THE EFFECTS OF ENERGY DENSITY AND PORTION SIZE
ON ENERGY INTAKE IN PRESCHOOL CHILDREN

A Dissertation in
Nutrition

By
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ABSTRACT

The development of strategies to moderate the energy intake of young children is essential to preventing the increase of childhood overweight. Reducing the energy density (kcal/g) of the diet has been shown to be an effective approach to moderate energy intake in adults, but whether this strategy will be effective in moderating the energy intake of young children has yet to be determined. A series of studies was developed to test the effects on young children’s *ad libitum* energy intake of lowering the energy density of foods and beverages. The findings from these experiments demonstrate that reducing the energy density of foods and beverages may be an effective approach to moderating energy intake in young children.

Study 1 tested the effect of reducing the energy density of an entrée on children’s *ad libitum* energy intake from the entrée and from the meal. In this within-subjects crossover study, 2- to 5-year-old children (37 boys and 40 girls) were served a test lunch one day per week for six weeks. Two versions of a macaroni and cheese entrée were formulated to differ in energy density while maintaining similar palatability. Each version was served to children three times. The higher-energy-density version of the entrée had 2.0 kcal/g and the other entrée was 30% lower in energy density with 1.4 kcal/g. Lunch, consumed ad libitum, also included broccoli, applesauce, and milk. Decreasing the energy density of the entrée by 30% significantly (P<0.0001) reduced children’s energy intake from the entrée by 25% (72±8 kcal) and total lunch energy intake by 18% (72±8 kcal). Children consumed significantly more of the lower-energy-density entrée (10±4 g; P<0.05). Therefore, decreasing the energy density of a lunch entrée resulted in a reduction in children’s energy intake from the entrée and from the meal.
Study 2 tested the effect of simultaneously reducing the energy density and portion size of an entrée on children’s ad libitum energy intake from the entrée and from the meal. In this within-subjects crossover study, 3- to 5-year-old children (30 boys and 31 girls) were served a test lunch one day per week for four weeks. Two versions of a pasta entrée were formulated to differ in energy density while maintaining similar palatability. The amount and type of vegetables and cheeses incorporated into the sauce of the pasta entrée were manipulated to create two versions that varied in energy density by 25% (1.6 or 1.2 kcal/g). Across the weeks, each version of the entrée was served to the children in each of two portion sizes (400 or 300 g). Lunch, consumed ad libitum, also included carrots, applesauce, and milk. Decreasing the energy density of the entrée by 25% significantly (P<0.0001) reduced children’s energy intake from the entrée by 25% (63±8 kcal) and total lunch energy intake by 17% (61±9 kcal). Increasing the proportion of vegetables in the pasta entrée increased children’s vegetable intake at lunch by half of a serving of vegetables (P<0.01). Decreasing portion size of the entrée by 25% did not significantly affect children’s total food or energy intake at lunch. Therefore, reducing the energy density of the entrée resulted in a reduction in children’s energy intake from the entrée and from the meal in both portion size conditions.

Study 3 tested the effect of lowering the energy density of multiple foods on children’s ad libitum energy intake over two days. In this within-subjects crossover study, 3- to 5-year-old children (10 boys and 16 girls) were served test breakfasts, lunches, and afternoon snacks two days per week for two weeks. During one week, foods and beverages served at these meals were reduced in energy density by an average of 27% (range, 19%-33%) compared to those served during the other week. Energy
density reductions were achieved by decreasing fat and sugar, and by increasing fruits and vegetables. Dinner and evening snack were sent home with children, but these meals were not varied in energy density. The same 2-day menu was served in both conditions. Children consumed a consistent weight of foods and beverages over two days in both conditions, and therefore, children consumed significantly less energy (14%; 389±72 kcal) in the lower-energy-density condition (P<0.0001). Differences in energy intake were significant at breakfast on Day 1 and accumulated at manipulated meals over two days (P<0.01). Children’s energy intake is influenced by the energy density of foods and beverages served over multiple days. These results strengthen the evidence that reducing the energy density of the diet is an effective approach to moderate children’s energy intake.

The results of the present three studies indicate that, like adults and school-aged children, preschool children consume a similar weight of food at meals, even when the food is reduced in energy density. Therefore, when the energy density of food is reduced, children consume significantly less energy at individual meals and over the course of up to two days. The results of the present research also demonstrate that children consume a consistent weight of beverages at individual meals and over the course of two days, and therefore, consume significantly less energy when the energy density of beverages is reduced. Additionally, the present research demonstrates the effectiveness of several different strategies to reduce the energy density of foods served to children: reducing the fat or sugar content of foods, combining fat reductions with increases in the vegetable content of foods, increasing the fruit content of foods, and combinations of these approaches. The lower-energy-density foods and beverages were
well-accepted by the children as indicated by both the taste tests and the consistent amounts consumed of the different versions of the foods and beverages. Overall, the results of the present research extend previous findings on the effects of energy density on *ad libitum* energy intake to a younger age group.
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CHAPTER I

INTRODUCTION
The prevalence of childhood overweight, defined as being at or above the 95th percentile of the sex-specific body mass index-for-age growth charts (BMI percentile), has increased in the last three decades (1-4). Based on data from the National Health and Nutrition Examination Survey (NHANES), about 5% of 2- to 5-year-old children were estimated to be overweight in 1971-1974 (2), but this estimate nearly tripled to about 14% in 2003-2004 (4). Particularly alarming is the estimate that more than a quarter (26%) of 2- to 5-year-old children were recently classified as overweight or at risk of overweight (BMI percentile $\geq 85$) (4).

Although childhood overweight may result in immediate health consequences (5), pediatric comorbidities are of low prevalence and usually affect only the severely overweight (6). However, childhood overweight is a risk factor for adult overweight and obesity (7-9). In turn, excess weight in adulthood is associated with many health consequences, including cardiovascular disease, type 2 diabetes mellitus, hypertension, stroke, dyslipidemia, osteoarthritis, and some cancers (10, 11). Additionally, there is some evidence to suggest that childhood overweight influences morbidities that manifest in adulthood (5, 12). Thus, preventing childhood overweight may help to reduce the likelihood of suffering health complications and becoming overweight or obese in adulthood.

The causes of overweight and obesity are thought to be multi-factorial (13, 14). The current environment, which promotes excessive food intake and discourages physical activity, is believed to be partially responsible for the rise in overweight and obesity (15, 16). In particular, the food environment, in which energy-dense foods are widely marketed and accessible to children, has been implicated as contributing to the increase in
childhood overweight (17, 18). Furthermore, the availability of large portions of energy- 
dense foods is thought to be promoting excessive energy intake in children (19, 20). 

Several organizations have recently issued recommendations in an effort to 
prevent childhood overweight (14, 21, 22). These recommendations include changes in 
behaviors such as limiting children’s intakes of energy-dense foods (21) and providing 
children with a variety of foods that are low in energy density (14). The American 
Medical Association and The Expert Committee on the Assessment, Prevention, and 
Treatment of Child and Adolescent Overweight and Obesity not only recommend 
limiting energy-dense foods, but they also recommend limiting the portion sizes of foods 
served to children (22). The question is whether these behaviors will effectively moderate 
young children’s energy intake.

**Energy Density**

Energy density refers to the amount of available energy in a given weight of food, 
and it is usually calculated as kilocalories per gram (kcal/g) or kilojoules per gram (kJ/g). 
The food components that have the largest influence on the energy density of a food are 
fat, which contributes 9 kcal/g, and water, which adds weight and volume to a food 
without adding energy. Carbohydrate and protein each supply 4 kcal/g, and fiber provides 
1.5-2.5 kcal/g. The energy density of a food can be manipulated by changing its 
macronutrient or water content.

Much of the research on energy density focuses on the effects of energy density 
on satiety and satiation. Satiety refers to the effect of food on subsequent hunger, fullness 
and food intake (23). The main way to test the effects of energy density on satiety is for
study participants to consume compulsory preloads varying in energy density prior to being served an *ad libitum* snack or meal. The effects of the preload are then assessed by measuring subsequent food intake at the *ad libitum* eating occasion. Satiation refers to the effect of food on the termination of eating within an eating occasion. In satiation studies, the food that is varied in energy density is consumed *ad libitum*. The effects of energy density on satiation are assessed by measuring food and energy intakes during *ad libitum* consumption (24).

**The Effects of Energy Density on Adults’ Energy Intake**

The energy density of foods has been shown to affect satiety. Studies have shown that compared to consuming a higher-energy-density preload, consuming a lower-energy-density preload prior to being served an *ad libitum* meal leads to a reduction in food and energy intake at the meal (25, 26). Specifically, incorporating water into a first course, which increases its volume and decreases its energy density, has been shown to reduce adults’ energy intake at a meal (25, 26). Eating a large portion of a low-energy-dense salad has also been shown to be an effective way to reduce energy intake at a meal (27). Research has also demonstrated that compared to not consuming a first course, consuming a low-energy-density first course, such as broth-based soup (28) or apples (29), leads to a reduction in food and energy intake at a meal. Consuming low-energy-density foods before a meal leads to a decrease in energy intake from the meal because the lower-energy-density food displaces intake of some of the higher-energy-density foods at a meal.
The energy density of foods has also been shown to affect adults’ *ad libitum* energy intake. Reducing the energy density of foods consumed *ad libitum* leads to a decrease in energy intake because adults tend to consume a consistent weight of foods even when they are reduced in energy density (30, 31). Adults’ energy intakes have been shown to parallel reductions in energy density. For example, covertly reducing the energy density by 25% of all foods served over the course of two days led to a 24% decrease in energy intake (31). Covert manipulations of the energy density of foods have been shown to affect adults’ energy intake for periods of up to 20 days (31-39).

Several studies have compared the effects of energy density on the energy intakes of obese and lean adults (33, 40, 41). These studies have shown that both groups of adults respond similarly to dietary manipulations in energy density; reducing the energy density of foods leads to significant reductions in energy intake for obese and lean adults (41).

The findings of these laboratory studies have highlighted the potential role of energy density in energy intake regulation. Dietary advice now includes consuming low-energy-density foods in order to reduce energy intake (42-44). For instance, recommendations include consuming a low-energy-density first course before a meal to displace intake of higher-energy-density foods at a meal or incorporating greater amounts of vegetables into dishes because these foods add weight to foods without adding significant amounts of energy.

Behavioral interventions have shown that reducing the energy density of the diet is associated with weight loss and weight maintenance (45, 46). Reducing the energy density of the diet for up to six months was associated with weight loss in overweight and obese adults (46). An intervention in which adults were counseled to reduce their fat
intake and increase their intake of fruits and vegetables showed that this strategy was effective to lose and maintain weight (45).

Epidemiological data have revealed associations between energy density of the diet and energy intake. Nationally representative data from the Continuing Survey of Food Intakes by Individual show that men and women with low-energy-dense diets have lower energy intakes than those who consume high-energy-dense diets (47). Adults who consume low-energy-dense diets have lower energy intakes even though they consume a greater weight of food than those who consume high-energy-dense diets.

The Effects of Energy Density on Adults’ Fruit and Vegetable Intakes

Consuming a low-energy-density diet has the potential to increase the quality of the diet. The energy density of foods is often decreased either by reducing the proportion of fat or sugar, or increasing the proportion of water-rich ingredients, such as vegetables and fruits, in recipes. Increasing the proportion of vegetables or fruits in foods has been shown to be an effective strategy to reduce the energy density of foods in order to decrease adults’ energy intakes in laboratory studies (31, 40, 48). Employing these strategies to reduce the energy density of foods can simultaneously decrease energy intake and increase intakes of fruits and vegetables.

Epidemiological data have revealed an association between the energy density of the diet and diet quality, such that low-energy-density diets are associated with high diet quality (49). Adults who consume a low-energy-density diet have been shown to consume a relatively high proportion of foods that are low in fat and high in micronutrient and water content. In particular, adults who consume a low-energy-density
diet have higher intakes of fruits and vegetables than adults with a high-energy-density diet (49).

**The Effects of Energy Density on Adults’ Macronutrient Intakes**

Although the macronutrient composition of foods has varied with the energy density of foods in many studies on the effects of energy density (33, 36), some studies have separated these factors to examine their independent effects on energy intake. Several studies have tested whether increases in fat content with energy density held constant influence adults’ energy intake (41, 50-52). The results of these studies showed that when energy density was held constant, changing the fat content of foods did not lead to alterations in energy intake. Therefore, it was not the fat content of the foods per se that influenced energy intake. In other studies, the energy density of foods was varied while the macronutrient (30, 37, 53) or fat content (41) was held constant. Additionally, one study systematically varied the fat content of foods in multiple energy density conditions (40). In all of these studies, energy density affected energy intake, such that decreasing the energy density of foods led to decreased energy intake.

**The Effects of Energy Density on Children’s Energy Intake**

**Satiety**

Much of the recent research on energy density in adults has focused on using energy density manipulations to reduce adults’ energy intake. In contrast to this objective, most of the research on energy density in children has focused on testing for energy intake regulation, rather than energy intake suppression, at subsequent eating occasions.
In several experimental studies (Table 1), children have demonstrated complete caloric compensation, meaning that they consumed about the same amount of energy from the preload and *ad libitum* meal (or snack) in both higher- and lower-energy-density conditions. Children have demonstrated the ability to completely compensate for changes in the energy density of several different types of preloads: sweetened beverages (54), pudding (55), and gelatin (56). Children have shown complete caloric compensation when several different time intervals between preload ingestion and meal (or snack) consumption were used: 0 minutes (54), 30 minutes (54, 55), 60 minutes (54), and 120 minutes (56). The results of these studies demonstrate that in some circumstances, children display tight regulation of their energy intake.

Although children have demonstrated an ability to completely compensate for changes in the energy density of foods in several studies, children do not always compensate accurately for changes in the energy density of preloads. In a study by Johnson *et al.* (57), compensation index scores were calculated for children who consumed beverage preloads varying in energy density prior to lunch. Compensation index scores indicate how well children compensate for the energy density of preloads. A perfect score is 100%, but scores between 50% and 100% indicate appropriate energy adjustment. The mean compensation index score for the children in the study was 45%, indicating that children consumed more total (preload + test meal) energy in the higher-energy-density condition. The compensation index scores varied widely across children; they ranged from -80%, indicating that the child consumed more energy during *ad libitum* consumption following the higher-energy-density preload, to 230%, meaning that the child overcompensated and consumed considerably less energy during *ad libitum* consumption.
consumption following the higher-energy-density preload. Similarly, in a study by Cecil et al. (58), average energy compensation was low for a high-energy-density preload compared to water (40%), for a low-energy-density preload compared to water (44%), and for a high-energy-density preload compared to a low-energy-density preload (35%). These results indicate that children adjusted their energy intake, but did not completely compensate for the energy ingested from the preloads. In a third study, changes in the energy density of an ice cream preload did not elicit adjustments in food intake at a subsequent meal, and children consumed consistent amounts of lunch across energy density conditions (59). Therefore, they consumed significantly more total (preload + test meal) energy when served the higher-energy-density preloads. The results of these studies indicate that children may not be able to completely compensate for the energy density of preloads in all circumstances.

A pattern emerges when comparing the studies in which children have demonstrated complete compensation with those in which children’s compensation has been incomplete. In studies where children have demonstrated complete compensation, the higher-energy-density preloads represented 17% or 19% of the children’s energy intakes at the baseline test meals (54). In contrast to these studies, in experiments where children have shown incomplete compensation, the higher-energy-density preloads represented at least 57% of the energy intake at the baseline test meals (58-60). Although children may be able to completely compensate for relatively low-energy preloads, this ability may be disrupted when high-energy preloads are consumed. The inability to completely compensate for higher-energy-density foods could be particularly problematic in the current food environment, where high-energy-density foods are widely available.
Lowering the energy density of foods served to children may help to reduce overconsumption of energy in young children.

**Individual differences in children’s responses to energy density**

Several studies have shown there to be variability in children’s abilities to compensate for changes in the energy density of preloads (57, 58, 60, 61), but the causes of this variability are not well understood. Most of the research on the effects on children’s energy intake of the energy density of preloads has been conducted with relatively small samples of children (54-56, 59-63), making it difficult to assess whether various subject characteristics influence children’s responses to energy density. However, several studies have examined whether individual differences in children’s physical characteristics and exposures to parental feeding-practices influence children’s abilities to regulate their energy intake.

**Age**

Several studies have examined whether young children’s ability to compensate for changes in the energy density of preloads decreases with age (55, 56, 58, 60, 64). A few of these studies have compared younger children with older children (56, 58, 64) and others have compared young children with adults (55, 60). One of the earliest studies on energy density in young children compared the compensatory abilities of children with those of adults (55). In this study, both children and adults consumed 3.5-ounce pudding preloads prior to lunch. Children showed clearer evidence of caloric compensation, with 20 of 21 children consuming less energy at lunch following ingestion of the higher-energy-density preload and only 16 of 26 adults showing the same pattern. Although this
study reported differences between young children’s and adults’ abilities to compensate, both children and adults consumed preloads of the same size. Another approach to comparing adults and children is to tailor the size of the preload to the age of the participant and use compensation index scores to make comparisons. In another study, the compensatory abilities of children were compared with those of young and elderly adults (60). In this study (60), the size of the preload was tailored to the age of the participants, and this study did not find differences in compensatory ability between age groups. There was no significant difference in compensatory abilities between age groups.

In a series of two experiments, the compensatory abilities of younger (2- to 5-year-old) and older (7- to 10-year-old) children were compared (56). In the first experiment, both groups of children received the same amount of flavored gelatin that was varied in energy density before lunch. Although older children did not show a significant difference in energy intake across conditions, younger children consumed more energy following ingestion of the lower-energy-density gelatin. In a follow-up experiment the size of the preload was adjusted for age. Again, younger children displayed better energy intake regulation than older children. Similar findings were reported in two other studies comparing younger and older children. When comparing the compensatory abilities of 6- to 9-year-old children (58), younger children compensated better than older children. Likewise, when comparing the compensatory abilities of children 5-12 years of age (64), compensatory abilities decreased with age.

**Child’s Sex and Anthropometrics**
In one study with a relatively large sample size of 77 children, Johnson and Birch (57) compared the compensatory abilities of children based on their physical characteristics. In this study, 3- to 5-year-old children consumed two juice preloads that differed in energy density prior to consuming lunch. Sex differences and anthropometric differences in children’s abilities to compensate for the preloads were found. Boys compensated better than girls; boys compensated for a significantly greater percentage (55%) of energy than did girls (35%). Children who compensated poorly had significantly more body fat according to skinfold measurements.

**Parental Child-feeding Practices and Contextual Cues**

Johnson and Birch also compared the regulatory abilities of children based on their exposures to parental child-feeding practices (57). Parents completed two questionnaires. One questionnaire assessed parents’ child-feeding practices and the other questionnaire assessed aspects of the parents’ eating behaviors. Differences in compensatory abilities of children were found to be related to parental child-feeding practices and eating behaviors. Mothers who reported that they were more controlling in their child-feeding practices had children who exhibited weaker compensatory abilities. Parents who reported having higher disinhibition also had children with weaker compensatory abilities. Likewise, mothers’ scores for dietary restraint were marginally negatively correlated with daughters’ compensation, meaning that mothers who reported controlling their own food intake had daughters who were not as good at compensating.

While the study by Johnson and Birch (57) highlighted associations between reported parental child-feeding practices and children’s compensatory abilities, another study directly tested whether different contexts would affect children’s abilities to
respond to changes in the energy density of preloads (65). In this study, children were divided into two groups. Prior to being served snacks, both groups of children consumed yogurt preloads that differed in energy density. Half of the children were told to concentrate on internal cues of hunger and satiety. The other children were encouraged to focus on external cues, such as “cleaning their plate” in order to earn a reward. The children who were focused on internal cues showed much better evidence of caloric compensation, indicating that children’s abilities to regulate their intake can be overridden when distracted by external cues. The results of this study provide evidence that children may respond less to their internal signals as they become more aware of external cues and influences.

**Single-meal studies and multiple-meal studies**

Several studies (Table 2) have tested the effects on preschool children’s energy intake of changing the energy density of meal components. In two studies by Wilson, the effects of the energy density of milk on children’s energy intakes were tested (66, 67). In the first study, children were served two types of milk (plain 2% milk or chocolate milk) that varied in energy density at lunch (66). All foods and milk were consumed ad libitum. Children not only consumed more chocolate milk than plain milk, but they also did not compensate for the increased energy density of the chocolate milk by decreasing their intake of other foods served during lunch. Children consumed 25% more energy when offered the chocolate milk at lunch. In a similar second study, children were served three types of milk (plain milk, sucrose-sweetened chocolate milk, and aspartame-sweetened chocolate milk) that varied in energy density at lunch (67). As in the first study, children
consumed significantly more energy at lunch when served chocolate-flavored milk. The results of these studies demonstrate that increases in the palatability of foods may lead to increased consumption without appropriate compensation, but these studies do not provide insight into the effects of energy density when the palatability of foods is matched.

It is necessary to match the palatability of the manipulated foods when these foods are consumed *ad libitum*. If the palatability of one version of the food is reduced, then *ad libitum* food consumption could be affected. For instance, if the lower-energy-density version of a dish tastes better than the higher-energy-density version of the dish, then children may consume more of the lower-energy-density dish. In this case, children who are consuming more of the lower-energy-density dish would incorrectly appear to be compensating for the reduced energy content of the dish by increasing their food intake.

In a laboratory study with school-aged (5- to 6-year-old) children, two versions of a macaroni and cheese dinner entrée were formulated to vary in energy density while keeping palatability similar (68). Children did not respond to the changes in the energy density of the entrée by adjusting their food intake, and therefore, they consumed about 15% less energy when served the lower-energy-density version of the entrée compared to the higher-energy-density version of the dish. Although children’s energy intake was reduced at the meal when the energy density of the dish was lowered, this study (68) did not measure energy intake following the manipulated meal. Children’s energy intakes at individual meals have been shown to be more variable than throughout the day (69, 70), suggesting that children compensate for reduced energy intake from a meal by increasing their energy intake at subsequent meals.
In a study by Birch et al., the effects of changing the energy density of meal components at multiple meals on subsequent energy intake were investigated (71). In this study, investigators manipulated the fat intake of children during 2-day periods. During the first three meals of the first day of each 2-day period, children were served foods (baked goods and chips) that contained either fat or a non-energy fat substitute (10% of energy from dietary fat). Children’s intake of the fat substitute was limited by researchers who monitored children’s intakes of manipulated foods and provided placebo versions of these foods when children reached the goal intake of 16 g. Children’s energy intakes were significantly reduced by 100 kcal by the end of the three meals with manipulated baked goods. Children compensated for the reduction in energy intake throughout the rest of the 2-day period. This study was designed to examine the effects of a fat substitute on children’s energy intake, so the protocol differs from the typical free-access protocol where foods are consumed ad libitum. Therefore, this study does not address the question of how children respond to changes in the energy density of foods consumed ad libitum.

**Epidemiological data**

Epidemiological data indicate that the energy density of children’s diets increase as they age (72-74). Young children’s energy intake has been shown to be associated with their dietary energy density (75). It has been estimated that children with high-energy-density diets have energy intakes that are 15% higher than their counterparts who consume low-energy-density diets (75). However, the energy density of children’s diets has not been found to be linked to children’s weight status (73). In a prospective cohort study, 4-year changes in daily energy density were assessed for two groups of children:
children with or without familial predisposition to obesity (based on maternal pre-pregnancy body mass index). The energy density of children’s diets did not differ by child’s weight status or by predisposition to obesity. The authors of this study have suggested that the sample size may have been too small to detect a relationship between energy density and weight status. The authors also suggested that the energy density of children’s diets may not have differed by predisposition to obesity because children of the same age group may be served similar foods by their respective caregivers.

The Effects of Energy Density on Children’s Fruit and Vegetable Intakes

Nationally representative data have revealed that few children meet the dietary recommendations intakes of vegetables and fruits (76). Data from the National Health and Nutrition Examination Survey (1999-2000) show that only about 48% of 2- to 3-year-old children consume the combined recommended amounts for fruits and vegetables. Only 5% of boys and 10% of girls 4-8 years of age consume the combined recommended amounts for fruits and vegetables.

Reducing the energy density of foods by increasing their vegetable or fruit content are two strategies that have been shown to effectively reduce energy intake in adults (31, 40, 48), but these strategies have not been tested in children. Sweet, palatable foods or beverages have been used as preloads in satiety studies conducted in children. In several studies, children consumed juice or other sweet drinks (54, 57, 58, 63, 64), and in other studies they consumed dessert-like foods such as yogurt (60, 62, 65), pudding (55, 61), gelatin (56), or ice cream (59) as preloads. Only one study used muffins (58) as preloads. These sweet, palatable foods were likely used as preloads in order to enhance the
probability of children consuming compulsory foods in their entirety. Likewise, in studies where children consumed manipulated foods during meals, palatable foods were also used. Chocolate milk (66, 67), macaroni and cheese (68), muffins, biscuits, cookies, and potato chips (71) have been served in these studies. Studies in which energy density strategies are used to moderate energy intake and simultaneously increase fruit and vegetables intakes are essential to understanding whether energy density manipulations can be used to improve children’s intakes of fruits and vegetables.

Portion Size

Epidemiological Data on Changes in the Portion Size of Foods

The increase in the prevalence of overweight and obesity has coincided with an increase in the portion sizes of foods that are available (77) and an increase in the portions of foods consumed (78). Increases in portion sizes have been reported for foods available for immediate consumption in take-out establishments, fast-food outlets, and family-style restaurants (77, 79). In some cases, the portion sizes of these foods are 2 to 8 times larger than standard servings (79). Nationally representative data from people two years of age and older indicate that there has been an increase in the portion sizes of foods consumed both inside and outside of the home (78).

The Effects of Portion Size on Adults' Energy Intake

The portion size of foods has been shown to influence food and energy intakes in both normal-weight and overweight adults (80). Laboratory studies have shown that increasing the portion size of amorphous dishes (80), unit foods (81), packaged snacks
(82), and beverages (83) leads to increases in food and energy intakes. Increasing the portion size of foods consumed in more naturalistic settings (restaurants and movie theaters) also leads to an increase in food consumption (84, 85). The effects of portion size have been shown to persist for up to 11 days (31, 86, 87).

The Effects of Portion Size on Children’s Energy Intake

Single-meal studies

The first study on the effects of portion size on young children’s food and energy intakes indicated that the susceptibility to larger portion sizes may be influenced by age (88). In this study, children were divided into two age groups and were served three different portions of a macaroni and cheese lunch entrée. Portions were tailored to each age group. The other meal components were not varied in portion size, and children consumed lunch ad libitum. Although younger children consumed similar weights of the entrée across conditions, older children consumed 60% more of the entrée when served the larger portion than when served the smaller portion. The report that the susceptibility to increases in portion size may be related to the age of the child led to multiple studies aimed at reproducing this finding (Table 3). However, these subsequent studies did not replicate the finding; increasing the portion size of an entrée led to significant increases in the food and energy intakes of children as young as two years of age (89, 90).

Multiple-meal studies

The portion size of foods has been shown to affect children’s food intake in several single-meal studies, but only one study has examined the effect of portion size on
children’s 24-hour food and energy intakes (91). In this study, children were served the same daily menu during each of two 24-hour periods. In one 24-hour period, reference portions of foods and beverages were served. In the other 24-hour period, the portion sizes of three entrées (macaroni and cheese, chicken, and cereal) and a snack (apple juice and graham crackers) were doubled. Doubling the portion size of foods led to an increase in intake of two (chicken and cereal) of the five portion-manipulated foods. Energy intake from portion manipulated foods was 23% greater and energy intake over the 24-hour period was 12% greater in the larger portion size condition.

In four of the five previously mentioned portion size studies, children did not compensate for their increased intake of portion-manipulated foods by decreasing their intake of other foods served at test meals (68, 89-91). In the multiple meal study by Fisher et al. (91), it was reported that children may have been decreasing their intake of foods that were not manipulated in portion size. However, the differences in food intake of these foods were not significant between conditions.

**Epidemiological studies**

Some epidemiological data indicate that increases in the portions of foods consumed may be part of energy intake regulation for young preschool children. A couple of studies have observed that children offered fewer eating occasions consume larger portions of foods at these eating occasions (92, 93). The authors of these studies have suggested that adjusting the portion size of foods consumed may be an important part of energy intake regulation for young children. In contrast to this belief, several other investigators have suggested that children may not be displaying energy intake regulation
when consuming larger portions of foods. One study reported that there was no association between the energy density of foods and portion size of foods consumed by 2-year-old children, indicating that children were not regulating their energy intake by adjusting the portions of foods consumed based on energy density of the foods (94). The results of another study indicate that children’s energy intake may be influenced by the portion of food served by the child’s caregiver (95). In this study, a significant relationship between energy density and portion size was found for 4- to 6-year-old children’s food intake. However, the portion of food served by the caregiver was inversely related to the energy density of the food, meaning that parents served smaller portions of energy-dense foods to children. The authors of this study concluded that the major determinant of energy intake was the caregiver.

**Energy Density and Portion Size**

*The Effects of Energy Density and Portion Size on Adults’ Energy Intake*

The effects of simultaneously changing the energy density and portion size of foods have been tested in several studies (27, 31, 48). The results of these studies have shown that energy density and portion size independently affect adults’ energy intake. For instance, in one study, adults were provided with all foods and beverages for each of four 2-day periods (31). Across the four sessions, the same daily menu was used, but all foods were varied in energy density and portion size between a standard (100%) and reduced level (75%). A 25% reduction in energy density led to an average decrease in energy intake across portion size conditions of 24%, and a 25% reduction in portion size led to an average decrease in energy intake across energy density conditions of 10%.
Energy density and portion size effects were independent and additive; reductions in both factors resulted in a reduction of 32% of energy intake.

The Effects of Energy Density and Portion Size on Children’s Energy Intake

To date, only one study has examined the effects of simultaneously changing the energy density and portion size of food on children’s energy intake (68), and this study was conducted in school-aged (5- to 6-year-old) children. In this study, children were served two portions (500 and 250 g) of a macaroni and cheese dinner entrée that varied in energy density (1.8 and 1.3 kcal/g). All other foods and beverages were not varied in energy density or portion size. Children consumed significantly more food in the lower-energy-density condition when the portion size of the dish was increased. However, this increase in food intake did not lead to a significant increase in energy intake. As was reported in adults, the effects on children’s energy intake of energy density and portion size were independent and additive.

In adults and school-aged children, lowering the energy density of foods has been shown to decrease energy intake because both age groups tend to consume a consistent weight of food even when the food is reduced in energy density (30, 31, 68). Reducing the energy density of the diet has become a strategy that is recommended to moderate energy intake in adults (42-44). Lowering the energy density of the diet not only moderates energy intake, but with increased intakes of fruits and vegetables, it has the potential to improve the quality of the diet.
The results of studies conducted in adults and school-aged children demonstrate that reducing the energy density of the diet is a promising approach to both moderate energy intake and increase fruit and vegetable intakes in preschool-aged children. However, whether reducing the energy density of the diet will moderate energy intake in preschool-aged children has yet to be determined. The satiety literature indicates that alterations in the energy density of compulsory preloads served prior to meals can result in compensatory adjustments in young children’s energy intake at subsequent eating occasions (54-56), so reducing the energy density of foods may not be an effective way to moderate children’s energy intakes.

The purpose of the following three studies is to determine whether reducing the energy density of foods and beverages consumed *ad libitum* is an effective approach to moderate energy intake in preschool children. These three studies are systematic, starting with lowering the energy density of one lunch entrée to understand how preschool children respond to changes in the energy density of foods consumed *ad libitum*. Because the portion size of foods may also influence children’s energy intake, the second study assesses how children respond to changes in the energy density and portion size of an entrée that is consumed *ad libitum*. The third study assesses how children respond to changes in the energy density of foods and beverages served at multiple meals over a 2-day period.

**Study 1: How does reducing the energy density of a lunch entrée affect preschool children’s energy intake from the entrée and from the meal?**
A number of studies have found that reducing the energy density of an entrée leads to a significant decrease in adults’ and school-aged children’s energy intakes from the entrée and from the meal (30, 31, 40, 41, 68). Adults and school-aged children tend to consume a consistent weight of food even when it is varied in energy density (30, 31, 68). However, little is known about how changing the energy density of an entrée influences preschool children’s *ad libitum* energy intake at a meal. Therefore, the aim of this study was to test the effects of reducing the energy density of an entrée on preschool children’s energy intakes from the entrée and from the meal. The entrée that was chosen for this study was macaroni and cheese because it is familiar to most children (96). Because manipulations of the fat content of foods are not thought to affect energy intake independent of manipulations of energy density (40, 41), the energy density of the macaroni and cheese was lowered via a reduction in the fat content of the entrée.

**Specific Aims and Hypotheses for Study 1:**

**Aim 1:** To test the effects on *ad libitum* energy intake from an entrée of decreasing the energy density of an entrée

**Hypothesis 1:** The energy density of the entrée will affect children’s *ad libitum* energy intake from the entrée; decreasing the energy density of the entrée will lead to a reduction in energy intake from the entrée.

**Aim 2:** To test the effects on *ad libitum* energy intake at lunch of decreasing the energy density of an entrée
**Hypothesis 2:** The energy density of the entrée will affect children’s *ad libitum* energy intake at lunch; decreasing the energy density of the entrée will lead to a reduction in energy intake at lunch.

**Study 2: How does simultaneously reducing the energy density and portion size of a lunch entrée affect preschool children’s energy intake from the entrée and from the meal?**

Several studies have shown that simultaneously changing the energy density and portion size of foods affects adults’ and school-aged children’s energy intakes (27, 31, 48, 68). Reductions in the energy density of foods using a combination of decreasing fat content and increasing vegetable content have been shown to be effective in lowering adults’ energy intake (31, 48). However, little is known about how changing the vegetable content of foods affects children’s responses to energy density. The aim of the present study was to test the effects on children’s *ad libitum* energy intake of varying the energy density and portion size of an entrée between a standard (100%) and reduced (75%) level. A secondary aim of this study was to assess whether manipulating the energy density of an entrée by reducing its fat content and increasing its vegetable content would influence children’s vegetable intake from the entrée.

**Specific Aims and Hypotheses for Study 2:**

**Aim 1:** To test the effects on *ad libitum* energy intake from an entrée of decreasing the energy density and portion size of an entrée
Hypothesis 1: The energy density and portion size of the entrée will affect children’s *ad libitum* energy intake from the entrée; decreasing the energy density and portion size of the entrée will lead to a reduction in energy intake from the entrée.

Aim 2: To test the effects on *ad libitum* energy intake at lunch of decreasing the energy density and portion size of an entrée

Hypothesis 2: The energy density and portion size of the entrée will affect children’s *ad libitum* energy intake at lunch; decreasing the energy density and portion size of the entrée will lead to a reduction in energy intake at lunch.

Aim 3: To test the effects on vegetable intake of decreasing the energy density of an entrée by increasing the proportion of vegetables in the entrée

Hypothesis 3: The vegetable content of an entrée will affect children’s vegetable intake; increasing the vegetable content of the entrée will lead to an increase in vegetable intake.

**Study 3: How does reducing the energy density of all foods and beverages served at multiple meals affect preschool children’s energy intake over the course of two days?**

The energy density of foods has been shown to affect adults’ energy intake for multiple days (31-39). Reductions in energy intake lead to parallel decreases in adults’ energy intake because adults consume a consistent weight of food even when the food is reduced in energy density. For example, reducing the energy density of a 2-day diet by 25% led to a 24% decrease in energy intake over two days (31). The effects of changing
the energy density of several meals over multiple days on children’s ad libitum energy intake are unknown. Therefore, the aim of the present study was to test the effects on children’s ad libitum energy intake of varying the energy density of foods and beverages served at multiple meals over the course of two days. Several strategies were used to reduce the energy density of foods and beverages, including reducing fat or sugar content, increasing fruit or vegetable content, or combinations of these approaches.

**Specific Aims and Hypotheses for Study 3:**

**Aim 1:** To test the effects on ad libitum energy intake of decreasing the energy density of foods and beverages served at multiple meals over two days

**Hypothesis 1:** The energy density of the foods and beverages will affect children’s ad libitum energy intake; decreasing the energy density of the foods and beverages will lead to a reduction in energy intake over two days.

**Aim 2:** To test the effects on ad libitum food and beverage intakes of decreasing the energy density of foods and beverages served at multiple meals over two days

**Hypothesis 2:** The energy density of the foods and beverages will not affect children’s total ad libitum food and beverage intake over two days; children will consume a consistent weight of foods and beverages in both energy density conditions.
Table 1. Effects of energy density of preloads on subsequent energy intake in young children

<table>
<thead>
<tr>
<th>Publication</th>
<th>Participants</th>
<th>Preload-ad-lib delay (min)</th>
<th>Preload</th>
<th>Macronutrient Manipulation</th>
<th>Flavor Pairing</th>
<th>Reduction in energy density</th>
<th>Evidence of caloric compensation?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birch et al. (54)</td>
<td>Exp 1: 24 4- and 5-year-old children</td>
<td>0, or 30, or 60</td>
<td>205 ml water, 3 beverages (90, 90, 3.5 kcal)</td>
<td>Carbohydrate</td>
<td>No</td>
<td>96%</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Exp 2: 20 2- and 3-year-old children</td>
<td>0, 30, 60</td>
<td>150 ml water, 3 beverages (65, 65, 2.5 kcal)</td>
<td>Carbohydrate</td>
<td>No</td>
<td>96%</td>
<td>Yes</td>
</tr>
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<td>Yes</td>
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<td></td>
<td>Yes</td>
</tr>
<tr>
<td>Birch and Deysher (55)</td>
<td>21 2.5- to 5-year old children</td>
<td>20 – 30</td>
<td>3.5 oz pudding (132, 32 kcal)</td>
<td>Carbohydrate</td>
<td>No</td>
<td>76%</td>
<td>Yes</td>
</tr>
<tr>
<td>Hetherington et al. (56)</td>
<td>Exp 1: 15 2- to 5-year-old (younger) children and 10 7- to 10-year-old (older) children</td>
<td>120</td>
<td>100 g raspberry gelatin (73, 6 kcal)</td>
<td>Carbohydrate</td>
<td>No</td>
<td>92%</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Exp 2: 19 younger and 12 older children</td>
<td></td>
<td>younger: 150 g raspberry gelatin (109, 9 kcal)  older: 225 g raspberry gelatin (164, 13 kcal)</td>
<td>Carbohydrate</td>
<td>No</td>
<td>92%</td>
<td>younger children: Yes older children: No</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>younger children: COMPX² 88% older children: COMPX 21.5%</td>
</tr>
<tr>
<td>Study</td>
<td>Age Group</td>
<td>Experimental Meals</td>
<td>Compensation to Load (kcal)</td>
<td>Carbohydrate</td>
<td>Fat</td>
<td>Compensation to Load (kcal)</td>
<td>No</td>
</tr>
<tr>
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</tr>
<tr>
<td>Cecil et al. (58)</td>
<td>74 6- to 9-year-old children</td>
<td>250 ml water (NE), 56 g muffin and 250 ml orange drink (LE; 187 kcal), 56 g muffin and 250 ml orange drink (HE; 389 kcal)</td>
<td>NE and LE: younger COMPX 44% and older COMPX 57</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Johnson and Taylor-Holloway (64)</td>
<td>262 5- to 12-year-old children</td>
<td>Not reported 163 g juice (150, 3 kcal)</td>
<td>NE and HE: younger COMPX 40% and older COMPX 31%</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Johnson et al. (57)</td>
<td>77 3- to 5-year-old children</td>
<td>163 g beverages (150, 3 kcal)</td>
<td>LE and HE: younger COMPX 35% and older COMPX 7%</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Zandstra et al. (60)</td>
<td>30 4- to 6-year-old Children</td>
<td>90 No yogurt, 200 g of 4 yogurts (287, 191, 191, 67 kcal)</td>
<td>No difference in compensation among children, young adults, and elderly</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>33 18- to 26-year-old young adults</td>
<td>No yogurt, 340 g of yogurts (488, 325, 325, 114 kcal)</td>
<td>No difference in compensation among children, young adults, and elderly</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>24 61- to 86-year-old elderly adults</td>
<td>No yogurt, 300 g of 4 yogurts (430, 287, 287, 100 kcal)</td>
<td>No difference in compensation among children, young adults, and elderly</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Authors</td>
<td>Experiment 1:</td>
<td>Experiment 2:</td>
<td>Preload (Calories)</td>
<td>Type of Food</td>
<td>Carbohydrate</td>
<td>Fat</td>
<td>Quality</td>
</tr>
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</tr>
<tr>
<td>Birch and Deysher (61)</td>
<td>18 3- to 5-year-old children</td>
<td>10 3- to 5-year-old children</td>
<td>20-40</td>
<td>100 ml pudding (156, 42 kcal)</td>
<td>100 ml pudding (156, 42 kcal)</td>
<td>Carbohydrate</td>
<td>Yes</td>
</tr>
<tr>
<td>Birch et al. (63)</td>
<td>11 3- and 4-year-old children</td>
<td>20-30</td>
<td>150 ml beverages (155, 5 kcal)</td>
<td>Carbohydrate</td>
<td>Yes</td>
<td>97%</td>
<td>Yes</td>
</tr>
<tr>
<td>Johnson et al. (62)</td>
<td>Exp 1: 12 3and 4-year-old children</td>
<td>60</td>
<td>120 g yogurt (264,132 kcal)</td>
<td>Fat</td>
<td>Yes</td>
<td>50%</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Exp 2: 9 2and 3-year-old children</td>
<td>90</td>
<td>100 g yogurt (230, 110 kcal)</td>
<td>Fat</td>
<td>Yes</td>
<td>50%</td>
<td>Yes</td>
</tr>
<tr>
<td>Birch et al. (59)</td>
<td>24 2- and 3-year-old children</td>
<td>120</td>
<td>109 g cereal and juice (80 kcal), 113 g ice cream (275, 228, 177 kcal)</td>
<td>Fat</td>
<td>No</td>
<td>36%</td>
<td>No</td>
</tr>
<tr>
<td>Birch et al. (65)</td>
<td>11 preschool-aged children</td>
<td>10</td>
<td>100 g yogurt (145, 60 kcal)</td>
<td>Carbohydrate</td>
<td>Yes</td>
<td>59%</td>
<td>Yes</td>
</tr>
</tbody>
</table>

1 Direct compensation refers to compensating on the first exposure to a preload
2 COMPX = compensation index score; calculated for the children using a formula that considered children’s energy intake from *ad libitum* and preload consumption in both energy density conditions. COMPX score of 100% indicates perfect compensation. COMPX scores less than 0% indicate that a child consumed more energy in the higher-ED condition than the lower-ED condition. COMPX scores between 0% and 100% indicate that there was incomplete compensation. COMPX scores greater than 100% indicate that the child overcompensated, consuming considerably less energy in the lower-ED condition than in the higher-ED condition.
<table>
<thead>
<tr>
<th>Publication</th>
<th>Participants</th>
<th>Meal</th>
<th>Manipulated foods</th>
<th>Macronutrient manipulation</th>
<th>Matched palatability</th>
<th>Reduction in energy density</th>
<th>Food intake</th>
<th>Energy intake</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wilson (66)</td>
<td>40 children 20-56 months</td>
<td>Lunch 2 days per week for 8 weeks</td>
<td>Milk (2% plain, chocolate)</td>
<td>Carbohydrate</td>
<td>No</td>
<td>24%</td>
<td>No change in food intake, but ↑ chocolate milk intake</td>
<td>↑ 25%</td>
</tr>
<tr>
<td>Wilson (67)</td>
<td>135 children 18-66 months</td>
<td>Lunch 2 days per week for 12 weeks</td>
<td>Milk (2% plain, aspartame-sweetened chocolate, sucrose-sweetened chocolate)</td>
<td>Carbohydrate</td>
<td>No</td>
<td>Not reported</td>
<td>No change in food intake, but ↑ chocolate milk intake</td>
<td>↑ 21% compared to plain 2% milk ↑ 18% compared to aspartame-sweetened chocolate milk</td>
</tr>
<tr>
<td>Fisher et al. (68)</td>
<td>53 5- to 6 year-old children</td>
<td>Dinner</td>
<td>Macaroni and cheese entrée</td>
<td>Fat</td>
<td>Yes</td>
<td>28%</td>
<td>No change</td>
<td>↓ 15% dinner</td>
</tr>
<tr>
<td>Birch et al. (71)</td>
<td>29 2- to 5-year-old children</td>
<td>Breakfast Snack Lunch</td>
<td>Muffins and biscuits cookies cookies and potato chips</td>
<td>Fat Fat</td>
<td>Yes Yes</td>
<td>↓ children’s total energy intake by 144 kcal in 3 meals</td>
<td>No change during meals with manipulated foods</td>
<td>↓ 11% breakfast, snack, and lunch ↓ 4% day 1 No difference day 2</td>
</tr>
<tr>
<td>Publication</td>
<td>Participants</td>
<td>Meal</td>
<td>Food</td>
<td>Portions</td>
<td>Change in portion size</td>
<td>Food intake</td>
<td>Energy intake</td>
<td></td>
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<td>---------------------------</td>
<td>------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Rolls et al.</td>
<td>16 children with mean age 3.6 y</td>
<td>Lunch 1 day/week for 3 weeks</td>
<td>Macaroni and cheese entrée</td>
<td>150, 263, and 376 g</td>
<td>75%↑ small to medium, 43%↑ medium to large, 150%↑ small to large</td>
<td>No effect of portion size</td>
<td>No effect of portion size</td>
<td></td>
</tr>
<tr>
<td>(88)</td>
<td>16 children with mean age 5.0 y</td>
<td></td>
<td></td>
<td>225, 338, and 450 g</td>
<td>50%↑ small to medium, 33%↑ medium to large, 100%↑ small to large</td>
<td>60%↑ entrée intake in large portion compared to small portion;</td>
<td>39%↑ total energy intake in large portion condition compared to small portion</td>
<td></td>
</tr>
<tr>
<td>Fisher et al.</td>
<td>11 children with mean age 3.5 y</td>
<td>Lunch 1 day/week for 12 weeks</td>
<td>Macaroni and cheese entrée</td>
<td>125 (R), 250 g (L), and self-selected (S)</td>
<td>100%↑ RRRR SS LLLL SS</td>
<td>25%↑ entrée intake in large (L) portion compared to reference (R) portion</td>
<td>15%↑ total energy intake in large portion condition compared to reference portion</td>
<td></td>
</tr>
<tr>
<td>(89)</td>
<td>18 children with mean age 4.3 y</td>
<td></td>
<td></td>
<td>175 (R), 350 g (L), and self-selected (S)</td>
<td></td>
<td>0.5 g↑ in bite size in large portion compared to reference portion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fisher et al.</td>
<td>25 children with mean age 2.6 y</td>
<td>Dinner 1 day/week for 3 weeks</td>
<td>Macaroni and cheese entrée</td>
<td>200 (R), 400 g (L), and self-selected (S)</td>
<td>100%↑</td>
<td>63% children ↑ entrée intake in large portion condition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(90)</td>
<td>25 children with mean age 5.6 y</td>
<td></td>
<td></td>
<td>250 (R), 500 g (L), and self-selected (S)</td>
<td></td>
<td>↑ bite size in large portion condition compared to</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<p>|                    |                                     |                      |                                   |                           |                                      | No effect on total food intake                                               |                                                                                  |
|                    |                                     |                      |                                   |                           |                                      | Self-served (S) portion sizes did not differ following reference and large portions |                                                                                  |
|                    |                                     |                      |                                   |                           |                                      | 13%↑ total energy intake in large portion condition compared to               |                                                                                  |
|                    |                                     |                      |                                   |                           |                                      | 40 of 65 children 11%↓ total energy intake when served self-selected         |                                                                                  |</p>
<table>
<thead>
<tr>
<th>Study</th>
<th>Participants</th>
<th>Intervention Details</th>
<th>Energy Intake Comparison</th>
<th>Portion Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fisher et al. (68)</td>
<td>53 children 5-6 years of age</td>
<td>4 dinners Macaroni and cheese entree 250 (R) and 500 g (L) of entrees with energy densities of 1.3 and 1.8 kcal/g</td>
<td>100%↑ 33%↑ entrée intake from large (L) portion compared to reference (R) portion</td>
<td>15%↑ total energy intake in large portion conditions compared to reference portions</td>
</tr>
<tr>
<td>Fisher et al. (91)</td>
<td>59 children 5 years of age</td>
<td>2 24-hour periods in which breakfast, lunch, and dinner entrees and afternoon snack were manipulated Macaroni and cheese entree (lunch), apple juice and graham crackers (snack), chicken nuggets (dinner), and oat ring cereal (breakfast) Reference and large portions</td>
<td>100%↑ ↑ intake of 2 (chicken nuggets and cereal) of 5 portion-manipulated foods</td>
<td>23%↑ energy intake from portion-manipulated foods 12%↑ total energy intake over 24 hours</td>
</tr>
</tbody>
</table>
REFERENCES


54. Birch LL, McPhee L, Sullivan S. Children's food intake following drinks sweetened with sucrose or aspartame: time course effects. Physiol Behav 1989;45:387-95.


86. Rolls BJ, Roe LS, Meengs JS. Larger portion sizes lead to sustained increase in energy intake over two days. J Am Diet Assoc 2006;106:543-9.

89. Fisher JO, Rolls BJ, Birch LL. Children's bite size and intake of an entrée are greater with large portions than with age-appropriate or self-selected portions. Am J Clin Nutr 2003;77:1164-70.
CHAPTER II

STUDY 1:

REDUCING THE ENERGY DENSITY OF AN ENTRÉE DECREASES
CHILDREN'S ENERGY INTAKE AT LUNCH

INTRODUCTION

During the past 3 decades the prevalence of childhood overweight has increased (1-4). In 2003-2004, more than one fourth (26%) of preschool children were considered “at risk of overweight or (already) overweight” (4). To treat and prevent childhood overweight, effective strategies are essential, especially tactics to combat the food environment, which has been implicated as contributing to the increase in overweight (5). The World Health Organization has suggested decreasing the consumption of foods that are high in energy density as one approach to help prevent childhood obesity (6). However, little is known about how changing the energy density of meals affects preschool children’s ad libitum energy intake. The present study tested whether decreasing the energy density of an entrée was an effective strategy for moderating preschool children’s energy intake during a meal.

In adults, the effects of covert manipulations of the energy density of meals on energy intake are clear; decreasing energy density can lead to reductions in energy intake at a single meal, during a single day, and over the course of 2 weeks (7-11). Adults tend to consume a consistent weight of food even when it is varied in energy density. In contrast, little is known about how changing the energy density of an entrée influences preschool children’s ad libitum energy intake during a meal. The literature indicates that alterations in the energy density of compulsory preloads served before meals can result in compensatory adjustments in young children’s energy intake at subsequent eating occasions (12-17). The findings of these preloading studies suggest that altering energy density may not be an effective approach to reducing energy intake in children.
The primary aim of the present study was to investigate the effects of reducing the energy density of a popular and familiar entrée—macaroni and cheese—on children’s energy intake at lunch. The main hypothesis was that children, like adults, would consume less energy from an entrée when it was lower in energy density, and this reduction in intake would lead to decreased energy intake at the meal. This hypothesis would be supported if children consumed a fairly consistent weight of the entrée and other lunch items when the energy density of the entrée was varied. A secondary aim of the study was to assess the influence of children’s physical characteristics and mothers’ child-feeding practices on the relationships between energy density of the entrée and the weight and energy of the entrée and lunch consumed.

METHODS

Design and General Overview

A within-subjects crossover design was used to test the effect of varying the energy density of a lunch entrée on energy intake of preschool children attending a child-care center. All children received breakfast and lunch 1 day per week for 7 weeks. Throughout the experiment, a standard breakfast of cereal, milk, and fruit was served to ensure a consistent level of hunger across lunch sessions, and a single lunch menu was used. The experimental lunches differed only in the energy density of the macaroni and cheese entrée; the higher-energy-density entrée had 2.0 kcal/g and the lower-energy-density entrée had 1.4 kcal/g. During the first week of the experiment, the macaroni and
cheese entrée was not manipulated because this week was used to acquaint the children and preschool teachers with the study procedures. Children were served each version of the entrée three times over the course of 6 weeks and were randomly assigned to one of two orders of presentation of the energy density conditions (Table 4).

Table 4. Experimental timeline for a study to test the effect of decreasing the energy density (ED) of an entrée on children’s food intake and energy intake at lunch

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>Week 1</th>
<th>Week 2</th>
<th>Week 3</th>
<th>Week 4</th>
<th>Week 5</th>
<th>Week 6</th>
<th>Week 7</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Order 1</strong></td>
<td>41</td>
<td>S(^a)</td>
<td>LED(^b)</td>
<td>HED</td>
<td>LED</td>
<td>HED</td>
<td>LED</td>
<td>HED</td>
</tr>
<tr>
<td><strong>Order 2</strong></td>
<td>36</td>
<td>S(^a)</td>
<td>HED(^c)</td>
<td>LED</td>
<td>HED</td>
<td>LED</td>
<td>HED</td>
<td>LED</td>
</tr>
</tbody>
</table>

\(^a\)S, standard macaroni and cheese with ED = 1.6 kcal/g  
\(^b\)LED, lower-energy density macaroni and cheese with ED = 1.4 kcal/g  
\(^c\)HED, higher-energy density macaroni and cheese with ED = 2.0 kcal/g

Children were recruited by letters (APPENDIX A) given to all parents at the child-care center with children who would be 2 years of age or older during the study. Parents provided written consent (APPENDIX B) for both their own participation and the participation of their children. The Pennsylvania State University Office for Research Protections reviewed and approved all procedures.

Participants

Ninety-one preschool children in full-day day-care at Pennsylvania State University were enrolled in the study. Twelve subjects were excluded from the analyses.
because they failed to meet the predefined criteria for minimum consumption of the entrée (25 g at half of their experimental meals), and two subjects were excluded due to absenteeism. The final sample consisted of 77 children.

Measures and Procedures

Lunch Procedures

Children in each of the nine classrooms at the child-care facility were served lunch at their regularly scheduled time and ate at tables of three to six children and one adult, which is standard practice at the facility. Food and drink spillage and any comments made by teachers or children pertaining to food were recorded by researchers. Table conversations pertaining to food were redirected from food-related topics to ensure that children’s lunch intakes were not influenced by peers or teachers. When children finished lunch, spilled or dropped foods were returned to the correct dish and lunch items were cleared. Spilled milk was cleaned up with paper towels and milk intake was corrected by subtracting the weight of the dry towels from the weight of the wet towels. Food and milk weights were recorded to the nearest 0.1 g using digital scales (Mettler-Toledo PR5001 and Mettler-Toledo XS4001S, Mettler-Toledo, Inc, Columbus, OH). Consumption of the foods and milk was determined by subtracting post-meal weights from pre-meal weights, and manufacturers’ nutrition information was used to calculate energy density and energy intakes.
Experimental Menu

The experimental entrée (Photograph 1) served to all children during the study was macaroni and cheese (Table 5). The energy density of the macaroni and cheese was manipulated by adding different ingredients to a commercially prepared entrée. A combination of water, vegetable oil, and salted butter was added to the commercially prepared entrée to make the higher-energy-density entrée (2.0 kcal/g). Water was added to the entrée to make the lower-energy-density entrée (1.4 kcal/g). Thus, compared with the higher-energy-density entrée, the lower-energy-density entrée was 30% lower in energy density. These two levels of energy density are similar to commercially available macaroni and cheese products. The 300-g portion of the entrée was chosen based on the amounts used in previous work with children of the same age as the subjects in this study (18). Other foods (Photograph 2) served during lunch were 2% milk (297 mL; University Creamery, State College, PA), steamed broccoli (60 g; Birds Eye Foods, Inc, Rochester, NY), and unsweetened applesauce (150 g; Knouse Foods, Inc, Peach Glen, PA). All lunch items were consumed ad libitum.

Photograph 1. Macaroni and cheese entrée.
Table 5. Nutrition information for two versions of macaroni and cheese served in a study to test the effect of decreasing the energy density of an entrée on children’s food intake and energy intake at lunch.

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Weight (g)</th>
<th>Energy (kcal)</th>
<th>Fat (g)</th>
<th>Carbohydrate (g)</th>
<th>Protein (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Higher-energy density version (2.0 kcal/g)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Macaroni and cheese(^a)</td>
<td>261.2</td>
<td>417.9</td>
<td>19.8</td>
<td>41.8</td>
<td>18.7</td>
</tr>
<tr>
<td>Water</td>
<td>15.5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Butter(^b)</td>
<td>15.5</td>
<td>110.7</td>
<td>12.2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Vegetable oil(^c)</td>
<td>7.8</td>
<td>66.9</td>
<td>7.8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>300</td>
<td>595.5</td>
<td>39.8</td>
<td>41.8</td>
<td>18.7</td>
</tr>
<tr>
<td><strong>Lower-energy density version (1.4 kcal/g)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Macaroni and cheese(^a)</td>
<td>260.2</td>
<td>416.3</td>
<td>19.7</td>
<td>41.6</td>
<td>18.6</td>
</tr>
<tr>
<td>Water</td>
<td>39.8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>300</td>
<td>416.3</td>
<td>19.7</td>
<td>41.6</td>
<td>18.6</td>
</tr>
</tbody>
</table>

\(^a\)Nestlé USA, Inc, Solon, OH
\(^b\)Independent Marketing Alliance, Houston, TX
\(^c\)J.M. Smucker Company, Orrville, OH

Photograph 2. Test meal.
Other Measures

Preference Assessments

The two versions of macaroni and cheese were formulated to be similar in palatability. The children’s preferences (APPENDIX C) for the two versions were evaluated twice (1 week apart) at the end of the study to assess whether one version was consistently preferred over the other. During preference assessments, the child was seated at a table with two samples of the entrée. To control for positional preferences (left or right), the position of the higher-energy-density and lower-energy-density samples was reversed during the second preference assessment. The child was told: “Please take a bite of both macaroni and cheeses and tell me if you think these macaroni and cheeses taste the same or different.” If the child said the samples had different tastes, the child was then asked “If you could pick one of these two macaroni and cheeses to eat more of, which one would you pick?” The child’s responses were recorded.

Children’s Body Weight and Height

For the majority of the children, body weight and height were measured within 2 weeks of the final test session. Body weight was measured in duplicate using a portable digital scale (4014 MedWeigh, Itin Scale Company, Brooklyn, NY). If the two measurements differed by more than 0.1 kg, a third measurement was taken. Height was measured in duplicate to the nearest 0.1 cm using a portable stadiometer (Seca 214, Seca North America East, Hanover, MD). If the two measurements varied by more than 0.2
cm, a third measurement was taken. Several children were absent on all 3 weight-assessment days, and three children moved away from the area before having their measurements taken. One child refused to be weighed or measured. The mean height and body weight of each child was used to calculate their sex-specific body mass index–for-age percentile (BMI percentile) using a program from the Centers for Disease Control and Prevention (19).

**Parental Questionnaires**

Parents were asked (APPENDIX D) to complete two questionnaires: the Child Feeding Questionnaire (CFQ) and a demographic questionnaire. Mothers were asked to complete the CFQ (APPENDIX E), which includes 75 questions that assess parental feeding strategies and opinions about body weight. The psychometric characteristics of this instrument are described elsewhere (20). Seven subscales assessed the mother’s perception of her own weight status throughout life, her perception of her child’s weight status throughout life, her concern for her child’s current body weight and risk of becoming overweight, her restriction of her child’s food intake, her exertion of pressure on her child to eat, her level of responsibility in child feeding, and her level of monitoring her child’s eating. The demographic questionnaire (APPENDIX F) consists of 21 questions that assess the background and the health status of each child, and either parent could complete this questionnaire.
Statistical Analysis

Data were analyzed using the SAS System for Windows (version 9.1, 2003, SAS Institute, Cary, NC), and results were considered significant at \( P < 0.05 \). The main outcomes for the study were weight and energy of macaroni and cheese consumed, and total weight and energy of lunch consumed. These outcomes were analyzed using a mixed linear model (PROC MIXED). The primary factor tested in the model was energy density condition; the following factors were also tested: child’s sex, order of presentation of the conditions (Table 4), and time period (three 2-week periods with one session of each condition). Children who ate more than 95% of the entrée at half or more of their experimental meals were classified as “plate cleaners”; three children met this criterion. Study outcomes were analyzed both with and without data from these children to assess their effect on the results.

\( t \) tests were used to determine whether boys and girls differed in terms of age, weight, height, and BMI percentile. Covariate analyses tested whether continuous subject characteristics, such as age, body weight, height, BMI percentile, and the seven subscales from the CFQ affected the relationships between the energy density of the entrée and the main outcomes of the study. Regression analyses, using subject characteristics (age, sex, and BMI percentile), the seven CFQ subscales, and energy density of the entrée, assessed which factors best predicted the mean amount (in grams and kilocalories) of total lunch that children consumed. Adjusted \( R^2 \) values will be reported. Multivariate analysis of variance was used to determine whether children responded to changes in the energy density of the entrée by adjusting the proportion of the individual foods and milk they
consumed. It was also used to determine whether the macronutrient composition of children’s lunch intake changed in response to the manipulation of the macaroni and cheese.

RESULTS

Subject Characteristics

The final group of 77 children had a mean (±standard error) age of 3.9±0.1 years (range, 2.0 to 5.5 years) and a mean sex-specific BMI–for-age percentile of 64.6±3.0 (n=66; range, 1.9 to 96.1). Three children were considered overweight due to having BMI percentiles greater than 95. Boys and girls did not significantly differ in mean age, body weight, height, or BMI percentile (Table 6). Parents provided demographic information for 68 of the 77 participants. Of these 68 children, 69% were white, 27% were Asian, and 4% were black or African American, and 90% of mothers and 85% of fathers reported having at least a 4-year university degree. The majority of parents, 81% of mothers and 96% of fathers, reported being employed. Most of the families (76%) reported earning a combined income of more than $50,000 per year.
Table 6. Characteristics of children participating in a study to test the effect of decreasing the energy density of an entrée on food intake at lunch (mean ± standard error; range)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Boys</th>
<th>Girls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>4.0 ± 0.1</td>
<td>3.8 ± 0.2</td>
</tr>
<tr>
<td></td>
<td>(2.1 – 5.3)</td>
<td>(2.0 – 5.5)</td>
</tr>
<tr>
<td></td>
<td>n = 37</td>
<td>n = 40</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>17.3 ± 0.4</td>
<td>16.6 ± 0.5</td>
</tr>
<tr>
<td></td>
<td>(12.8 – 23.9)</td>
<td>(13.0 – 23.3)</td>
</tr>
<tr>
<td></td>
<td>n = 34</td>
<td>n = 32</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>103.2 ± 1.2</td>
<td>100.4 ± 1.3</td>
</tr>
<tr>
<td></td>
<td>(90.0 – 117.1)</td>
<td>(86.5 – 115.3)</td>
</tr>
<tr>
<td></td>
<td>n = 34</td>
<td>n = 33</td>
</tr>
<tr>
<td>Sex-specific BMI-for-age percentile</td>
<td>61.3 ± 4.5</td>
<td>68.1 ± 4.0</td>
</tr>
<tr>
<td></td>
<td>(2.4 – 96.1)</td>
<td>(1.9 – 96.1)</td>
</tr>
<tr>
<td></td>
<td>n = 34</td>
<td>n = 32</td>
</tr>
</tbody>
</table>

Entrée Intake

The energy density of the macaroni and cheese had a significant effect on energy intake of the entrée ($P<0.0001$). Decreasing the energy density of the macaroni and cheese by 30% resulted in a 25% (72.3±8.3 kcal) decrease in energy consumed from the entrée (Figure 1). Across three occasions of measurement in each condition, children consumed a mean of 288.1±10.9 kcal from the higher-energy-density entrée and 216.6±8.1 kcal from the lower-energy-density entrée. The energy density of the entrée also had a small but significant effect on the weight of entrée consumed ($P<0.05$). Compared with the higher-energy-density entrée, children consumed an additional 10.1±4.2 g of the lower-energy-density entrée (Figure 2). Excluding three children who
were identified as “plate cleaners” from the analyses did not affect the main outcomes, and therefore these children were included in all of the reported analyses.

**Figure 1**: Energy intake from foods and milk (mean ± standard error) consumed by children in the two conditions of energy density (ED). *Compared with when served the higher-ED (2.0 kcal/g) entrée, children consumed significantly less energy from macaroni and cheese (P<0.0001) and from the meal (P<0.0001) when served the lower-ED (1.4 kcal/g) entrée.
Figure 2: Weight of foods and milk (mean ± standard error) consumed by children in the two conditions of energy density (ED). Compared with the higher-ED (2.0 kcal/g) condition, children consumed significantly (P<0.05) more macaroni and cheese in the lower-ED (1.4 kcal/g) condition. However, there was no difference in the total weight of food consumed at lunch between conditions.

There was no significant effect of order of experimental conditions on either the weight of the entrée consumed or energy intake of the entrée. There was a significant effect of period on the weight (P<0.01) and amount of energy (P<0.01) of the entrée consumed. Children consumed a greater weight (P<0.01) of macaroni and cheese and more energy (P<0.05) from the entrée in the second and third periods than in the first period.
Lunch Intake

Children did not compensate for the decrease in energy intake from the macaroni and cheese by increasing their intake of the other foods offered during lunch, so the energy density of the macaroni and cheese entrée had a significant effect on lunch energy intake ($P<0.0001$). Decreasing the energy density of the entrée by 30% resulted in an 18% decrease in energy consumption during the meal (Table 7). Mean lunch energy intake for the higher-energy-density condition differed from mean lunch energy intake for the lower-energy-density condition by 71.8±7.9 kcal (Figure 1). Mean lunch intake did not significantly differ by energy density condition (Figure 2). There was a significant main effect of sex on lunch intake ($P<0.001$) and lunch energy intake ($P<0.05$).
Table 7. Energy intakes and weight of foods consumed (mean ± standard error) at lunch for a study to test the effect of decreasing the energy density of an entrée on children’s food intake and energy intake at lunch

<table>
<thead>
<tr>
<th>Lunch Component</th>
<th>Higher-energy density condition*</th>
<th>Lower-energy density condition*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Boys</td>
<td>Girls</td>
</tr>
<tr>
<td></td>
<td>n = 37</td>
<td>n = 40</td>
</tr>
<tr>
<td>Macaroni and cheese</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight (g)</td>
<td>155.3 ± 7.8</td>
<td>133.5 ± 7.5</td>
</tr>
<tr>
<td>Energy (kcal)</td>
<td>310.7 ± 15.6</td>
<td>267.1 ± 15.1</td>
</tr>
<tr>
<td>Broccoli</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight (g)</td>
<td>23.0 ± 2.1</td>
<td>23.0 ± 2.1</td>
</tr>
<tr>
<td>Energy (kcal)</td>
<td>8.1 ± 0.7</td>
<td>8.1 ± 0.7</td>
</tr>
<tr>
<td>Applesauce</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight (g)</td>
<td>89.0 ± 5.2</td>
<td>66.0 ± 5.5</td>
</tr>
<tr>
<td>Energy (kcal)</td>
<td>36.5 ± 2.1</td>
<td>27.0 ± 2.2</td>
</tr>
<tr>
<td>Milk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight (g)</td>
<td>157.8 ± 9.6</td>
<td>115.8 ± 7.9</td>
</tr>
<tr>
<td>Energy (kcal)</td>
<td>74.4 ± 4.5</td>
<td>54.6 ± 3.7</td>
</tr>
<tr>
<td>Total weight of food (g)</td>
<td>424.2 ± 11.0</td>
<td>338.2 ± 12.2</td>
</tr>
<tr>
<td>Total energy intake (kcal)</td>
<td>429.3 ± 15.2</td>
<td>356.8 ± 15.6</td>
</tr>
</tbody>
</table>

*In each condition, only the macaroni and cheese was manipulated in energy density.
*Significantly different from the mean of the higher-energy density condition in both sexes, P < 0.05.
***Significantly different from the mean of the higher-energy density condition in both sexes, P < 0.0001.
Multivariate analysis of variance demonstrated that there was no overall effect of condition on the proportion of total meal weight that was consumed from each lunch item. However, there was an overall effect of condition on the proportion of total energy that was consumed from each item \( (P<0.0001) \), which was attributable to differences in energy intake from macaroni and cheese. Multivariate analysis of variance also showed a significant effect of condition on the proportion of energy consumed from fat, carbohydrate, and protein during the meal \( (P<0.0001) \), which can be explained by the differences in the macronutrient composition of the manipulated entrée. In the higher-energy-density condition children ate a mean of 37.8% energy from carbohydrate, 14.0% energy from protein, and 48.2% energy from fat. In the lower-energy-density condition, they ate a mean of 47.6% energy from carbohydrate, 17.7% energy from protein, and 34.6% energy from fat.

**Children’s Characteristics and Mothers’ Child-feeding Practices**

Of the 35 children older than the age of 4 years who gave preference assessments, 74.3% reported no difference in the taste of the two versions of the entrée, 17.1% reported favoring the lower-energy-density entrée, and 8.6% reported liking the higher-energy-density version of the entrée.

Children’s age, body weight, height, and BMI percentile did not impact the relationship between the energy density of the macaroni and cheese entrée and lunch energy intake. Thus, serving a lower-energy-density entrée to children reduced energy
intake regardless of their physical characteristics. In particular, the effect of energy density on lunch energy intake was similar for children across a range of BMI percentiles (Figure 3).

![Figure 3: Plot of children’s mean energy intake from lunch and sex-specific body mass index-for-age percentile (BMI-for-age percentile) for boys and girls. The effect of energy density (ED) is consistent, regardless of BMI-for-age percentile.](image)

Sixty-four mothers completed the CFQ. Covariate analyses revealed that there was a significant interaction ($P<0.05$) between mother’s score for pressuring her child to eat and child’s sex on the amount of energy consumed from the total lunch. Girls with mothers who reported placing less pressure on their daughters to eat consumed more energy from the lunch than girls whose mothers reported a greater degree of pressure to eat. In boys, there was no significant relationship between this score and energy intake.
The score had no effect on the relationship between the energy density of the entrée and energy intake at lunch.

Regression Analyses

Energy density, child characteristics (sex, age, and BMI percentile), and maternal scores for child-feeding practices were considered together as predictors of food and energy intake. The significant predictors of mean weight of lunch consumed were the child’s age and the combination of child’s sex and mother’s score for pressuring her child to eat ($R^2=0.31; P<0.0001$). The significant predictors of mean lunch energy intake in each condition were these predictors and the energy density of the macaroni and cheese ($R^2=0.25; P<0.0001$). Food intake and energy intake were greater in boys, and energy intake was greater when the higher-energy-density entrée was served.

DISCUSSION

In this study, a 30% reduction in the energy density of an entrée led to a 25% decrease in children’s energy intake from the entrée and an 18% decrease in their energy intake from the meal. The reduction in the energy density of the macaroni and cheese was achieved while not reducing the palatability of the food. The age of the child and the child’s sex-specific BMI–for-age percentile did not impact the relationship between the energy density of the entrée and the child’s intake from the entrée or from the total meal.
The main findings of this study are similar to those of adult studies in which decreasing the energy density of an entrée or meal led to reduced energy intake during ad libitum consumption. Kral and colleagues (21) found that decreasing the energy density of a lunch entrée by approximately 29% significantly reduced energy intake from the entrée. Bell and colleagues (8) decreased the energy density of the main entrées served to women during lunch, dinner, and an evening snack (mean energy density 0.8 kcal/g, 1.1 kcal/g, and 1.3 kcal/g, respectively) for three 2-day periods. Energy intake from the entrées was significantly reduced in both the medium– and lower-energy-density conditions compared with the higher-energy-density condition. More recently, Rolls and colleagues (22) reported that the reduction in energy intake from manipulated foods paralleled the decrease in the energy density of these foods. Decreasing the energy density by 25% led to a significant reduction in energy intake of 24% because women ate a consistent weight of food across conditions. In the present study, a 30% reduction in the energy density of the entrée led to a 25% decrease in energy intake from the entrée.

Little previous research has tested preschool children’s responses to changes in the energy density of foods consumed ad libitum. Most of the research on preschool children’s responses to changes in the energy density of foods has been conducted using a preload protocol to test the effects of energy density on satiety (12-17, 23). In these previous studies, a compulsory preload varying in energy density was served to preschool children 0 to 120 minutes prior to a standard snack or a meal, and ad libitum intake of this snack or meal provided evidence of responsiveness to energy density. In several of these satiety studies, children compensated for reductions in the energy density of the preloads by increasing their energy intake during subsequent consumption (12-17). The
results of the present study, in which children did not compensate for the reduction in the energy density of the entrée, probably differ from those of the previous preload studies due to differences in the protocol used. Children may be better at compensating for reductions in the energy density of foods when there is a delay between the consumption of the manipulated food and the ad libitum meal. In the present study, the manipulated food was consumed ad libitum, so children may not have been able to detect and adjust for the difference in energy density as they were eating.

Another difference between the previous satiety studies and the present research that could explain the discrepancy in the results is the magnitude of the change in the energy density of the manipulated foods. In the previous satiety studies that provided evidence of children’s compensation for the changes in the energy density of the preloads (12-17), the lower-energy-density preload was 49% to 98% lower in energy density compared with the higher-energy-density preload. In the present study, the reduction in energy density was only 30%, which may have been too small to be detected by the children. One satiety study (23) provided evidence that the magnitude of the change in energy density may influence children’s ability to compensate for reductions in the energy density of foods. Preschool children were served a preload that was 36% lower in energy density than the higher-energy-density preload before eating an ad libitum lunch. Across preload conditions, the children ate a consistent weight of food at lunch, so they consumed more total (preload+lunch) energy when served the higher-energy-density preload. Smaller changes in energy density are more difficult to detect, making it less likely for children to compensate.
Although most previous studies of preschool children’s responses to changes in the energy density of foods used a preload protocol, one recent laboratory study of slightly older children tested the effect of the energy density of an entrée on energy intake. In this within-subjects crossover study, Fisher and colleagues (24) tested the effect of energy density on children’s intakes with 5- to 6-year-old children. Children were served a dinner entrée of macaroni and cheese that varied in energy density (1.3 kcal/g and 1.8 kcal/g). The entrée and other dinner foods were consumed ad libitum. Children consumed significantly less energy from the lower-energy-density entrée than from the higher-energy-density version. The findings of the present study, with a younger sample of children in a child-care setting, support the work of Fisher and colleagues (24).

In the present study, one of the main outcome measures was intake of the manipulated food. Children ate a significantly greater weight of the lower-energy-density entrée than the higher-energy-density entrée. The children would have had to consume an additional 62 g of the lower-energy-density entrée relative to the mean intake of the higher-energy-density entrée to make up for the difference in energy density, but they only made up for approximately 16% of the energy deficit by consuming an additional 10 g. It is unlikely that this increase in intake was driven by within-meal energy compensation because the meal duration of approximately 5 to 20 minutes was probably not long enough for postingestive feedback to occur. What is important about this increase in intake is that it provides further evidence that reducing the energy density of macaroni and cheese did not decrease the palatability of the entrée.
There was an inverse relationship between mothers’ scores for pressuring daughters to eat and daughters’ energy intake at lunch, but this relationship did not occur for mothers and sons. Mothers who reported greater use of pressure to get daughters to eat had daughters who ate less. Previous studies have found sex differences in children’s responses to mothers’ child-feeding practices. Johnson and Birch (25) found evidence to suggest that the sex of the child may not only influence a parent’s child-feeding practices, but boys and girls may also respond differently to the information about eating that they receive from parents. Fisher and colleagues (26) found that girls who received more maternal pressure to eat were likely to have lower fruit, vegetable, and micronutrient intakes even when total energy intake was taken into account. Maternal pressure to eat has also been linked to girls’ eating restraint and disinhibition (27) as well as pickiness (28). Thus, although maternal pressure to eat did not influence the effect of energy density on intake in the present study, the relationship with girls’ energy intake provides further evidence that girls are impacted by maternal child-feeding practices.

A secondary aim of the present study was to assess the influence of mothers’ child-feeding practices and children’s physical characteristics on the relationships between the energy density of the entrée and the weight and energy of the entrée and lunch consumed. None of the mothers’ child-feeding practices or children’s physical characteristics (age, weight, height, or BMI percentile) significantly affected the relationship between the energy density of the entrée and the weight or energy intake of food consumed. These findings suggest that reducing the energy density of foods may be a successful approach to reducing energy intake for a range of preschool children.
The present study had limitations, including the use of a convenience sample and the use of a single meal. All children were associated with one child-care center in which there was a relatively small amount of ethnic diversity, and parents tended to be highly educated and earned a higher than average family income. Children also tended to be within the normal range for BMI percentiles. Because the sample of children was fairly homogeneous, the findings of the study should not be generalized to all preschool children. It is possible that children of different ethnicities, children with less educated parents, and children who are overweight may respond differently than the participants in this study to changes in energy density. Thus, research in a more diverse group of children is needed to extend the findings of this study.

This study focused on the effects of changing the energy density of an entrée at a single meal, and it is possible that children could have increased their energy intake at subsequent eating occasions throughout the rest of the day to compensate for reduced energy intake at lunch. Therefore, more research is also needed to investigate the longer-term effects of changing the energy density of foods on preschool children’s energy intake.

Conclusions

This study is the first to demonstrate that a decrease in the energy density of an entrée leads to a reduction in 2- to 5-year-old children’s ad libitum energy intake from both an entrée and from an entire meal. The results provide evidence that decreasing the
energy density of foods while maintaining palatability may be an effective strategy to reduce preschool children’s energy intake at a meal. The 25% reduction in energy intake from the entrée is similar to the results found in studies with adults (22) and slightly older children (24).

The present study manipulated fat in the recipe to change the energy density of the entrée, but the energy density of foods can also be changed by increasing the proportion of water-rich ingredients, such as fruits and vegetables. Studies investigating how children respond to changes in the energy density of foods accomplished with other manipulation strategies, such as increasing fruit and vegetable content in recipes, are needed.
REFERENCES


18. Fisher JO, Rolls BJ, Birch LL. Children's bite size and intake of an entrée are greater with large portions than with age-appropriate or self-selected portions. Am J Clin Nutr 2003;77:1164-70.


CHAPTER III

STUDY 2:

REDUCTIONS IN ENTRÉE ENERGY DENSITY INCREASE CHILDREN’S VEGETABLE INTAKE AND REDUCE ENERGY INTAKE

INTRODUCTION

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

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

METHODS

Design

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

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

**Participants**

Children were recruited by letters (APPENDIX G) given to all parents at the child care facility with children who would be at least 3 years of age at the start of the study. Parents provided written consent (APPENDIX H) for both their own participation and the participation of their child, and all procedures were reviewed and approved by the Pennsylvania State University Office for Research Protections.
Seventy-five preschool children in full-day daycare participated in the study. Twelve children were excluded from the analyses because they failed to meet the predefined minimum consumption criteria: these children ate less than 25 grams of the entrée on three or more occasions. Two children were excluded due to absenteeism. The final group of 61 children (30 boys and 31 girls) had a mean (±standard error) age of 4.4±0.1 years (range: 3.1-5.6 years) and a mean sex-specific body mass index-for-age percentile (BMI percentile) of 62.5±3.3 (range: 3.2–97.8). Twelve children had BMI percentiles above 85 and one child had a BMI percentile above 95. Boys and girls did not differ significantly from each other in mean age, body weight, height or BMI percentile (Table 8). Of the 51 children whose parents provided demographic information, 63% were non-Hispanic White, 31% were Asian, and 6% were Black or African American, and 87% of mothers and 83% of fathers reported having at least a 4-year university degree. The majority of parents, 83% of mothers and 90% of fathers, reported being employed. Most of the families (66%) reported earning a combined income of >$50,000 per year.
Table 8. Characteristics of children (mean ± standard error; range) participating in a study to test the effect of decreasing the energy density of an entrée on food intake at lunch

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Boys</th>
<th>Girls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>4.5±0.1</td>
<td>4.3±0.1</td>
</tr>
<tr>
<td></td>
<td>(3.1–5.6)</td>
<td>(3.1–5.5)</td>
</tr>
<tr>
<td></td>
<td>n=30</td>
<td>n=31</td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>18.1±0.5</td>
<td>17.8±0.5</td>
</tr>
<tr>
<td></td>
<td>(13.7–25.4)</td>
<td>(13.9–24.6)</td>
</tr>
<tr>
<td></td>
<td>n=29</td>
<td>n=29</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>106.2±1.1</td>
<td>105.0±1.2</td>
</tr>
<tr>
<td></td>
<td>(97.1–120.1)</td>
<td>(92.0–117.6)</td>
</tr>
<tr>
<td></td>
<td>n=28</td>
<td>n=29</td>
</tr>
<tr>
<td>Sex-specific body mass index-for-age percentile</td>
<td>59.0±4.9</td>
<td>65.9±4.3</td>
</tr>
<tr>
<td></td>
<td>(3.2–94.9)</td>
<td>(3.8–97.8)</td>
</tr>
<tr>
<td></td>
<td>n=28</td>
<td>n=29</td>
</tr>
</tbody>
</table>

Measures and Procedures

Lunch procedures

Children’s food intake was measured during each of the four test lunches. Children in each of five classrooms at the daycare center were served lunch at their regularly scheduled time and ate at tables of 3-6 children and one adult, which is standard practice at the center. Teachers were instructed not to encourage children to eat and not to discuss food. Food and drink spillage and any comments made by children or teachers pertaining to food were recorded by trained observers. Conversations about food-related topics were redirected to minimize the influence of teachers’ and peers’ comments on children’s lunch intake. When children finished lunch, dropped and spilled foods were returned to the proper dish and lunch items were cleared. Food weights were recorded to
the nearest 0.1 g using digital scales (Mettler-Toledo PR5001 and XS4001S, Mettler-Toledo, Inc., Columbus, OH). Children’s consumption of all foods was determined by subtracting post- from pre-meal weights, and manufacturers’ nutrition information was used to calculate energy density and energy intake.

**Experimental Menu**

The experimental entrée (Photograph 3) served to all children during the study was pasta with cheese and a tomato-based vegetable sauce (Table 9). Two entrées were formulated to differ in energy density; the higher-ED entrée had 1.6 kcal/g and the lower-ED entrée was reduced in energy density by 25% (1.2 kcal/g). The energy density of the entrée was reduced by increasing the amount of pureed broccoli and cauliflower (thus increasing water content; Photograph 4), and decreasing the amount of cheese and substituting low-fat cheeses (thus decreasing fat content). The higher-ED entrée had 35% of energy as fat, 48% as carbohydrate, and 17% as protein; the lower-ED entrée had 28% energy as fat, 54% as carbohydrate, and 18% as protein. The larger portion (400 g) of the entrée was chosen so as not to limit the intake of the children. This portion is larger than the 90th percentiles for pasta, macaroni and cheese, and spaghetti with sauce consumption data for 2- to 5-year-old children from the Continuing Survey of Food Intakes by Individuals (11). The smaller portion (300 g) was chosen so that it was 25% smaller than the larger portion. Other foods served during lunch (Photograph 5) were 2% milk (297 mL, University Creamery, State College, PA), 4 carrot sticks (22-32 g, Foodhold U.S.A., LLC, Landover, MD), and unsweetened applesauce (150 g, Knouse Foods, Inc., Peach Glen, PA). All lunch items were consumed ad libitum.
Photograph 3. Test entrées in two portions (Higher-ED on left).
### Table 9. Nutrition information for two versions of the pasta entrée (300 g portion)

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

<sup>a</sup> American Italian Pasta Co., Kansas City, MO
<sup>b</sup> Birds Eye Food INC, Rochester, NY
<sup>c</sup> Hanover Foods Corporation, Hanover, PA
<sup>d</sup> Kraft Foods North America, Glenview, IL
<sup>e</sup> Campbell Soup Company, Camden, NJ
<sup>f</sup> Foodhold U.S.A, LLC, Landover, MD
<sup>g</sup> Del Monte Foods, San Francisco, CA
<sup>h</sup> Unilever, Englewood, NJ
<sup>i</sup> Cooked total is the weight of food after water loss due to cooking
<sup>j</sup> The other 2 entrées had the same proportion of ingredients scaled to 400 g
Photograph 4. Test entrées with vegetable content (Higher-ED on left).

Photograph 5. Test meal.

Other Measures

Preference Assessments and Portion Size Comparisons

The two versions of the pasta were formulated to be similar in palatability. Children’s preferences (APPENDIX I) for the two pastas were assessed at the end of the study to evaluate whether one version was consistently preferred over the other. Prior to
individual preference assessments, the meaning of three cartoon faces (“yummy”, “just ok”, and “yucky”; APPENDIX J) was explained to all children in the classroom in an interactive demonstration. Similar protocols with cartoon faces have been used in other studies of preschool aged children (12), and preference data have been shown to predict preschool children’s intake (13, 14). During each preference assessment, the child was seated at a table with two samples of the entrée. Three cartoon faces were set in front of the child. The child was told “Please take a bite of one of the pastas. Do you think it tastes yummy, just ok, or yucky? Now, take a bite of the other pasta. Do you think it tastes yummy, just ok, or yucky?” If the same category was chosen for both samples, the child was then asked, “Do you think that one of the pastas tastes better than the other or do they both taste the same?” Next, the child was simultaneously shown two plated portions (400 g and 300 g) of the entrée and was asked, “Does one of these plates have more pasta than the other or do they have the same amount of pasta?” The child’s responses were recorded.

**Children’s Body Weight and Height**

Body weight and height measurements for the majority of children were obtained within 2 weeks of the final test day. Body weight was measured to the nearest 0.1 kg using a portable digital scale (Seca Onda 843, Seca North America East, Hanover, MD). Height was measured in duplicate to the nearest 0.1 cm using a portable stadiometer (Seca 214, Seca North America East, Hanover, MD). If the two measurements varied by >0.2 cm, then a third measurement was taken. Body weight and mean height of each
child were used to calculate their sex-specific body mass index-for-age percentile (BMI percentile) using a program from the Centers for Disease Control and Prevention (15).

**Parental Questionnaires**

Parents were asked (APPENDIX K) to complete two questionnaires, the Child Feeding Questionnaire (CFQ) and a demographic questionnaire. The CFQ (APPENDIX E) is composed of 75 questions that assess parental feeding strategies and opinions about body weight. The psychometric characteristics of this instrument are described elsewhere (16). For the purposes of this study, only four of the seven subscales were used in the analysis: the scores for the mother’s restriction of her child’s food intake, her exertion of pressure on her child to eat, her level of monitoring her child’s eating, and her level of responsibility in child-feeding. Fifty-one mothers completed the CFQ. The demographic questionnaire (APPENDIX L) consists of 16 questions that assess the background and the health status of the child, and either parent could complete this questionnaire. Fifty-one parents completed this questionnaire.

**Statistical Analysis**

Data were analyzed using a mixed linear model with repeated measures in the SAS System for Windows (version 9.1, 2003, SAS Institute, Cary, NC). Results were considered significant at P<0.05 and will be reported as mean ± standard error. The main outcomes for the study were weight and energy of pasta consumed, weight of vegetable consumed, and total weight and energy of lunch consumed. The fixed-factor effects for the model were energy density and portion size, and the interaction of these 2 factors was
tested for significance prior to assessment of the main effects of the factors. If no interaction was found, then analyses were done with only the main effects. The influences on the main outcomes of child’s sex were tested, and data were combined for subsequent analyses if there was no significant effect of subject sex. Children who ate more than 95% (285 g) of the entrée during both of the smaller portion conditions were classified as “plate cleaners”; 3 children met this criterion. Study outcomes were analyzed both with and without data from these children in order to assess their effect on the results.

*t* tests were used to determine whether boys and girls differed in terms of age, body weight, height, and BMI percentile. Covariate analyses tested whether continuous subject characteristics, such as age, body weight, height, and BMI percentile, and maternal scores for child-feeding related to eating behavior (restriction, pressure, monitoring, and responsibility) affected the relationships between the experimental variables and the main outcomes of the study. Multivariate analysis of variance was used to determine whether children responded to the change in the portion size and energy density of the pasta by adjusting the proportion of the individual foods and milk they consumed. It was also used to determine whether the proportions of macronutrients consumed at lunch changed in response to the modifications to the pasta recipe. Regression analyses, using energy density of the entrée, portion size of the entrée, child characteristics (age, sex, and BMI percentile), and the maternal scores for child-feeding related to eating behavior (restriction, pressure, monitoring, and responsibility), were done to assess which factors best predicted food and energy intake at lunch. Adjusted R-square (R²) values are reported.
RESULTS

Entrée Intake

Analyses indicated no difference in intake by sex of the child, so data were combined for subsequent analyses. Energy density and portion size did not interact to affect children’s entrée intake. Energy intake from the entrée was significantly affected by the energy density of the pasta (P<0.0001; Figure 4A) but not the portion size of the pasta (Figure 4B). Children consumed a mean of 251.1±11.0 kcal from the higher-ED entrée and 187.6±9.6 kcal from the lower-ED entrée across portion sizes. Thus, decreasing the energy density of the pasta by 25% resulted in a 25% (63.1±8.3 kcal) decrease in energy consumed from the entrée. The weight of pasta consumed was not significantly affected by either the energy density (Figure 5A) or the portion size (Figure 5B) of the entrée. Excluding 3 children who were recognized as “plate cleaners” from the analyses did not affect the main outcomes, and therefore, these children were included in all of the reported analyses.
**Figure 4**: Preschool children’s energy intake from foods (mean ± standard error) for (A) the 2 energy densities (1.6 and 1.2 kcal/g) with the 2 portion sizes (400 and 300 g) averaged and (B) the 2 portion sizes with the 2 energy densities averaged. *Compared to when served the higher-ED entrée, children consumed significantly (P<0.0001) less energy from both the pasta dish and the meal when served the lower-ED entrée. Portion size did not significantly affect children’s energy intake.

**Figure 5**: Preschool children’s food intake (mean ± standard error) for (A) the 2 energy densities (1.6 and 1.2 kcal/g) with the 2 portion sizes (400 and 300 g) averaged and (B) the 2 portion sizes with the 2 energy densities averaged. (B) Neither energy density nor portion size affected the weight of food children consumed.
Vegetable Intake

Subject sex was unrelated to the amount of vegetable consumed, so data were combined for subsequent analyses. Changing the portion size of the entrée did not have a significant effect on the amount of vegetable consumed during lunch. Changing the energy density of the entrée by increasing the amount of pureed vegetables (broccoli and cauliflower) significantly increased vegetable consumption (P<0.0001). When served the lower-ED version of the pasta, children’s mean consumption of broccoli and cauliflower increased by more than half of a serving of vegetables (serving=3 tablespoons cooked vegetables (17)) . Children consumed a mean of 5.3±0.2 g of pureed broccoli and cauliflower from the two higher-ED versions of the entrée and a mean of 15.6±0.8 g of pureed vegetables from the two lower-ED versions of the entrée. When the tomato content of the pasta sauce and the carrots served as a side dish were included in children’s vegetable intake during lunch, results remained significant (P<0.01).

Lunch Intake

Children did not compensate for the decrease in energy intake from the lower-ED pasta by increasing their intake of the other foods offered during lunch, so the energy density of the entrée had a significant effect on lunch energy intake (P<0.0001). Decreasing the energy density of the pasta by 25% resulted in a 17% decrease in energy consumption during the meal (Table 10). Mean lunch energy intake (363.6±11.0 kcal) for the higher-ED conditions differed from mean lunch energy intake (302.6±10.0 kcal) for the lower-ED conditions by 60.7±8.9 kcal. There were no effects of energy density or portion size on the weight of food consumed during lunch. The effect of subject sex on
the total weight of food consumed at lunch had a trend for significance (P=0.0511); girls consumed 383.5±11.7 g and boys consumed 439.5±11.0 g.

| Table 10. Children’s food intakes and energy intakes (mean ± standard error) at lunch |
|---------------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|
| Lunch component                          | 400 g of pasta with 1.6 kcal/g | 300 g of pasta with 1.6 kcal/g | 400 g of pasta with 1.2 kcal/g | 300 g of pasta with 1.2 kcal/g |
| Pasta                                     |                                    |                                    |                                    |                                    |
| Weight (g)                                | 158.6±10.3                        | 155.9±9.2                          | 161.0±12.1                         | 150.0±10.4                         |
| Energy (kcal)                             | 253.2±16.5                        | 248.9±14.7                         | 194.2±14.6                         | 180.9±12.5                         |
| Applesauce                                |                                    |                                    |                                    |                                    |
| Weight (g)                                | 89.0±7.2                          | 94.0±6.6                           | 96.7±6.3                           | 100.5±7.0                          |
| Energy (kcal)                             | 36.5±3.0                          | 38.5±2.7                           | 39.6±2.6                           | 41.2±2.9                           |
| Carrots                                   |                                    |                                    |                                    |                                    |
| Weight (g)                                | 11.0±1.5                          | 11.9±1.5                           | 13.6±1.6                           | 12.5±1.6                           |
| Energy (kcal)                             | 4.9±0.7                           | 5.3±0.7                            | 6.1±0.7                            | 5.6±0.7                            |
| Milk                                      |                                    |                                    |                                    |                                    |
| Weight (g)                                | 146.8±12.9                        | 152.4±13.0                         | 151.3±12.5                         | 141.0±12.3                         |
| Energy (kcal)                             | 69.2±6.1                          | 71.9±6.1                           | 71.3±5.9                           | 66.5±5.8                           |
| Total                                     |                                    |                                    |                                    |                                    |
| Weight (g)                                | 403.0±15.8                        | 414.0±16.2                         | 422.6±17.3                         | 403.8±17.0                         |
| Energy (kcal)                             | 362.7±16.1                        | 364.5±14.9                         | 311.2±14.7                         | 294.1±13.6                         |
Multivariate analysis of variance demonstrated that there was no overall effect of portion size or energy density on the proportion of total meal weight that was consumed from each lunch item. Multivariate analysis of variance also showed a significant effect of energy density on the proportion of energy consumed from fat, carbohydrate, and protein during lunch (P<0.0001), which can be explained by the differences in the macronutrient composition of the manipulated entrée. In the higher-ED conditions, children ate a mean of 30.2% energy from fat, 53.1% energy from carbohydrate, and 16.7% energy from protein. In the lower-ED conditions, they consumed an average of 23.1% energy from fat, 59.6% energy from carbohydrate, and 17.3% energy from protein.

Regression analyses revealed that the significant predictors of the weight of lunch consumed were the mother’s score for pressuring her child to eat, the child’s age, and the child’s sex (R²=0.15; P<0.0001). The significant predictors of the amount of energy consumed at lunch were the energy density of the pasta, the child’s age, and the mother’s score for pressuring her child to eat (R²=0.17; P<0.0001). Intake was greater when the higher-ED entrée was served, when the maternal score for pressuring was lower, and in boys.

**Participant Characteristics**

Of the 52 children who participated in preference assessments, 37 children (71%) rated the lower-ED pasta as “yummy”, 10 children (19%) rated it as “just ok”, and 5 children (10%) rated it as “yucky”. Thirty-four children (65%) rated the higher-ED pasta as “yummy”, 14 children (27%) rated it as “just ok”, and 4 children (8%) rated it as
“yucky”. Twenty-eight children (54%) rated the taste of both versions of the pasta as the same, 13 children (25%) rated the lower-ED pasta more favorably than the higher-ED pasta, and 11 children (21%) rated the higher-ED pasta more favorably than the lower-ED pasta. The children’s preferences for the pasta entrées did not significantly affect the weight of pasta that they consumed. Of the 51 children who participated in the portion size comparisons for the entrée, 27 children (53%) thought that there was no size difference between the 300 g and 400 g portions, 3 children (6%) thought the 300 g portion was larger than the 400 g portion, and 21 children (41%) correctly identified the 400 g portion as larger than the 300 g portion. The children’s ability to recognize the 400 g portion as larger than the 300 g portion did not significantly affect the weight of pasta that they consumed.

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

DISCUSSION

Decreasing the energy density of an entrée by 25% led to a 25% (63 kcal) reduction in children’s energy intake from the entrée and a 17% (61 kcal) reduction in energy intake at the meal. However, decreasing the portion size of the entrée by 25% did not significantly affect children’s food or energy intakes. The reduction in the energy density of the pasta was achieved by increasing the vegetable content and decreasing the fat content without detrimentally affecting taste; 79% of the children who participated in the assessment reported that the lower-ED entrée tasted the same or better than the
higher-ED entrée. Because the lower-ED entrée had a larger proportion of pureed vegetables, children consumed a significantly greater amount of vegetables when it was served. Children consumed about a half of a serving more of vegetables at lunch when they were served the lower-ED version of the pasta.

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

The findings on the effect of portion size on *ad libitum* energy intake differ from those conducted with adults (22-28) and preschool children (5-7) in which increasing the
portion size of foods led to an increase in food intake. The disparity in the results could be due to several methodological differences between studies. First, the portion size reduction in this study was 25%, but the reduction was 50% in most of the studies in which portion size affected preschool children’s energy intake (5-7). In one study (5) in which three portions (225, 338, and 450 g) of macaroni and cheese were served to children, significant differences in intake were only found between the large and small portions. The 33% change (medium portion vs. small portion) and 25% change (large portion vs. medium portion) in portion size did not lead to significant differences in intake. Thus, it is likely that the magnitude of the change in portion size affects children’s food intake. Second, both of the portion sizes served in this study were large. The reduced portion size, 300 g, was larger than what is considered an age-appropriate amount (11) for the younger children in this study; across both portion sizes, children consumed a mean of 156 g, or about half of the smaller portion size. A third difference between studies is the type of food served. In all of the previous research on the effects of portion size on preschool children’s intake, macaroni and cheese was served. Additionally, in one study in which all foods served to adults over 11 days were changed in portion size, there was a significant effect of portion size on intake for all categories of foods except fruit served as a snack and vegetables (28). It is possible that children’s responses to portion size could be food-specific. Studies in which a larger range of portions are served to children are needed to assess whether there is a dose-related response to portion size. In addition, studies are needed in which a wide variety of foods are varied in portion size to assess whether portion size effects are specific to the type of food served.
In previous studies of energy density in children (4, 10, 21), the energy density of entrées was decreased through fat reductions. The present study is the first to decrease the energy density of the test entrée for children by combining the strategies of decreasing fat content and increasing vegetable content. This increase in vegetable content led to a significant increase in children’s vegetable consumption when they were served the lower-ED entrée; the average amount of vegetable consumed from the lower-ED entrée was more than half of a serving of cooked vegetables (17). Increasing the vegetable content of the lower-ED entrée led to a 10% increase in vegetable intake (broccoli, cauliflower, tomato sauce, and carrots) during lunch.

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

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

This study is the first to show that decreasing the energy density of an entrée by increasing vegetables and reducing fat decreased children’s ad libitum energy intake, while also increasing their vegetable intake. Although reducing the portion size of the entrée did not affect children’s energy intake, decreasing the energy density of the entrée led to a 25% reduction in energy intake from the entrée and a 17% reduction in energy intake at lunch. The results of this study demonstrate that reducing the energy density of an entrée by decreasing fat and increasing vegetable content can simultaneously lead to a reduction in energy intake and an increase in vegetable intake for preschool children.
REFERENCES


6. Fisher JO, Rolls BJ, Birch LL. Children's bite size and intake of an entrée are greater with large portions than with age-appropriate or self-selected portions. Am J Clin Nutr 2003;77:1164-70.


26. Levitsky DA, Youn T. The more food young adults are served, the more they overeat. J Nutr 2004;134:2546-9.


CHAPTER IV

STUDY 3:
REDUCING THE ENERGY DENSITY OF MULTIPLE MEALS SERVED OVER TWO DAYS DECREASES CHILDREN'S ENERGY INTAKE
INTRODUCTION

Several organizations have recently issued recommendations on the prevention of childhood overweight and obesity (1-3). Recommended changes include limiting children’s consumption of energy-dense foods (1, 2) and providing children with a variety of foods that are low in energy density (ED; kcal/g) (3). Reducing the energy density of foods has been shown to be an effective strategy for moderating energy intake in adults and children because both age groups tend to consume a consistent weight of food even when it is reduced in energy density (4-7). In adults, decreasing dietary energy density has been shown to reduce ad libitum energy intake for periods of up to two weeks (6, 8), however, little is known about how changing the energy density of meals over multiple days affects young children’s ad libitum energy intake.

Single-meal studies show that energy density influences preschool children’s energy intake. Reducing the energy density of an entrée led to significant reductions in children’s energy intakes from both the entrée and the entire meal (4, 5, 9). However, previous research has shown that young children exhibit greater variability in their energy intake at individual meals than throughout the day (10, 11), suggesting that children adjust their food intake at successive meals over the course of the day. Therefore, the effects of energy density may not persist beyond a single meal if children adjust their food intake at later eating occasions to compensate for reduced energy intake.

A variety of strategies can be used to reduce the energy density of foods, including decreasing the fat or sugar content of foods, increasing the fruit or
vegetable content of foods, or combinations of these approaches. Several of these strategies have been shown to successfully reduce energy intake among adults (6). Previous single-meal studies have demonstrated the effectiveness of two different strategies to reduce the energy density of entrées served to children: decreasing fat content (4, 9) and combining decreases in fat content with increases in vegetable content (5). In the present experiment, a number of approaches were used to reduce the energy density of foods and beverages, including fat and sugar reductions, and the addition of fruits and vegetables.

The present experiment investigates the effects of reducing the energy density of multiple meals over the course of two days on preschool children’s food and energy intakes. The energy density of meals consumed at a child care facility (breakfast, lunch, and afternoon snack) was manipulated, and dinner and evening snack were not varied in energy density. The primary aim of the study was to assess whether reducing the energy density of foods and beverages served at multiple meals would lead to persistent and significant decreases in energy intake over two days.

METHODS

Experimental Design

A within-subjects crossover design was used to test the effect on preschool children’s energy intake of varying the energy density of multiple foods served in a child care facility. Children were served the same 2-day menu during each of two experimental conditions. There was a 12-day washout period between experimental sessions. Children were served test breakfasts, lunches, and afternoon snacks at the
child care facility, and they were provided with dinners and evening snacks for consumption at home (Table 11). The foods and beverages served during breakfasts, lunches, and afternoon snacks during one week of the study were reduced in energy density by an average of 27% (range: 19% to 33%) compared to the other experimental week. Dinner and evening snacks were not varied in energy density. All foods and beverages were consumed _ad libitum._
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<td>Week 5</td>
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1. The same dinner was served on Day 1 in both energy density conditions
2. The same evening snack was served on both Day 1 and Day 2 in both energy density conditions
3. The same dinner was served on Day 2 in both energy density conditions
Children were recruited by distributing letters (APPENDIX M) to all parents at the child care center with children who would be between three to six years of age during the study. Parents provided written consent (APPENDIX N) for both their own participation and the participation of their child. All study procedures were reviewed and approved by The Pennsylvania State University Office for Research Protections. There were two cohorts of children (2 classrooms in each cohort).

Calculations to determine the sample size for the study were based on data from single-meal experiments involving manipulations of energy density in children. The minimum clinically significant difference in daily energy intake between energy density conditions of interest was determined to be 100 kcal per day. A power analysis showed that a sample of 56 children would allow detection of this difference at a significance level of 0.05 and power of 80% using a one-sided test. If, however, the effect of energy density in children were similar to that found in previous experiments among adults, then the 18% decrease in energy density would be expected to produce a parallel decrease in energy intake, equivalent to about 250 kcal per day. In order to detect a change of this magnitude, a sample size of 11 would be required.

Participants

Twenty-nine children in full-day care at The Pennsylvania State University were enrolled in the study. Two children were excluded from the analyses because they were absent during one week of the study, and one subject was excluded due to a
combination of absenteeism and difficulty following the study protocol. The final sample consisted of 26 3- to 5-year-old children (10 boys and 16 girls).

Measures and Procedures

Food Preparation

Foods and beverages were prepared in the kitchen of the Laboratory for the Study of Human Ingestive Behavior. Foods that were served cold or at room temperature were weighed at the lab. Foods that were served warm were weighed and plated at the child care facility. Beverages were weighed in the lab and served in plastic juice box containers. All foods and beverages were weighed after meals at the child care center.

Foods and beverages that were sent home with children were packaged in reusable plastic containers. These foods were packed in individual coolers, and parents wrote down the times that dinner and evening snack were consumed on a provided form (APPENDIX O). Coolers were available for pick-up at the child care facility in the afternoon and were returned to the child care facility the following morning.

Meal Procedures

Children in each of four classrooms at the child care facility were served breakfast, lunch, and an afternoon snack at their regularly scheduled times. Children ate meals at tables of 3-6 children with one adult. Food and drink spillage and any comments made by teachers or children about food were recorded. Table
conversations pertaining to food were redirected away from food-related topics to ensure that children’s food intakes were not influenced by peers or teachers. When children finished eating, spilled or dropped foods were returned to the correct dish and items were cleared. Food and beverage weights were recorded to the nearest 0.1 g using digital scales (Mettler-Toledo PR5001 and Mettler-Toledo XS4001S, Mettler-Toledo, INC., Columbus, Ohio). Consumption of the foods and beverages was determined by subtracting post- from pre-meal weights. Manufacturers’ nutrition information and the USDA National Nutrient Database for Standard Reference (12) were used to calculate energy density and energy intakes.

Dinner and evening snack were sent home with children. Parents were instructed to allow their child to consume only the provided foods and beverages and to leave any remaining foods and beverages in containers (APPENDIX O). Parents were also instructed not to let any other family members consume the provided foods and beverages. To minimize the likelihood of the children in the study wanting to eat the foods served to their siblings, dinner and evening snack were also provided for the siblings of study participants. Food and beverage containers were returned unwashed to the child care facility for post-weighing.

Experimental Menu

The experimental 2-day menu served to all children during the study included both commercially available products and foods that were prepared from recipes (Tables 12 and 13). The energy density of the 2-day menu was 1.1 kcal/g (1.6 kcal/g without beverages) in the higher-ED condition and 0.9 kcal/g (1.4 kcal/g without...
beverages) in the lower-ED condition. The energy density of the manipulated foods and beverages was 1.2 kcal/g (1.8 kcal/g without beverages) in the higher-ED condition and 0.9 kcal/g (1.3 kcal/g without beverages) in the lower-ED condition (Photographs 6-11). The energy density of the non-manipulated foods and caloric beverages served at these meals was 1.0 kcal/g (1.4 kcal/g without beverages; Photographs 12 and 13).

Reductions in energy density were achieved either by substituting one commercially available product for another or by changing the ingredients in recipes. The main strategies to reduce the energy density of foods and beverages were to decrease the fat or sugar content of foods and beverages. However, several other general strategies for decreasing energy density were used, such as increasing vegetable or fruit content of foods or using combinations of several approaches.

To ensure that children had opportunities to consume adequate energy on test days, the dinner and evening snack (Photographs 12 and 13), which were not manipulated in energy density, consisted of popular foods in ample quantities. Dinner consisted of a protein source, starch, vegetable, fruit, roll, and 2% milk (Tables 12 and 13). There were four options for protein, and three options for starch, vegetable, and fruit. Parents chose one food from each meal component category for each of two dinners (APPENDIX P). Options for each meal component were similar in energy density. A roll, condiments, and 2% milk were served with all dinners. Evening snack consisted of fruit, crackers, 2% milk, and water. There were three options for fruit and crackers. Options for each snack component were similar in energy density. Parents
chose one fruit and one cracker for evening snack. The same evening snack was served daily in both energy density conditions.

Food portions were chosen based on amounts used in previous work with children of the same age as the present participants (5, 9) and on the serving sizes of commercial products. Children were served more than enough food to meet their energy needs in both experimental conditions (13). Children were served at least 5803 kcal over two days in the higher-ED condition and at least 4797 kcal over two days in the lower-ED condition.
<table>
<thead>
<tr>
<th>Manipulated meals</th>
<th>Energy density</th>
<th></th>
<th>Lower</th>
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<th>Energy density reduction</th>
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<tr>
<td></td>
<td>Portion (g)</td>
<td>Higher</td>
<td>kcal</td>
<td>Lower</td>
<td>Kcal</td>
</tr>
<tr>
<td>Breakfast</td>
<td></td>
<td></td>
<td>kcal/g</td>
<td></td>
<td>kcal</td>
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<td>83</td>
<td>0.40</td>
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</tr>
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<td>240</td>
<td>0.60</td>
<td>144</td>
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<td>98</td>
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<td>kcal</td>
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<td>360</td>
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<td>kcal</td>
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<tr>
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<td>Non-manipulated meals</td>
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<td></td>
<td>kcal</td>
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<td></td>
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<td>Protein(^f)</td>
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<td>Fruit(^f)</td>
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<td>15</td>
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<td>15</td>
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<td>705-731</td>
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<tr>
<td>Crackers⁵</td>
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<td>Fruit⁶</td>
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<td>2,374-2,409</td>
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<td>All meals without water</td>
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<td>2,374-2,409</td>
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</table>

¹ Children had choice of four options for protein: chicken breast, ham steak, turkey sausage, or vegetable patty
² Children had choice of three options for starch: mashed potatoes, noodles, or rice
³ Children had choice of three options for vegetable: broccoli, carrots, or cauliflower
⁴ Children had choice of three options for fruit: canned Mandarin oranges, canned pineapple, or canned tropical mixed fruit
⁵ Children had choice of three options for crackers: cheese crackers, graham crackers, or wheat crackers
⁶ Children had choice of three options for fruit: applesauce, canned peaches, or canned pears
⁷ Product information for foods and beverages can be obtained by contacting the corresponding author
<table>
<thead>
<tr>
<th>Table 13</th>
<th>Portion size and energy density of foods and beverages served on Day 2</th>
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<tbody>
<tr>
<td></td>
<td>Portion (g)</td>
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<td>Manipulated meals</td>
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<tr>
<td>Breakfast</td>
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<td>Afternoon snack</td>
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<td>Cheese crackers</td>
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<tr>
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<td>Total</td>
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<tr>
<td>Total manipulated meals</td>
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<td>Non-manipulated meals</td>
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<tr>
<td>Dinner</td>
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<tr>
<td>Protein</td>
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<td>Starch</td>
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<td>Vegetable</td>
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<td>Fruit</td>
<td>100</td>
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<tr>
<td>Bread</td>
<td>35</td>
</tr>
<tr>
<td>Milk</td>
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<tr>
<td>Mustard</td>
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103
<table>
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<tr>
<th>Food Item</th>
<th>Amount (g)</th>
<th>Calories (kcal)</th>
<th>Exchange (g)</th>
<th>Exchange Calories (kcal)</th>
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</thead>
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<tr>
<td>Ketchup</td>
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<td>1.11</td>
<td>20</td>
<td>1.11</td>
</tr>
<tr>
<td>Barbeque sauce</td>
<td>12</td>
<td>1.25</td>
<td>15</td>
<td>1.25</td>
</tr>
<tr>
<td>Butter</td>
<td>10</td>
<td>7.00</td>
<td>70</td>
<td>7.00</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>664</strong></td>
<td><strong>705-731</strong></td>
<td><strong>705-731</strong></td>
<td></td>
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<tr>
<td><strong>Evening snack</strong></td>
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<td>Crackers⁵</td>
<td>30</td>
<td>4.48-4.66</td>
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<td>Water</td>
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<td><strong>295-304</strong></td>
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<tr>
<td><strong>Total without water</strong></td>
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<td></td>
<td></td>
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<tr>
<td><strong>Total non-manipulated meals</strong></td>
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<td><strong>1,000-1,035</strong></td>
<td><strong>1,000-1,035</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Total non-manipulated meals without water</strong></td>
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<td><strong>1,000-1,035</strong></td>
<td><strong>1,000-1,035</strong></td>
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<tr>
<td><strong>All meals⁷</strong></td>
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<td><strong>2,967-3,007</strong></td>
<td><strong>2,423-2,463</strong></td>
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<tr>
<td><strong>All meals without water</strong></td>
<td><strong>2,553-2,563</strong></td>
<td><strong>2,967-3,007</strong></td>
<td><strong>2,423-2,463</strong></td>
<td></td>
</tr>
</tbody>
</table>

¹ Children had choice of four options for protein: chicken breast, ham steak, turkey sausage, or vegetable patty
² Children had choice of three options for starch: mashed potatoes, noodles, or rice
³ Children had choice of three options for vegetable: broccoli, carrots, or cauliflower
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⁶ Children had choice of three options for fruit: applesauce, canned peaches, or canned pears
⁷ Product information for foods and beverages can be obtained by contacting the corresponding author
Photograph 6. Breakfast (Day 1)

[Image of breakfast]

Photograph 7. Lunch (Day 1)

[Image of lunch]

Photograph 8. Afternoon snack (Day 1)

[Image of afternoon snack]
Photograph 9. Breakfast (Day 2)

Photograph 10. Lunch (Day 2)

Photograph 11. Afternoon snack (Day 2)
Photograph 12. Dinner and evening snack (Day 1)

Photograph 13. Dinner and evening snack (Day 2)
Other Measures

Food and Beverage Taste Assessments

Children’s taste ratings for prepared foods and milk were assessed at the beginning of the study in order to determine whether one version was consistently liked more than the other. Because it was impractical to do taste assessments on all of the foods served in the study, only the foods that provided a substantial amount of available energy (milk, coffee cake, blueberry muffins, macaroni and cheese, pasta, cookie bars) were assessed.

Children’s taste ratings for the test foods were assessed using a protocol (APPENDIX Q) with cartoon faces (APPENDIX J). Similar protocols have been used in other recent studies of preschool-aged children (5, 14). Prior to individual taste assessments, one researcher explained the meaning of three cartoon faces (“yummy”, “yucky” and “just ok”) to all children in the classroom in an interactive demonstration. During taste assessments, each child visited two separate tables and assessed six test foods at each table. The order of the foods presented at each table was randomized so that children did not taste all higher-ED foods at one table and all lower-ED foods at the other table. Three paper cartoon faces were set before the child, and the child was reminded of the meaning of the faces. The child was told “Please take a bite (drink) of (food). Do you think it tastes yummy, just ok, or yucky?” The child’s response was recorded, and another food was presented. Once the child finished assessing the six foods, the child went to a second table to assess the other version of the same six foods.

Seventeen children completed taste assessments for both versions of all six foods. Two children were absent on the day that taste ratings were assessed, and five children
refused to participate in assessments. Two children did not taste both versions of all six foods.

**Children’s Body Weight and Height**

Body weight and height measurements for a majority of the children were obtained within one week of the final test session. Body weight was measured in duplicate to the nearest 0.1 kg using a portable digital scale (Itin Scale Company, Inc, Brooklyn, NY). If the second measurement varied from the first measurement by more than 0.2 kg, a third measurement was taken. Height was measured in duplicate to the nearest 0.1 cm using a portable stadiometer (Seca North America East, Hanover, MD). If the two measurements varied by more than 0.4 cm, a third measurement was taken. One child was absent on the day that weight and height measurements were taken, and one child refused to be weighed or measured more than once. The mean body weight and height of each child was used to calculate their sex-specific body mass index-for-age percentile (BMI percentile) using a program from the Centers for Disease Control and Prevention (15).

**Parental Questionnaires**

Parents were asked (APPENDIX R) to complete two questionnaires: a demographic questionnaire and a discharge questionnaire. The demographic questionnaire (APPENDIX L) consisted of 16 questions that assess the background and the health status of the child. Twenty-five parents completed the demographic questionnaire. The discharge questionnaire (APPENDIX S) consisted of three questions.
One question addressed the appropriateness of the food options and portions for dinner and evening snack. A second question asked whether parents observed differences in their child’s hunger level during the evenings of the study compared to the child’s usual hunger level. The third question asked parents to report the type and amount of any non-study foods that were consumed by their child during the study. Sixteen parents completed the discharge questionnaire.

**Statistical Analysis**

Data were analyzed using the SAS System for Windows (version 9.1, 2003, SAS Institute, Cary, NC). Results, considered significant at P<0.05, will be reported as mean ± standard error. The main outcomes for the study were weight and energy of the foods consumed over the course of two days. These outcomes were analyzed using a mixed linear model (PROC MIXED). The primary factor tested in the model was energy density condition. The influences on the main outcomes of order of presentation of the energy density conditions and child’s sex were tested. Children who ate more than 95% of the entrée at three or more meals over the course of two days were classified as “plate cleaners”; three children met this criterion. Study outcomes were analyzed both with and without data from these children to assess their effect on the results. Food and energy intakes from reported non-study foods were added to the data for six children who consumed non-study foods during the study. Study outcomes were analyzed both with and without data from these non-study foods to assess their effect on the results.

$t$-tests were used to determine whether boys and girls differed in terms of age, body weight, height, and BMI percentile. Paired $t$-tests were used to determine whether
children’s taste ratings for the test foods differed by condition, and the influence of taste ratings on food and beverage intakes was assessed using a mixed linear model. Paired t tests were also used to determine whether there were differences in fiber, sugar, saturated fat, fruit, and vegetable intakes between conditions. Covariate analyses were used to test for interactions between continuous subject characteristics, such as age, body weight, height, and BMI percentile and the energy density of the foods and beverages on the main outcomes of the study. If there was no significant interaction between a covariate and energy density on a main outcome, then the main effect of the covariate on the outcome was tested. Multivariate analysis of variance was used to determine whether the macronutrient composition of children’s food intake changed in response to the manipulation of the foods.

RESULTS

Subject Characteristics

The final group of 26 children (10 boys) had a mean age of 4.2±0.1 years (range, 3.0–5.6 years) and a mean BMI percentile of 72 (n=24; range, 44–99). Four children were at risk for overweight (BMI percentile ≥ 85) and one child was overweight (BMI percentile ≥ 95). Boys and girls did not differ significantly from each other in age or BMI percentile. Boys were significantly heavier (P<0.01) and taller (P<0.05) than girls (Table 14). Parents provided demographic information for 25 of the 26 children. Of these 25 children, 15 were white, 8 were Asian, and 2 were black or African American, and 80% of mothers and 70% of fathers reported having at least a 4-year university degree. The
majority of parents, 88% of mothers and 96% of fathers, reported being employed. Most of the families (74%) reported earning a combined income of $>50,000 per year.

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<th>Table 14</th>
<th>Characteristics of children¹</th>
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<tr>
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<tr>
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<td>103.1-113.0</td>
<td>91.5-114.8</td>
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<td>n=10</td>
<td>n=14</td>
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<tr>
<td>Sex-specific BMI-for-age percentile</td>
<td>76.7±5.2</td>
</tr>
<tr>
<td>44.3-94.6</td>
<td>49.2-98.6</td>
</tr>
<tr>
<td>n=10</td>
<td>n=14</td>
</tr>
</tbody>
</table>

¹± SEM
²Girls significantly different from boys, P < 0.05

Food and Beverage Taste Assessments

There were no significant differences between the children’s taste ratings of the two versions of each of the six test foods. Both versions of each of the six test foods were rated as “yummy” or “just ok” by a majority of the children. Children’s taste ratings for the six test foods did not significantly affect the amount (g) consumed.

Food, Energy, and Macronutrient Intakes

*Weight of food consumed over two days*
There were no significant differences in children’s responses to energy density between cohorts, so the data from both cohorts were combined for analyses. There was no significant difference in the total weight of food and beverages consumed at each eating occasion over the course of two days between energy density conditions, with the exception of afternoon snack on Day 2 (Table 15). Children consumed a significantly greater weight of juice (P<0.05) and total snack (P<0.05) on Day 2 in the lower-ED condition than in the higher-ED condition. However, there was no significant difference in the total weight of juice consumed over two days between conditions. There were also no significant differences in the total food intake over two days or the total beverage intake over two days between energy density conditions. Children consumed 1227±66 g of food and 1215±103 g of beverages in the higher-ED condition and 1248±59 g of foods and 1182±86 g of beverages in the lower-ED condition. Children consumed 2441±121 g of foods and beverages in the higher-ED condition and 2429±96 g of foods and beverages in the lower-ED condition. There were no significant differences in cumulative food intakes over the course of the two days (Figure 6). Excluding three children who were identified as “plate cleaners” from the analyses did not affect the main outcomes, and therefore, these children were included in all of the reported analyses. The parents of six children reported intake of non-study foods, however, these foods are not included in the final analyses because their inclusion did not affect the main outcomes and because these foods were not weighed. There was no significant effect of order of presentation of the energy density conditions on food intake over two days.
<table>
<thead>
<tr>
<th>Energy density</th>
<th>Higher (g)</th>
<th>Lower (g)</th>
<th>Higher (g)</th>
<th>Lower (g)</th>
<th>Higher (kcal)</th>
<th>Lower (kcal)</th>
<th>Higher (kcal)</th>
<th>Lower (kcal)</th>
<th>Cumulative difference in energy intake (kcal)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Day 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td><strong>Manipulated meals</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breakfast</td>
<td>230±17</td>
<td>200±23</td>
<td>230±17</td>
<td>200±23</td>
<td>289±25</td>
<td>217±24(^3)</td>
<td>289±25</td>
<td>217±24(^3)</td>
<td>72±21</td>
</tr>
<tr>
<td>Lunch</td>
<td>380±23</td>
<td>381±23</td>
<td>610±34</td>
<td>581±38</td>
<td>373±26</td>
<td>263±20(^4)</td>
<td>662±35</td>
<td>481±29(^5)</td>
<td>182±31</td>
</tr>
<tr>
<td>Afternoon snack</td>
<td>165±15</td>
<td>141±13</td>
<td>775±38</td>
<td>722±41</td>
<td>251±20</td>
<td>184±13(^5)</td>
<td>913±45</td>
<td>665±33(^5)</td>
<td>248±36</td>
</tr>
<tr>
<td><strong>Non-manipulated meals</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dinner</td>
<td>321±20</td>
<td>333±15</td>
<td>1096±46</td>
<td>1055±45</td>
<td>346±20</td>
<td>377±18</td>
<td>1259±51</td>
<td>1042±39(^5)</td>
<td>217±38</td>
</tr>
<tr>
<td>Evening snack</td>
<td>168±21</td>
<td>172±19</td>
<td>1264±57</td>
<td>1227±49</td>
<td>157±17</td>
<td>165±15</td>
<td>1416±55</td>
<td>1208±42(^5)</td>
<td>208±52</td>
</tr>
<tr>
<td><strong>Day 2</strong></td>
<td></td>
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<tr>
<td><strong>Manipulated meals</strong></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breakfast</td>
<td>167±21</td>
<td>160±17</td>
<td>1430±70</td>
<td>1387±59</td>
<td>199±27</td>
<td>137±18(^3)</td>
<td>1615±75</td>
<td>1345±53(^5)</td>
<td>271±52</td>
</tr>
<tr>
<td>Lunch</td>
<td>356±29</td>
<td>368±29</td>
<td>1787±87</td>
<td>1754±78</td>
<td>415±41</td>
<td>318±28(^4)</td>
<td>2030±90</td>
<td>1662±61(^3)</td>
<td>368±58</td>
</tr>
<tr>
<td>Afternoon snack</td>
<td>167±14</td>
<td>201±13(^5)</td>
<td>1954±91</td>
<td>1956±82</td>
<td>199±17</td>
<td>177±13</td>
<td>2229±93</td>
<td>1839±63(^5)</td>
<td>391±62</td>
</tr>
<tr>
<td><strong>Non-manipulated meals</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dinner</td>
<td>325±29</td>
<td>319±23</td>
<td>2279±108</td>
<td>2275±84</td>
<td>365±26</td>
<td>359±22</td>
<td>2594±104</td>
<td>2198±62(^5)</td>
<td>397±70</td>
</tr>
<tr>
<td>Evening snack</td>
<td>163±21</td>
<td>155±19</td>
<td>2442±121</td>
<td>2429±96</td>
<td>144±15</td>
<td>152±16</td>
<td>2739±110</td>
<td>2350±68(^5)</td>
<td>389±72</td>
</tr>
</tbody>
</table>

\(^1\) ± SEM

\(^2\) Lower-energy-density significantly different from higher-energy-density, P<0.05

\(^3\) Lower-energy-density significantly different from higher-energy-density, P<0.01

\(^4\) Lower-energy-density significantly different from higher-energy-density, P<0.001

\(^5\) Lower-energy-density significantly different from higher-energy-density, P<0.0001
Figure 6. Cumulative food and energy intakes by meals over two days. There was no effect of energy density on cumulative food intake over two days. There was a significant effect of energy density on cumulative energy intake starting at breakfast and accumulating over the course of two days (P<0.0001). Arrows indicate meals (dinner and evening snack) that were not varied in energy density on Day 1 and Day 2.
Energy Consumed Over Two Days

The energy density of the manipulated foods and beverages had a significant effect on children’s total energy intake over two days (P<0.0001). Decreasing the energy density of the foods and beverages by a mean of 27% (range, 19-33%) resulted in a 25% (431±56 kcal) decrease in energy intake from the manipulated foods and beverages and a 14% (389±72 kcal) decrease in total energy consumption over the course of two days (Table 15). Children consumed 1727±84 kcal in the higher-ED condition and 1297±60 kcal in the lower-ED condition from manipulated foods and beverages over two days. Children consumed 2739±110 kcal in the higher-ED condition and 2350±68 kcal in the lower-ED condition from manipulated and non-manipulated meals over two days. Differences in energy intake were significant at breakfast on Day 1 and these differences accumulated at manipulated meals over two days (P<0.01; Figure 6). There was no significant effect of order of presentation of the energy density conditions on energy intake over two days.

Macronutrient Composition and Specific Food and Beverage Intakes

Multivariate analysis of variance revealed that there was an overall effect of the strategies used to vary energy density on the proportion of energy consumed from protein, carbohydrate, and fat from the manipulated foods and beverages as well as all foods and beverages (P<0.0001; Table 16). There were no significant differences in children’s fiber intakes between conditions.
Table 16
Macronutrient, sugar, and saturated fat intakes from foods and beverages consumed at manipulated meals and non-manipulated meals

<table>
<thead>
<tr>
<th>Energy density</th>
<th>Manipulated foods and beverages</th>
<th>Manipulated and non-manipulated foods and beverages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intake (g)</td>
<td>Percent of energy</td>
</tr>
<tr>
<td></td>
<td>Higher</td>
<td>Lower</td>
</tr>
<tr>
<td>Protein</td>
<td>47±2.6</td>
<td>47±2.7</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>217±11.5</td>
<td>199±10.2</td>
</tr>
<tr>
<td>Sugar</td>
<td>145±8.1</td>
<td>123±6.8</td>
</tr>
<tr>
<td>Fat</td>
<td>71±3.8</td>
<td>33±1.6</td>
</tr>
<tr>
<td>Saturated fat</td>
<td>35±1.8</td>
<td>17±0.9</td>
</tr>
</tbody>
</table>

1 ± SEM
2 Lower-energy-density significantly different from higher-energy-density, P<0.05
3 Lower-energy-density significantly different from higher-energy-density, P<0.001
4 Lower-energy-density significantly different from higher-energy-density, P<0.0001
5 Lower-energy-density significantly different from higher-energy-density condition when assessed by Multivariate Analysis of Variance, P<0.05
The foods that contributed the most to the reduction in energy intake over two days were the breakfast and lunch entrées (coffeecake, blueberry muffins, pasta, macaroni and cheese) and the beverages (milk and juice). Forty-four percent of the reduction in energy intake was associated with reducing the energy density of the entrées, and 30% of the reduction in energy intake was associated with reducing the energy density of the beverages. Eight percent of the reduction in energy intake was attributable to decreasing the energy density of canned fruit, 11% was attributable to decreasing the energy density of snacks (cookie, crackers, string cheese), and the rest of the reduction was due to reducing the energy density of other foods (yogurt, green beans, and carrots with dip).

Increasing the fruit content of the lower-ED versions of blueberry muffins and strawberry yogurt led to significant increases in fruit intake from these foods at breakfast (P<0.01). Children consumed 9±1.5 g of fruit from the higher-ED versions of these foods and 20±4.0 g of fruit from the lower-ED versions of these foods. Increasing the cauliflower and broccoli content of the pasta dish led to a significant increase in vegetable intake from this food (P<0.0001). Children consumed 4±0.5 g of vegetables from the pasta in the higher-ED condition and 12±1.6 g of vegetables from the pasta in the lower-ED condition. However, over the course of two days, there were no significant differences in children’s total fruit and vegetable intakes between conditions.

Energy Density

The mean energy density of the foods and caloric beverages consumed over two days was 1.1 kcal/g in the higher-ED condition and 0.9 kcal/g in the lower-ED condition.
The mean energy density of the manipulated foods and beverages consumed over two days was 1.2 kcal/g in the higher-ED condition and 0.9 kcal/g in the lower-ED condition.

**Estimated Energy Requirements**

Estimated Energy Requirements were calculated for each child assuming sedentary behavior (13). Over two days, children consumed 113%±4.0% (range, 73%-160%) of their estimated energy needs in the higher-ED condition and 97%±2.5% (range, 72%-119%) of their estimated energy needs in the lower-ED condition.

**Participant Characteristics**

There were no significant effects of the children’s characteristics (age, body weight, height, and BMI percentile) on the relationships between energy density and food intake and energy intake. However, older children consumed more energy than younger children (P<0.05). Heavier children consumed more energy than lighter children (P<0.01), and taller children consumed more energy than shorter children (P<0.05). There was a main effect of child’s sex on total food and beverage intake (P<0.001) as well as total energy intake (P<0.001). Boys consumed more grams of food and more energy than girls. Boys consumed 2904±176 g of foods and beverages and 3202±162 kcal in the higher-ED condition and 2739±129 g of foods and beverages and 2597±105 kcal in the lower-ED condition. Girls consumed 2153±116 g of foods and beverages and 2450±91 kcal in the higher-ED condition and 2236±109 g of foods and beverages and 2196±64 kcal in the lower-ED condition.
Discharge Questionnaire

Most parents reported that the food options for dinner and evening snack were appropriate. Most parents reported that the food portions for dinner and evening snack were either appropriate or larger than what the child would normally be given. About half of the parents reported no noticeable differences in their child’s hunger level during the evenings of the study compared to the child’s usual hunger level.

DISCUSSION

The present study is the first to assess the effects on preschool children’s energy intake of changing the energy density of multiple meals over the course of two days. Children ate a consistent total weight of foods and beverages over two days in both energy density conditions, and therefore, consumed significantly less (14%) energy in the lower-ED condition. Several different strategies used to reduce the energy density of foods and beverages were effective in decreasing children’s energy intake. The lower-ED foods and beverages were well-accepted by the children as indicated by both the taste tests and the consistent amounts consumed of the different versions of the foods and beverages. The results of this study indicate that the energy density of foods and beverages can be reduced with little impact on acceptability and that such reductions effectively moderate preschool children’s energy intake.

The effects of energy density on ad libitum food and energy intakes are similar to those seen in previous experimental studies conducted in adults (6-8, 16, 17) and children (4, 5, 9). Previous research has shown that decreasing the energy density of foods leads to a reduction in energy intake at a meal because both adults and children consume a
consistent weight of foods even when foods are reduced in energy density (4-6, 9). Longer-term studies in adults have shown that the effect of energy density on energy intake persists throughout a single day (16) and over multiple days (6-8, 17). In adults the tendency to consume a consistent weight of food continues over multiple days so that reductions in energy density lead to parallel decreases in adults’ energy intake. For instance, a 25% reduction in energy density of all foods over 2-days led to a 24% reduction in adults’ energy intake and the effect did not diminish over time. Similarly, in the present study, an 18% reduction in the energy density of the foods and beverages served over a 2-day period led to a 14% reduction in children’s energy intake and the effect was sustained over both days.

The primary aim of the present study was to assess whether reductions in the energy density of multiple meals would lead to a persistent and significant reduction in energy intake. Children consumed significantly less energy (389 kcal) from foods and beverages in the lower-ED condition, and there was no clear evidence of compensation at manipulated meals or non-manipulated meals over two days. Children consumed significantly more juice at snack on Day 2 in the lower-ED condition, but if this had been a compensatory adjustment in intake, then it should have continued at dinner and evening snack on Day 2.

The lack of compensation for reductions in energy intake warrants further exploration. The intake data suggest that children consumed amounts of energy that were close to their energy needs in the lower-ED condition and amounts in excess of their energy needs in the higher-ED condition. Calculations of the percentage of energy consumed in relation to estimated energy requirements reached 160% for some children.
in the higher-ED condition. There is evidence from studies conducted in adults that energy intakes above energy needs may be less tightly controlled than energy intakes below energy needs (18-21). Preloading studies conducted in young children also show that children may be imprecise in adjusting their food intake when they consume energy-dense preloads. In studies where children have demonstrated energy compensation, the energy content of the preloads was 17% to 19% of children’s baseline meal energy intakes (22). Conversely, in studies where children have not shown accurate energy compensation, the energy content of preloads was in excess of 57% of baseline meal energy intakes. In the higher-ED condition of the present study, children were served full-fat and full-sugar versions of many foods. When served these energy-dense foods, children may not have been able to effectively modify their food intake to adjust for excess energy intake.

In the absence of data on children’s energy expenditure, it is not possible to know whether energy intake exceeded energy requirements. However, there was a substantial difference in the amount of energy children consumed between energy density conditions. Previous research in both adults and children has indicated that compensatory adjustments in food intake following increased or decreased energy intake do not always occur immediately (18, 23, 24), but that these adjustments may occur gradually over multiple meals (18, 25). Therefore, whether substantial differences in children’s energy intake would persist beyond a 2-day period has yet to be determined.

Not only did lowering the energy density of foods and beverages lead to moderation in children’s energy intake, but it also resulted in diets that were closer to the Dietary Guidelines for total fat and saturated fat. In the higher-ED condition, children
consumed 35% of energy from fat and 17% of energy from saturated fat over two days. In the lower-ED condition, children consumed 26% of energy from fat and 13% of energy from saturated fat. A fat intake of 30% to 35% of energy is recommended for children 2 to 3 years of age, and a fat intake of 25% to 35% of energy is recommended for children 4 years of age and older (26). A saturated fat intake of less than 10% of energy is also recommended for both groups of children (26). The results of the present study show that children’s fat intakes are closely related to the types of foods that are provided to children. Therefore, providing children with foods that are in line with the Dietary Guidelines may help children to meet these recommendations.

Several of the strategies used to reduce the energy density of foods and beverages had significant effects on children’s energy and nutrient intakes. For example, substantial portions of the reductions in children’s energy (20%) and saturated fat (33%) intakes were obtained by substituting 1% milk for whole milk. The U.S. Department of Agriculture recommends that preschool-aged children consume two cups of low-fat or nonfat milk or equivalent milk products per day (26). Despite these recommendations, nationally representative data indicate that preschool-aged children consume significantly more whole than low-fat or nonfat milk (27, 28). Peterson and Sigman-Grant (29) have previously recognized the potential of substituting low-fat or nonfat milk for whole milk as an opportunity to reduce fat intake without negatively affecting children’s micronutrient intake. Children in the present study did not report significant differences in their taste ratings of whole and 1% milk, and they consumed similar amounts of both types of milk over two days. The results of the present study demonstrate that reducing
the energy density of beverages, such as milk, effectively decreases children’s energy and fat intakes.

Substantial portions of the reductions in children’s energy (9%) and total sugar (43%) intakes were obtained by substituting reduced-sugar juice drink for regular juice drink. Sugar-sweetened beverages have been shown to be associated with childhood overweight (30), and reducing sweet drink consumption has previously been recommended as a strategy to manage preschool children’s weight (31). Epidemiological data have shown that 52% of preschool-aged children consume sweet juice drinks over the course of two days (32). Reducing the energy density of beverages, such as juice drinks, may be a useful way to reduce children’s energy and sugar intakes while allowing children to continue to consume these drinks.

Another strategy that was used to reduce energy density was to increase the fruit and vegetable content of foods. Increasing the fruit content of muffins and yogurt led to significant increases in fruit intake from these foods, and increasing the vegetable content of pasta led to a significant increase in vegetable intake from this dish. Increasing children’s consumption of fruits and vegetables is vital considering many American children are not meeting dietary recommendations for these foods (33). Previous research with preschool-aged children demonstrated that increasing the vegetable content of pasta led to significant increases in children’s vegetable intake from the entrée and from the meal (5). The results of the present study extend these findings to show that fruit intake at meals can also be increased when greater amounts of fruit are incorporated into foods. Though the increases in fruit and vegetable intakes were not enough to impact children’s total fruit and vegetable intakes over two days, greater intakes may have been achieved if
larger amounts of fruits and vegetables had been incorporated into test foods or if this strategy had been used for more foods. While it is important for children to be exposed to a variety of fruits and vegetables so that they develop a liking for these foods, adding fruits and vegetables to foods could also have a significant impact on children’s energy and nutrient intakes.

The present study had limitations, including the use of a convenience sample from one daycare facility and the relatively short duration of the study. Parents were highly educated and earned a higher than average family income, so the findings of the study should not be generalized to all preschool children. Future research should use samples of more diverse children and be conducted for longer periods of time to extend the findings of this study.

The present study is the first to show that decreasing the energy density of multiple foods served over the course of two days leads to a reduction in preschool children’s *ad libitum* energy intake. Children consumed a consistent total weight of foods and beverages over two days even when the energy density of foods and beverages was reduced by an average of 27%, findings in agreement with studies conducted over multiple days in adults (6). The two main strategies to reduce the energy density of foods, decreasing fat or sugar content of foods and beverages, effectively reduced children’s energy intake and improved children’s intakes of fat and sugar. These strategies could be used individually or in combination with increases in vegetable and fruit content of foods to moderate children’s energy intake and enhance the quality of children’s diets.
REFERENCES

CHAPTER V

CONCLUSIONS
Summary of Findings

The results of the present three studies demonstrate that the energy density of foods and beverages affects young children’s energy intake because children consume a similar weight of foods and beverages at meals, even when the foods and beverages are reduced in energy density. When the energy density of a lunch entrée was lowered 30% by reducing the fat content of the entrée, children consumed 25% less energy (72 ± 8 kcal) from the entrée and 18% less energy (72 ± 8 kcal) from the meal (Study 1). Similarly, when the energy density of a lunch entrée was reduced 25% by decreasing the fat content and increasing the vegetable content of the entrée, children consumed 25% less energy (63 ± 8 kcal) from the entrée and 17% less energy (61 ± 9 kcal) from the meal (Study 2). Portion size of the entrée did not significantly affect children’s energy intake from the entrée or from the meal. Decreasing the energy density of foods and beverages served over two days by 18% via several strategies led to a 14% (389 ± 72 kcal) reduction in children’s energy intake over two days (Study 3).

Overall, the results of these three studies show that lowering the energy density of the diet may be an effective strategy to moderate young children’s energy intake. A number of different approaches to reduce the energy density of foods and beverages were shown to be effective in young children. The findings of these three studies support recommendations of major health organizations concerning the prevention of childhood overweight because they demonstrate that providing children with foods that are low in energy density moderates children’s energy intakes.
Practical Implications

The primary goal of the present research was to assess whether decreasing the energy density of foods and beverages is an effective strategy to moderate energy intake in preschool children. The series of three experiments presented here provides evidence that reductions in energy density can be used to moderate young children’s energy intake, and this research has several practical implications.

One of the practical implications of the present research is that reducing the energy density of foods and beverages does not necessarily decrease the acceptability of these foods and beverages to children. In study 1, the majority of children who participated in preference assessments reported that the lower-energy-density version of the macaroni and cheese entrée tasted the same or better than the higher-energy-density version of this dish. A similar pattern was found in study 2 for the pasta entrée. In study 3, there were no differences in the taste ratings of the six test foods (milk, coffee cake, blueberry muffin, macaroni and cheese, pasta, and cookie) that were assessed. Furthermore, children consumed similar amounts of both versions of all of these foods during the three studies. Taken together, the taste assessments and the consistency in food and beverage intakes suggest that reductions in the energy density of foods and beverages can be achieved without detrimentally affecting palatability.

Another practical implication of the present research is that significant reductions in energy intake and improvements in the nutrient composition of food intake can be made by substituting reduced-fat or reduced-sugar commercially available products for full-fat and full-sugar products. In study 3, many of the lower-energy-density versions of foods and beverages were reduced-fat or reduced-sugar commercially available products.
Substituting different versions of commercially available products is a relatively easy way to lower the energy density of the diet of children, and the relative ease of this buying strategy may be appealing to child care providers and parents.

Another practical implication of the present research is that many different strategies to reduce energy density could be used in combination to meet the nutritional needs of individual children. For instance, children who do not consume enough fruits and vegetables may benefit from the incorporation of fruits and vegetables into mixed dishes or baked goods. A variety of approaches to reduce energy density could be used to promote healthful eating in children.

Potential Mechanisms

Energy Density

Why do children consume similar weights of an entrée when it is varied in energy density, but compensate for the energy density of preloads?

Much of the satiety research on children’s responses to the energy density of foods has revealed that children adjust their food intake in response to the energy density of preloads. In some cases, this adjustment is calorie for calorie so that children consume the same amount of total energy (preload + test meal) in each energy density condition (1-3). However, the results of Study 1 and Study 2 showed that children did not adjust their food intake in response to the energy density of an entrée at test meals. The reason for the disparity in the results of the satiety and satiation studies is not clear (4), but one possibility is that satiety and satiation protocols differentially stimulate mechanisms that control food intake. Food intake is thought to be influenced by cognitive and orosensory
factors and physiological controls (5), and the differences in the timing of food ingestion between satiety and satiation protocols may influence the degree to which these factors and controls influence food intake. For instance, the satiety protocol allows time for the body to adjust hormone levels in response to food ingestion before the test meal is consumed, suggesting that these hormone levels may be very influential in test meal intake. Conversely, in the satiation protocol, the test food is consumed *ad libitum*, suggesting that the body’s hormone response may play less of a role in food intake than more immediate controls like gastric distention.

In the satiety protocol, the preload is generally consumed 20-120 minutes prior to the consumption of the *ad libitum* test meal. Between preload and *ad libitum* consumption, satiety signals are likely stimulated in the body. Numerous pancreatic and intestinal hormones have been shown to influence food intake in humans (6-11). These hormones begin to increase within 30 minutes of food ingestion and can remain elevated for several hours (12-17). Importantly, several of these hormones have been shown to increase in proportion to caloric load (8, 14, 17, 18). Therefore, it is likely that the preload stimulates the release of satiety hormones, many of which are released in proportion to the energy content of the preload. When subsequent *ad libitum* consumption is initiated, the satiety hormones are already elevated and acting within the body.

In the satiation protocol, the food that is varied in energy density is consumed *ad libitum*. In Study 1 and Study 2, children consumed lunch in about 5-20 minutes. Children consumed similar weights of individual foods at lunches across energy density conditions. The weight and volume of a food are usually proportional to each other.
Therefore, it is possible that children were consuming consistent volumes of food across conditions. The volume of food influences meal termination via gastric distention, which activates vagal afferents that send signals from the stomach to the hypothalamus (19, 20). These signals result in the perception of fullness (21). Several studies conducted in adults have demonstrated that gastric distention influences food intake. In early studies on gastric distention, balloons inserted into the stomach were inflated to different volumes (22, 23). As the volume of the balloon increased, food intake decreased. Later studies used different volumes of food, rather than balloons, to test whether food volume influenced food intake. The volume of a food, independent of its energy content or energy density, was shown to influence food intake. In a study where different volumes of food were infused intragastrically, increasing the volume of food, but not the energy content, affected food intake (24). Incorporating air into food, which increases the volume of the food without decreasing the energy density of the food, has also been shown to affect food intake (25). Therefore, it is likely that the major influence on food intake in the single-meal studies was gastric distention associated with the volume of foods and beverages ingested.

Why did children not consume the same amount of energy over two days in both energy density conditions?

In study 3, there were no significant differences in the weight of food consumed over the course of two days between energy density conditions. This consistency in food intake led to significantly different (389 kcal) energy intakes between conditions. Why children did not adjust their food intake over two days and consume similar amounts of
energy across energy density conditions is unclear. A couple of possible explanations for this finding have been offered in the discussion section of study 3, but one of these explanations warrants further elaboration.

As was previously mentioned, a possible explanation for the consistency in food intake over two days, and consequential difference in energy intake, is that the mechanisms involved in long-term energy intake regulation may not have immediate effects on food intake behavior. Studies in both children and adults have demonstrated that adjustments in food intake do not necessarily occur immediately (26-29) and can take several meals to begin to occur (26, 29). It has also been suggested that biological systems responsible for energy balance may take up to two to four days to respond to changes in energy balance (30, 31). Additionally, there is one longer-term energy density study providing evidence that it may take even longer than 4 days for biological systems to recognize energy imbalance (32). In this study, the energy density of the diet was varied between two 14-day periods. Healthy male subjects consumed significantly more energy over the 14-day period when provided with a higher-energy-density diet compared to when provided with a lower-energy-density diet. There was no compensatory change in energy intake during the 14-day period. This study suggests that compensatory adjustments may not occur even within a 14-day period. However, men in this study did report feeling hungrier when consuming the lower-energy-density diet, so it could also be the case that they were prevented from compensating in the lower-energy-density condition because they were not served energy-dense foods.

**Portion Size**
Why do large portions increase children’s food intake?

Currently, there are a number of potential explanations behind why large portions elicit increases in children’s food and energy intakes. A review of the potential mechanisms driving children to consume greater amounts of food when confronted with large portions has been published recently (4). In this review, Fisher and Kral discuss the evidence supporting cognitive explanations and visual explanations for the effect of portion size in children. One of the proposed cognitive explanations is that of the existence of “consumption norms”. “Consumptions norms” are thought to play a role in increased intake from larger portions because the existence of these portions “sanctions” increased intake from larger portions. Fisher and Kral suggest that cognitive explanations, such as “consumption norms”, for the effect of portion size on children’s food intake are not supported by experimental evidence because children appear to be largely unaware of “consumption norms”. Instead, Fisher and Kral suggest that a more plausible explanation for the effect of portion size on children’s intake is that visual cues associated with portion size lead to changes in children’s eating behavior. Specifically, children consume larger bites of food when the portion size of the food is increased. This result has been found in some studies (33, 34), but why increased portion sizes causes children to consume larger bites of food has yet to be determined.

Why did the large portion of pasta in study 2 not lead to increased intake?

Several explanations for the lack of an effect of portion size have already been suggested in the discussion section of study 2, but how the results of study 2 fit with the hypothesis that visual cues elicit changes in eating behavior warrants exploration. In their
review, Fisher and Kral (4) report that the visual cues to which children attend when presented with large portions of food are not well understood. Fisher and Kral (4) also report that recent research on 5- to 6-year-old children’s perceptions of portion sizes of food has suggested that the most important determinant of whether children recognize increases in portion size may be the diameter of the portion of food. In study 2, both portions of the entrée were served on plates of the same diameter and food was purposely plated to be similar in diameter so that children served different portions would not be able to easily tell that their portion was different than those of the other children at the table. When children were asked at the end of the study if two plated portions of the entrée differed in size, more than half of the children incorrectly reported that the two portions were the same size. This finding suggests that children were largely unaware of the difference in the portion sizes of the entrée during the study, which may explain why there was no effect of portion size on food intake.

**Future Research**

*Energy Density*

The present research demonstrates that reducing the energy density of foods and beverages may be an effective strategy to moderate energy intake in preschool children, but this research is only the first step in understanding how decreasing the energy density of the diet affects preschool children’s *ad libitum* energy intake. There are still a number of questions about how and why the energy density of foods and beverages affects children’s energy intake.
Fruit and Vegetable Intakes

The energy density of the diet may be lowered by decreasing the energy density of individual foods. Reductions in the energy density of individual foods may be achieved through several strategies, including increasing the vegetable or fruit content of foods. These strategies not only lead to decreases in energy intake, but they can also lead to simultaneous increases in fruit and vegetable intake. For instance, in study 2 and study 3, increasing the vegetable or fruit content of foods led to significant increases in children’s vegetable and fruit intakes from these foods. However, in study 3, these increases in fruit and vegetable intake had little impact over the course of the 2-day period. Future studies should assess whether significant increases in children’s daily fruit and vegetables intakes can be achieved by incorporating larger amounts of fruits and vegetables into foods or applying this strategy to a number of foods served throughout the day.

Another way to lower the energy density of the diet is to increase the proportion of water-rich foods, such as fruits and vegetables, in the diet. This approach can simultaneously reduce energy intake and increase fruit and vegetable intakes (35). Future research should assess whether significant reductions in children’s energy intake and increases in daily fruit and vegetable intakes may be achieved by adding more opportunities to consume fruits and vegetables to the diet.

Diet Quality

Low-energy-density diets have been associated with high diet quality in adults (36). Diet quality encompasses both macronutrient and micronutrient intakes. The present
research was not directly aimed at assessing how a lower-energy-density diet affects overall diet quality. Future research should assess how lowering the energy density of the diet affects the diet quality of children.

**Energy Requirements**

Children need adequate amounts of energy to be able to grow and develop. One of the factors taken into consideration when calculating children’s energy needs is physical activity, which is one of the most important determinants of energy needs. In the present research, physical activity was not assessed, and therefore, accurate calculation of energy needs could not be determined for individual children. Future research should assess physical activity so that estimates of children’s energy needs can be compared to children’s energy intake when the energy density of the diet is varied.

**Time**

The effects of the energy density of foods on adults’ *ad libitum* energy intake have been tested for periods of up to 20 days (32, 37-46). Study 3 was the first study to assess the effects of changing the energy density of foods and beverages served to preschool children at multiple meals over the course of more than one day. As was previously mentioned, research in adults and children has shown that compensatory adjustments in food intake following increased or decreased energy intake do not always occur immediately (26-29), but that these adjustments may occur gradually over multiple meals (26, 29). It may also take days for changes in energy balance to be detected (30, 31). Future studies in which the energy density of foods and beverages is varied for
longer periods of time are essential to understanding whether the effects of energy density persist beyond two days.

**Learning**

Some of the earliest work investigating the effects on very young children’s energy intake of energy density was conducted by Fomon *et al.* (47-49). These early studies indicated that infants could learn to adjust their energy intake in response to the energy density of formula. In one study (48), 1.5- to 3-month-old infants were fed either a formula of the normal energy density (67 kcal/100 ml) or a formula with twice the concentration (133 kcal/100 ml). For the first six weeks of the study, infants who were fed the higher-energy-density formula consumed more energy and gained more weight than those fed the formula with standard concentration. However, after six weeks, both groups of infants consumed about the same amount of energy per kilogram of body weight. Fomon *et al.* (47) conducted another study in which the difference in the formula concentrations was smaller (100 kcal/100 ml vs. 53 kcal/100 ml). As in the first study, infants fed the higher-energy-density formula consumed more energy and gained more weight during the first six weeks of the study, but energy intake for the two groups of infants was essentially the same after six weeks. Both of these studies show that infants fed higher-energy-density formula were not able to compensate initially, but they were able to learn to adjust their intake of the formula.

Preschool children have also been shown to learn to adjust their energy intake with repeated exposures to preloads varying in energy density (50-53). In several conditioning studies, children have demonstrated better compensation for the energy
content of preloads with increased exposure to these preloads. For example, in one conditioning study (52), compensation upon initial exposure to the preload was only 33%, which is considered to be well below the acceptable range of 50% to 100%. However, by the end of seven exposures to the preload, children’s compensation reached 85%.

Learned energy compensation has also been shown to occur in older children (54). In one study, 15 to 17-year-old boys consumed novel snacks that varied in energy density prior to dinner. During the first part of the study, children consumed a fixed amount of the snack prior to dinner. Then, for five consecutive days, the boys consumed the same snack *ad libitum* prior to dinner. On the sixth day, boys consumed fixed amounts of the snack prior to dinner. Boys did not compensate for the 200 kcal difference in the energy of the snacks at the first dinner. However, following repeated exposure to the snack, appropriate energy compensation occurred.

Early childhood is a period when young children are learning about foods and being exposed to new foods (55). During this period in life, children are thought to be learning to associate the postingestive consequences of foods with the flavors of foods (56). Disrupting what children already know about familiar foods by altering the energy density of these foods may lead to immediate changes in children’s energy intake, but as children are repeatedly exposed to the lower-energy-density versions of foods, they may learn to adjust their food intake. Future research should test whether children learn to adjust their energy intake with repeated consumption of foods that are varied in energy density and consumed *ad libitum*.

*Diverse Children*
There appears to be a lot of variability in individual children’s responses to the energy density of foods. Some of the satiety studies have revealed child characteristics (3, 57-59) and exposures to parental feeding-practices (59) that may explain some of the variability in children’s responses to energy density. However, differences in children’s responses to energy density of foods consumed ad libitum were not well characterized in the present research. Future research should be conducted with larger samples of more diverse children to allow for the detection of individual characteristics that may explain differences in responses to the energy density of foods.

**Mechanisms**

The mechanisms underlying children’s responses to the energy density of foods are not well understood. It is not clear why children respond differently to changes in the energy density of foods between satiety and satiation protocols. As was suggested previously, it is possible that hormones play a large role in meal termination in the satiety protocol while gastric distention plays a large role in meal termination in the satiation protocol. However, this explanation does not account for the previously mentioned pattern in which children can accurately compensate for relatively low-energy preloads (compared to baseline meal intake) but do not accurately compensate for relatively high-energy preloads. If preloads elicit hormonal responses, and these hormones are released in proportion to the caloric load of the preload, then children should be able to accurately compensate for the caloric load of high-energy preloads. Future research should address the mechanisms underlying children’s responses to the energy density of foods consumed during both satiety and satiation protocols.
**Portion Size**

The results of study 2 demonstrated that changing the portion size of an entrée does not necessarily influence children’s food intake from the entrée. This result raises a number of questions about how and why portion size affects food intake.

**Magnitude**

It appears as though larger changes in the portion size of foods may be more likely to increase children’s food intake. In study 2, the portion size of the entrée was increased 33% (decreased 25%), and there was no significant effect of portion size on food intake. In previous studies conducted with children, the magnitude of the change in the portion size of foods has ranged from 33% to 150% (27, 33, 34, 60, 61). Doubling portions has led to significant increases in food intake in five studies (27, 33, 34, 60, 61), with the exception of the younger children in the initial portion size study by Rolls *et al.* (60). The study by Rolls *et al.* (60) is also the only study to examine a dose-related response to portion size. For the older children in this study, the change in portion size between conditions was 50% between the small and medium portion sizes and 33% between the medium and large portion sizes. There were no differences in food intake between the small and medium or medium and large portions. However, the large portion was 200% the weight of the small portion, and there was a significant increase in food intake between the small and large portions. Future studies should assess whether the magnitude of the change in portion size of foods influences children’s responses to portion size.
Liking and Preferences

The majority of children in study 2 reported that they thought both versions of the pasta were “yummy” or “just ok”. However, children’s preference for the pasta in relation to other foods is unknown. Food preferences have been shown to be important determinants of food intake in children (56, 62, 63), so it is possible that preference for foods influences whether increased portions of foods will lead to increased consumption of foods.

In adults, there is some evidence that food preferences may influence the effects of portion size (64). For example, in a study where the portion size of all foods was increased for 11 days, adults increased their intake of all types of foods with the exception of vegetables and fruits consumed as snacks (64). The authors suggested that one possible explanation for a lack of increase in intake when portions of these foods were increased is that these foods were competing against highly palatable foods within eating occasions. Food preferences were not directly assessed in this study. It is possible that fruits and vegetables may have been less-preferred compared to other foods served at these meals, so increased intake of preferred foods may have displaced intake of fruits and vegetables.

In a 24-hour portion size study conducted with children, five foods were increased in portion size, but children’s intakes of only two foods increased (27). It is possible that the foods that did not elicit an increase in intake were not well-liked by the children, but children’s taste ratings for these foods were not reported. It is also possible that children preferred other foods served during the meals, so increases in the portion size of less-
preferred foods did not lead to increased intakes of these foods. Future research should assess whether liking for foods and preferences for foods influence children’s responses to the portion size of foods.

Mechanisms

What drives children to consume greater amounts of foods when food portion sizes are increased is unclear, but several potential mechanisms have been suggested by other investigators (4). Future research should be aimed at trying to understand why changing the portion size of foods affects children’s food and energy intakes.

Final Conclusions

In conclusion, the results of the present three studies indicate that, like adults and school-aged children, preschool children consume a similar weight of food at meals, even when the food is reduced in energy density. Therefore, when the energy density of food is reduced, children consume significantly less energy at individual meals and over the course of up to two days. The results of the present research also demonstrate that children consume a consistent weight of beverages at individual meals and over the course of two days, and therefore, consume significantly less energy when the energy density of beverages is decreased. Additionally, the present research demonstrates the effectiveness of several different strategies to lower the energy density of foods served to children: reducing the fat or sugar content of foods, combining fat reductions with increases in the vegetable content of foods, increasing the fruit content of foods, and combinations of these approaches. The lower-energy-density foods and beverages were
well-accepted by the children as indicated by both the taste tests and the consistent amounts consumed of the different versions of the foods and beverages. Overall, the results of the present research extend previous findings on the effects of energy density on *ad libitum* energy intake to a younger age group.
REFERENCES

33. Fisher JO, Rolls BJ, Birch LL. Children's bite size and intake of an entrée are greater with large portions than with age-appropriate or self-selected portions. Am J Clin Nutr 2003;77:1164-70.


64. Rolls BJ, Roe LS, Meengs JS. The effect of large portion sizes on energy intake is sustained for 11 days. Obesity 2007;15:1535-43.
APPENDIX A

RECRUITMENT LETTER

STUDY 1
September 2005

Dear Parents,

The Children’s Eating Laboratory is getting ready for the beginning of new projects with the Child Development Laboratory and the Bennett Family Center! The title of our new project is “Children’s Eating Behavior at Lunchtime”. This study is intended to examine children’s responses to changes in the energy density of the main course at lunchtime. Energy density refers to the amount of energy in a specific weight of food (kcal/g). We will be using macaroni and cheese, a food commonly served in the daycare centers, as the main course in our study. The energy density of the macaroni and cheese will be manipulated in this study through the addition/removal of butter, oil, and water. Our goal for the “Children’s Eating Behavior at Lunchtime” study is to have full participation in the classrooms at the Child Development Laboratory and the Bennett Family Center.

This study will take place from October - December 2005. One day per week for seven weeks, children will continue to eat meals with his/her class. Children will participate in the following activities:

- **Breakfast in the Classroom**
  The breakfast will consist of cereal, milk, and fruit. This breakfast will meet the same standards as the breakfasts normally served and the menu will be included in the monthly meal menus of the centers. All children in the centers on these seven days (one day per week) will be served the same breakfast, but only the children enrolled in the study will have their breakfast consumption assessed.

- **Lunch in the Classroom**
  The lunch will consist of milk, macaroni and cheese, unsweetened applesauce, and broccoli. This lunch will meet the same standards as the lunches normally served and the menu will be included in the monthly meal menus of the centers. All children in the centers on these seven days will be served the same lunch, but only the children enrolled in the study will have their lunch consumption measured.

- **The Tasting Game**
  “The Tasting Game” is used to understand children’s food preferences and involves interviewing children individually. Children are asked to take a taste of each food and tell us about their preferences for the foods by using a series of cartoon faces, depicting “like”, “dislike”, and “just okay.” Your child will participate in the tasting game once one or two weeks after the last lunch of the study.
• **Height and weight**
  These measurements will be taken once at the beginning of the study by a trained staff member.

In addition to the information obtained from your child, we would like you to complete several questionnaires (6 double-sided pages) regarding your own eating patterns, child feeding practices, and background information, such as age, ethnicity, occupation, height, weight, and education. These questionnaires typically require approximately 10-15 minutes to complete.

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. Each family will earn a $10 gift card to Giant for the completion of the questionnaires and seven weeks of breakfasts and lunches. Additionally, each participating classroom will receive $50 of educational materials (books, toy, etc.). All of the information that you and your child provide is completely confidential.

**Please read and sign the consent form attached to this letter. Return completed form to the ‘Children’s Eating Laboratory Drop-off Box’ in your child’s classroom.** I would be happy to provide you with any additional information if you have questions regarding this research or other aspects of our work. The Children’s Eating Laboratory phone number is (814) 863-9972.

Sincerely,

Leann L. Birch, Ph.D.  Barbara J. Rolls, Ph.D.
Principal Investigator          Principal Investigator
APPENDIX B

CONSENT FORM

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

Title of Project: Children’s Eating Behavior at Lunchtime

Principal Investigators: Leann L. Birch, Ph.D. and Barbara J. Rolls, Ph.D.
Telephone: 863-8481

Other Investigator(s): Jennifer Meengs and Kathleen Leahy
Telephone: 863-8482

1. Purpose of the study: The purpose of this research is to investigate children’s responses to changing energy density of the main course at lunchtime.

2. Procedures to be followed: If you agree to allow your child to take part in this research, your child will be a part of a project looking at how children respond to varying energy density of a main course at lunch. This activity will take place during the child’s regularly scheduled breakfast and lunchtime one day per week for seven weeks. In addition to the lunchtime activity, children will also meet one time with a research assistant for a brief interview that will involve assessing the child’s preferences for the macaroni and cheeses used in the study. Your child’s height and weight will also be measured once during the study by a trained staff member.

In addition to the information obtained from your child, we would like you to complete several questionnaires (6 double-sided pages) regarding your own eating patterns, child feeding practices, and background information, such as age, ethnicity, occupation, height, weight, and education.

3. Discomforts and risks: There are no risks involved in eating the test meals and filling out the questionnaires beyond those encountered in everyday life. It may be possible that someone could have an allergic reaction to one of the food items or food item ingredients.

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, one brief interview, and height and weight measurements, will be about four and a half hours. The parent questionnaires typically require approximately 10-15 minutes to complete.
6. **Statement of confidentiality:** The Office for Research Protections and the Biomedical Institutional Review Board (IRB) may review records related to this project. Your participation and your child’s participation in this research are confidential. Only the investigators and their assistants will have access to your identity and your child’s identity and to information that can be associated with these identities. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared.

7. **Right to ask questions:** You can ask questions about this research. Contact Kathleen Leahy or Jennifer Meengs at 863-8482 with questions. If you have questions about your rights as a research participant, contact The Pennsylvania State University’s Office for Research Protections at (814) 865-1775.

8. **Compensation:** Once you have completed the questionnaires, your family will receive one payment of a $10 gift card to Giant for the completion of the questionnaires and seven breakfasts and lunches.

9. **Voluntary participation:** Your participation and your child’s participation are voluntary. You and your child can stop at any time. You do not have to answer any questions you do not want to answer, and your child does not have to eat any foods that he/she does not want to eat.

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 have against The Pennsylvania State University for injury resulting from negligence of the University or its investigators.

If you agree to take part in this research study and to allow your child to take part in the study as well, please sign your name and indicate the date below.

You will be given a copy of this signed and dated consent for your records.

______________________________________________
Child's Name

_________________________________________  _____________________
Parent Signature  Date

_________________________________________  _____________________
Person Obtaining Consent  Date
APPENDIX C

PREFERENCE ASSESSMENT SCRIPT

STUDY 1
Interviewer: “Hello, my name is __________. I am going to ask you a few questions about food today. Please take a seat. Now, I would like you to take a taste of each of these macaroni and cheeses.”

Wait for child to taste both foods with spoon.

Interviewer: “Good! Now do you think that they taste the same, or do they taste different?”

Wait for child to indicate if the two dishes taste the same or different.

Interviewer: “Ok. Now if you had to choose one of these two dishes to eat more of, which macaroni and cheese 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?”
September 2005

Dear Parents,

Thank you very much for participating in our study! We have made a copy of your signed consent form for your records. We have also given you two questionnaires to complete about you and your child. These questionnaires should be completed by one parent in the household. Some of you may have more than one child participating in our study. We would like you to fill out a set of questionnaires for each child participating in the study. If you are completing multiple sets of questionnaires, please keep one child in mind for each set of questionnaires that you complete. We ask that you complete the questionnaires at your convenience and that you return them to the envelope in your child’s classroom. We will frequently check the envelopes in the classrooms and leave Giant gift cards for the parents who return the questionnaires.

Additionally, there have been two changes in the menu for the study. Breakfast will consist of cereal instead of bagels. Since some young children have difficulty eating raw carrots, broccoli will be served instead of carrots.

Again, we really appreciate your participation! If you have any questions, please do not hesitate to call us! The telephone number is 863-8482. Thank you!

Sincerely,

Jennifer Meengs and Katie Leahy
Child Feeding Questionnaire

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>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I have to be sure that my child does not eat too much.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2. A tasty snack is one of the best ways to reward my child.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3. My child knows when she is hungry.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>4. I have to be sure that 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>5. I have to be sure that my child does not eat too many snack foods (chips, cheese puffs).</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>6. I have to be sure that 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>7. I have to be sure that my child does not eat too much of her favorite foods.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>8. If my child says “I’m still hungry” after eating most of the food on her plate, I offer her more to eat.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>9. Generally, my child should only be permitted to eat at set mealtimes.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>10. When my child says “I’m hungry”, I believe her.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>11. My child should always eat all of the food on her plate.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>12. I have to be especially careful to make sure my child eats enough.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Question</td>
<td>Level 1</td>
<td>Level 2</td>
<td>Level 3</td>
<td>Level 4</td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------------------------------------------------</td>
<td>---------</td>
<td>---------</td>
<td>---------</td>
<td>---------</td>
</tr>
<tr>
<td>13.</td>
<td>If my child says “I’m hungry” between meals, I let her snack.</td>
<td>disagreed</td>
<td>disagree</td>
<td>neutral</td>
<td>agree</td>
</tr>
<tr>
<td>14.</td>
<td>My child often has to be strongly encouraged to eat things that she doesn’t like because those foods are often good for her.</td>
<td>disagreed</td>
<td>disagree</td>
<td>neutral</td>
<td>agree</td>
</tr>
<tr>
<td>15.</td>
<td>If my child refuses to eat a new food, I continue to offer it to her on other occasions.</td>
<td>disagreed</td>
<td>disagree</td>
<td>neutral</td>
<td>agree</td>
</tr>
<tr>
<td>16.</td>
<td>When my child says “I’m full”, I believe her.</td>
<td>disagreed</td>
<td>disagree</td>
<td>neutral</td>
<td>agree</td>
</tr>
<tr>
<td>17.</td>
<td>I intentionally keep some foods out of my child’s reach.</td>
<td>disagreed</td>
<td>disagree</td>
<td>neutral</td>
<td>agree</td>
</tr>
<tr>
<td>18.</td>
<td>I have to be especially careful to make sure that my child eats enough healthy foods.</td>
<td>disagreed</td>
<td>disagree</td>
<td>neutral</td>
<td>agree</td>
</tr>
<tr>
<td>19.</td>
<td>If my child says “I’m not hungry”, I try to get her to eat anyway.</td>
<td>disagreed</td>
<td>disagree</td>
<td>neutral</td>
<td>agree</td>
</tr>
<tr>
<td>20.</td>
<td>I offer sweets (candy, ice cream, cakes, pastries) to my child as a reward for eating other foods that are good for her.</td>
<td>disagreed</td>
<td>disagree</td>
<td>neutral</td>
<td>agree</td>
</tr>
<tr>
<td>21.</td>
<td>I offer snack foods (chips, cheese puffs) to my child as a reward for eating other foods that are good for her.</td>
<td>disagreed</td>
<td>disagree</td>
<td>neutral</td>
<td>agree</td>
</tr>
<tr>
<td>22.</td>
<td>I offer high fat foods to my child as a reward for eating other foods that are good for her.</td>
<td>disagreed</td>
<td>disagree</td>
<td>neutral</td>
<td>agree</td>
</tr>
<tr>
<td>23.</td>
<td>I offer my child her favorite foods as a reward for eating other foods that are good for her.</td>
<td>disagreed</td>
<td>disagree</td>
<td>neutral</td>
<td>agree</td>
</tr>
<tr>
<td>24.</td>
<td>If my child has refused to eat a new food, I typically do not offer it to her on other occasions.</td>
<td>disagreed</td>
<td>disagree</td>
<td>neutral</td>
<td>agree</td>
</tr>
<tr>
<td>25.</td>
<td>If I did not guide or regulate my child’s eating, she would eat much less than she should.</td>
<td>disagreed</td>
<td>disagree</td>
<td>neutral</td>
<td>agree</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>26. My child is unwilling to eat many of the foods that our family eats at mealtimes.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>27. My child decides how much of each food goes on her plate at mealtime.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>28. I offer <em>sweets</em> (<em>candy, ice cream, cake, pastries</em>) 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>29. I offer <em>snack foods</em> (<em>chips, cheese puffs</em>) 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>30. I offer <em>high fat foods</em> 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>31. I offer my child her <em>favorite foods</em> in exchange for good behavior.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>32. It is my responsibility to decide how much of each food gets put on my child’s plate at mealtimes.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>33. My child gets distracted at mealtimes.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>34. My child knows when she is full.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>35. If I did not guide or regulate my child’s eating, she would eat much more than she should.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>36. If I did not guide or regulate my child’s eating, she would eat too many <em>junk foods</em>.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>37. If I did not guide or regulate my child’s eating, she would eat too many <em>sweets</em> (<em>candy, ice cream</em>).</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>38. If I did not guide or regulate my child’s eating, she would eat too many <em>snack foods</em> (<em>chips, cheese puffs</em>).</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Question</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------------------------------------------------</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>39.</td>
<td>If I did not guide or regulate my child’s eating, she would eat too many high fat foods.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>40.</td>
<td>If I did not guide or regulate my child’s eating, she would eat too much of her favorite foods.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>41.</td>
<td>My child is fussy or picky about what she eats.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>42.</td>
<td>My child’s diet consists of only a few foods.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>43.</td>
<td>If I did not guide or regulate my child’s eating, she would select healthy foods.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</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>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>unconcerned</td>
<td>slightly unconcerned</td>
<td>neutral</td>
<td>slightly concerned</td>
<td>concerned</td>
</tr>
</tbody>
</table>

44. How concerned are you about what your child eats when you are not around her?  
1 2 3 4 5

45. How concerned are you about your child eating too much when you are not around her?  
1 2 3 4 5

46. How concerned are you about your child not eating enough when you are not around her?  
1 2 3 4 5

47. How concerned are you about your child having to diet to maintain a desirable weight?  
1 2 3 4 5

48. How concerned are you about your child developing health problems (diabetes, heart disease) due to a poor diet?  
1 2 3 4 5

49. How concerned are you about your child becoming overweight?  
1 2 3 4 5

50. How concerned are you about your child developing an eating disorder?  
1 2 3 4 5

51. How concerned are you about your child developing high cholesterol levels?  
1 2 3 4 5

52. How concerned are you that your child currently has an eating problem  
1 2 3 4 5
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.

53. How much do you keep track of the sweets (candy, ice cream cake, pies, pastries) that your child eats?
   1  2  3  4  5

54. How much do you keep track of the junk food that your child eats?
   1  2  3  4  5

55. How much do you keep track of the snack food (potato chips, Doritos, cheese puffs) that your child eats?
   1  2  3  4  5

56. How much do you keep track of the high fat foods that your child eats?
   1  2  3  4  5

57. How much do you keep track of the favorite foods that your child eats?
   1  2  3  4  5

58. Indicate which meals you typically eat with your child on........

**Weekdays**

___ breakfast
___ lunch
___ dinner
___ snacks

**Weekends**

___ breakfast
___ lunch
___ dinner
___ snacks
**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>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>59. When your child is at home, how often are you responsible for feeding her?</td>
<td>never</td>
<td>seldom</td>
<td>half of time</td>
<td>most of time</td>
<td>always</td>
</tr>
<tr>
<td>60. How often are you responsible for planning meals?</td>
<td>never</td>
<td>seldom</td>
<td>half of time</td>
<td>most of time</td>
<td>always</td>
</tr>
<tr>
<td>61. How often are you responsible for preparing meals?</td>
<td>never</td>
<td>seldom</td>
<td>half of time</td>
<td>most of time</td>
<td>always</td>
</tr>
<tr>
<td>62. How often are you responsible for teaching your child table manners?</td>
<td>never</td>
<td>seldom</td>
<td>half of time</td>
<td>most of time</td>
<td>always</td>
</tr>
<tr>
<td>63. How often are you responsible for deciding what your child’s portion sizes are?</td>
<td>never</td>
<td>seldom</td>
<td>half of time</td>
<td>most of time</td>
<td>always</td>
</tr>
<tr>
<td>64. How often are you responsible for deciding how many helpings your child gets?</td>
<td>never</td>
<td>seldom</td>
<td>half of time</td>
<td>most of time</td>
<td>always</td>
</tr>
<tr>
<td>65. How often are you responsible for deciding if your child has eaten the right kind of foods?</td>
<td>never</td>
<td>seldom</td>
<td>half of time</td>
<td>most of time</td>
<td>always</td>
</tr>
<tr>
<td>66. How often are you responsible for deciding if your child has had enough to eat?</td>
<td>never</td>
<td>seldom</td>
<td>half of time</td>
<td>most of time</td>
<td>always</td>
</tr>
<tr>
<td>67. How often are you responsible for deciding when your child is done eating and can leave the table?</td>
<td>never</td>
<td>seldom</td>
<td>half of time</td>
<td>most of time</td>
<td>always</td>
</tr>
</tbody>
</table>
68. Think back to when you were a child. On the whole, were you

1) markedly underweight  2) slightly underweight  3) average  4) slightly overweight  5) markedly overweight

69. During which years was your weight more or less than average? Please record a scale number for each time period listed below.

1) markedly underweight  2) slightly underweight  3) average  4) slightly overweight  5) markedly overweight

1) preschool age (3rd to 5th birthday)  2) 5 to 10  3) adolescence  4) 20's  5) currently

70. During which years was your child's weight more or less than average? Please record a scale number for each time period listed below.

1) markedly underweight  2) slightly underweight  3) average  4) slightly overweight  5) markedly overweight

*Please Note: if your child has not reached a certain age group please place a 0 in that category.

1) first year of life  2) toddler  3) preschool  4) kindergarten
<table>
<thead>
<tr>
<th></th>
<th></th>
<th>slightly disagree</th>
<th>neutral</th>
<th>slightly agree</th>
<th>agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>71.</td>
<td>A snack is a good way to keep my child from fidgeting (in the car, church, Dr.’s office, store, etc.)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>72.</td>
<td>A snack is a good way to soothe my child when she is distressed (mad at a friend, hurt, worried, crying).</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>73.</td>
<td>Sharing a snack with my child is a good way for us to feel close.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>74.</td>
<td>When I can’t provide my child with other things that she wants such as toys or special clothes, a special snack usually satisfies her.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>75.</td>
<td>My family has special foods that we use to celebrate our child’s special achievements (sporting events, recitals, plays, etc.).</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>
APPENDIX F

DEMOGRAPHIC QUESTIONNAIRE

STUDY 1
Demographic/Background Information

I am the ____ mother or the ____father of this child.

When is your child’s birthday? ____________________________

Who lives in your household?
Mother ____ Grandmothers ____
Father ____ Grandfathers ____
Siblings ____ 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:

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 ___Retired
___Yes
_____Hrs per week at work
(not traveling to & from)

DAD
___No __Retired
___Yes
_____Hrs per week at work
(not traveling to & from)
On average, how frequently does your family eat-out or get take-out for dinner?

1) once a month or less  
2) twice a month  
3) once a week  
4) two times a week  
5) three times week  
6) four or more times a week

On average, how many nights a week does your family eat dinner together as a group (*with most family members*)?  

_________ nights

YES  NO

Has your child been on any antibiotics in the past week?

If YES, what?_______________________________________________________

Has your child taken any other medication in the last day?

If YES, what?_______________________________________________________

Does your child have asthma that requires an inhaler?

If YES, does he/she have an inhaler with him/her today? ___________________

Does your child have any food allergies?

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

______________________________________________________________

Does your child suffer from lactose intolerance?

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 today)?

If YES, please specify ________________________________________________

______________________________________________________________
Has your child had any major illnesses?  
If yes, please describe:____________________________________

What is your weight (in pounds)? ______________

What is your height (in inches)? ______________

How often is your child sick?  
1) he/she is never sick 
2) he/she is rarely sick 
3) he/she is sometimes sick 
4) he/she is quite sickly and seems to catch most things

How would you rate your own health?  
1) poor 
2) fair 
3) average 
4) good 
5) excellent

How would you rate the health of your child’s other parent?  
1) poor 
2) fair 
3) average 
4) good 
5) excellent
APPENDIX G

RECRUITMENT LETTER

STUDY 2
March 2006

Dear Parents,

We would like to thank the parents and children from the Bennett Family Center who participated in the “Children’s Eating Behavior at Luncheon” study that we conducted last fall. Your child’s participation in this research is greatly appreciated, and will truly make a difference in helping us to find ways to enhance the diets of children in the Bennett Family Center as well as in other preschools. The studies we are conducting are designed to determine how the energy density of foods served influences children’s eating behavior and energy intake.

We plan to conduct more studies at the Bennett Family Center during the coming months. The next study will take place this spring and we would like to ask you to allow your child to participate in this study. Even if your child did not participate in the fall study, please consider allowing them to participate in the next study.

The study that we will conduct this spring is similar in format to the study we conducted last fall. For lunch we will serve a home-made baked pasta dish with vegetables as the main course in our study, along with other menu items. The portion size and energy density (calories in a portion of food) of the baked pasta dish will be varied through the addition/removal of cheese, vegetable puree, chopped vegetables, and sauce. The rest of the items on the lunch menu will be the same across days. Our goal for this study is to have full participation in the pre-school and kindergarten classrooms at the Bennett Family Center.

This study will take place from March – May 2006. Children will participate one day per week for seven weeks. Children will participate in the following activities:

- **Breakfast in the Classroom**
  The breakfast will consist of cereal, milk, and fruit. This breakfast will meet the same standards as the breakfasts normally served and the menu will be included in the monthly meal menus of the centers. All children in the pre-school and kindergarten classrooms on these seven days (one day per week) will be served the same breakfast.

- **Lunch in the Classroom**
  The lunch will consist of milk, a baked pasta dish, and unsweetened applesauce. This lunch will meet the same standards as the lunches normally served and the menu will be included in the monthly meal menus of the center. All children in the pre-school and kindergarten classrooms on these seven days will be served the same lunch, but only the children enrolled in the study will have their lunch consumption assessed.
• **The Tasting Game**
  “The Tasting Game” is used to assess children’s food preferences for menu items and involves interviewing children individually. Children are asked to take a taste of each food and tell us about their preferences for the foods. Your child will participate in the tasting game once after the last lunch of the study.

• **Height and weight**
  These measurements will be taken once by a trained staff member.

In addition to the information obtained from your child, we would like you to complete a questionnaire packet which typically takes about 10-15 minutes, and asks about your own eating patterns, child feeding practices, and background information.

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. Each family will be given a $10 gift card to Giant for the completion of the questionnaires and seven weeks of breakfasts and lunches. All of the information that you and your child provide is completely **confidential**.

**Please read and sign the consent form attached to this letter. Return the completed form to the ‘Children’s Eating Laboratory Drop-off Box’ 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. The Children’s Eating Laboratory phone number is (814) 863-9972, or you may contact Jennifer Meengs, R.D., Lab Manager for Dr. Barbara Rolls at 863-2877.

Sincerely,

Leann L. Birch, Ph.D.  
Principal Investigator

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

CONSENT FORM

STUDY 2
Informed Consent Form for Biomedical Research
The Pennsylvania State University

Title of Project:  Children’s Eating Behavior at Lunchtime

Principal Investigators:  Leann L. Birch, Ph.D. and Barbara J. Rolls, Ph.D.
Telephone: 863-8481

Other Investigator(s):  Jennifer Meengs and Kathleen Leahy
Telephone: 863-8482

1. Purpose of the study: The purpose of this research is to investigate children’s
responses to changing energy density and portion size of the main course at lunchtime.

2. Procedures to be followed: If you agree to allow your child to take part in this
research, your child will be a part of a project looking at how children respond to
varying energy density and portion size of a main course at lunch. This activity will take
place during the child’s regularly scheduled breakfast and lunchtime one day per week
for seven weeks. In addition to the lunchtime activity, children will also meet one time
with a research assistant for a brief interview that will involve assessing the child’s
preferences for the baked pasta dish used in the study. Your child’s height and weight
will also be measured once during the study by a trained staff member.

In addition to the information obtained from your child, we would like you to complete
several questionnaires (6 double-sided pages) regarding your own eating patterns, child
feeding practices, and background information, such as age, ethnicity, occupation,
height, weight, and education. Parents who previously completed these questionnaires
may not be asked to complete them again.

3. Discomforts and risks: There are no risks involved in eating the test meals and
filling out the questionnaires beyond those encountered in everyday life. It may be
possible that someone could have an allergic reaction to one of the food items or food
item ingredients.

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, one brief interview, and height and weight
measurements, will be about four and a half hours. The parent questionnaires typically
require approximately 10-15 minutes to complete.

6. Statement of confidentiality: The following may review and copy records related to
this research: The Office of Human Research Protections in the U.S. Department of
Health and Human Services, the Biomedical Institutional Review Board and the PSU Office for Research Protections.

Your participation and your child’s participation in this research are confidential. Only the investigators and their assistants will have access to your identity and your child’s identity and to information that can be associated with these identities. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared.

7. Right to ask questions: You can ask questions about this research. Contact Kathleen Leahy or Jennifer Meengs at 863-8482 with questions. If you have questions about your rights as a research participant, contact The Pennsylvania State University’s Office for Research Protections at (814) 865-1775.

8. Compensation: Once you have completed the questionnaires, your family will receive one payment of a $10 gift card to Giant for the completion of the questionnaires and seven breakfasts and lunches.

9. Voluntary participation: Your participation and your child’s participation are voluntary. You and your child can stop at any time. You do not have to answer any questions you do not want to answer, and your child does not have to eat any foods that he/she does not want to eat.

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 have against The Pennsylvania State University for injury resulting from negligence of the University or its investigators.

If you agree to take part in this research study and to allow your child to take part in the study as well, please sign your name and indicate the date below.

You will be given a copy of this signed and dated consent for your records.

I give permission for my child, __________________________, to participate in this research project.

(print name of child)

________________________________________  _______________________
Parent Signature                                      Date

________________________________________  _______________________
Person Obtaining Consent                             Date
APPENDIX I

PREFERENCE ASSESSMENT SCRIPT

STUDY 2
Explain to the children in the classroom how to play the Tasting Game again:

“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 three faces here. Do you see a face that looks like the face you make when you eat something that tastes really yummy? Point to the face that you would make is you ate something that tasted really yummy.”

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

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

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

“This is our yucky face. See how she’s frowning and sticking out her tongue like she’s saying Ohhh 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 really yummy, but it doesn’t taste really yucky, it tastes just kind of OK.

Now, I really like _oranges_. I think that _oranges_ tastes really yummy. Show me the face that I would make if I ate _oranges_.”

Again, either reinforce the children for the correct choice or show them the correct face.

“Ok, now, what if I don’t like _oranges_? I think that _oranges_ taste really yucky. Show me the face that I would make if I ate _oranges_.”

Again, either reinforce the children for the correct choice or show them the correct face.

“Ok, now, I think that _oranges_ are just Ok. I think that _oranges_ taste just Ok. They are not really yummy, but they are not really yucky. Show me the face that I would make if I ate _oranges_.”

Again, either reinforce the children for the correct choice or show them the correct face.

To be done with individual kids:

“Ok, now I’d like to play the game with real food. I have two foods here and I’d like to know whether you think they taste really yummy, really 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? Eat the food that you would like to taste first.”

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 really yummy, really yucky, or did it taste just ok? Put the cup in front of the face that you made when you tasted the _pasta_.”

Wait for the child to pace the cup in front of one of the faces.

“You thought that one was _appropriate face_!!! Ok, now take a taste of the other pasta”

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

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

Again, wait for the child to pace the cup in front of one of the faces. 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!”

**Rank Ordering (only if 2 pastas at same face):**

When the child has tasted both foods and placed the cups in front of the appropriate faces, begin the rank order preference if both foods are in front of one face.

"Good job! You are so good at playing this game. OK, let's look at the yummy face".

Move the yummy face and all cups in front of it forward and place them directly in front of the child.

"These are the foods that you thought tasted really yummy (or just ok, or really yucky). This is the one that you tasted first, and this is the one that you tasted second. Now, I'd like you to tell me if one tastes better than the other or if you think they taste the same.”

Wait for the child to answer. Mark the response when the child has already left the table.

**Size Estimation:**

“Now look at these two plates of pasta. Do you think one plate has more pasta than the other or do they have the same amount of pasta on them?”
Wait for the child to taste both pastas and answer. Mark the response when the child has already left the table.

“Thank you for playing the tasting game with me. Which sticker would you like?”
APPENDIX J

“YUMMY”, “JUST OK”, AND “YUCKY” FACES

STUDY 2 AND STUDY 3
APPENDIX K

PARENT LETTER FOR QUESTIONNAIRES

STUDY 2
March 2006

Dear Parents,

Thank you very much for participating in our study! We have made a copy of your signed consent form for your records. We have also given you two questionnaires to complete about you and your child. Since most of our research focuses on mothers, these questionnaires should be completed by the mother of the study participant. If the mother is unavailable or is not the primary person in charge of making meals for the child, then please have the person with this responsibility fill out both questionnaires instead. If the person filling out the questionnaires is not the mother of the child, please cross out the word “mothers” and write the person’s relationship to the child at the top of each questionnaire. Some of you may have more than one child participating in our study. We would like you to fill out a set of questionnaires for each child participating in the study. If you are completing multiple sets of questionnaires, please keep one child in mind for each set of questionnaires that you complete. We ask that you complete the questionnaires at your convenience and that you return them to the envelope labeled “Children’s Eating” in your child’s classroom. We will frequently check the envelopes in the classrooms and leave Giant gift cards for the parents who return the questionnaires.

Additionally, we have added baby carrots as a side dish for the lunches we will serve during the study.

Again, we really appreciate your participation! If you have any questions, please do not hesitate to call us! The telephone number is 863-8482. Thank you!

Sincerely,

Jennifer Meengs and Katie Leahy
APPENDIX L

DEMOGRAPHIC QUESTIONNAIRE

STUDY 2 AND STUDY 3
Demographic/Background Information

*Mothers,* please complete this questionnaire and return it to the “Children’s Eating” envelope in your child’s classroom. Thank you!

What is your child’s date of birth?  

Who lives in your household?  

<table>
<thead>
<tr>
<th>Mother</th>
<th>Grandmothers</th>
<th>Father</th>
<th>Grandfathers</th>
<th>Siblings</th>
<th>Aunts</th>
<th>Uncles</th>
<th>Cousins</th>
<th>Other</th>
</tr>
</thead>
</table>

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  
- Retired  
- Yes  
- Hrs per week at work (not traveling to & from)  

**DAD**  

- No  
- Retired  
- Yes  
- Hrs per week at work (not traveling to & from)
On average, how frequently does your family eat-out or get take-out for dinner?

1) once a month or less
2) twice a month
3) once a week
4) two times a week
5) three times a week
6) four or more times a week

On average, how many nights a week does your family eat dinner together as a group (with most family members)?

________ nights

YES   NO

Is your child on any medications?
If YES, please specify _______________________________________________

Does your child have any food allergies?
If YES, how does this affect his/her diet? ________________________________

Does your child suffer from lactose intolerance?
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)?
If YES, please specify _______________________________________________

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  _____

What is your weight (in pounds)? _________________

What is your height (in inches)? _________________
APPENDIX M

RECRUITMENT LETTER

STUDY 3
Dear Parents:

The Children’s Eating Laboratory and the Laboratory for the Study of Human Ingestive Behavior are getting ready to collaborate on new projects with child care centers in the Centre County region! The title of our new project is “Children’s Eating Behavior”. This study is intended to examine children’s responses to changes in the energy density of foods throughout the course of two 2-day periods. Energy density refers to the amount of energy in a specific weight of food (kcal/g), and it is easily changed by adding water-rich foods like fruits and vegetables to meals and dishes. We will be changing the energy density of several foods that are commonly consumed by kids over the course of two days to see how children’s eating behavior is affected by these foods.

This study will take place in March 2007. Two days per week for two weeks, Mar. 6-7 and March 20-21, we will provide all meals to children. Children will be asked to consume only the foods and drinks provided by us for these two 2-day periods. Children will consume breakfast, lunch, and afternoon snack at their child care center and dinner and an evening snack that will be packed to take home. Children will participate in the following activities:

- **Breakfast, Lunch, and Afternoon Snack in the Classroom**
  The breakfasts may consist of muffins, coffee cake, yogurt, milk, and fruit. The lunches may consist of vegetables, fruit, milk, and a pasta dish. The afternoon snacks may consist of cheese, baked goods, and juice. These meals will meet the same standards as the meals normally served.

- **Dinner and Evening Snack at Home**
  The dinner may consist of vegetables, fruit, milk, and a ready-to-eat entrée that will require some heating, and this dinner will be eaten by the child at home. Only the child participating in the study may eat the foods provided for dinner and snack. Parents will be asked to leave any uneaten foods in their containers and return these to the child care facility for collection on the morning of the following day. Meals may also be provided for other school-aged children in the home upon request.

- **The Tasting Game**
  “The Tasting Game” is used to assess children’s food preferences for menu items and involves interviewing children individually. Children are asked to taste a food that was served during the study and tell us about their preferences for the food. Your child will participate in the tasting game at the beginning of the study.

- **Height and weight**
  These measurements will be taken once by a trained staff member.
In addition to the information obtained from your child, we would like you to complete a questionnaire packet which typically takes about 10-15 minutes, and asks about your own eating patterns, child feeding practices, and background information.

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. Each family will be given a $20 gift card to Giant for the completion of the questionnaires and two 2-day sessions of meal consumption. All of the information that you and your child provide is completely confidential.

You must be at least 18 years of age to participate and provide consent for your child to take part in the research activities, and your child must be at least 3 years of age and less than 6 years of age. If you are interested in participating, please read and sign the consent form attached to this letter. Also, please complete the “Dinner Options” sheet for your child. Please return both forms to the ‘Children’s Eating Behavior’ envelope in your child’s classroom by Friday, February 23, 2007. 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 Kathleen Leahy or Jennifer Meengs, R.D. at 863-8482.

Sincerely,

Leann L. Birch, Ph.D.  Barbara J. Rolls, Ph.D.
Principal Investigator          Principal Investigator
Menu

Day 1

*Breakfast:*
- Coffee Cake
- Milk
- Peaches

*Lunch:*
- Baked Pasta
- Milk
- Green Beans
- Applesauce

*Snack:*
- Chocolate Chip Cookie Bar
- Cranberry Grape Juice

Day 2

*Breakfast:*
- Blueberry Muffin
- Milk
- Yogurt with Strawberries

*Lunch:*
- Macaroni and Cheese
- Milk
- Carrot Sticks with Ranch Dip
- Pears

*Snack:*
- String Cheese
- Cheez-It Crackers
- Cranberry Grape Juice
APPENDIX N

CONSENT FORM

STUDY 3
Informed Consent Form for Biomedical Research

The Pennsylvania State University

Title of Project: Children’s Eating Behavior

Principal Investigators: Leann L. Birch, Ph.D. and Barbara J. Rolls, Ph.D.
Telephone: 863-8481

Other Investigator(s): Jennifer Meengs and Kathleen Leahy
Telephone: 863-8482

1. Purpose of the study: The purpose of this research is to investigate children’s responses to changing energy density of foods over the course of two days. Energy density refers to the amount of energy available in a specific weight of food, and it is usually reported as kilocalories per gram.

2. Procedures to be followed: If you agree to allow your child to take part in this research, your child will be a part of a project looking at how children respond to varying energy density of several foods over the course of two days. The activities will take place during the child’s regularly scheduled breakfast, lunch, and snack period at school and during dinner and evening snack at home two days per week for two weeks. Children will also meet one time with a research assistant for a brief interview that will involve assessing the child’s preferences for several of the dishes used in the study. Your child’s height and weight will also be measured once during the study by a trained staff member.

In addition to the information obtained from your child, we would like you to complete several questionnaires (6 double-sided pages) regarding your own eating patterns, child feeding practices, and background information, such as age, ethnicity, occupation, height, weight, and education.

3. Discomforts and risks: There are no risks involved in eating the test meals and filling out the questionnaires beyond those encountered in everyday life. It may be possible that someone could have an allergic reaction to one of the food items or food item ingredients if the allergy is previously unknown. In the event of such an allergic reaction, the parent(s) of the child will be notified immediately so that a 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, one brief interview, and height and weight measurements, will be about four days (3 hours per day) and 1 hour. The parent questionnaires typically require approximately 10-15 minutes to complete. Parents will also be responsible for storing, heating, and serving dinner and evening snack foods and for returning the food containers to the child care facility, which will take about 5 hours total.

6. Statement of confidentiality: The following may review and copy records related to this research: The Office of Human Research Protections in the U.S. Department of Health and Human Services, the Biomedical Institutional Review Board and the PSU Office for Research Protections.
Your participation and your child’s participation in this research are confidential. Only the investigators and their assistants will have access to your identity and your child’s identity and to information that can be associated with these identities. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared.

7. Right to ask questions: You can ask questions about this research. Contact Kathleen Leahy or Jennifer Meengs at 863-8482 with questions. If you have questions about your rights as a research participant, contact The Pennsylvania State University’s Office for Research Protections at (814) 865-1775.

8. Compensation: Your family will receive one payment of a $20 gift card to Giant for the completion of the questionnaires and two 2-day sessions of food intake.

9. Voluntary participation: Your participation and your child’s participation are voluntary. You and your child can stop at any time. You do not have to answer any questions you do not want to answer, and 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 take part in this research study and to allow your child to take part in the study as well, please sign your name and indicate the date below. You must be at least 18 years of age to participate and provide consent for your child to take part in the research activities.

You will be given a copy of this signed and dated consent for your records.

I give permission for my child, __________________________, to participate in this research project.

(Please print name of child)

________________________________________  _____________________
Parent Signature  Date

________________________________________  _____________________
Person Obtaining Consent  Date
APPENDIX O

DINNER INSTRUCTIONS

STUDY 3
Monday Evening:
This is just a friendly reminder that the Children’s Eating Behavior study starts tomorrow morning. Please do not allow your child to eat or drink anything (except water) before coming to the child care center Tuesday morning.

Thank you!
Katie Leahy and Jennifer Meengs

Tuesday Evening:
Tonight your child will be taking home dinner and an evening snack.
• Please **refrigerate** these meals as soon as possible and **heat** them according to the instructions.
• Please allow your child to eat dinner and evening snack at their **usual dinner and snack times** and **record** these times in the space provided below.
• Please do not try to influence your child’s food and drink consumption, but allow your child to eat and drink **as much or as little** of the provided foods and beverages as they would like to consume.
• Remember that the foods and beverages are **for the study participant only**.
• If you remove the foods from the containers, please make sure to **serve the entire portion** provided and **return any uneaten foods to their original containers**.
• Please **return left over foods and beverages in their containers** to your child’s child care facility in the morning along with this instruction sheet.
• Please **do not allow your child to eat or drink anything other than the water** we have provided Wednesday morning.

| Dinner Time: ___________________ |
| Snack Time: ____________________ |

Again, we really appreciate your participation!
Katie Leahy and Jennifer Meengs

Wednesday Evening:
Tonight your child will be taking home dinner and an evening snack.
• Please **refrigerate** these meals as soon as possible and **heat** them according to the instructions.
• Please allow your child to eat dinner and evening snack at their **usual dinner and snack times** and **record** these times in the space provided below.
• Please do not try to influence your child’s food and drink consumption, but allow your child to eat and drink **as much or as little** of the provided foods and beverages as they would like to consume.
• Remember that the foods and beverages are **for the study participant only**.
• If you remove the foods from the containers, please make sure to **serve the entire portion** provided and **return any uneaten foods to their original containers**.
• Please **return left over foods and beverages in their containers** to your child’s child care facility in the morning along with this instruction sheet Thursday morning.

Again, we really appreciate your participation!
Katie Leahy and Jennifer Meengs
Dinner Options

Your child will be given 2 different dinners and 1 evening snack during the study. Please review these choices with your child and choose the foods that your child likes and is willing to eat.

<table>
<thead>
<tr>
<th>DINNER</th>
<th>EVENING SNACK</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Entrée:</strong></td>
<td><strong>Dry:</strong></td>
</tr>
<tr>
<td>Hillshire Farms Turkey Kielbasa/Sausage</td>
<td>Wheat Thins Crackers</td>
</tr>
<tr>
<td>Tyson Chicken</td>
<td>Mini Teddy Grahams</td>
</tr>
<tr>
<td>Morningstar Farms Veggie Burger</td>
<td>Baby Goldfish Crackers</td>
</tr>
<tr>
<td>Hatfield Ham Steak</td>
<td></td>
</tr>
<tr>
<td><strong>Starch:</strong></td>
<td><strong>Fruit:</strong></td>
</tr>
<tr>
<td>Success Rice</td>
<td>Luck Leaf Unsweetened applesauce</td>
</tr>
<tr>
<td>Giant Egg Noodles</td>
<td>Del Monte Diced pears</td>
</tr>
<tr>
<td>Ore-Ida Mashed Potatoes</td>
<td>Del Monte Diced peaches</td>
</tr>
<tr>
<td><strong>Fruit:</strong></td>
<td></td>
</tr>
<tr>
<td>Dole Tropical Mixed Fruit</td>
<td></td>
</tr>
<tr>
<td>Dole Pineapple</td>
<td></td>
</tr>
<tr>
<td>Dole Mandarin Oranges</td>
<td></td>
</tr>
<tr>
<td><strong>Vegetable:</strong></td>
<td></td>
</tr>
<tr>
<td>Birds Eye Broccoli</td>
<td></td>
</tr>
<tr>
<td>Giant Carrots</td>
<td></td>
</tr>
<tr>
<td>Hanover Cauliflower</td>
<td></td>
</tr>
</tbody>
</table>

Please select one item from each dinner category for your child’s 2 dinners:

**Dinner 1:**
- Entrée
- Starch
- Fruit
- Vegetable

**Dinner 2:**
- Entrée
- Starch
- Fruit
- Vegetable

Please select one item from each evening snack category for your child’s 2 dinners:

**Evening Snack:**
- Dry
- Fruit

Number of children in the household that would also like this provided dinner ________

Food Allergies

Does your child have any food allergies? (Please circle one)  
YES  NO

If yes, what is the food allergy? _____________________________________________
Explain to the children \textbf{in the classroom} how to play the Tasting Game again:

“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 three faces here. Do you see a face that looks like the face you make when you eat something that tastes really yummy? Point to the face that you would make is you ate something that tasted really yummy.”

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

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

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

“This is our yucky face. See how she’s frowning and sticking out her tongue like she’s saying Ohhh 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 really yummy, but it doesn’t taste really yucky, it tastes just kind of OK.

Now, I really like _oranges_. I think that _oranges_ tastes really yummy. Show me the face that I would make if I ate _oranges_.”

Again, either reinforce the children for the correct choice or show them the correct face.

“Ok, now, what if I don’t like _oranges_? I think that _oranges_ taste really yucky. Show me the face that I would make if I ate _oranges_.”

Again, either reinforce the children for the correct choice or show them the correct face.

“Ok, now, I think that _oranges_ are just Ok. I think that _oranges_ taste just Ok. They are not really yummy, but they are not really yucky. Show me the face that I would make if I ate _oranges_.”

Again, either reinforce the children for the correct choice or show them the correct face.

To be done with \textbf{individual} kids:

“Ok, now I’d like to play the game with real food. I have some snacks here and I’d like to know whether you think they taste really yummy, really yucky, or if they taste just Ok. I’d like you to taste the __________ and then put the cup in front of the face that you make when you eat it.”

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 really yummy, really 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 and respond:

“You thought that one was _[appropriate face]_!!! Ok, the next food is __________.”

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 really yummy, really 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 preference 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 R

PARENT LETTER FOR QUESTIONNAIRES

STUDY 3
Dear Parents,

Thank you very much for participating in our study! We have made a copy of your signed consent form for your records. We have also given you two questionnaires to complete about you and your child. Since most of our research focuses on mothers, these questionnaires should be completed by the mother of the study participant. If the mother is unavailable or is not the primary person in charge of making meals for the child, then please have the person with this responsibility fill out both questionnaires instead. If the person filling out the questionnaires is not the mother of the child, please cross out the word “mothers” and write the person’s relationship to the child at the top of each questionnaire. Some of you may have more than one child participating in our study. We would like you to fill out a set of questionnaires for each child participating in the study. If you are completing multiple sets of questionnaires, please keep one child in mind for each set of questionnaires that you complete. We ask that you complete the questionnaires at your convenience and that you return them to the envelope labeled “Children’s Eating Behavior” in your child’s classroom. We will frequently check the envelopes in the classrooms and leave Giant gift cards for the parents who return the questionnaires.

Again, we really appreciate your participation! If you have any questions, please do not hesitate to call us! The telephone number is 863-8482. Thank you!

Sincerely,

Jennifer Meengs and Katie Leahy
APPENDIX S

DISCHARGE QUESTIONNAIRE

STUDY 3
Dear Parents,

Thank you again for participating in the Children’s Eating Behavior Study! We would like to take this opportunity to let you share some feedback with us about the study. Please return your comments to the “Children’s Eating Behavior” envelope in your child’s classroom. Thank you!

Katie Leahy and Jennifer Meengs

Do you feel that the dinner and evening snack options and portions were appropriate for your child? Were the foods well-liked?

_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________

Did your child seem hungrier or less hungry than usual during any nights of the study?

_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________

We understand that our study protocol can be challenging for parents and children. Did you give your child any foods other than those provided by us during the evenings and mornings of the study? If yes, we would appreciate it if you would describe these foods and the times they were served to help us to get an idea of how much your child ate during the study.

_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________
Vita

Kathleen Erin Leahy

EDUCATION

2008  The Pennsylvania State University, Ph.D. in Nutritional Sciences, University Park, PA

2004  University of Pennsylvania, B.A. in Psychology, Philadelphia, PA

PROFESSIONAL EXPERIENCE

2004-Present  The Pennsylvania State University, University Park, PA
Graduate Student under Dr. Barbara Rolls, Laboratory for the Study of Human Ingestive Behavior

2006  The Pennsylvania State University, University Park, PA
Graduate Research Assistant under Dr. Leann Birch, Center for Childhood Obesity Research

TEACHING EXPERIENCE


HONORS AND AWARDS

Representative, College of Health and Human Development Graduate Student Council, The Pennsylvania State University, 2007-2008

Award, Third place at Graduate Student Exhibition, The Pennsylvania State University, 2007

Secretary, Nutrition Graduate Student Association, The Pennsylvania State University, 2005-2006

Honor, cum Laude, University of Pennsylvania, 2004


Member, National Society of Collegiate Scholars, University of Pennsylvania, 2003

PUBLICATIONS


Leahy K, Birch L, Rolls B. Decreasing the energy density of multiple foods reduces preschool children’s energy intake over two days. Obesity. 2007;15(Supplement):A21.
