Intake at a single, palatable buffet test meal is associated with total body fat and regional fat distribution in children

S. Nicole Fearnbach ¹, David Thivel ^{2,3}, Karol Meyermann ⁴, Kathleen L. Keller ^{1,4,5}

¹ Department of Nutritional Sciences, The Pennsylvania State University

² AME2P Research Group, EA3533, Clermont University, Clermont-Ferrand, FR

³ Regional Center for Human Nutrition (CRHN Auvergne), Clermont-Ferrand, FR

⁴ New York Nutrition Obesity Research Center, St. Luke's-Roosevelt Hospital Center, Columbia University Medical Center

⁵ Department of Food Science, The Pennsylvania State University

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Corresponding Author: Kathleen L. Keller

Address – 321 Chandlee Laboratory, The Pennsylvania State University, University Park, PA
16802

Email – klk37@psu.edu

1 Abstract:

2 Previous studies testing the relationship between short-term, *ad libitum* test-meal intake and
3 body composition in children have shown inconsistent relationships. The objective of this study
4 was to determine whether children's intake at a palatable, buffet meal was associated with
5 body composition, assessed by dual-energy x-ray absorptiometry (DXA). A sample of 71 children
6 (4-6 years) participated in 4 sessions where *ad libitum* food intake was measured. Children's
7 intake at two of the test-meals was retained for the present analysis: a baseline meal
8 consisting of moderately palatable foods and a highly palatable buffet including sweets, sweet-
9 fats, and savory-fats. On the last visit, anthropometrics and DXA were assessed to determine
10 child body composition. Children consumed significantly more calories at the palatable buffet
11 compared to the baseline test-meal. Children's total fat-free mass was positively associated
12 with intake at both the baseline meal and the palatable buffet meal. Total energy intake at both
13 meals and intake of savory-fats at the palatable buffet were positively associated with
14 children's total fat mass, total percent body fat, and percent android fat. Intake of sweet-fats
15 was associated with child fat-free mass index. Intake of sweets was not correlated with body
16 composition. Children's intake at a palatable test-meal, particularly of savory-fat foods, was
17 associated with measures of total and regional body fat.

Introduction:

Recent studies have shown that objectively measured, but not self-reported, energy intake can predict the development of overweight in youth (Stice & Durant, 2014). Objective measures of energy intake, including laboratory test meals, have advantages compared to self-report measures such as food frequency questionnaires, food diaries, and 24-hour recalls because the amount eaten can be measured directly (Goran, 1998). In addition, self-report measures of energy intake have been criticized in the literature due to their inaccuracies, which may contribute to misleading results in nutrition and obesity research (Schoeller, 1995; Schoeller et al., 2013). For example, a majority of self-reported energy intake data from the National Health and Nutrition Examination Survey (NHANES) are not physiologically plausible (Archer, Hand, & Blair, 2013). Moreover, there are examples of both under- and over-reporting across other studies that use self-reported energy intake, particularly in children and adolescents (Fisher, Johnson, Lindquist, Birch, & Goran, 2000; Forrestal, 2011; Santos, Pascoal, Fisberg, Cintra, & Martini, 2010). Heavier youth are more likely to underreport the amount they eat on self-report measures compared to their actual intake (Wolkoff et al., 2011). The lack of accuracy of self-report dietary data demonstrates the need for development of improved measures to estimate energy intake in free-living individuals. Laboratory test-meals offer a practical, objective measure of energy intake that may better correlate with usual eating patterns.

A criticism of single-meal studies is that they may not be representative of consumption under free-living conditions (Acheson, Campbell, Edholm, Miller, & Stock, 1980). The laboratory environment may elicit different eating behavior compared to a more naturalistic environment

(Allirot et al., 2012). In addition, intake from meal-to-meal, particularly in children, is thought to vary (Birch, Johnson, Andresen, Peters, & Schulte, 1991). For all these reasons, measuring intake at a single test-meal in the laboratory has often not been associated with weight status (Fisher, Liu, Birch, & Rolls, 2007), despite recent reports of the contrary (Stice and Durant, 2014). Although children's intake tends to vary across eating occasions, previous studies from our laboratory that tested *ad libitum* intake at multi-item test-meals, administered across multiple days, showed moderate-to-high within-child correlations ranging from $r = 0.50 - 0.73$ [unpublished data]. Similar results have been found in adults (Laessle & Geiermann, 2012). These results suggest that it might be possible to use children's intake at a single laboratory test-meal to make predictions about usual energy intake and tendency to overeat. However, the type of foods and/or meal-conditions that would demonstrate an association between intake and body fatness are not known. Among children, laboratory test-meal intake has been shown to vary by type of food given (Epstein et al., 2009), portion size (Kral, Kabay, Roe, & Rolls, 2010), palatability (Keller, Kirzner, Pietrobelli, St-Onge, & Faith, 2009), and brand packaging (Forman, Halford, Summe, MacDougall, & Keller, 2009), all of which are factors that influence energy intake in free-living settings. The associations between child body composition and intake at test-meals of common foods that vary on these attributes have sparsely been examined.

In studies conducted in adolescents and adults with overweight and obesity, evidence suggests that fat free mass may be more closely associated with energy intake than fat mass (Blundell et al., 2012a; Blundell et al., 2012b; Cameron et al., 2014; Caudwell et al., 2013; Weise et al., 2014). Blundell and colleagues found that fat-free mass, but not fat mass or body mass

index, was associated with self-determined meal size and daily energy intake in two samples of adults with obesity (Blundell et al., 2012a). It is suggested that a physiological signal associated with fat-free mass may act as an appetitive driver, which may interact with signals related to body fatness (i.e. leptin). This is likely due to the contribution fat-free mass makes in determining resting metabolic rate, which is the largest component of daily energy expenditure (Blundell et al., 2012a; Caudwell et al., 2013). Similar findings have been reported in adolescents with obesity (Cameron et al., 2014), but this has not been examined in younger populations. It is also unknown whether fat-free mass remains the strongest predictor of energy intake across meals that vary in variety and palatability.

The first objective of this study was to determine the association between children's intake at a multi-item test-meal consisting of highly palatable foods and body composition, assessed by dual-energy x-ray absorptiometry (DXA). We hypothesized that children's intake at the highly palatable buffet would be associated with DXA measures of body fat. Secondly, we assessed the relationship between children's intake at a baseline test-meal consisting of familiar, moderately palatable foods, and body composition. We hypothesized that children's energy intake at a standard baseline meal, without the presence of highly palatable foods, would be associated with fat-free mass. Understanding how the association between energy intake and body composition is affected by the selection and palatability of foods offered at a laboratory test-meal would improve the ability to study the relationship between eating behavior and obesity risk.

Methods and Procedures:

89 *Participants*

90 Participants were recruited from the community by placing advertisements on popular
91 websites and around the hospital. Interested families were screened over the phone to ensure
92 children were healthy, without food allergies, and not taking prescription medications. After
93 receiving information about the study, parents signed informed consent for their children.

94 Children provided voluntary verbal agreement to participate, but written assent was not
95 required. This study was approved by the Institutional Review Board of St. Luke's Roosevelt
96 Hospital Center.

97

98 *Design*

99 This study consisted of four 1-hour dinner sessions that took place between 4:00pm and
100 6:00pm and a fifth session for body composition measurement using DXA. The overall purpose
101 of the study was to examine the relationship between taste genetics and children's eating
102 behavior. Results from this study have been reported elsewhere (Keller et al., 2014; Keller,
103 Olsen, Kuilema, Meyermann, & Belle, 2013; Keller et al., 2010; Olsen, van Belle, Meyermann, &
104 Keller, 2011). The purpose of this secondary analysis was to investigate the association between
105 children's body composition and eating behavior at two of the test-meals, a standard baseline
106 meal and a highly palatable buffet designed to elicit excess consumption.

107 Visit one included a baseline standard *ad libitum* meal, preceded by child taste and food
108 preference assessments. The test meals served at visits two and three included high- or low-fat
109 versions of the same foods, the details of which have been previously reported (Keller et al.,
110 2014; Keller et al., 2013; Keller et al., 2010; Olsen et al., 2011). Test meal four was a palatable

buffet meal consisting of a range of high-energy-dense foods including sweets, sweet-fats, and savory-fats. Children attended the test-meal sessions at least 2 hours fasted. For the purpose of this study, only test meals one and four were considered because the purpose of visits two and three was to compare children's intake of a limited number of food items that varied in fat content.

Procedures for the baseline test-meal

The baseline test meal took place on the first test session, and was comprised of standard portions of macaroni and cheese, peanut butter, grape jelly and white bread, grapes, carrots, broccoli, graham crackers, strawberry yogurt, and whole milk. Serving sizes for these foods are listed in **Table 1**. Prior to the meal, children were given an explanation about the foods available at the test-meal and told they could eat as much or as little as they wanted. Children had 30 minutes to eat, but they were not required to eat for this entire time if they finished early. The majority of children consumed their meal within 15-20 minutes. They were also informed that they could ask for additional servings of any of the foods provided. Because children at this age may be too shy to request extra servings, researchers were instructed to ask the children if they would like more any time they finished a food/beverage. During the meal, a researcher was seated at the table to assist the child if they needed help with any of the foods. The researcher read a nonfood related book to the child as he/she ate. This provided a consistent distraction and avoided the unrealistic situation of the child eating alone in the laboratory. When possible, the same researcher was used for each test visit to increase the child's level of comfort.

Parents, the majority of whom were mothers (89.7%), were seated in an adjacent waiting room. They could not hear or see what children were eating, but they were allowed to interrupt during the meal if they had any concerns. Further details on the procedures for this test-meal are published elsewhere (Keller et al., 2014; Keller et al., 2013; Keller et al., 2010; Olsen et al., 2011).

To determine total meal intake, the total weight of each food consumed was measured from pre- to post-meal and nutrient values were calculated using nutrition facts label information. For the purposes of this study, total energy intake at the test-meal was retained for the primary analyses. We also examined the proportion of total energy intake from individual macronutrients (i.e. fats, carbohydrates, and proteins).

Procedures and nutrient analyses for the palatable buffet test-meal

The purpose of the fourth meal condition was to assess children's susceptibility to overeating highly palatable foods of different flavor/taste qualities (sweet, sweet-fat, and savory-fat). Foods in the savory-fat or sweet-fat category had either savory or sweet as their predominant flavor characteristic and contained at least 20% of calories from fat. Savory fat foods included items such as chicken nuggets and potato chips. Sweet-fats included baked goods such as cookies, cupcakes, and donuts. Items in the sweet category were primarily sweet tasting and contained less than 1 gram of fat per serving. Food items included in this group were sweet, non-fat candies and sugar-sweetened beverages. The food items were selected because they were highly palatable and familiar to most children (Phillips, 2003). All foods and

beverages were served in plain plastic packaging and prepared immediately prior to the visit. A summary of the foods and serving sizes from the buffet test meal is listed in **Table 1**.

Test-meal procedures were similar to the baseline meal. Prior to the meal, children were given an explanation about the foods available at the test-meal and told they could eat as much or as little as they want. Children had 30 minutes to eat, but again, did not have to eat for the entire time. They were also informed that they could ask for additional servings of any of the foods provided. During the meal, a researcher was seated at the table to assist the child and read a nonfood related book to the child as he/she ate.

Pre- and post-weights (in grams) for each of the foods were measured and intake was converted to kilocalories (kcal) using the nutrition facts panel. Total energy intake for the entire meal, as well as energy intake from savory-fats, sweet-fats, and sweets was retained for the analyses. We also examined the proportion of energy intake from individual macronutrients.

Anthropometric measurements and body composition

Anthropometric measures (height and weight) were performed by a trained researcher. Children were weighed and measured using a standard balance scale (Detecto, Model 437, Webb City, MO) and stadiometer (Seca, Model 202, Chino, CA) in light clothing. Height and weight were converted to BMI (kg/m^2), and BMI z-score (BMIz) and percentile were calculated using the Centers for Disease Control and Prevention (CDC) conversion program (Cole, Bellizzi, Flegal, & Dietz, 2000). CDC cut-offs for child age- and sex-specific BMI percentile were used to define normal weight (<85 %ile), overweight (85-95 %ile), and obese (≥ 95 %ile) classification.

Body composition was assessed using whole body dual-energy X-ray absorptiometry (DXA) (DPX, Lunar Corp., Madison, WI) using Pediatric Software Version 3.8G (Lunar Corp., Madison, WI). The following measures were extracted from the whole body scan and tested in partial correlations: total body fat free mass (FFM), total body fat mass (FM), android percent fat, gynoid percent fat, and total body measures of percent fat (Aucouturier, Meyer, Thivel, Taillardat, & Duche, 2009; Glickman, Marn, Supiano, & Dengel, 2004). To control for differences in body composition as a function of child height, FFM index and FM index (kg/m^2) were calculated by dividing the absolute FFM and FM, respectively, by the height squared (VanItallie, Yang, Heymsfield, Funk, & Boileau, 1990).

Resting energy expenditure

Sex-specific World Health Organization (WHO) equations for 3- to 10-year-olds were used to calculate estimated resting energy expenditure (REE) from child weight (Balas-Nakash, Villanueva-Quintana, Vadillo-Ortega, & Perichart-Perera, 2008). Resting metabolic rate, which is largely driven by fat-free mass, has previously been associated with meal size and daily energy intake in adults (Blundell et al., 2012; Caudwell et al., 2013).

$$\text{Males ages 3-10: REE} = 22.7 * \text{wt}(\text{kg}) + 495$$

$$\text{Females ages 3-10: REE} = 22.5 * \text{wt}(\text{kg}) + 499$$

Statistical analyses

Descriptive statistics were performed to determine means and standard deviations for continuous variables and frequencies for categorical variables. Independent samples t-tests

were used to check for differences in test-meal intake and body composition by child sex. Intakes from the various food categories at the palatable buffet (savory-fats, sweet-fats, sweets) were not normally distributed, and therefore were square root transformed prior to further analyses. The primary study aims were tested using partial correlations, controlling for child age and sex, to determine the association between test-meal intake and body composition. Adjustments were made for child ethnicity, but this did not affect the associations between body composition and intake variables. Therefore, results are reported without these adjustments. Variables that were included in these correlations included: FFM, FFM index, FM, FM index, total percent fat, gynoid percent fat, android percent fat, REE, BMIz, total energy intake at the baseline meal, % of calories from fats, carbohydrates, and proteins at the baseline meal, total energy intake at the palatable buffet meal, intake from savory fats, and intake from sweet fats, intake from sweets, and % of calories from fats, carbohydrates, and proteins at the palatable buffet meal. Analyses were run with and without statistical outliers, which were identified with box plots using a step of 1.5 times the interquartile range. Data were analyzed with SPSS V.21.0. The level of significance was set at $p < 0.05$.

Results:

Out of the 79 children initially enrolled in the study, 71 children between the ages of four to six years (mean $\pm$ SD = 5.6 ± 0.8 years) had complete data for the test-meals and DXA. Sample characteristics for these 71 children are reported in **Table 2**. Descriptive values for body composition measures obtained from DXA as well as calculated FFM index, FM index, REE and BMIz are listed in **Table 3**. Values are listed for all children and broken down separately by child

sex. Boys had significantly greater FFM index ($t = 3.35, p < 0.01$), and girls had significantly greater gynoid percent fat ($t = -2.78, p < 0.01$). There were no other significant differences between groups.

Descriptive values for the test meal variables are listed in **Table 4**, including total intake at the baseline meal (kcal), total intake at the palatable buffet meal (kcal), and intake from the different food groups at the palatable buffet (savory-fats, sweet-fats, and sweets). Values are listed for all children and broken down separately by child sex. Children's intake at the palatable buffet (667 ± 274 kcal) was significantly greater than baseline meal (474 ± 250 kcal) ($t = 3.35, p < 0.001$). Boys tended to consume more total energy than girls, but this difference did not reach significance ($t = 1.86, p = 0.07$). Despite a tendency for boys to consume more, the proportion of intake from each of the food groups (savory-fats, sweet-fats, & sweets) in boys and girls was similar.

Partial correlations between body composition and intake variables, controlling for child age and sex, are reported in **Table 5**. All of the body composition variables were significantly associated with total intake at both test-meals ($p < 0.05$) and intake from savory-fats at the palatable buffet ($p < 0.05$). Only FFM index was positively associated with intake of sweet-fats at the palatable buffet ($p < 0.05$).

In testing the first hypothesis that children's intake at the highly palatable buffet would be associated with DXA measures of body fat, positive associations were found between total intake and all measures of body fat. The association between total intake at the palatable buffet and total percent body fat is depicted in **Figure 1A** ($r = 0.38, p < 0.01$). In examining the different categories of foods, only intake of savory fats was associated with child body

composition. A positive association was found between intake from savory-fats and android percent fat ($r = 0.44$, $p < 0.01$), as shown in **Figure 1B**. This association remained significant even after controlling for total intake at the palatable buffet ($p < 0.05$). There were no significant associations between the body composition variables and intake from sweets at the palatable buffet. The positive associations between body fat and intake measures remained significant even after controlling for child FFM index ($p < 0.05$).

In testing the secondary hypothesis that children's energy intake at a standard baseline meal would be correlated with FFM, we did find a positive association ($r = 0.42$, $p < 0.01$). However, total intake at this baseline meal was also positively associated with all measures of body fat ($p < 0.05$). Finally, the proportion of total calories consumed from fats, carbohydrates, and proteins did not differ between the two test-meals. None of the body composition measures were significantly associated with intake of fats, carbohydrates, or proteins at either the baseline or the palatable buffet test-meals (all $p > 0.05$).

Discussion:

The primary goal of this study was to determine the relationship between children's intake at a single, palatable buffet meal and body composition, which was used as a proxy for the tendency to overeat under free-living conditions. In line with our primary hypothesis, we found that intake at a single-session buffet test-meal made up of highly palatable foods was associated with children's body composition, specifically greater central body fat (android fat percentage). Of the food categories within the buffet, only intake of savory-fat foods was correlated with total body and regional fat measures assessed by DXA. Increased intake from

savory-fats, but not sweets or sweet-fats, was associated with greater body fat in children. These findings demonstrate that intake assessed from a single-meal was positively related to children's total body fat and regional fat deposition, but the causal direction in this pathway is not known. If we assume that body fatness is an indicator of habitual overconsumption, it may be possible to predict the tendency to overeat using a highly palatable test-meal such as the one tested in the present study. Children in this study consumed significantly more calories at the palatable buffet compared to the baseline test meal, indicating that the palatable buffet did promote overconsumption, as intended.

In regards to our second hypothesis, children's intake at a baseline test-meal consisting of common foods of moderate palatability was positively associated with total body FFM, which has been demonstrated previously in adults by Blundell and colleagues (Blundell et al., 2012). Both FFM and FFM index were positively associated with total intake at the palatable buffet and intake of savory fats, contributing to the literature on FFM as a general appetitive driver (Blundell et al., 2012a; Blundell et al., 2012b; Cameron et al., 2014; Caudwell et al., 2013; Weise et al., 2014). Fat-free mass is a major determinant of basal metabolic rate, which is proposed to influence appetite and eating behavior, and this positive relationship between FFM and energy intake has been seen in adolescents with obesity (Cameron et al., 2014) and adults with overweight and obesity (Blundell et al., 2012).

The current findings, and other studies (Gubbels, Kremers, Goldbohm, Stafleu, & Thijs, 2012; Maffeis et al., 2008), have found that intake of savory-fat foods may be positively associated with child weight status. In these previous studies (Gubbels et al., 2012; Maffeis et al., 2008), investigators used foods like pizza, French fries, and crackers and described them as

“savory,” but many of these foods also contain fat and therefore are in line with the savory-fat category of foods in the present study. Maffei et al. tested 1837 Italian children and found that when parents’ BMI was included in the analyses, children’s intake of savory-fat foods (servings/week) and participation in sports (hours/week), both assessed by parental report, showed independent associations with obesity. Intake of savory-fat foods was positively associated with obesity, while participation in sports was negatively associated with obesity. In logistic regression analyses, each weekly serving of savory-fat/salty food items reportedly eaten by children increased the likelihood of the child being obese by 2%. In their sample, children with obesity reported consumption of an average of 11 servings of savory-fat snacks per week, compared to 8 servings of sweet snacks per week. Convergent with our analyses, the authors also found that children’s intake of sweet foods was not predictive of child body composition.

Other studies have also implicated intake of savory-fat foods in the development of overweight. The KOALA Longitudinal Study of 2074 Dutch children found that a sedentary-snacking pattern at age 5, derived from parent-reported measures of children’s dietary intake and physical activity, was positively associated with children’s BMI z-score and incidence of overweight at ages 7 and 8 years (Gubbels et al., 2012). It is important to note that the snacking category included both savory-fat (i.e. potato chips, biscuits, fried foods) and sweet snacks (i.e. candy bars, cakes, ice cream), and it is not known whether this association was due to one or both categories of foods. Unfortunately, the authors did not report on individual correlations between intake of different food types and weight gain in children. It would be valuable to investigate the independent contributions of savory-fat foods to weight gain within a longitudinal cohort like the KOALA Study.

It is unclear exactly why we found associations between body fatness and intake of savory-fat food items, but not sweets or sweet-fats. One possibility is that the savory-fat foods make up main meal dishes, or entrées, and that we are simply capturing greater intake from main meal items in children with higher levels of body fatness. These foods also tend to be higher in salt content, and greater intake of salt has been associated with higher BMI z-score and percent body fat in children and adolescents (Libuda, Kersting, & Alexy, 2012). Other studies have attempted to examine underlying mechanisms for this phenomenon. Some insight might come from recent papers examining the brain's response to savory food cues (Griffioen-Roose et al., 2014). When adults were in a low-protein dietary state, brain response in the inferior orbitofrontal cortex (implicated in emotion and reward-driven decision-making) was higher for savory food odor and visual cues relative to a control condition, and the participants also exhibited a higher preference for savory foods (Griffioen-Roose et al., 2014). Additionally, another study found a relationship between a polymorphism in the FTO gene, which has been associated with body mass index and obesity risk, and greater total energy and protein intake, but lower carbohydrate intake (Qi et al., 2014). Similar findings were reported in a subsample of children and adolescents (Qi et al., 2015). While the savory-fat foods in our study contained higher amounts of protein than the sweet or sweet-fat foods, we did not find any associations between body composition variables and macronutrient intake.

There were several strengths and limitations in the current study. This study was a cross-sectional, correlational study, which does not allow for prediction in a specific direction. Therefore, we cannot determine whether body fatness is a cause or consequence of increased intake, or both. In addition, the order of the test-meals was not randomized. Differences in

329 intake between the test-meals could possibly be related to familiarity with the laboratory
330 environment, in addition to the differences in palatability between the meals. Children also had
331 30 minutes to eat, which could be considered a long meal duration for some children. It is
332 possible that the presence of food after the initial cessation of eating may have resulted in
333 additional consumption. However, children could decide to end the meal at any point prior to
334 30-minute time limit.

335 Children in the cohort came from diverse ethnic backgrounds, which contributes to the
336 generalizability of results from this study. However, this study was not powered to look at
337 differences in the association between test-meal intake and body composition across ethnic
338 group. It is known that body fat deposition can vary across ethnic group (Deurenberg &
339 Deurenberg-Yap, 2001). In exploratory analyses, no differences in intake or body composition
340 were seen between ethnic groups, but this may be due in part to the small sample size in some
341 subgroups. Controlling for ethnicity in partial correlation analyses did not affect any of the
342 associations between body composition and intake variables. Further studies in larger cohorts
343 should investigate potential differences in the association between food intake and body
344 composition between different ethnic groups.

345 Our methods also included an accurate measure of body composition that allowed for
346 the analysis of total body fat mass, fat-free mass, and regional body fat, which is a strength
347 compared to conventional anthropometric measures like body mass index and percentile that
348 rely solely on height and weight. A limitation of our study, however, was that our measure of
349 REE was estimated using pediatric-specific equations, which are generalized to all children
350 between the ages of 3-10 years old across all ethnicities. However, the equations used here

have been validated (Balas-Nakash et al., 2008), and REE was highly correlated with DXA-measured FFM ($p < 0.001$). These findings are in line with previous research on the relationship between resting metabolic rate and energy intake (Blundell et al., 2012b; Caudwell et al., 2013).

An additional strength to the study was the inclusion of objective and direct measures of short-term food intake. The direct measure of energy intake at a highly palatable buffet, with a comparison baseline meal, is a strength compared to self- or parent-reported measures typically used (Archer et al., 2013; Champagne et al., 1998). We were also able to demonstrate significantly greater intake at the palatable buffet compared to the baseline test-meal, suggesting that altering the variety and palatability of the foods at the test-meal can elicit overconsumption in young children. For future studies designed to assess the relationship between laboratory test-meal intake and childhood obesity, investigators might design meals that include a selection of savory-fat options.

In conclusion, this study found that children's *ad libitum* intake of a palatable test-meal consisting of sweet, sweet-fat, and savory-fat foods was associated with a pattern of body fat deposition associated with greater health risks (Must & Strauss, 1999). Some children exhibited a tendency to overeat in the presence of a variety of highly palatable foods, and this pattern of eating was associated with higher levels of total body and regional fat. Additionally, children's intake from a single, highly palatable laboratory test-meal was associated with regional body fat deposition, suggesting that future studies might be able to predict obesity-related health risks based on measures of laboratory eating behavior (Must & Strauss, 1999). Additional studies are needed to clarify the role of savory-fat food intake in obesity. Contrary to current scientific understanding (Acheson et al., 1980; Birch et al., 1991), our findings demonstrate robust

- 373 positive associations between energy intake at an objectively measured, single test-meal and
- 374 children's body composition assessed by DXA.

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Author Contributions

SNF carried out data analysis, interpretation, and representation in figures/tables. DT assisted in data analysis and interpretation. KM carried out data collection. KKL conceived and carried out experiments, and assisted in data interpretation. All authors were involved in writing and editing the paper and had final approval of the submitted and published versions.

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Table 1. Serving sizes for foods served at the baseline and palatable buffet test-meals

Foods at Baseline Test-meal	Serving Size
Macaroni & Cheese	135 grams
Peanut butter (creamy)	30 grams
Grape jelly	30 grams
White bread	2 slices (50 grams)
Green grapes	110 grams
Baby carrots	30 grams
Broccoli spears	85 grams
Graham crackers	25 grams
Strawberry yogurt	170 grams
Whole milk	1 cup (245 grams)
Foods at Palatable Buffet Test-meal	Serving Size
<i>Savory-fats</i>	
Cheese bagel bites	4 pieces (~145 grams)
Cheese pizza rolls	4 pieces (~80 grams)
Chicken nuggets	5 nuggets (~105 grams)
Mozzarella sticks	4 sticks (~100 grams)
Potato chips	28 grams
<i>Sweet-fats</i>	
Chocolate chip cookies	3 cookies (~35 grams)
Mini-brownies	4 mini-brownies (~60 grams)
Chocolate cupcakes	2 mini-cupcakes (~50 grams)
Donut holes	4 holes (~50 grams)
Whole-fat chocolate milk	1 cup (245 grams)
<i>Sweets</i>	
Red licorice	4 pieces (~50 grams)
Fruit leather	1 package (~20 grams)
Gummy candies	~45 grams
Fruit candies	~45 grams
Fruit punch	1 cup (235 grams)

Table 2. Participant characteristics

	Boys (<i>n</i> = 28)	Girls (<i>n</i> = 43)	Total (<i>n</i> = 71)
	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)
Ethnicity			
<i>African-American</i>	11 (39)	19 (44)	30 (42)
<i>Asian</i>	1 (4)	1 (2)	2 (3)
<i>Caucasian</i>	3 (11)	4 (9)	7 (10)
<i>Hispanic/Latino</i>	10 (36)	14 (33)	24 (34)
<i>Other</i>	3 (11)	5 (12)	8 (11)
Weight Status			
<i>Normal Weight</i>	12 (43)	23 (53)	35 (49)
<i>Overweight</i>	7 (25)	11 (26)	18 (25)
<i>Obese</i>	9 (32)	9 (21)	18 (25)
	Mean ± SD	Mean ± SD	Mean ± SD (range)
Age (yr)	5.5 ± 0.8	5.6 ± 0.9	5.6 ± 0.8 (4 – 6.9)
BMIz	1.1 ± 1.1	0.9 ± 0.9	1.0 ± 1.0 (-1.7 – 2.9)

Table 2. Descriptive statistics for the sample

Table 3. Body composition descriptive statistics

	Boys (n = 28) Mean $\pm$ SD	Girls (n = 43) Mean $\pm$ SD	Total (n = 71) Mean $\pm$ SD (range)
Total FFM (kg)	16.9 $\pm$ 2.5	16.1 $\pm$ 3.4	16.4 $\pm$ 3.1 (10.3 – 27.0)
FFM index (kg/m ²) ^a	13.2 $\pm$ 0.9	12.4 $\pm$ 1.0	12.7 $\pm$ 1.0 (10.3 – 15.9)
Total FM (kg)	4.7 $\pm$ 4.4	5.3 $\pm$ 3.7	5.1 $\pm$ 3.9 (1.1 – 22.4)
FM index (kg/m ²)	3.5 $\pm$ 2.7	3.9 $\pm$ 2.1	3.8 $\pm$ 2.4 (0.8 – 13.2)
Total % Fat	19 $\pm$ 10	23 $\pm$ 8	22 $\pm$ 9 (7 – 48)
Gynoid % Fat ^b	32 $\pm$ 10	37 $\pm$ 7	35 $\pm$ 9 (17 – 57)
Android % Fat	20 $\pm$ 13	23 $\pm$ 10	22 $\pm$ 11 (8 – 54)
REE (kcal)	1021 $\pm$ 155	1011 $\pm$ 148	1015 $\pm$ 150 (826 – 1622)
BMIz	1.1 $\pm$ 1.1	0.9 $\pm$ 0.9	1.0 $\pm$ 1.0 (-1.7 – 2.9)

Table 3. Descriptive statistics for children's body composition variables obtained from DXA, broken down by child sex. REE was calculated using World Health Organization (WHO) sex-specific equations for children ages 3-10 years. ^a Boys had significantly higher FFM index ($p < 0.01$); ^b Girls had significantly greater gynoid percent fat ($p < 0.01$)

Table 4. Test-meal intake descriptive statistics

	Boys (<i>n</i> = 28) Mean $\pm$ SD	Girls (<i>n</i> = 43) Mean $\pm$ SD	Total (<i>n</i> = 71) Mean $\pm$ SD (range)
Total intake at baseline meal (kcal)	449 $\pm$ 221	491 $\pm$ 268	474 $\pm$ 250 (31 – 1312)
Total intake at palatable buffet (kcal) ^c	760 $\pm$ 357	606 $\pm$ 331	667 $\pm$ 374 (90 – 1685)
Intake from savory fats at the palatable buffet (kcal)	279 $\pm$ 202	218 $\pm$ 197	242 $\pm$ 200 (0 – 787)
Intake from sweet fats at the palatable buffet (kcal)	289 $\pm$ 255	231 $\pm$ 233	253 $\pm$ 242 (0 – 997)
Intake from sweets at the palatable buffet (kcal)	193 $\pm$ 112	157 $\pm$ 100	170 $\pm$ 105 (0 – 441)

Table 4. Descriptive statistics for children’s energy intake (kcal) from the baseline meal, palatable buffet meal, and individual food groups at the palatable buffet (savory-fats, sweet-fats, and sweets), broken down by child sex.

^c Boys tended to consume more calories than girls, but this difference did not reach significance ($p = 0.07$).

Table 5. Partial correlations

	Total intake at baseline meal (kcal)	Total intake at palatable buffet (kcal)	Intake from savory-fats at the palatable buffet (kcal)	Intake from sweet-fats at the palatable buffet (kcal)	Intake from sweets at the palatable buffet (kcal)
Total FFM (kg)	.42**	.35*	.34**	.10	.13
FFM index (kg/m ²)	.40**	.42**	.27*	.27*	.21
Total FM (kg)	.49**	.43**	.43**	.13	.13
FM index (kg/m ²)	.48**	.44**	.41**	.16	.13
Total % Fat	.40**	.38**	.39**	.12	.09
Gynoid % Fat	.35*	.31*	.35**	.08	.02
Android % Fat	.41**	.43**	.44**	.14	.07
REE	.46**	.39**	.41**	.10	.11
BMIz	.38**	.42**	.36**	.20	.09

Table 5. Partial correlations between body composition and intake variables, controlling for child age and sex; Intakes from the food categories (savory-fats, sweet-fats, sweets) were square root transformed prior to analysis; * $p < 0.05$, ** $p < 0.01$

Figure 1. A) Scatterplot of the association between total intake at the palatable buffet (kcal) and total % body fat, with markers by child sex; $r = 0.38$, $p < 0.01$; **B)** Scatterplot of the association between intake from savory-fats (kcal) at the palatable buffet and android % fat, with markers by child sex; $r = 0.44$, $p < 0.01$.