained staff member of our laboratory.

**Parent Activity**
- Parents will be asked to complete three questionnaires. We will distribute the questionnaires toward the later weeks of the study. Upon completion of the Parent Activity, the participating parent will receive $20. Arrangements will be made to meet parents during pick-up time to exchange the questionnaires and payment.
Your participation in this research gives your child the opportunity to take part in these “special” activities while also allowing them to decline participation at any time in the study.

If you are interested in participating, please read and sign the consent form attached to this letter. Please return the forms to the ‘Perceptions of Different Tastes at a Single Meal – Preschool Study” envelope at the front desk. We would be happy to provide you with any additional information if you have questions regarding this research or other aspects of our work. If you have any questions, please contact Samantha Kling or Christine Sanchez at 863-8482.

Sincerely,

Barbara J. Rolls, Ph.D.
Principal Investigator
APPENDIX B

CONSENT FORM

STUDY 1
Informed Consent Form for Biomedical Research
The Pennsylvania State University – Preschool Study

Title of Project: Perceptions of Different Tastes at a Single Meal

Principal Investigators: Barbara J. Rolls, Ph.D.
226 Henderson Building, University Park, PA 16802
Email: bjr4@psu.edu; Telephone: 814-863-8481

Other Investigator(s): Jennifer Meengs, MS, RD
Telephone: 814-863-2877

1. Purpose of the study: The purpose of this research is to test how children respond to changes of portion sizes of foods at a meal.

2. Procedures to be followed: If you agree to allow your child to take part in this research, your child will have lunch for 6 different testing sessions that are provided by the Laboratory for the Study of Human Ingestive Behavior. Lunch will take place during the child’s regularly scheduled lunch period in a pre-school classroom at your childcare center. At the end of the study, children will meet with a research assistant for a brief interview that includes The Tasting Game, which will involve assessing the child’s preference of the foods used in the study. Your child’s height and weight will also be measured once during the study by a trained lab staff member. We may take a photograph of the children during a test session to be used in poster or slide presentations of this study at scientific meetings. If you do not wish your child to be included in a photograph, there is a place for you to indicate such at the end of this consent form.

Parents will be asked to complete a set of questionnaires, which will be distributed toward the end of the study. We will schedule appointments around a parent’s pick up of their child from the center for the parents to return the questionnaires and receive payment.

3. Discomforts and risks: There are no risks involved in eating the meals. The foods served will be commonly served items at the day care center. It is possible that investigators will discover a participant’s previously unknown food allergy during the course of the study. If this occurs, the parent(s) of the child will be notified immediately so that a quick decision about medical care can be made and action can be taken.

4. Benefits: You and your child will be aiding in our understanding of human eating behavior.
5. **Duration/time of the procedures and study:** The total time your child will spend participating in this project, including meals, the game, and height and weight measurements, will be roughly 3 hours and 15 minutes (30 minutes for each meal and 15 minutes for obtaining height and weight and the games). The total time for parents will be roughly 20 – 30 minutes to complete the questionnaires.

6. **Compensation:** The parent who completes the questionnaires will be paid $20.00 upon completion of these assessments. There is no separate payment for the child’s participation.

7. **Statement of confidentiality:** You and your child’s participation in food portion of the research will remain confidential. The investigators and their assistants will have access to you and your child’s identity and to information that can be associated with these identities, but this information will not be shared. Children participating in the study will be assigned a number, color, and letter of the alphabet to protect their identity. If parents agree to the use of photographs in poster or oral presentations, facial images may be recognizable, but no names or other identifiable information will be included. The following may review and copy records related to this research: Penn State’s Office for Research Protections, the Institutional Review Board, and the US Department of Health and Human Services Office for Human Research Protections.

8. **Right to ask questions:** Please contact Jennifer Meengs at 863-8481 with questions, complaints or concerns about the research. You can also call this number if you feel this study has harmed you or your child. If you have questions, concerns, or problems about your rights as a research participant or would like to offer input, please contact Penn State’s Office for Research Protections (ORP) at (814)865-1775. The ORP cannot answer questions about research procedures. Questions about research procedures can be answered by the research team.

9. **Voluntary participation:** Your participation and your child’s participation are voluntary. You and your child can stop at any time. You and your child can choose not to answer any questions you don’t want to answer. Your child does not have to eat any foods that he/she does not want to eat. Refusal to take part in or withdrawing from this study will involve no penalty or loss of benefits you would receive otherwise.

10. **Injury Clause:** In the unlikely event you or your child become injured as a result of your participation in this study, medical care is available but neither financial compensation nor free medical treatment is provided. By signing this document, you are not waiving any rights that you or your child have against The Pennsylvania State University for injury resulting
from negligence of the University or its investigators.

If you agree to the information outlined above, please sign the form below and mark today’s date. You will receive a copy of this form. You must be at least 18 years of age or older to enroll yourself in this study.

Child’s Name: ___________________________ Date of Birth: __________

Child’s Ethnicity:
☐ HISPANIC OR LATINO
☐ NOT HISPANIC OR LATINO
☐ PREFER TO NOT ANSWER

Child’s Race:
☐ AMERICAN INDIAN/ALASKAN NATIVE ☐ WHITE
☐ ASIAN ☐ HAWAIIAN/PACIFIC ISLANDER
☐ BLACK OR AFRICAN AMERICAN ☐ PREFER TO NOT ANSWER

☐ My child’s photograph MAY be used in presenting the results from this research in a poster or oral presentation.

☐ My child’s photograph MAY NOT be used in presenting the results from this research in a poster or oral presentation. NOTE: Images will be destroyed within 3 years of completing this research.

_________________________________________          ________________
Parent Signature                                      Date

________________________________________________
Parent Email

________________________________________________
Person Obtaining Consent                      ________________

Date
APPENDIX C

INTAKE DATA COLLECTION SHEETS

STUDY 1
Letter: ________________
Subject ID: ______________
Classroom: ________________

**Intake Sheets: PSS – Preschool Study**

**Condition 1: 100% LED**

Check 1: __________
Date: ________________
Check 2: __________
Week: ________________

<table>
<thead>
<tr>
<th>Lunch Food</th>
<th>Pre-Weight</th>
<th>Post-Weight</th>
<th>Amount Consumed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grilled chicken (100 g) Cut in half after cooking</td>
<td>(w/o plate)</td>
<td>(w/o plate)</td>
<td># of pieces # of pieces # of pieces</td>
</tr>
<tr>
<td>LED Mac n Cheese (100g)</td>
<td>(w/o plate)</td>
<td>(w/o plate)</td>
<td></td>
</tr>
<tr>
<td>Broccoli (75g)</td>
<td>(w/o bowl)</td>
<td>(w/bowl)</td>
<td></td>
</tr>
<tr>
<td>LED applesauce (100g)</td>
<td>(w/o bowl)</td>
<td>(w/bowl)</td>
<td></td>
</tr>
<tr>
<td>Low-sugar ketchup (20g) Weighed WITH clear plastic cap</td>
<td>(w/o cup)</td>
<td>(w/cup)</td>
<td></td>
</tr>
<tr>
<td>1% Milk (183g) Weighed WITH red cap</td>
<td>(w/o bottle)</td>
<td>(w/bottle)</td>
<td></td>
</tr>
<tr>
<td>Water in bottle (237ml) Weighed WITH cap</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Serving instructions:**
- Chicken from 12 – 3 o’clock; Mac n cheese 3-6 o’clock; Veg on left side
- Milk served with red cap screwed on but top cap off
- Ketchup served with plastic cap off
- Water served with cap off

**Weighing**
- Scrape chicken and mac n cheese onto separate plate to weigh

Disk 1: ________________________  Disk 2: ________________________
### Intake Sheets: PSS – Preschool Study

**Condition 2: 150% LED**

<table>
<thead>
<tr>
<th>Lunch Food</th>
<th>Pre-Weight</th>
<th>Post-Weight</th>
<th>Amount Consumed</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grilled chicken (150 g)</strong></td>
<td>(w/o plate)</td>
<td>(w/o plate)</td>
<td></td>
</tr>
<tr>
<td><em>Cut in half after cooking</em></td>
<td># of pieces</td>
<td># of pieces</td>
<td># of pieces</td>
</tr>
<tr>
<td><strong>LED Mac n Cheese (150g)</strong></td>
<td>(w/o plate)</td>
<td>(w/o plate)</td>
<td></td>
</tr>
<tr>
<td><strong>Seasoned broccoli (112.5g)</strong></td>
<td>(w/o bowl)</td>
<td>(w/bowl)</td>
<td></td>
</tr>
<tr>
<td><strong>LED applesauce (150g)</strong></td>
<td>(w/o bowl)</td>
<td>(w/bowl)</td>
<td></td>
</tr>
<tr>
<td><strong>LED ketchup (30g)</strong></td>
<td>(w/o cup)</td>
<td>(w/cup)</td>
<td></td>
</tr>
<tr>
<td><em>Weighed WITH clear plastic cap</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>1% Milk (274.5g)</strong></td>
<td>(w/o bottle)</td>
<td>(w/bottle)</td>
<td></td>
</tr>
<tr>
<td><em>Weighed WITH red cap</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Water in bottle (237ml)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Weighed WITH cap</em></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Serving instructions:**
- Chicken from 12 – 3 o’clock; Mac n cheese 3-6 o’clock; Veg on left side
- Milk served with red cap screwed on but top cap off
- Ketchup served with plastic cap off
- Water served with cap off

**Weighing**
- Scrape chicken and mac n cheese onto separate plate to weigh

Disk 1: ________________________  Disk 2: ________________________
Intake Sheets: PSS – Preschool Study  
**Condition 3: 200% LED**

<table>
<thead>
<tr>
<th>Lunch Food</th>
<th>Pre-Weight</th>
<th>Post-Weight</th>
<th>Amount Consumed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grilled chicken (200 g)</td>
<td>(w/o plate)</td>
<td>(w/o plate)</td>
<td></td>
</tr>
<tr>
<td><em>Cut in half after cooking</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td># of pieces</td>
<td></td>
<td># of pieces</td>
<td># of pieces</td>
</tr>
<tr>
<td>LED Mac n Cheese (200g)</td>
<td>(w/o plate)</td>
<td>(wo/plate)</td>
<td></td>
</tr>
<tr>
<td>Broccoli (150g)</td>
<td>(w/o bowl)</td>
<td>(w/bowl)</td>
<td>(w/bowl)</td>
</tr>
<tr>
<td>LED applesauce (200g)</td>
<td>(w/o bowl)</td>
<td>(w/bowl)</td>
<td></td>
</tr>
<tr>
<td>Low-sugar ketchup (40g)</td>
<td>(w/o cup)</td>
<td>(w/cup)</td>
<td></td>
</tr>
<tr>
<td><em>Weighed WITH clear plastic cap</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1% Milk (366g)</td>
<td>(w/o bottle)</td>
<td>(w/bottle)</td>
<td></td>
</tr>
<tr>
<td><em>Weighed WITH red cap</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water in bottle (237ml)</td>
<td>(w/o bottle)</td>
<td>(w/bottle)</td>
<td></td>
</tr>
<tr>
<td><em>Weighed with cap</em></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Serving instructions:**
- Chicken from 12 – 3 o’clock; Mac n cheese 3-6 o’clock; Veg on left side
- Milk served with red cap screwed on but top cap off
- Ketchup served with plastic cap off
- Water served with cap off

**Weighing**
- Scrape chicken and mac n cheese onto separate plate to weigh

Disk 1: ________________________     Disk 2: ________________________
Letter: ________________  
Subject ID: ______________  
Classroom: ______________

**Intake Sheets: PSS – Preschool Study**  
**Condition 4: 100% HED**

<table>
<thead>
<tr>
<th>Lunch Food</th>
<th>Pre-Weight</th>
<th>Post-Weight</th>
<th>Amount Consumed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chicken nuggets (100 g)</td>
<td>(w/o plate)</td>
<td>(w/o plate)</td>
<td></td>
</tr>
<tr>
<td><em>Cut in half after cooking</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td># of pieces</td>
<td># of pieces</td>
<td># of pieces</td>
</tr>
<tr>
<td>HED Mac n Cheese (100g)</td>
<td>(w/o plate)</td>
<td>(w/o plate)</td>
<td></td>
</tr>
<tr>
<td>Peas (75g)</td>
<td>(w/o bowl)</td>
<td>(w/bowl)</td>
<td></td>
</tr>
<tr>
<td>HED applesauce (100g)</td>
<td>(w/o bowl)</td>
<td>(w/bowl)</td>
<td></td>
</tr>
<tr>
<td>Regular ketchup (20g)</td>
<td>(w/o cup)</td>
<td>(w/cup)</td>
<td></td>
</tr>
<tr>
<td><em>Weighed WITH clear plastic cap</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whole Milk (183g)</td>
<td>(w/o bottle)</td>
<td>(w/bottle)</td>
<td></td>
</tr>
<tr>
<td><em>Weighed WITH red cap</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water in bottle (237ml)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Weighed WITH cap</em></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Serving instructions:
- Chicken from 12 – 3 o’clock; Mac n cheese 3-6 o’clock; Veg on left side
- Milk served with red cap screwed on but top cap off
- Ketchup served with plastic cap off
- Water served with cap off

Weighing
- Scrape chicken and mac n cheese onto separate plate to weigh

Check 1: __________  Date: ____________________  
Check 2: __________  Week: ______________

Disk 1: ________________________  Disk 2: ________________________
### Intake Sheets: PSS – Preschool Study

**Condition 5: 150% HED**

<table>
<thead>
<tr>
<th>Lunch Food</th>
<th>Pre-Weight</th>
<th>Post-Weight</th>
<th>Amount Consumed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chicken nuggets (150 g)</td>
<td>(w/o plate)</td>
<td>(w/o plate)</td>
<td></td>
</tr>
<tr>
<td><em>Cut in half after cooking</em></td>
<td># of pieces</td>
<td># of pieces</td>
<td># of pieces</td>
</tr>
<tr>
<td>HED Mac n Cheese (150g)</td>
<td>(w/o plate)</td>
<td>(w/o plate)</td>
<td></td>
</tr>
<tr>
<td>Seasoned Peas (112.5g)</td>
<td>(w/o bowl )</td>
<td>(w/bowl)</td>
<td></td>
</tr>
<tr>
<td>HED applesauce (150g)</td>
<td>(w/o bowl )</td>
<td>(w/bowl)</td>
<td></td>
</tr>
<tr>
<td>Regular ketchup (30g)</td>
<td>(w/o cup)</td>
<td>(w/cup)</td>
<td></td>
</tr>
<tr>
<td><em>Weighed WITH clear plastic cap</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whole Milk (274.5g)</td>
<td>(w/o bottle)</td>
<td>(w/bottle)</td>
<td></td>
</tr>
<tr>
<td><em>Weighed WITH red cap</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water in bottle (237ml)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Weighed WITH cap</em></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Serving instructions:**
- Chicken from 12 – 3 o’clock; Mac n cheese 3-6 o’clock; Veg on left side
- Milk served with red cap screwed on but top cap off
- Ketchup served with plastic cap off
- Water served with cap off

**Weighing**
- Scrape chicken and mac n cheese onto separate plate to weigh

Disk 1: ________________________  Disk 2: ________________________
Intake Sheets: PSS – Preschool Study  
**Condition 6: 200% HED**

<table>
<thead>
<tr>
<th>Lunch Food</th>
<th>Pre-Weight</th>
<th>Post-Weight</th>
<th>Amount Consumed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chicken nuggets (200 g)</td>
<td>(w/o plate)</td>
<td>(w/o plate)</td>
<td></td>
</tr>
<tr>
<td>Cut in half after cooking</td>
<td># of pieces</td>
<td># of pieces</td>
<td># of pieces</td>
</tr>
<tr>
<td>HED Mac n Cheese (200g)</td>
<td>(w/o plate)</td>
<td>(w/o plate)</td>
<td></td>
</tr>
<tr>
<td>Seasoned Peas (150)</td>
<td>(w/o bowl )</td>
<td>(w/bowl)</td>
<td></td>
</tr>
<tr>
<td>HED applesauce (200g)</td>
<td>(w/o bowl )</td>
<td>(w/bowl)</td>
<td></td>
</tr>
<tr>
<td>Regular ketchup (40g)</td>
<td>(w/o cup)</td>
<td>(w/cup)</td>
<td></td>
</tr>
<tr>
<td>Weighed WITH clear plastic cap</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whole Milk (366g)</td>
<td>(w/o bottle)</td>
<td>(w/bottle)</td>
<td></td>
</tr>
<tr>
<td>Weighed WITH red cap</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water in bottle (237ml)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weighed with cap</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Serving instructions:
- Chicken from 12 – 3 o’clock; Mac n cheese 3-6 o’clock; Veg on left side
- Milk served with red cap screwed on but top cap off
- Ketchup served with plastic cap off
- Water served with cap off

Weighing
- Scrape chicken and mac n cheese onto separate plate to weigh

Disk 1: ________________________   Disk 2: ________________________
APPENDIX D

HEIGHT AND WEIGHT SCRIPT

STUDY 1 AND 2
**Height and Weight Script**

“Hello! I am looking for *(child’s name)* to come out into the hallway with me.” Wait for child to appear and come into the hallway.

“Hello, *(child’s name)*! My name is ______ and I will be measuring how tall you are. Please take off your shoes and step on this sticker with your heels all the way to the back of the board and your head nice and straight. Ok, I am just going to make sure that your chin is nice and straight.” Align heals, head, back, and chin properly. Tell measurement to assistant for recording.

“Ok, now please step on the sticker on this scale and we will wait for the numbers to stop moving.” Wait for numbers to stop flashing. Tell weight to assistant for recording.

“Ok, now __*(researcher’s name)*______ is going to do both things with you again just to make sure that I did them correctly.” Child should go to other researcher.

“Hello, *(child’s name)*! My name is __________ and I will also be measuring how tall you are. Please step on this sticker with your heals all the way to the back of the board and your head nice and straight. Ok, I am just going to make sure that your chin is nice and straight.” Align heals, head, back, and chin properly. Tell measurement to assistant for recording.

“Ok, now please step on the sticker on this scale and we will wait for the numbers to stop moving.” Wait for numbers to stop flashing. Tell weight to assistant for recording.

“Ok, now you can put your shoes back on and pick a sticker. Thank you for doing such a great job!” Allow child to put shoes back on and pick sticker.
APPENDIX E

HEIGHT AND WEIGH DATA COLLECTION SHEET

STUDY 1 AND 2
## Classroom - XX/XX/XXXX

<table>
<thead>
<tr>
<th>SASID</th>
<th>ID Letter</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
APPENDIX F

PREFERENCE ASSESSMENT SCRIPT

STUDY 1
Children’s Food Liking Assessment

Explain to the child how to play the Tasting Game:

“I’d like to play the tasting game with you today. I’d like to know what you think about the foods that I have. I have five faces here. Do you see a face that looks like the face you make when you eat something that tastes super yummy? Point to the face that you would make is you ate something that tasted super yummy.”

The interviewer should either point to the super yummy face or reinforce the child for picking the correct face.

“This is the super yummy face, see how he’s smiling and licking his lips with his tongue like he’s thinking super yummy! OK, now, do you see a face up here that looks like the face that you make when you eat something that tastes yummy?”

Again, either point to the yummy face or reinforce the child for picking the correct one.

“This is our yummy face. See how he’s smiling like he’s saying yummy? Ok, now, do you see a face up here that looks like the face that you make when you eat something that tastes super yucky?”

The interviewer should either point to the super yucky face or reinforce the child for picking the correct face.

“This is the super yucky face. See how he’s frowning and has his tongue sticking out like he’s thinking super yucky? OK, now do you see a face up here that looks like the face that you would make when you eat something that tastes yucky?”

Again, either point to the yucky face or reinforce the child for picking the correct one.

“This is the yucky face. See how he’s frowning like he’s thinking yucky? OK, now this other face is our just OK face. This is the face that you make when you taste something and it doesn’t taste yummy, but it doesn’t taste yucky, it tastes just kind of OK”

Again, either point to the “just OK” face or reinforce the child for picking the correct one.

“This is the just OK face. See how he’s is not frowning or smiling?”

What is your favorite food? So, if I gave you some (favorite food) to taste, which face would you point to?

Allow child to point to the face to make sure they understand. Either reinforce the child for the correct choice or show them the correct face. If the child points at “yummy” or “super yummy,” the child’s response is correct so assume they understand.
What is your least favorite food, or a food you think is yucky? So, if I gave you some (least favorite food) to taste, which face would you point to?

Allow child to point to the face to make sure they understand. Either reinforce the child for the correct choice or show them the correct face. If the child points at “yucky” or “super yucky,” the child’s response is correct so assume they understand.

Great work, now one more question and we will start our tasting game.

What if I gave you something to taste and you couldn’t decide if it was yummy or yucky? What face would you point to?

Allow child to point to the face to make sure they understand. Either reinforce the child for the correct choice or show them the correct face. If the child points at “just OK” the child’s response is correct and assume they understand.

“OK, now I’d like to play the game with real food. I have some foods here and I’d like to know whether you think they taste super yummy, yummy, super yucky, yucky, or if they taste just OK. I’d like you to taste each one and then put the cup in front of the face that you make when you eat it. OK? Here is your first food to taste.”

Allow the child to take a taste. When the child is finished, point to each face and ask:

“What do you think? Did that taste super yummy, yummy, super yucky, yucky, or did it taste just OK? Put the cup in front of the face that you made when you tasted the __________.”

Wait for the child to place the cup in front of one of the faces. When the child is finished, mark the response on the preference sheet. Respond to the child and give the child the next food to taste (the order of the foods will be predetermined).

“You thought that one was (appropriate face)! Here is another food to taste.”

Allow the child to take a taste of the second food. Again, pointing to the appropriate faces, ask the child:

“What do you think? Did that taste super yummy, yummy, super yucky, yucky, or did it taste just OK? Put the cup in front of the face that you made when you tasted the __________.”

Again, wait for the child to place the cup in front of one of the faces. When the child is finished, mark the response on the data sheet. And repeat this step for the remaining foods. Periodically reinforce the child. Be careful to reinforce child for playing the game, not for the actual choices that he/she makes. Avoid reinforcement directly after the child places a food into a category and use phrases such as:
“You are really good at this game!”
“I’m having so much fun playing this game with you!”
APPENDIX G

“SUPER YUMMY,” “YUMMY,” JUST OK,” “YUCKY,” AND “SUPER YUCKY”
FACES FOR PREFERENCE AND LIKING ASSESSMENTS

STUDY 1 AND 2
<table>
<thead>
<tr>
<th>Order of Samples</th>
<th>Food</th>
<th>Face Chosen (highlight chosen face)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grilled chicken breast</td>
<td>![Emojis]</td>
</tr>
<tr>
<td></td>
<td>Chicken nuggets</td>
<td>![Emojis]</td>
</tr>
<tr>
<td></td>
<td>Broccoli</td>
<td>![Emojis]</td>
</tr>
<tr>
<td></td>
<td>Peas</td>
<td>![Emojis]</td>
</tr>
<tr>
<td></td>
<td>LED Mac n cheese</td>
<td>![Emojis]</td>
</tr>
<tr>
<td></td>
<td>HED Mac n cheese</td>
<td>![Emojis]</td>
</tr>
<tr>
<td></td>
<td>LED applesauce</td>
<td>![Emojis]</td>
</tr>
<tr>
<td></td>
<td>HED applesauce</td>
<td>![Emojis]</td>
</tr>
<tr>
<td></td>
<td>1% milk</td>
<td>![Emojis]</td>
</tr>
<tr>
<td></td>
<td>Whole milk</td>
<td>![Emojis]</td>
</tr>
</tbody>
</table>
APPENDIX I

CHILD EATING BEHAVIOUR QUESTIONNAIRE

STUDY 1 AND 2
**Child Eating Behaviour Questionnaire**

Please read the following statements and tick the boxes most appropriate to your child’s eating behaviour.

<table>
<thead>
<tr>
<th></th>
<th>Never</th>
<th>Rarely</th>
<th>Some-times</th>
<th>Often</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>My child loves food</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My child eats more when worried</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My child has a big appetite</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My child finishes his/her meal quickly</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My child is interested in food</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My child is always asking for a drink</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My child refuses new foods at first</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My child eats slowly</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My child eats less when angry</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My child enjoys tasting new foods</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My child eats less when s/he is tired</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My child is always asking for food</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My child eats more when annoyed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If allowed to, my child would eat too much</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My child eats more when anxious</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My child enjoys a wide variety of foods</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My child leaves food on his/her plate at the end of a meal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My child takes more than 30 minutes to finish a meal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Never</td>
<td>Rarely</td>
<td>Some times</td>
<td>Often</td>
<td>Always</td>
</tr>
<tr>
<td>-----------------------------------------------------------------</td>
<td>-------</td>
<td>--------</td>
<td>------------</td>
<td>-------</td>
<td>--------</td>
</tr>
<tr>
<td>Given the choice, my child would eat most of the time</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My child looks forward to mealtimes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My child gets full before his/her meal is finished</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My child enjoys eating</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My child eats more when s/he is happy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My child is difficult to please with meals</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My child eats less when upset</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My child gets full up easily</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My child eats more when s/he has nothing else to do</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Even if my child is full up s/he finds room to eat his/her favourite food</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If given the chance, my child would drink continuously throughout the day</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My child cannot eat a meal if s/he has had a snack just before</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If given the chance, my child would always be having a drink</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My child is interested in tasting food s/he hasn't tasted before</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My child decides that s/he doesn't like a food, even without tasting it</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If given the chance, my child would always have food in his/her mouth</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My child eats more and more slowly during the course of a meal</td>
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</tr>
</tbody>
</table>

**References**

APPENDIX J

CHILD FEEDING QUESTIONNAIRE

STUDY 1 AND 2
CHILD FEEDING QUESTIONNAIRE

INSTRUCTIONS: Using the scale below, please circle one number for each question which best corresponds to your answer. Please answer about your child who is in our study.

<table>
<thead>
<tr>
<th>ID #: Date:</th>
<th>never</th>
<th>seldom</th>
<th>half of time</th>
<th>most of time</th>
<th>always</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. When your child is home, how often are you responsible for feeding him/her?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2. How often are you responsible for deciding what your child’s portion sizes are?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3. How often are you responsible for deciding if your child has eaten the right kind of foods?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

Using the scale below, please indicate how you would classify your own weight at each of these 4 time periods listed below (Please circle ONLY ONE number for each time period)

<table>
<thead>
<tr>
<th></th>
<th>markedly underweight</th>
<th>underweight</th>
<th>average</th>
<th>overweight</th>
<th>markedly overweight</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. Your childhood (5 to 10 years old)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5. Your adolescence</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>6. Your 20’s</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>7. Currently</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
Using the scale below, please indicate how you would classify your child’s weight at each of these 6 time periods listed below. (Please circle only one number for each time period)

<table>
<thead>
<tr>
<th>Time Period</th>
<th>markedly underweight</th>
<th>underweight</th>
<th>average</th>
<th>overweight</th>
<th>markedly overweight</th>
</tr>
</thead>
<tbody>
<tr>
<td>8. Your child during the first year of life</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>9. Your child as a toddler</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>10. Your child as a preschooler</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>11. Your child as kindergartener</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

Using the scale below, please circle one number for each question which best corresponds to your answer. Please answer about your child who is in our study.

<table>
<thead>
<tr>
<th>Question</th>
<th>unconcerned</th>
<th>slightly unconcerned</th>
<th>neutral</th>
<th>slightly concerned</th>
<th>very concerned</th>
</tr>
</thead>
<tbody>
<tr>
<td>12. How concerned are you about your child eating too much when you are not around him/her?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>13. How concerned are you about your child having to diet to maintain a desirable weight?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>14. How concerned are you about your child becoming overweight?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
INSTRUCTIONS:
Using the scale below, please circle one number for each question which best corresponds to your answer. Please answer about your child who is in our study.

<table>
<thead>
<tr>
<th>Question</th>
<th>disagree</th>
<th>slightly disagree</th>
<th>neutral</th>
<th>slightly agree</th>
<th>agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>15. I have to be sure my child does not eat too many sweets (candy, ice cream, cake or pastries).</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>16. I have to be sure my child does not eat too many high fat foods.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>17. I have to be sure my child does not eat too many of his/her favorite foods.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>18. I intentionally keep some foods out of my child’s reach.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>19. I offer sweets (candy, ice cream, cake or pastries) to my child as a reward for good behavior.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>20. I offer my child his/her favorite foods in exchange for good behavior.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>21. If I did not regulate or guide my child’s eating, he/she would eat too many junk foods.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>22. If I did not regulate or guide my child’s eating, he/she would eat too many of his/her favorite foods.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>23. My child should always eat all of the food on his/her plate.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>24. I have to be especially careful to ensure my child eats enough.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>25. If my child says “I’m not hungry” I try to get him/her to eat anyway.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>26. If I did not guide or regulate my child’s eating, he/she would eat much less than he/she should.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
**INSTRUCTIONS:**
Using the scale below, please circle one number for each question which best corresponds to your answer. **Please answer about your child who is in our study.**

<table>
<thead>
<tr>
<th></th>
<th>never</th>
<th>rarely</th>
<th>sometimes</th>
<th>mostly</th>
<th>always</th>
</tr>
</thead>
<tbody>
<tr>
<td>27. How much do you keep track of the <em>sweets</em> (candy, ice cream, cake or pastries) that your child eats?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>28. How much do you keep track of the <em>snack food</em> (potato chips, Doritos, cheese puffs) that your child eats?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>29. How much do you keep track of the <em>high fat</em> foods that your child eats?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

**References**
APPENDIX K

DEMOGRAPHICS QUESTIONNAIRE

STUDY 1
Perceptions of Different Tastes at a Single Meal – Preschool Study Questionnaires

What is your child’s date of birth?

________________________________________

Please indicate who lives in your household, and if applicable how many (i.e. siblings 2).

Mother _____ Grandmothers _____
Father _____ Grandfathers _____
Siblings _____ Aunts _____
Uncles _____ Cousins _____
Other _____

Who in your household has the primary role in food preparation?

________________________________________

What is your marital status:

___ Married  ___ Single  ___ Widowed  ___ Divorced
___ Separated  ___ Remarried  ___ Living together (not married)

What is your total or combined family income, before taxes?

___ Less than $20,000
___ $21,000 - $35,000
___ $36,000 - $50,000
___ $51,000-$75,000
___ $76,000-$100,000
___ $100,000+

What is the highest level of formal education for:

MOM
___ High school (12 yrs)
___ Associates (14 yrs)
___ Technical/Vocational School(14 yrs)
___ Bachelors (16 yrs)
___ Masters (18 yrs)
___ PhD (20 yrs)
___ MD (20 yrs)
___ JD (20 yrs)
___ Other, describe____________

DAD
___ High school (12 yrs)
___ Associates (14 yrs)
___ Technical /Vocational School (14 yrs)
___ Bachelors (16 yrs)
___ Masters (18 yrs)
___ PhD (20 yrs)
___ MD (20 yrs)
___ JD (20 yrs)
___ Other, describe____________
Are you currently employed?

**MOM**
- ___ No
- ___ Yes
- ___ Hrs per week at work (not traveling to & from)

**DAD**
- ___ No
- ___ Yes
- ___ Hrs per week at work (not traveling to & from)

Is your child on any medications?  
- YES  
- NO

If YES, please specify ________________________________________________

Does your child have any food allergies?  
- YES  
- NO

If YES, how does this affect his/her diet?  __________________________________

Does your child suffer from lactose intolerance?  
- YES  
- NO

If YES, how does this affect his/her diet?  __________________________________

Does your child have a special diet (anything that will affect what he/she can eat)?  
- YES  
- NO

If YES, please specify ________________________________________________

Has your child had any major illnesses?  
- YES  
- NO

If YES, please describe ________________________________________________

What ethnicity is your child (please check only one)?
- Hispanic or Latino
- Not Hispanic or Latino

What race is your child (please check only one)?
- American Indian/Alaskan Native
- Asian
- Black or African American
- White
- Hawaiian/Pacific Islander
APPENDIX L

FIGURES OF RESULTS RELATED TO CHILD ENJOYMENT OF FOOD AND PARENTAL MONITORING

STUDY 1
APPENDIX L. Effect of parent-report of (A) parental monitoring and (B) child food enjoyment and on the relationships between meal portion size or energy density and weight of the meal consumed. The data were analyzed using analysis of covariance, which showed that the slopes of the regression lines across the three covariates differed from each other (all P<0.01). From the Child Feeding Questionnaire, parental ratings of use of monitoring significantly affected the relationship between portion size and total meal intake by weight (P=0.006). From the Child Eating Behaviour Questionnaire, ratings of child enjoyment of food significantly affected the relationship between ED and total meal intake (both P<0.01).
APPENDIX M

RECRUITMENT LETTER

STUDY 2
Dear Parents:

The (Insert Center) and the Researchers with the Laboratory for the Study of Human Ingestive Behavior at Penn State are collaborating on a new project. The title of our new project is “Perceptions of Different Beverages at a Meal – Preschool Study.” We are seeking a group of children ages 3 – 6 and their parent to participate in a research study. If you are a parent of a child in this age group and are interested in having you and your child participate, please continue reading this letter and the attached Parent Informed Consent form. Parental consent is required for all children under the age of 18. All children at the center are eligible for inclusion in this research study.

The purpose of this research is to test how children respond to different beverages at a meal.

At 5 different lunch times (beginning roughly [insert month]), we will provide lunch. Lunch will take place during the child’s regularly scheduled lunch period in a pre-school classroom at your childcare center. Children will participate in the following activities:

**Lunch**
- Lunch will be served to children by the Laboratory of Human Ingestive Behavior. It will consist of foods typically served at the daycare center: Chicken nuggets, macaroni and cheese, steamed broccoli, sliced bananas, and milk.

**The Tasting Game**
- “The Tasting Game” is used to assess children’s food preferences for menu items and reasons they stop eating at a lunchtime meal. This involves interviewing children individually. At the end of the study, children taste a food that is served during the study and tell us about their preferences for the food.

**Height and weight**
- These measurements will be taken once by a trained staff member of our laboratory.

**Parent Activity**
- Parents will be asked to complete three questionnaires. We will distribute the questionnaires toward the later weeks of the study. Upon completion of the Parent Activity, the participating parent will receive $30. Arrangements will be made to meet parents during pick-up time to exchange the questionnaires and payment.

Your participation in this research gives your child the opportunity to take part in these “special” activities while also allowing them to decline participation at any time in the study.

If you are interested in participating, please read and sign the consent form attached to this letter. Please return the forms to the ‘Perceptions of Different Beverages at a Meal – Preschool Study” envelope at the front desk or in your child’s classroom. We would be happy to provide you with any additional information if you have questions regarding
this research or other aspects of our work. If you have any questions, please contact Samantha Kling, Graduate Research Assistant, at 863-8482.

Sincerely,

Barbara J. Rolls, Ph.D.
Principal Investigator
Informed Consent Form for Biomedical Research
The Pennsylvania State University – Preschool Study

Title of Project: Perceptions of Different Beverages at a Meal – Preschool Study

Principal Investigators: Barbara J. Rolls, Ph.D.
226 Henderson Building, University Park, PA 16802
Email: bjr4@psu.edu; Telephone: 814-863-8482

Other Investigator(s): Samantha Kling, Research Assistant
Telephone: 814-863-8482

1. Purpose of the study: The purpose of this research is to test how children respond to different beverages at a meal.

2. Procedures to be followed: If you agree to allow your child to take part in this research, your child will have lunch for 5 different testing sessions that are provided by the Laboratory for the Study of Human Ingestive Behavior. Lunch will take place during the child’s regularly scheduled lunch period in a pre-school classroom at your childcare center. At the end of the study, children will meet with a research assistant for a brief interview that includes The Tasting Game, which will involve assessing the child’s preference of the foods used in the study and reasons they stop eating at a lunchtime meal. Your child’s height and weight will also be measured once during the study by a trained lab staff member. We may take a photograph of the children during a test session to be used in poster or slide presentations of this study at scientific meetings. If you do not wish your child to be included in a photograph, there is a place for you to indicate such at the end of this consent form.

Parents will be asked to complete a set of questionnaires, which will be distributed toward the end of the study. We will schedule appointments around a parent’s pick up of their child from the center for the parents to return the questionnaires and receive payment.

3. Discomforts and risks: There are no risks involved in eating the meals. The foods served will be commonly served items at the day care center. It is possible that investigators will discover a participant's previously unknown food allergy during the course of the study. If this occurs, the parent(s) of the child will be notified immediately so that a quick decision about medical care can be made and action can be taken.

4. Benefits: You and your child will be aiding in our understanding of human eating behavior.
5. **Duration/time of the procedures and study:** The total time your child will spend participating in this project, including meals, the game, and height and weight measurements, will be roughly 2 hours and 45 minutes (30 minutes for each meal and 15 minutes for obtaining height and weight and the games). The total time for parents will be roughly 20 – 30 minutes to complete the questionnaires.

6. **Compensation:** The parent who completes the questionnaires will be paid $30.00 upon completion of these assessments. There is no separate payment for the child’s participation.

7. **Statement of confidentiality:** You and your child’s participation in food portion of the research will remain confidential. The investigators and their assistants will have access to you and your child’s identity and to information that can be associated with these identities, but this information will not be shared. Children participating in the study will be assigned a number, color, and letter of the alphabet to protect their identity. If parents agree to the use of photographs in poster or oral presentations, facial images may be recognizable, but no names or other identifiable information will be included. The following may review and copy records related to this research: Penn State’s Office for Research Protections, the Institutional Review Board, and the US Department of Health and Human Services Office for Human Research Protections.

8. **Right to ask questions:** Please contact Samantha Kling at 863-8482 with questions, complaints or concerns about the research. You can also call this number if you feel this study has harmed you or your child. If you have questions, concerns, or problems about your rights as a research participant or would like to offer input, please contact Penn State’s Office for Research Protections (ORP) at (814)865-1775. The ORP cannot answer questions about research procedures. Questions about research procedures can be answered by the research team.

9. **Voluntary participation:** Your participation and your child’s participation are voluntary. You and your child can stop at any time. You and your child can choose not to answer any questions you don’t want to answer. Your child does not have to eat any foods or beverages that he/she does not want to eat. Refusal to take part in or withdrawing from this study will involve no penalty or loss of benefits you would receive otherwise.

10. **Injury Clause:** In the unlikely event you or your child become injured as a result of your participation in this study, medical care is available but neither financial compensation nor free medical treatment is provided. By signing this document, you are not waiving any rights that you or your child have against The Pennsylvania State University for injury resulting
from negligence of the University or its investigators.

If you agree to the information outlined above, please sign the form below and mark today’s date. You will receive a copy of this form. You must be at least 18 years of age or older to enroll yourself in this study.

Child’s Name: ___________________________ Date of Birth: __________

Does your child have a special diet (anything that will affect) □ Yes □ No

Child’s Ethnicity:
□ HISPANIC OR LATINO
□ NOT HISPANIC OR LATINO
□ PREFER TO NOT ANSWER

Child’s Race:
□ AMERICAN INDIAN/ALASKAN NATIVE □ WHITE
□ ASIAN □ HAWAIIAN/PACIFIC ISLANDER
□ BLACK OR AFRICAN AMERICAN □ PREFER TO NOT ANSWER

□ My child’s photograph MAY be used in presenting the results from this research in a poster or oral presentation.

□ My child’s photograph MAY NOT be used in presenting the results from this research in a poster or oral presentation. NOTE: Images will be destroyed within 3 years of completing this research.

_____________________________ Date

_____________________________

Parent Email

_____________________________

Person Obtaining Consent Date
APPENDIX O

INTAKE DATA COLLECTION SHEETS

STUDY 2
Intake Sheets: Preschool Beverage Study

Condition 1: 100% Portion Size of 1% Low-Fat Milk

Check 1: __________ Date: __________________
Check 2: __________ Week: _________________

<table>
<thead>
<tr>
<th>Lunch Food</th>
<th>Pre-Weight</th>
<th>Post-Weight</th>
<th>Amount Consumed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breaded chicken nuggets (120 g)</td>
<td>(w/o plate)</td>
<td>(w/o plate)</td>
<td></td>
</tr>
<tr>
<td><em>Cut in half after cooking</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mac and cheese (150 g)</td>
<td>(w/o plate)</td>
<td>(w/o plate)</td>
<td></td>
</tr>
<tr>
<td>Broccoli (80 g)</td>
<td>(w/o bowl)</td>
<td>(w/ bowl)</td>
<td></td>
</tr>
<tr>
<td>Banana slices (80 g)</td>
<td>(w/o cup)</td>
<td>(w/ cup)</td>
<td></td>
</tr>
<tr>
<td><em>Weigh with cup only (no lid)</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low-Fat 1% Milk (203.0 g)</td>
<td>(w/o bottle)</td>
<td>(w/ bottle)</td>
<td></td>
</tr>
<tr>
<td><em>Weighed WITH cap and straw</em></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Serving instructions:
- Chicken from 12 – 3 o’clock; Mac and cheese 3-6 o’clock; Veg on left side

Weighing
- Scrape chicken and mac and cheese onto separate plate to weigh

Disk 1: ________________________ Disk 2: ________________________
Intake Sheets: Preschool Beverage Study
Condition 2: 150% Portion Size of 1% Low-Fat Milk

Check 1: __________
Date: ______________
Check 2: __________
Week: ________________

<table>
<thead>
<tr>
<th>Lunch Food</th>
<th>Pre-Weight</th>
<th>Post-Weight</th>
<th>Amount Consumed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breaded chicken nuggets (120 g) Cut in half after cooking</td>
<td>(w/o plate)</td>
<td>(w/o plate)</td>
<td></td>
</tr>
<tr>
<td>Mac and cheese (150 g)</td>
<td>(w/o plate)</td>
<td>(w/o plate)</td>
<td></td>
</tr>
<tr>
<td>Broccoli (80 g)</td>
<td>(w/o bowl)</td>
<td>(w/ bowl)</td>
<td>(w/ bowl)</td>
</tr>
<tr>
<td>Banana slices (80 g) Weigh with cup only (no lid)</td>
<td>(w/o cup)</td>
<td>(w/ cup)</td>
<td>(w/ cup)</td>
</tr>
<tr>
<td>Low-Fat 1% Milk (294.5 g) Weighed WITH cap and straw</td>
<td>(w/o bottle)</td>
<td>(w/ bottle)</td>
<td>(w/ bottle)</td>
</tr>
</tbody>
</table>

Serving instructions:
- Chicken from 12 – 3 o’clock; Mac and cheese 3-6 o’clock; Veg on left side

Weighing
- Scrape chicken and mac and cheese onto separate plate to weigh

Disk 1: ________________________
Disk 2: ________________________
**Intake Sheets: Preschool Beverage Study**

**Condition 3: 100% Portion Size of Whole Milk**

<table>
<thead>
<tr>
<th>Lunch Food</th>
<th>Pre-Weight</th>
<th>Post-Weight</th>
<th>Amount Consumed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breaded chicken nuggets</td>
<td>(w/o plate)</td>
<td>(w/o plate)</td>
<td></td>
</tr>
<tr>
<td>(120 g)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cut in half after cooking</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mac and cheese (150 g)</td>
<td>(w/o plate)</td>
<td>(w/o plate)</td>
<td></td>
</tr>
<tr>
<td>Broccoli (80 g)</td>
<td>(w/o bowl)</td>
<td>(w/ bowl)</td>
<td>(w/ bowl)</td>
</tr>
<tr>
<td>Banana slices (80 g)</td>
<td>(w/o cup)</td>
<td>(w/ cup)</td>
<td>(w/ cup)</td>
</tr>
<tr>
<td>Weigh with cup only (no lid)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whole Milk (203.0 g)</td>
<td>(w/o bottle)</td>
<td>(w/ bottle)</td>
<td>(w/ bottle)</td>
</tr>
<tr>
<td>Weighed WITH cap and straw</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Serving instructions:**
- Chicken from 12 – 3 o’clock; Mac and cheese 3-6 o’clock; Veg on left side

**Weighing**
- Scrape chicken and mac and cheese onto separate plate to weigh

---

Disk 1: _______________________  Disk 2: _______________________
Intake Sheets: Preschool Beverage Study
Condition 4: 150% Portion Size of Whole Milk

Check 1: __________
Date: ________________
Check 2: __________
Week: ________________

<table>
<thead>
<tr>
<th>Lunch Food</th>
<th>Pre-Weight</th>
<th>Post-Weight</th>
<th>Amount Consumed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breaded chicken nuggets (120 g)</td>
<td>(w/o plate)</td>
<td>(w/o plate)</td>
<td></td>
</tr>
<tr>
<td><em>Cut in half after cooking</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mac and cheese (150 g)</td>
<td>(w/o plate)</td>
<td>(w/o plate)</td>
<td></td>
</tr>
<tr>
<td>Broccoli (80 g)</td>
<td>(w/o bowl)</td>
<td>(w/ bowl)</td>
<td></td>
</tr>
<tr>
<td>Banana slices (80 g)</td>
<td>(w/o cup)</td>
<td>(w/ cup)</td>
<td></td>
</tr>
<tr>
<td><em>Weigh with cup only (no lid)</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whole Milk (294.5 g)</td>
<td>(w/o bottle)</td>
<td>(w/ bottle)</td>
<td></td>
</tr>
<tr>
<td><em>Weighed WITH cap and straw</em></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Serving instructions:
- Chicken from 12 – 3 o’clock; Mac and cheese 3-6 o’clock; Veg on left side

Weighing
- Scrape chicken and mac and cheese onto separate plate to weigh

Disk 1: ________________________  Disk 2: ________________________
APPENDIX P

LIKING AND PREFERENCE ASSESSMENT SCRIPT

STUDY 2
Children’s Food Liking and Preference Assessment

Liking Assessment

Explain to the child how to play the Tasting Game:

“I’d like to play the tasting game with you today. I’d like to know what you think about the foods that I have. I have five faces here. Do you see a face that looks like the face you make when you eat something that tastes super yummy? Point to the face that you would make is you ate something that tasted super yummy.”

The interviewer should either point to the super yummy face or reinforce the child for picking the correct face.

“This is the super yummy face, see how he’s smiling and licking his lips with his tongue like he’s thinking super yummy! OK, now, do you see a face up here that looks like the face that you make when you eat something that tastes yummy?”

Again, either point to the yummy face or reinforce the child for picking the correct one.

“This is our yummy face. See how he’s smiling like he’s saying yummy? Ok, now, do you see a face up here that looks like the face that you make when you eat something that tastes super yucky?”

The interviewer should either point to the super yucky face or reinforce the child for picking the correct face.

“This is the super yucky face. See how he’s frowning and has his tongue sticking out like he’s thinking super yucky? OK, now do you see a face up here that looks like the face that you would make when you eat something that tastes yucky?”

Again, either point to the yucky face or reinforce the child for picking the correct one.

“This is the yucky face. See how he’s frowning like he’s thinking yucky? OK, now this other face is our just OK face. This is the face that you make when you taste something and it doesn’t taste yummy, but it doesn’t taste yucky, it tastes just kind of OK.”

Again, either point to the “just OK” face or reinforce the child for picking the correct one.

“This is the just OK face. See how he’s is not frowning or smiling?”

What is your favorite food? So, if I gave you some (favorite food) to taste, which face would you point to?
Allow child to point to the face to make sure they understand. Either reinforce the child for the correct choice or show them the correct face. If the child points at “yummy” or “super yummy,” the child’s response is correct so assume they understand.

**What is your least favorite food, or a food you think is yucky?** So, if I gave you some (least favorite food) to taste, which face would you point to?

Allow child to point to the face to make sure they understand. Either reinforce the child for the correct choice or show them the correct face. If the child points at “yucky” or “super yucky,” the child’s response is correct so assume they understand.

Great work, now one more question and we will start our tasting game.

**What if I gave you something to taste and you couldn’t decide if it was yummy or yucky? What face would you point to?**

Allow child to point to the face to make sure they understand. Either reinforce the child for the correct choice or show them the correct face. If the child points at “just OK” the child’s response is correct and assume they understand.

“**OK, now I’d like to play the game with real food. I have some foods here and I’d like to know whether you think they taste super yummy, yummy, super yucky, yucky, or if they taste just OK. I’d like you to taste each one and then put the cup in front of the face that you make when you eat it. OK? Here is your first food to taste.**”

Allow the child to take a taste. When the child is finished, point to each face and ask:

“**What do you think? Did that taste super yummy, yummy, super yucky, yucky, or did it taste just OK? Put the cup in front of the face that you made when you tasted the ___________.**”

Wait for the child to place the cup in front of one of the faces. When the child is finished, mark the response on the preference sheet. Respond to the child and give the child the next food to taste (the order of the foods will be predetermined).

“**You thought that one was (appropriate face)! Here is another food to taste.**”

Allow the child to take a taste of the second food. Again, pointing to the appropriate faces, ask the child:

“**What do you think? Did that taste super yummy, yummy, super yucky, yucky, or did it taste just OK? Put the cup in front of the face that you made when you tasted the ___________.**”
Again, wait for the child to place the cup in front of one of the faces. When the child is finished, mark the response on the data sheet. And repeat this step for the remaining foods. Periodically reinforce the child. Be careful to reinforce child for playing the game, not for the actual choices that he/she makes. Avoid reinforcement directly after the child places a food into a category and use phrases such as:

“You are really good at this game!”
“I’m having so much fun playing this game with you!”

Preference Assessment

“Ok. Now if you had to choose one of these two milks to drink more of, which milk would you choose?”

Wait for child to indicate which of the two dishes they would choose.

Interviewer: “Ok. You are all done! Thank you for playing the tasting game with me. Which sticker would you like?”
## Food Preference Assessment

**Letter:**

**SAS ID:**

**Classroom:**

**Interviewer:**

**Date:**

<table>
<thead>
<tr>
<th>Order of Samples</th>
<th>Food</th>
<th>Face Chosen (highlight chosen face)</th>
<th>Ranking of the Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1% milk</td>
<td><img src="" alt="Ratings" /></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whole milk</td>
<td><img src="" alt="Ratings" /></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX R

BEVERAGE CONSUMPTION QUESTIONNAIRE – FOOD FREQUENCY

STUDY 2
**Beverage Consumption Questionnaire**

<table>
<thead>
<tr>
<th>1. During the past month, often did YOUR CHILD CONSUME the following beverages?</th>
<th>1 time last month or never</th>
<th>2 - 3 times last month</th>
<th>1 - 2 times per week</th>
<th>3 - 4 times per week</th>
<th>5 - 6 times per week</th>
<th>1 time per day</th>
<th>2 or more times per day</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Whole milk</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>b) 2% milk</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>c) 1% milk</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>d) Fat-free milk</td>
<td></td>
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<tr>
<td>e) Chocolate milk</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f) 100% fruit juice</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>g) Fruit beverages, such as Sunny D or fruit punch</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>h) Regular soda</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i) Diluted 100% fruit juice</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>j) Diet soda</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>k) Non-dairy milk (e.g., soy or rice milk)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>l) water</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2. During the past month, often did YOU CONSUME the following beverages?

<table>
<thead>
<tr>
<th>Beverage</th>
<th>1 time last month or never</th>
<th>2 - 3 times last month</th>
<th>1 - 2 times per week</th>
<th>3 - 4 times per week</th>
<th>5 - 6 times per week</th>
<th>1 time per day</th>
<th>2 or more times per day</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Whole milk</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) 2% milk</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>c) 1% milk</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>d) Fat-free milk</td>
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<td></td>
</tr>
<tr>
<td>e) Chocolate milk</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f) 100% fruit juice</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>g) Fruit beverages, such as Sunny D or fruit punch</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>h) Regular soda</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i) Diluted 100% fruit juice</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>j) Diet soda</td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>k) Non-dairy milk (e.g., soy or rice milk)</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>l) water</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3. Do you try to LIMIT your child’s consumption of the following beverages?

<table>
<thead>
<tr>
<th>Beverage</th>
<th>Never</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Often</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Whole milk</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) 2% milk</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c) 1% milk</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d) Fat-free milk</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>e) Chocolate milk</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f) 100% fruit juice</td>
<td></td>
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<tr>
<td>g) Fruit beverages, such as Sunny D or fruit punch</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>h) Regular soda</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i) Diluted 100% fruit juice</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>j) Diet soda</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>k) Non-dairy milk, such as soy or rice milk</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>l) water</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### 4. Milk is served as a drink with my child’s:

<table>
<thead>
<tr>
<th></th>
<th>Never</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Most Always</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>breakfast</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>lunch</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>dinner</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>snacks</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milk is served alone</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

### 5. 100% juice is served as a drink with my child’s:

<table>
<thead>
<tr>
<th></th>
<th>Never</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Most Always</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>breakfast</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>lunch</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>dinner</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>snacks</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Juice is served alone</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
6. Regular soda is served as a drink with my child’s:

<table>
<thead>
<tr>
<th></th>
<th>Never</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Most Always</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>breakfast</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>lunch</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>dinner</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>snacks</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soda is served alone</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7. Water is served as a drink with my child’s:

<table>
<thead>
<tr>
<th></th>
<th>Never</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Most Always</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>breakfast</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>lunch</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>dinner</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>snack</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water is served alone</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX S

DEMOGRAPHICS QUESTIONNAIRE

STUDY 2
Demographics Questionnaire

What is your child’s date of birth (MM/DD/YY)? __________________________

What is your child’s sex? □ Male □ Female

Relationship to child: □ Mother □ Father □ Other (describe) _____________

Who in your household has the primary role in food preparation?
______________________________________________________________________

Mother’s
Height:___________________   Weight:____________________

Father’s
Height:___________________   Weight:____________________

Please indicate who lives in your household, and if applicable how many (i.e. siblings __2__).

Mother       ____
Father        ____
Siblings     ____
Grandmothers ____
Grandfathers ____
Aunts        ____
Uncles       ____
Cousins      ____
Other        ____

What is your marital status:
□ Married
□ Single
□ Widowed
□ Divorced
□ Separated
□ Remarried
□ Living together (not married)

What is your total or combined family income, before taxes?
□ Less than $20,000
□ $21,000 - $35,000
□ $36,000 - $50,000
□ $51,000-$75,000
□ $76,000-$100,000
□ $100,000+
What is the highest level of formal education for:

**MOTHER’S**
- [ ] Some high school
- [ ] High school
- [ ] Some college
- [ ] Associates
- [ ] Technical/Vocational School
- [ ] Bachelors
- [ ] Some Graduate School
- [ ] Masters
- [ ] PhD
- [ ] MD
- [ ] JD
- [ ] Other, describe________

**FATHER’S**
- [ ] Some high school
- [ ] High school
- [ ] Some college
- [ ] Associates
- [ ] Technical/Vocational School
- [ ] Bachelors
- [ ] Some Graduate School
- [ ] Masters
- [ ] PhD
- [ ] MD
- [ ] JD
- [ ] Other, describe________

Are you currently employed?

**MOTHER**
- [ ] No
- [ ] Yes
- [ ] Retired

_____ Hrs per week at work
   (not traveling to & from)

**FATHER**
- [ ] No
- [ ] Yes
- [ ] Retired

_____ Hrs per week at work not traveling to & from)
<table>
<thead>
<tr>
<th>Question</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is your child on any medications?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If YES, please specify</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does your child have any food allergies?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If YES, how does this affect his/her diet?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does your child suffer from lactose intolerance?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If YES, how does this affect his/her diet?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does your child have a special diet (anything that will affect what he/she can eat)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If YES, please specify</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Has your child had any major illnesses?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If YES, please describe</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

What ethnicity is your child (please check only one)?
- Hispanic or Latino
- Not Hispanic or Latino
- Prefer not to answer

Hispanic: A person of Cuban, Mexican, Puerto Rican, Cuban, South or Central American, or other Spanish culture or origin, regardless of race.

What race is your child (please check only one)?
- White
- Black or African American
- American Indian/Alaskan Native
- Asian
- South Asian (including India, Pakistan, or Bangladesh)
- Hawaiian/Pacific Islander
- More than one race
- Prefer not to answer
APPENDIX T

STATISTICAL METHODS AND RESULTS
FROM RANDOM COEFFICIENT MODELS
STUDY 1
Statistical analysis

Data analyses were conducted using a random coefficient model (1), also known as hierarchical models or multilevel models (SAS version 9.4; SAS Institute, Inc., Cary, NC). These methods were used to model change in intake or response to portion size, which was defined as the continuous trajectory of meal intake (by weight) across the various meal portions served (by weight) centered at baseline. Response to portion size was assessed in terms of weight, because food weight would allow comparison of intake between the lower- and higher-ED foods and milk. The model was developed by sequentially adding intercept, linear, and polynomial factors of the amount served (by weight) as continuous fixed effects and as random effects that varied for each subject (2). The methods of Singer & Willett (2003) were used to calculate pseudo-$R^2$ values for the proportion of total outcome variation explained by each model (3). For the outcome of intake of individual foods and milk, a similar random coefficient model was developed that included all of the foods and milk as separate variables. Testing all of the foods in the same model allowed the intake trajectory for each food to account for ED, portion size, and intake of other foods in the meal.

RESULTS

Characterization of the response to portion size of the entire meal by weight

Results from the random coefficient analysis showed that the response to portion size, defined as the total food weight consumed in response to total food weight served, was characterized by a quadratic curve (Appendix Ta). There was no difference between
the portion size response in the lower- and higher-ED meals (P=0.146). In the baseline portion, 283 ± 10.6 g of food was consumed (intercept). The mean curve had a positive linear coefficient (instantaneous slope of 0.28 ± 0.04 (P<0.0001)) and a small negative quadratic coefficient of -0.00027 ± 0.000073 (P=0.0003). The linear coefficient indicated that as meal portion size was increased beyond the baseline amount, children ate a mean of 28% of the additional food; this rate of intake, however, was rapidly reduced by the quadratic coefficient as the meal size was further increased. The pseudo-R2 value showed that the total weight served across the meals explained 6% of the variability in the weight of food consumed at the meal. The contribution of random subject effects to the response curve was significant for the intercept (P<0.0001) indicating that there was variation between individuals in intake of the baseline portion size. The linear coefficient, representing the proportion of additional food consumed as portions were increased, and the quadratic coefficient, representing the deceleration of intake rate as portions were increased, did not vary significantly across subjects.
Appendix Ta. Mean intakes for entire meals served to 120 preschool children. The mean curves of food intake in response to increases in the portion served were modeled by a random coefficient analysis. The weight consumed of the entire meal was influenced by the weight served (P<0.0001).

Influences on intake curves of individual foods by weight

Analyses with all foods and milk together in the model showed that the intake response curves had significant differences across the individual foods and milk and by ED (Appendix Tb). Intake of the individual foods and milk differed at baseline (P<0.0001), which indicates that children were consuming more of some foods, such as applesauce, than other foods, such as vegetables, when the 100% portion size was served. Children consumed less of lower-ED chicken than the higher-ED chicken (P<0.0001). The linear coefficients (instantaneous slopes) of the intake response curves were significantly greater for applesauce (mean 0.59) and macaroni and cheese (mean 0.30) than for milk (mean 0.28), which was significantly greater than green vegetables (mean 0.10) and chicken (mean 0.14; P<0.0001). Increases in portion size and differences in response between foods explained almost one-third of the variation in the food weight consumed (Pseudo-R2 = 31%). The quadratic coefficient of -0.0013 ± 0.0003 did not differ across the foods and milk.
Appendix Tb. Mean intakes individual foods served at a meal to 120 preschool children. The mean curves of food intake in response to increases in the portion served were modeled by a random coefficient analysis. The weight consumed of the entire meal was influenced by the weight served (P<0.0001).

References
SAMANTHA M.R. KLING
Curriculum Vitae

EDUCATION & TRAINING
2016 Ph.D in Nutritional Sciences, The Pennsylvania State University, University Park, PA
2011 B.S. in Dietetics, Iowa State University, Ames, IA

RESEARCH EXPERIENCE
2011-2016 Graduate Research Assistant, The Pennsylvania State University, University Park, PA
2010-2011 Undergraduate Research Assistant, Iowa State University, Ames, IA

GRANTS
07/01/2014 – 06/30/2016 Principal Investigator, “The effects of different beverages on eating behavior in preschool children”, USDA Childhood Obesity Prevention Transdisciplinary Training Program Seed Grant

AWARDS & HONORS
American Society for Nutrition’s Emerging Leaders in Nutrition Science Poster Competition April 2016
Society for the Study of Ingestive Behavior New Investigator Travel Award (NITA) Recipient July 2015
American Society for Nutrition’s Clinical Emerging Leader Award Competition Finalist at Experimental Biology 2015 March 2015
Mary Frances Picciano Graduate Student Endowment in Nutrition Sciences August 2013 – May 2014
Pat Simons Travel Award for The Obesity Society Scientific Meeting November 2012

PUBLICATIONS
Kling SMR, Roe LS, Rolls BJ. Does the energy density or portion size of milk affect preschool children’s intake at a meal? Appetite. 2016. doi: 10.1016/j.appet.2016.06.022.


SELECTED ORAL PRESENTATIONS
Kling SMR, Roe LS, Rolls BJ. Does milk portion size or energy density affect preschool children’s lunch intake? Paper to be presented at: Experimental Biology 2016; April 2 – 6, 2016, San Diego, CA.

Kling SMR, Roe LS, Rolls BJ. Does the energy density or portion size of milk affect preschool children’s intake at a meal? Paper presented at: SSIB 2015, the 23rd Annual Meeting of the Society for the Study of Ingestive Behavior; July 7 – July 11, 2015, Denver, CO.

Kling SMR, Keller KL, Roe LS, Rolls BJ. Double trouble: energy density and portion size combine to increase preschool children’s lunch intake. Paper presented at: Experimental Biology 2015; March 28 – April 1; Boston, MA.

Kling SMR, Keller KL, Meengs, JS, Roe LS, Rolls BJ. Do children adjust their intake when meals differ in energy density and portion size? Paper presented at: SSIB 2014, the 22nd Annual Meeting of the Society for the Study of Ingestive Behavior; July 29 - August 2, 2014; Seattle, WA.