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How Much and What: Using a Buffet to Determine Self-regulation of Food Intake Among Young School-Age Children

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Abstract

Energy compensation indices are commonly used to examine self-regulation of food intake in children. However, previous studies failed to consider children's ability to self-regulate under complete autonomy. This study examined self-regulation of food intake among young children and the effect of calorie manipulation on food/nutrient intake using an unlimited lunch buffet paradigm. Participants were 66 children (M^{age} = 6.14, SD = 1.15 years; 68.2% male; 89.4% Latinx; 59.1% overweight/obese [OV/OB]). Children participated in a crossover research trial, one week apart. Participants consumed 2 different types of preloads followed by an *ad-libitum* lunch during each trial. A compensation index (COMPX) was calculated to identify the level of self-regulation in food intake. Food/nutrient intake was compared between both sessions. Results indicated OV/OB children showed poorer self-regulation compared to healthy weight children (t=2.19, p = .032; Hedges' g = 0.55). There were significant differences in food intake/selection between OV/OB and healthy weight groups. OV/OB children consumed a higher amount of calorie, fat, and cholesterol after the high energy preload compared to healthy weight children (d's range: 0.31-0.48). Our findings support differences between the amount of self-regulation between normal and OV/OB children as well as the items they select in order to compensate.

Keywords

Self-regulation; Compensation index; Hunger and satiety cues; Food intake regulation; Calorie compensation

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Conflict of interest
The authors declare that there is no conflict of interest.

1. Introduction

Childhood obesity has been one of the most significant public health issues for decades (Ludwig 2018). According to the latest reports from 2015-2016, 18.5% of children and adolescents were classified as obese including 5.6% classified as being severely obese in the United States (Fryer et al. 2018). These rates are even higher in minority groups with Latinx children being more likely than their peers to be classified as overweight/obese through all stages of their childhood and adolescence (Skinner et al. 2018). It is widely believed that obesity, in both children and adults, results from an imbalance between energy intake and energy expenditure (Tremblay et al. 2004; Davidson and Birch 2001). The most significant determinants associated with obesity and weight change includes a higher consumption of non-nutritious calorie dense foods referred to as “empty calories”, increased availability of foods and drinks high in calories, and decreased intake of home cooked foods (Anderson and Butcher 2006). Since research has shown that simply restricting intake is not effective for inhibiting overconsumption (Birch and Fisher 1998; Clark et al. 2007; Jansen et al. 2007), it is also important to isolate individual differences in processes such as self-regulation, that play a role in determining food choice and other decisions that influence variations in calorie intake to further understand the mechanisms behind pediatric obesity.

Self-regulation is defined as the multiple processes including one’s cognitions, affects and actions along with features of one’s environment involved in goal-directed behavior. At the core of self-regulation is the idea that individuals who are aware of their goals are able to steer and direct their behaviors (Boekaerts et al. 2005). Self-regulation is an important concept in considering the gap between intention to behavior (Gellert et al. 2012). Two behaviors within self-regulation may impact children’s caloric intake: 1. energy compensation (the ability to adjust food intake between successive eating occasions) (Birch and Deysher 1986), and 2. food choice in the presence of a variety of options. Some literature has indicated that infants have an innate ability to self-regulate their consumption driven by biological responses to hunger and satiety cues (Birch et al 1986; Birch and Johnson 1991). Other have argued that there is a hereditable variation in the appetite of infants that can lead to early weight gain and adiposity (Llewellyn & Fildes, 2017). Despite these different views, most literature agrees that as children get older, any innate ability they have to self-regulate decreases and their ability to self-regulate food choices becomes influenced by the external environment (Brugailleres et al, 2019; Rolls et al. 2000; Smethers et al., 2019).

Research has determined the existence of self-regulatory skills in eating and energy compensation in children by estimating the compensation index (COMPX) (Birch et al 1986; Johnson 2000; Birch and Deysher 1985; Hetherington et al. 2000; Johnson and Birch 1994; Carnell et al. 2017). COMPX is a proxy to measure children’s self-regulation. This method measures the degree to which individuals terminate eating or decide not to initiate eating by recognizing their perceived satiety. The estimation of the index is based on the participants’ response to the calorie content of the preload drink (Johnson and Birch 1994). Moreover, it has been hypothesized that Body Mass Index (BMI) is associated with calorie compensation ability, assuming children classified as overweight and obese [OV/OB]) fail to regulate their energy intake (Johnson and Taylor-Holloway 2006; Johnson and Birch 1994).

Even though self-regulation seems to be influential on food intake and food choices during young age, the majority of studies examining self-regulation in children have done so in a laboratory setting using a specific test meal (Birch et al 1986; Johnson 2000; Birch and Deysher 1985; Hetherington et al. 2000; Johnson and Birch 1994; Carnell et al. 2017). The exceptions include one naturalistic study where adolescents ate a fast food meal in a food court where COMP-X was not measured (Ebbeling 2004) and another study that took place in a classroom setting utilizing a set meal with no opportunity for additional portions (Carnell & Wardel, 2007). Previous studies have neglected to examine self-regulation in children while presented with a variety of unlimited food choices in a real-life setting. This is important because studies have indicated that a variety of internal (hunger/satiety) and external factors (palatability of food, cognitive factors etc) may influence meal termination and satiation (Blundel et al., 2010). The main objective of this study was to assess self-regulation of food intake in young children, using COMPX, and examine its association with weight status. Additionally, this study investigated children's food preference and food choices patterns while exposed to a buffet style lunch in a naturalistic setting. We hypothesized that OV/OB children will have less self-regulation of calorie consumption compared to healthy weight children. In addition, we expect that OV/OB children will select less nutrient dense food choices relative to healthy weight children.

2. Materials and Methods

2.1. Overview

This paper is part of a larger longitudinal study examining the development of behavioral phenotypes based on self-regulation process as it relates to health outcomes. This study was approved by *blinded for review* Institutional Review Board (IRB). Participants were preschool to early elementary school age children, ages 4-8 years old (n = 66) and consent forms were signed by parents and children were asked to verbally consent before taking part in the study. Children participated in a crossover research design trial, one week apart, where they consumed two different types of preload drinks (either high-calorie or low-calorie) followed by an *ad libitum* lunch during each trial. In addition, anthropometric measurements were done by a trained researcher. After the trials, energy intake was estimated and compared between both trials, and a compensation index (COMPX) was calculated to identify the level of self-regulation in food intake for each participant independently. The final data set including children's COMPX, anthropometries and food selection data were analyzed.

2.2. Subjects

Participants were preschool to early elementary school age children (4-8 years old) recruited from Miami-Dade County schools in the city of Miami, Florida. Recruitment from Miami-Dade County schools, provided the researchers with the opportunity of having access to a population with ethnic and socioeconomic diversity. Subjects were excluded if they had dietary restrictions, a pervasive developmental disorder such as autism spectrum disorder, psychosis, or PTSD, an IQ<70 measured by the Block Design and Vocabulary subtests from the Wechsler Preschool and Primary Scale of Intelligence—Third Edition (WPPSI-III; Wechsler 2002), or were on a psychotropic medication which causes weight change. Trials took place within a multi-session summer camp located in a school location. Despite including multiple make-up days each session not all children completed the study. Some reasons children did not complete included illness, travel and holidays. Since the calculation of compensation indices requires the completion of 2 eating occasions, children who only completed 1 trial could not be included in the analysis. Initially 108 participants were included in the buffet trials. The total number of participants successfully completed the protocol and used in the analysis included 66 children (boys (68.2%) and girls (31.8%)), 89.4% Latinx, with a mean age of 6.14 years old (SD = 1.15). The majority of parents were married (69.7%) and the data from maternal education level showed that 1/3 of them were college graduates with a bachelor's degree (33.3%).

2.3. Materials

Following the procedures outlined by Johnson & Birch (1994), children consumed two preload juice drinks, in a randomized order, which were similar in look and taste but differed in calorie content, by changing the amount of carbohydrate in the drinks. The preloads were prepared a day before each session and were kept in the refrigerator before being served. The high calorie drink was made using 195 g maltodextrin added to 1 L heated water (~65° C). After 15 minutes when the mixture was cooled, 177.5 g sucrose with 290 g cherry Kool-Aid drink mix (Kraft Heinz, Chicago, IL) were added and the volume of the mixture was brought to 1.4 L. The low-calorie drink was made by mixing 1 pack of unsweetened drink mix Kool-Aid (Kraft Heinz, Chicago, IL) and 24 packs of Splenda (TC Heartland, Carmel, IN) to 1.8 L room temperature water. Each participant received 3 oz of the preload drink with 158 kcal and 5 kcal for high calorie and low-calorie preload drink respectively.

The lunches served was for *ad libitum* consumption where participants were able to eat whatever and as much as they wanted. Foods were presented to students on a buffet line. All subjects were presented with a large quantity of food to avoid the effect of food availability on food consumption. As students entered the buffet line, they were asked what they wanted to eat. Students identified which foods they wanted to select and how many servings they would like of that food item. All the food items were served using a standard serving scoops by trained lunch helpers who were familiar with the amount of one serving for each food item and hygiene standards. After students had selected all of the food items they wanted to eat they were seated for lunch. Throughout the lunch period students were reminded that they could return to the buffet line as many times as they wanted until they were done eating. The menu included foods familiar to the study sample that were typically served in local schools including mac and cheese (Publix deli, 130.11 kcal/scoop), turkey sandwich (Publix deli, 380 kcal/sandwich), Pizza (Domino's cheese pizza, 290 kcal/slice), broccoli (Publix steam-in-bag, 30 kcal/scoop), baby carrots (Publix, 23.5 kcal/serving), red seedless grapes (43.2 kcal/scoop), bananas (105 kcal/banana), whole grain chips (Sun Chips, 93.8 kcal/scoop), Graham crackers (Teddy Graham, Honey, 86.66 kcal/scoop), Cookies (reduced fat Chips Ahoy, 50 kcal/cookie), low fat milk (Publix purple cap, 150 kcal/ 8 oz), apple juice (Mott's juice box, 100 kcal/box), and small water bottles (Publix spring water).

2.4. Procedure

Each child participated in two nearly identical sessions, one week apart. The only difference between the sessions was the type of preload they received. Participants were identified by numbers instead of names to maintain confidentiality. Children were assigned in groups ranging in size from 5 to 20 for the lunch trials. During the randomized trials, the students were offered a morning snack at ~9:00 a.m. (3 hours before lunch time) in order for them to start the trial with a similar energy balance. The snack was a small snack pack of Goldfish cheese crackers (Pepperidge Farm) and its nutrient values were not included in the final intake analysis. The intake of the morning snack was ad-libitum. After ~2.5 hours (~11:30 a.m.) students were offered 3 oz of the preload drink and were asked not to have any physical activity for 30 minutes prior to lunch.

The order of the preload condition (either low or high calorie) for the first visit was randomly assigned to each group of participants using a random number generator. The preload condition for the second visit was counterbalanced and participants who received a low-calorie preload drink during the first visit were offered a high-calorie preload drink during the second visit and vice versa, to avoid potential effects of the order of the preloads. Additionally, because this methodology focuses on the differences between the two sessions (e.g., calorie and nutrient intake) and not each session solely, the effect of the order of the preload was minimal. With the exception of the person responsible for making the beverage, all researchers, classroom helpers, and participants were blinded about the preload condition. Around 12:00 p.m., children were asked to go to the buffet lunch area to eat. Children were instructed that the food is self-selected, and they can have unlimited amount until they are no longer hungry during the 45 minutes period. One week later, participants received the same morning snack, a different type of preload and repeated the *ad-libitum* buffet lunch.

2.5. Plate waste reliability and validity

Research team members, graduate-level dietetics students, were trained on how to use the serving scoops accurately and what one serving of food looked like on the plate. Prior to starting each trial, servers weighed one serving of each food item to get the standard weights of each item. Researchers tracked the number of servings each child selected as they went through the buffet line. Participant plates were weighed before and after consumption and pictures were taken at each time point. Food intake was estimated by comparing the participants’ plates’ weights and pictures taken before and after consumption. Single serving photographs were used as guides to measure leftovers. Initial pictures (before eating) were coded by two independent researchers, then the codes were compared to the recorded tray line records. To increase inter-rater reliability, the final plates (leftovers) were coded by three independent researchers using the pictures of one serving size of each food item. A fourth researcher calculated inter-rater reliabilities of the three coders and compared them to the pictures. On a separate sheet, the weight of the leftover food for each plate was calculated based on the pictures and compared to the actual final plate weight to increase inter rater reliability.

2.6. Nutrient analysis

Participants calorie and nutrient analysis was assessed using a food and nutrient tracking application (Evans 2017). The application pulled data directly from the food manufacturers' website in order to calculate nutrient values per serving. Calorie and nutrient intake were measured for both students' food selected, and food consumed during the buffets.

2.7. Anthropometrics

Anthropometrics measures included height (cm), weight (kg), and BMI z-scores based on the Center for Disease Control (CDC) growth charts. Three consecutive measurements were taken, and the mean was used in the analysis. Measurements were done by a trained professional and reported to the nearest 0.5 cm for height and 1 kg in weight.

2.8. Data analysis

Data was analyzed using SPSS v.23. Descriptive statistics, including means, standard deviations, and the range were measured for all the variables. Compensation scores were measured for each participant individually using COMPX formula:

$$\frac{Ad\ libitum\ KJ_{Low\ energy\ preload} - Ad\ libitum\ KJ_{High\ enegy\ preload}}{Drink\ preload\ KJ_{High} - Drink\ preload\ KJ_{Low}} \times 100\%$$

The interpretation of the range of the compensation scores is expected to vary from eating the same amount or more after taking the high-calorie preload drink (shown with negative numbers) to eating less after the low-calorie preload drink (shown with positive numbers). A score of 100% (perfect COMPX) shows that the participants consumed the perfect amount of the calorie difference between the two preload drinks (~640 KJ or 153 kcal) during lunch when they were offered with the low-calorie drink.

This study utilized baseline data of 66 elementary school-aged children from a larger study examining the development of behavioral phenotypes based on the self-regulation process as it relates to health outcomes. A Shapiro-Wilk test indicated that data were statistically normally distributed, and the results from the *Leven's F* test confirmed the homogeneity of variances, therefore we used independent *t*-tests to examine differences in COMPX scores in the OV/OB group compared to the healthy weight group. Paired *t*-tests were used to detect the effect of the preloads on food choices, food consumption, calorie selected, calorie consumed, nutrient selected, and nutrient intake.

Intraclass correlation coefficient (ICC) (a two-way mixed effect model, absolute agreement) was performed to examine the inter-rater reliability for participants food intake between 3 raters. ICC and 95% confidence intervals (CI) were reported. Interpretation was as follows: <0.50, poor; between 0.50 and 0.75, fair, between 0.75 and 0.90 good; above 0.90, excellent.

3. Results

This study aimed to (1) assess self-regulation using COMPX in young school-age children (2) to compare children's COMPX scores between different BMI z-scores categories (normal and OV/OB), and (3) to observe children's food and nutrient choices and consumption where they have complete autonomy.

3.1. Sample characteristics

The results from the descriptive data indicated that the majority of the participants were boys (69.7%) and 30.3% were girls (SD = 0.46). Anthropometrics data showed that 27 (40.9%) students were in the healthy weight category, 17 (25.8%) were overweight, and 22 (33.3%) were classified as obese (>95th percentile) (SD = 0.86).

3.2. Inter-rater reliability in food intake

Final plate weights based on the leftover observed estimations were compared to the actual final plate weights obtained during the buffets using a scale. The results of the observed vs weighed plate waste data indicated an excellent total ICC of 0.984 (CI = 0.968-0.991). The variation of ICC was between 0.960 (CI = 0.947-0.971), the highest for pizza, and the lowest for broccoli (0.840 (CI = 0.786-0.882)), varying from excellent to good. ICCs for all the food items are presented in Table 2.

3.3. Self-regulation measured by COMPX

A box plot was used to plot the distribution of the data set. The data of two participants were identified as outliers and were removed from the original data set before the analysis ($n = 64$). The results from the paired t-test showed that the main effect of the preloads on calorie intake was not significant ($t = -1.63$, $p = .108$; Cohen's $d = 0.18$) which indicates low ability to calorie compensate in children in general. In other words, when comparing both buffet sessions, children's intake did not differ significantly in response to low calorie preload drink compared to high calorie preload drink. The average COMPX score for the total sample was −41.03 (SD = 201.14).

The average compensation scores (COMPX), which indicates children's responsiveness to calorie density of the preload drink, was 21.59 (SD = 190.30) in healthy weight children, and −86.74 (SD = 198.88) in OV/OB children. Looking at the COMPX scores' means in different BMI z-scores categories showed that children with healthy weight appeared to have higher self-regulation skills of food intake compared to OV/OB children ($t = 2.19$, $p = .032$; Hedges' $g = 0.554$). Participants' scores widely differed in the extent to which they regulated their food intake in response to the calorie content of the preload. The COMPX scores range was from −538.69 in children who consumed more after the high energy preload drink to 390.94 in children who consumed less after the low energy preload drink. Children's compensation scores and means are reported in Table 3, divided into healthy weight vs OV/OB categories.

We also examined the absolute value of COMPX (absCOMPX) which represents the distance to 100% perfect compensation in either direction. For healthy weight children the mean absCOMPX was 168.48% (SD:127.81) and for children with OV/OB the mean absCOMPX was 220.81% (SD:174.71). When looking at the absolute value, there was no significant difference found between the two groups ($t = -1.32$, $p = 0.192$; Hedges' $g = 0.358$).

3.4. Children's food choice and food intake

Independent t-tests and effect sizes were calculated in order to examine the differences in average number of servings of food selection and consumed between normal and OV/OB children (Table 4). OV/OB children selected and consumed significantly more servings of bananas than healthy weight children ($t = -2.62$, $p = .011$; $t = -2.91$, $p = .005$ respectively). Due to the large number of multiple comparisons in this analysis, Bonferroni's correction (α/n of analyses) was considered (Dunn, 1961). Utilizing this technique, a p-value of <0.004 is required for statistical significance, indicating no difference in food selected or consumed between normal and OV/OB controls. Effect size analysis indicated medium effect for banana selection (Hedges g =.65) and consumption (Hedges g =.74) along with juice consumption (Hedges g = .54).

We performed paired t-tests to compare the results of food choice decisions and food consumption between the two buffet sessions for 66 participants. The results of food selection analysis revealed that there was only a significant difference for milk selection ($t = -2.67$, $p = .010$) between both sessions with the mean of 0.23 (SD = 0.44) and 0.45 (SD = 0.66) after low calorie preload and high calorie preload respectively. Food consumption data showed that there was a significant difference in pizza consumption ($t = -2.04$, $p = .045$) with the mean servings of 1.13 (SD = 0.91) for low energy preload session and 1.34 (SD = 0.96) for high energy preload session. The results shown in Tables 5 and 6 present the comparison (paired t-test) in food selection and food consumption based on BMI z-scores cutoffs categorized into healthy weight and OV/OB.

Looking at the tables above confirms that healthy weight children did not show many significant differences in food consumption between the two buffets ($p > .05$); however there was a significant difference in the mean number of the cookies selected between ($t = 2.13$, $p = .043$). In addition, OV/OB children showed significantly higher selected amounts of milk ($t = -0.39$, $p = .004$) and higher consumption of pizza ($t = -2.22$, $p = .032$) and cookies ($t = -2.15$, $p = .038$) after the high energy preload drink. To correct for multiple comparisons, a Bonferroni correction of p< .004 can be used to interpret the data. Using the correction there is no significant differences in food choice decisions or food consumption between the two buffet sessions. Effect sizes indicate a medium effect (Hedges g = 0.56) for milk selection in the OV/OB group.

3.5. Children's food choice and nutrient intake

Paired t-tests were performed to compare the results of participants' nutrients selected and nutrients intake between the two buffet sessions for the 66 participants. The results indicated that there was a significant difference between the consumption means of calories ($t = -2.21$, $p = .033$), total fat ($t = -2.26$, $p = .029$), saturated fat ($t = -3.04$, $p = .004$), and cholesterol ($t = -2.11$, $p = .041$) among OV/OB children. There was no significant difference in healthy weight participants ($p > .05$). For this data a Bonferroni correction of p< .005 can be used. Based on this correction, there are no significant differences for nutrient intakes in the food choices or consumed in the two groups. Effect sizes indicate a medium effect size for saturated fat intake in the OV/OB group (Cohen's d = .48). These results suggest that

OV/OB participants consumed a higher amount of saturated fat after the high energy preload drink.

4. Discussion

This study evaluated the level of self-regulatory skills in food intake and its comparison between children with different weight status. Furthermore, we examined the effect of calorie manipulation on children's food and nutrient choices when exposed to a large variety of food items via a buffet style lunch in a naturalistic setting. Our primary findings show that young children who are OV/OB are more likely to overcompensate their energy intake compared to their healthy weight counterparts however when looking at the distance from 100% compensation or overall dysregulation, there was no significant differences found between the two groups. However, when examining food selection and consumption under these conditions, we find that OV/OB children tend to have a higher consumption of foods high in saturated fats.

First, it is important to note that our study confirms the use of a buffet style paradigm to examine young children's self-regulation of energy intake in a naturalistic setting. Within this model, our results are consistent with previous studies which showed that healthy weight children are somewhat able to calorie compensate in response to calorie manipulation (Birch et al 1986; Johnson 2000; Birch and Deysher 1985; Hetherington et al. 2000; Johnson and Birch 1994; Carnell and Wardle 2017). That is to say, a large number of children consumed a lower number of calories after drinking the high-calorie preload drink and consumed more calories after drinking the low-calorie preload drink before lunch. Caloric compensation is inherently a self-regulation process requiring individuals' capability of detecting and responding to internal bodily signals of hunger and satiety, which leads to the consumption of only the amount of calories the body requires (Johnson 2000). Such self-regulation of energy intake, even in children, contributes to their ability to terminate eating when they reach the level of calories their body demands. Our findings contribute to the existing literature by utilizing a methodology that allowed us to examine self-regulation within the context of children's food choice decisions and food intake during a meal in a naturalistic setting. It will be important for future studies to examine the stability of children's self-regulation of energy intake within this buffet style paradigm and how it may predict later obesogenic related variables.

As part of our secondary aim, we examined young children's food selection and found that OV/OB children appeared to be more affected by calorie manipulation in food consumption. OV/OB children seemed to have a slightly higher desire for more calorie dense food items including pizza and cookies after being offered the high energy preload. This may be the reason OV/OB children showed a higher saturated fat intake after the high energy preload drink leading to weight gain as there is a positive correlation between calorie dense food intake and obesity among children (El-Gazzar et al. 2019). However, the calorie content of the preloads did not seem to change the food preference or nutrient intake in healthy weight children. Cecil et al. (2005) declared there is an unclear influence path between obesity and self-regulation of food intake. However, our study has shown even at this young age, when given food choices at a buffet without any parental input, children who are OV/OB gravitate towards these choices confirming the research of Fearnbeck and colleagues (2015) who found that children's fat free mass was correlated with intake of high fat choices at a palatable buffet test meal in laboratory conditions. These choices likely further contribute to the stability of their weight complications.

This study had several limitations and strengths. The first limitation is that it is impossible to look at the response to internal cues separately from the children's responsiveness to external stimulus in the buffet trials. For example, children were able to see each other's plates and discuss their opinions about different food items and the amount of food they had in their plates. Consequently, children's food choices and food intake may have been affected by social influence (McFerran et al. 2010). However, it gave the researchers a better picture of the children's daily experiences. Another limitation is sitting in groups. Children sat in groups to eat during lunches which seems to be another influential factor in food intake among individuals (Herman et al. 2003). According to Herman et al. (2003), the presence of others can diminish or facilitate food intake. Due to a variety of study constraints, we were not able to weigh each individual food item separately. Instead, we used a mix of plate waste photos and full plate weights to estimate nutrient intake. Our high average ICC of 0.984 between the estimated serving weights and actual plate weights increase our confidence in these estimations. Relatively small sample size is another limitation for this study. Moreover, is important to understand that the COMPX methodology is not considered perfect, and it only provides a picture of participants' regulatory skills and intake at a one-time point in life. Therefore, more longitudinal studies are needed to draw a better picture of individuals' eating habits and self-regulation of food intake.

Strengths of this study include the access to the large percentage of Latinx students, which provides valuable insights into an underrepresented minority community in this area of research; however, given the sample size, further research is required for generalization purposes. In addition, the use of a buffet style lunch increased students' autonomy in food selection and food intake which provided the researchers with the opportunity to examine students' food choices when exposed to a variety of different options. Another strength of this study is the use of multiple raters to increase validity of plate waste measurements and lower the risk of leftover miscalculation. Using pictures to estimate leftover food in plate waste methods is known to be a faster and more reliable method, as compared to self-reporting (Martin et al. 2008). However, calculating the amount of food consumed by the participants by only looking at the pictures of the plates may often be difficult and biased, raising inaccuracy and misconception (Martins et al. 2014). In order to improve inter-rater reliability in plate waste methods, we used 3 different raters to estimate the leftover food and compare the actual final plate weight with the estimated final plate weight. This method provides the opportunity to make an accurate estimation about the participants' food/calorie intake. Consequently, it raises the validity and reliability of the data.

5. Conclusion

In summary, expanding on prior work, the current study measured young children's self-regulation of energy intake using an unlimited lunch buffet paradigm that included a variety of food choices in a real-life eating scenario. Our study findings showed individual differences in self-regulation of energy intake with none of the children obtaining a perfect compensation score. Most importantly we observed those young children classified as OV/OB displayed significant overconsumption of energy intake relative to healthy weight children. Thus, the unlimited lunch buffet style seemed to be successful in making it challenging for children, especially those classified as OV/OB, to regulate their food consumption. Further work is needed to increase generalizability and to better understand the neurobiological underpinnings involved in such self-regulation of energy intake in young children as well as how it may interact with environmental factors (e.g., food availability). Perhaps more comprehensive studies, which includes multiple levels of influence such as environmental effect, parental influence, and the ability to detect internal bodily signals may assist in better understanding behaviors related to food intake.

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Highlights

- The buffet style lunch provided a reliable methodology to investigate the food intake/selection in children under complete autonomy.
- School-aged children ability to calorie compensate in response to calorie manipulation is limited.
- Children classified as overweight/obese show poorer self-regulation than healthy weight children.

Table 1:

Summary of participants characteristics.

		N	Percentage
Sex	Male	45	68.2
	Female	21	31.8
Ethnicity	Hispanic	59	89.4
	Non-Hispanic	7	10.6
Race	African-American	1	1.5
	White	63	95.5
	Asian	2	3.0
BMI z-scores	Healthy Weight	27	40.9
	Overweight	17	25.8
	Obese	22	33.3
Parents marital status	Single, never married	4	6.1
	Living with a partner	6	9.1
	Married	46	69.7
	Separated	3	4.5
	Divorced	7	10.6
Maternal education level	High school graduate	8	9.1
	Some college	10	15.2
	Associates degree	10	15.2
	College graduate (BS)	22	33.3
	Advanced degree (MS, MBA, MD)	18	27.3

Sample size (N).

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Table 2:

Inter-rater reliability results of plate waste data calculating 2-way mixed-effects model.

		95% Confidence Interval		F Test with True Value 0			
	Intraclass Correlation	**Lower Bound**	**Upper Bound**	**Value**	***df*1**	***df*2**	**Sig.**
Mac and Cheese	0.954	0.938	0.966	21.864	131	262	0.000
Pizza	0.960	0.947	0.971	25.199	131	262	0.000
Turkey Sandwich	0.862	0.815	0.898	7.192	131	262	0.000
Grapes	0.859	0.811	0.896	7.063	131	262	0.000
Banana	0.915	0.886	0.937	11.644	131	262	0.000
Carrots	0.921	0.895	0.942	12.659	131	262	0.000
Broccoli	0.840	0.786	0.882	6.219	131	262	0.000
Chips	0.955	0.940	0.967	22.177	131	262	0.000
Cracker	0.927	0.902	0.946	13.610	131	262	0.000
Cookie	0.923	0.897	0.943	12.881	131	262	0.000

Degree freedom (*df*), Significance (Sig.).

Table 3:

COMPX scores for normal and OV/OB children.

BMI z-scores category	n	M	SD
Healthy weight	27	21.59	190.30
OV/OB	37	−86.74	198.88
Total	64	−41.03	201.14

Mean (M), Standard Deviation (SD).

Table 4:

Comparison of average food selected, and food consumed in healthy weight and OV/OB children.

Food	Food Selected					Food Consumed				
	Healthy Weight M(SD)	OV/OB M(SD)	*t*	Sig.	Hedges *g*	Healthy Weight M(SD)	OV/OB M(SD)	*t*	Sig.	Hedges *g*
M&C	0.67 (1.08)	0.69 (0.88)	−0.11	0.916	0.02	0.41 (0.80)	0.49 (0.75)	−.42	0.674	0.10
Pizza	2.72 (2.54)	2.15 (1.22)	1.21	0.231	0.30	1.10 (0.77)	1.33 (0.90)	−1.07	0.289	0.27
Sandwich	0.06 (0.21)	0.17 (0.37)	−1.41	0.163	0.35	0.00 (0.00)	0.03 (0.10)	−1.48	0.143	0.38
Grapes	0.95 (1.08)	0.85 (0.86)	0.44	0.663	0.10	0.66 (0.83)	0.63 (0.64)	0.20	0.846	0.04
Bananas	0.13 (0.22)	0.48 (0.68)	−2.62	0.011*	0.65	0.03 (0.11)	0.22 (0.32)	−2.91	0.005*	0.74
Carrots	0.15 (0.27)	0.14 (0.42)	0.04	0.966	0.03	0.02 (0.72)	0.03 (0.09)	−0.11	0.911	0.02
Broccoli	0.18 (0.32)	0.16 (0.41)	0.13	0.896	0.05	0.10 (0.26)	0.08 (0.23)	0.33	0.745	0.08
Chips	0.59 (0.86)	0.84 (1.15)	−0.93	0.358	0.24	0.39 (0.69)	0.73 (1.05)	−1.46	0.149	0.36
Crackers	0.37 (0.54)	0.59 (0.80)	−1.27	0.208	0.31	0.20 (0.28)	0.44 (0.65)	−1.76	0.083	0.45
Cookies	6.44 (4.95)	5.67 (4.18)	0.67	0.504	0.17	4.23 (3.14)	4.50 (3.17)	−0.33	0.742	0.08
Milk	0.28 (0.35)	0.39 (0.51)	−1.00	0.320	0.24	0.19 (0.27)	0.31 (0.62)	−0.65	0.523	0.23
Juice	1.04 (1.22)	1.10 (0.90)	−0.24	0.803	0.06	0.44 (0.65)	0.68 (0.18)	−0.51	0.617	0.54

*Comparison is significant at the 0.05 level (2-tailed). Mean (M), Standard Deviation (SD), Significance (Sig.), Mac and Cheese (M&C).

Table 5:

Comparison of the amount of food selected in healthy weight and OV/OB children between the two buffet sessions.

Food	Healthy Weight (n=27)					OV/OB (n=37)				
	Low-Cal Preload M(SD)	**High-Cal Preload M(SD)**	**t**	**Sig.**	**Cohen's *d***	**Low-Cal Preload M(SD)**	**High-Cal Preload M(SD)**	**t**	**Sig.**	**Cohen's *d***
M&C	0.70(1.32)	0.62(1.04)	0.38	0.703	0.07	0.67(0.87)	0.70(1.09)	−0.17	0.861	0.03
Pizza	2.59(2.60)	2.85(2.78)	−0.75	0.458	0.09	2.12(1.47)	2.17(1.44)	−0.20	0.841	0.03
Sandwich	0.07(0.26)	0.03(0.19)	1.00	0.327	0.09	0.17(0.38)	0.15(0.43)	0.44	0.661	0.04
Grapes	1.02(1.18)	0.88(1.18)	0.72	0.472	0.11	0.93(1.08)	0.76(0.87)	1.08	0.286	0.17
Bananas	0.14(0.36)	0.11(0.32)	0.37	0.713	0.08	0.41(0.67)	0.56(0.88)	−1.23	0.225	0.19
Carrots	0.14(0.36)	0.14(0.36)	0.00	1.000	0.00	0.10(0.57)	0.17(0.45)	−0.74	0.458	0.13
Broccoli	0.16(0.36)	0.18(0.39)	−0.23	0.814	0.05	0.13(0.46)	0.19(0.48)	−0.77	0.442	0.12
Chips	0.67(1.10)	0.51(0.97)	0.68	0.502	0.15	0.77(1.19)	0.89(1.36)	−0.65	0.517	0.09
Crackers	0.49(0.85)	0.24(0.46)	1.50	0.144	0.18	0.66(1.03)	0.51(0.79)	1.08	0.284	0.16
Cookies	7.53(6.36)	5.34(4.70)	2.13	0.043*	0.39	5.13(4.92)	6.21(5.03)	−1.23	0.226	0.21
Milk	0.25(0.44)	0.29(0.46)	−0.32	0.746	0.08	0.21(0.44)	0.56(0.75)	−3.09	0.004*	0.56
Juice	0.96(1.01)	1.11(1.57)	−0.75	0.460	0.11	1.17(1.02)	1.02(1.06)	0.90	0.373	0.14

*Comparison is significant at the 0.05 level (2-tailed). Mean (M), Standard Deviation (SD), Significance (Sig.), Mac and Cheese (M&C).

Table 6:

Comparison of the amount of food consumed in healthy weight and OV/OB children between the two buffet sessions.

Food	Healthy Weight (n=27)					OV/OB (n=37)				
	Low-Cal Preload M(SD)	High-Cal Preload M(SD)	t	Sig.	Cohen's *d*	Low-Cal Preload M(SD)	High-Cal Preload M(SD)	t	Sig.	Cohen's *d*
M&C	0.41(0.82)	0.41(0.82)	0.07	0.943	0	0.47(0.74)	0.51(0.93)	−0.34	0.730	0.04
Pizza	1.05(0.84)	1.14(0.90)	−0.54	0.590	0.10	1.18(0.96)	1.47(0.99)	−2.22	0.032 *	0.29
Sandwich	0.00(0.00)	0.00(0.00)	−1.00	0.327	0.10	0.05(0.18)	0.00(0.02)	1.92	0.062	0.39
Grapes	0.66(0.89)	0.65(0.92)	0.07	0.941	0.01	0.61(0.67)	0.63(0.80)	−0.16	0.867	0.02
Bananas	0.05(0.21)	0.00(0.00)	1.36	0.185	0.01	0.23(0.41)	0.19(0.39)	0.57	0.570	0.08
Carrots	0.01(0.04)	0.03(0.11)	−1.24	0.224	0.24	0.03(0.13)	0.02(0.09)	0.29	0.767	0.08
Broccoli	0.11(0.27)	0.08(0.27)	0.86	0.395	0.11	0.04(0.19)	0.11(0.33)	−1.63	0.109	0.25
Chips	0.37(0.62)	0.41(0.86)	−0.33	0.742	0.05	0.60(0.91)	0.85(1.36)	−1.60	0.117	0.21
Crackers	0.27(0.41)	0.12(0.28)	1.79	0.085	0.42	0.45(0.77)	0.42(0.72)	0.22	0.826	0.04
Cookies	4.61(3.90)	3.85(3.04)	1.23	0.227	0.21	3.86(3.18)	5.13(4.07)	−2.15	0.038 *	0.34
Milk	0.12(0.23)	0.25(0.41)	−1.20	0.255	0.39	0.20(0.35)	0.42(0.90)	−1.35	0.200	0.32
Juice	0.54(0.79)	0.33(0.60)	1.28	0.225	0.29	0.60(0.70)	0.53(0.70)	0.66	0.519	0.1

*Comparison is significant at the 0.05 level (2-tailed). Mean (M), Standard Deviation (SD), Significance (Sig.), Mac and Cheese (M&C).

Table 7:

Comparison of nutrients selected in healthy weight and OV/OB children between the two buffet sessions.

Food	Healthy Weight (n=27)					OV/OB (n=37)				
	Low-Cal Preload M(SD)	**High-Cal Preload M(SD)**	**t**	**Sig.**	**Cohen's *d***	**Low-Cal Preload M(SD)**	**High-Cal Preload M(SD)**	**t**	**Sig.**	**Cohen's *d***
Calories	1553.18 (900.53)	1427.44 (828.31)	0.94	0.353	0.14	1408.28 (664.54)	1503.07 (634.57)	−0.75	0.453	0.14
Total fat	52.48 (32.48)	47.03 (28.21)	1.13	0.266	0.17	44.46 (22.71)	49.20 (22.24)	−1.10	0.278	0.21
Saturated fat	22.14 (14.55)	20.92 (13.55)	0.59	0.558	0.08	18.69 (9.82)	20.97 (10.69)	−1.16	0.250	0.22
Trans fat	0.00	0.00	-	-	-	0.00	0.00	-	-	-
Cholesterol	87.22 (69.48)	87.77 (64.94)	−0.06	0.952	0.00	81.12 (44.13)	89.33 (60.06)	−0.85	0.397	0.15
Sodium	2322.33 (1695.86)	2229.14 (1629.88)	0.39	0.697	0.05	2079.74 (1130.00)	2122.38 (1269.14)	−0.18	0.852	0.03
Potassium	292.00 (317.44)	312.59 (390.99)	−0.33	0.740	0.05	468.23 (400.42)	510.97 (457.81)	−0.62	0.536	0.09
Carbs	225.18 (120.87)	204.81 (112.69)	1.10	0.280	0.17	209.17 (98.46)	220.12 (87.88)	−0.63	0.532	0.11
Fiber	8.96 (6.09)	8.44 (5.01)	0.60	0.552	0.09	9.79 (6.04)	10.25 (6.72)	−0.38	0.705	0.07
Sugar	79.03 (38.22)	70.14 (43.80)	1.18	0.245	0.21	79.41 (42.77)	83.82 (38.16)	−0.67	0.507	0.11
Protein	47.03 (34.63)	45.11 (31.34)	0.41	0.685	0.05	44.20 (23.52)	47.20 (28.93)	−0.60	0.547	0.11

Mean (M), Standard Deviation (SD), Significance (Sig.).

Table 8:

Comparison of nutrients consumed in healthy weight and OV/OB children between the two buffet sessions.

Food	Healthy Weight (n=27)					OV/OB (n=37)				
	Low-Cal Preload M(SD)	**High-Cal Preload M(SD)**	**t**	**Sig.**	**Cohen's *d***	**Low-Cal Preload M(SD)**	**High-Cal Preload M(SD)**	**t**	**Sig.**	**Cohen's *d***
Calories	785.18 (338.28)	752.14 (278.18)	0.59	0.560	0.10	888.48 (316.20)	1027.61 (450.44)	−2.21	0.033 *	0.35
Total fat	26.11 (12.75)	25.03 (9.48)	0.65	0.516	0.09	28.38 (11.55)	33.79 (17.16)	−2.26	0.029 *	0.36
Saturated fat	10.70 (5.53)	10.55 (4.68)	0.18	0.855	0.02	11.61 (5.66)	15.05 (8.22)	−3.04	0.004 **	0.48
Trans fat	0.00	0.00	-	-	-	0.00	0.00	-	-	-
Cholesterol	37.07 (22.10)	39.59 (23.07)	−0.64	0.522	0.11	45.25 (29.97)	55.69 (36.43)	−2.11	0.041 *	0.31
Sodium	1032.48 (545.73)	1043.81 (457.55)	−0.12	0.904	0.02	1209.38 (634.64)	1341.66 (744.06)	−1.24	0.221	0.19
Potassium	197.96 (233.55)	173.55 (232.47)	0.63	0.533	0.10	307.94 (243.73)	279.64 (197.11)	0.67	0.505	0.12
Carbs	118.96 (50.11)	111.44 (35.21)	1.00	0.326	0.17	135.53 (42.96)	149.79 (63.15)	−1.58	0.120	0.26
Fiber	3.74 (1.95)	5.59 (9.78)	−0.98	0.334	0.26	5.33 (2.76)	5.59 (3.07)	−0.46	0.643	0.08
Sugar	49.22 (24.00)	45.22 (24.94)	1.09	0.285	0.16	53.46 (23.38)	57.10 (24.76)	−0.89	0.376	0.15
Protein	20.14 (10.24)	21.00 (9.56)	−0.53	0.596	0.08	25.46 (14.49)	29.15 (15.63)	−1.51	0.138	0.24

* Comparison is significant at the 0.05 level (2-tailed).

** Comparison is significant at the 0.01 level (2-tailed). Mean (M), Standard Deviation (SD), Significance (Sig.).