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Increased restrictive feeding practices are associated with reduced energy density in 4–6-year-old, multi-ethnic children at *ad libitum* laboratory test-meals[☆]

Shama Sud^a, Nina Carmela Tamayo^a, Myles S. Faith^b, and Kathleen L. Keller^{a,*}

^aNew York Obesity Research Center, St. Luke's-Roosevelt Hospital Center, Columbia University College of Physicians & Surgeons, 1090 Amsterdam Avenue 14th Floor, New York, NY 10025, USA

^bWeight and Eating Disorders Program, University of Pennsylvania School of Medicine, 3535 Market Street Suite 3108, Philadelphia, PA 19194, USA

Abstract

Increased reports of restrictive feeding have shown positive relationships to child obesity, however, the mechanism between the two has not been elucidated. This study examined the relationship between reported use of restrictive feeding practices and 4–6-year-old children's self-selected energy density (ED) and total energy intake from an *ad libitum*, laboratory dinner including macaroni and cheese, string beans, grapes, baby carrots, cheese sticks, pudding, milks, and a variety of sweetened beverages. A second objective explored the relationship between ED and child body mass index (BMI) *z*-score. Seventy ($n = 70$) healthy children from primarily non-Caucasian and lower socioeconomic status families participated. Mothers completed the Child Feeding Questionnaire (CFQ) to assess restrictive feeding practices. Energy density (kcal/g) values for both foods and drinks ($ED_{\text{food+drink}}$) and ED for foods only (ED_{foods}) were calculated by dividing the average number of calories consumed by the average weight eaten across 4 meals. Higher maternal restriction was associated with lower $ED_{\text{food+drink}}$. In overweight and obese children only, higher maternal restriction was associated with lower ED_{food} . There was a non-significant trend for both ED measures to be negatively associated with child BMI *z*-score. Overall, restrictive feeding practices were not associated with child BMI *z*-score. However, when analyzing separate aspects of restriction, parents reported *higher* use of restricting access to palatable foods but *lower* use of using palatable foods as rewards with heavier children. Previous reports of positive associations between child obesity and restrictive feeding practices may not apply in predominantly non-Caucasian, lower socioeconomic status cohorts of children.

Keywords

Energy density; Feeding practices; Children; Obesity; Food intake

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*Corresponding author. kk2092@columbia.edu (K.L. Keller).

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Introduction

The childhood obesity epidemic in the United States has made it increasingly important to identify environmental predictors of excess weight gain (Ogden et al., 2006). The home feeding environment is of particular interest because greater parental control over child feeding has been associated with child overweight (Clark, Goyder, Bissell, Blank, & Peters, 2007; Faith et al., 2003) and reduced ability to compensate for changes in the caloric density of the diet (Johnson & Birch, 1994). Further, Goldstein, Daun, and Tepper (2007) and others (Birch et al., 2001; Faith et al., 2004b) have found negative associations between pressuring children to eat and level of obesity. In addition, overly restrictive feeding practices have been associated with increased overweight in girls (Birch, Fisher, & Davison, 2003). Parental feeding practices are associated with the development of obesity in some studies, although the underlying mechanisms are poorly understood.

The relationship between parental use of restrictive feeding practices and child eating behavior is not clear. Most parents use some form of restriction over their child's eating, but whether this practice is ultimately helpful or harmful to self-regulatory eating behavior is unclear. Birch and colleagues have demonstrated, in primarily Caucasian children from middle to high socioeconomic status, that restriction of palatable, high-fat snack foods is associated with increased intake of these restricted foods in laboratory eating paradigms where children are not hungry (Birch et al., 2003; Fisher & Birch, 1999). Other studies that support this notion show that restricting children's access to foods may result in increased preferences for these foods (Birch, Zimmerman, & Hind, 2006; Lepper, Sagotovsky, Dafoe, & Greene, 1982). While some of the aforementioned studies have been done under experimentally controlled conditions (Fisher & Birch, 1999), none demonstrate that restrictive feeding practices *cause* children to poorly self-regulate their eating. One possibility is that restrictive feeding practices used in the context of an emotionally nurturing home environment, reflective of an authoritative parenting style, may be associated with positive outcomes for child eating behavior (Querido, Warner & Eyberg, 2002). On the other hand, highly restrictive parents that lack emotional warmth, the so called authoritarian style, may be more likely to see the negative outcomes of restriction (Lamborn, Mounts, Steinberg, & Dornbusch, 1991). The extent to which these parenting styles are used may differ depending on ethnic background (Knight, Virdin, & Roosa, 1994). For this reason, we may see different relationships between restrictive feeding practices, a component of both authoritative and authoritarian parenting styles, and child eating behavior in Caucasian vs. non-Caucasian families.

One possible mechanism by which parental feeding practices impact obesity is by influencing the energy density (ED) or kcal/g, contained in the foods children select and consume. Energy density is an important predictor of both short and long-term energy intake in children. Leahy, Birch, Fisher, and Rolls (2008) found that children ate 25% fewer calories when the ED of a lunch entrée was reduced by 25%. In longer term experimental studies, manipulating the energy density of meals for 2 days/week over a 2-week period resulted in significant decreases in energy intake in 3–5-year-old children (Leahy, Birch, Fisher, and Rolls, 2008). In addition, covert increases in ED of *ad libitum* meals correspond to increases in energy intake (Stubbs, Harbron, Murgatroyd, & Prentice, 1995). These

findings demonstrate that for adults (Stubbs et al., 1995) and children (Leahy, Birch, Fisher, and Rolls, 2008), the ED of the diet impacts total energy consumed. Accordingly, the American Medical Association recommends eating lower ED foods as a means to prevent excess weight gain (Rao, 2008). However, the relationship between ED and childhood obesity has not been rigorously studied. Only one longitudinal study done by Kral et al. (2007) has been conducted to date, and they found no differences in ED consumed at an *ad libitum* meal between children at high vs. low risk for obesity. They concluded that ED is influenced by environmental factors, like feeding practices, more so than genetic factors. To date, the association between parental feeding practices and the ED of a self-selected, *ad libitum* meal has not been rigorously studied, but doing so could shed light on previous reported associations between restrictive feeding and obesity (Clark et al., 2007; Faith et al., 2003).

The goal of the present study was to determine the associations between use of restrictive feeding practices and ED and total energy consumed at an *ad libitum*, multi-item laboratory meal. We chose to focus on these two outcome variables at a standard buffet meal because several studies have suggested that reducing ED of main meal items is a successful strategy for reducing overall energy intake (Leahy, Birch, Fisher, and Rolls, 2008; Leahy, Birch, & Rolls, 2008). What is not known, however, is whether parental feeding practices influence children's abilities to adhere to a reduced ED diet. Thus, understanding the association between restrictive feeding and children's self-selection at a controlled test-meal is an important step in understanding the implications of this feeding practice. A second goal of this study was to follow-up on findings from Kral et al. (2007) to determine the association between ED and child body mass index (BMI). Based on previous empirical findings (Birch et al., 2003; Fisher & Birch, 1999, 2002), we hypothesized that children of parents who reported high levels of restriction would select higher ED meals. Furthermore, we hypothesized that ED would be positively associated with child BMI *z*-score.

Methods

Participants

Children were enrolled in the Child Taste and Eating Study, a cross-sectional, laboratory-based study designed to investigate the role of taste genetics in childhood obesity. A subset of children from this cohort ($n = 72$) who completed at least 3 out of 4 dinner visits was analyzed for the current report. This subset consisted of 70 children (34 males; 36 females), with a mean age of 5.2 ± 0.8 years. Children were from ethnically diverse backgrounds, with 34.3% African-American, 30.0% Hispanic, 20% Caucasian, 2.9% Asian and 12.8% who self-described as "other". Mothers reported income dichotomously as ($< \$20,000$ or $>$ or equal to $\$20,000/\text{year}$). Using this cut-off, 18.2% of families reported an annual salary $< \$20,000$ (the poverty line for a family of 4 at the time of the study).

Families were recruited by placing advertisements on popular Internet websites (craigslist.com) and through flyers placed in and around the hospital community. Interested parents were instructed to phone research staff where they were screened for eligibility. Inclusion criteria were: between 4 and 6 years of age, healthy, free from food allergies, not on any medications known to influence eating or weight, and no diagnosed learning

disabilities. This study was approved by the Institutional Review Board of St. Luke's Roosevelt Hospital. All parents provided written consent for their children to participate. Families were given a modest compensation for participating, and children received a toy after each visit.

Experimental procedures

Families attended 4 dinner visits at the Child Taste and Eating Laboratory. Parents were instructed to have children fast for the 2 h preceding each visit. On the first visit, mothers completed the Child Feeding Questionnaire (CFQ) (Birch et al., 2001) to assess parental feeding practices and attitudes. Visits lasted approximately 1 h and consisted of games to determine children's taste responses and food preferences for a range of fruits, vegetables, sweets, and high-fat foods (not part of the present study) followed by a 30 min *ad libitum*, multi-item test-meal.

Multi-item meal

The dinner consisted of macaroni and cheese, grapes, green beans, carrots, graham crackers, cheese, pudding, whole-fat milk, whole-fat chocolate milk, and a variety of sweetened beverages. Before serving the foods, all brand packaging was removed and beverages were transferred to clear plastic cups with straws. The energy densities and macronutrient contents of these foods are provided in Table 1. These foods were chosen because they are familiar and palatable to most children this age and they have been successfully used in past studies with this age group, including studies done in our lab (Faith et al., 2004a; Johnson & Birch, 1994). Also, they present a range of ED values, from high (e.g. macaroni and cheese, graham crackers) to low (e.g. string beans, carrots).

Dinner visits took place at the Child Taste and Eating Laboratory. In order to increase children's level of comfort, a 15 min acclimation period was offered at the beginning of the visit where children were allowed to play with toys and were introduced to the research staff. After children were acclimated, they were invited to eat their dinner in a separate room, adjacent to the mothers' waiting room. Mothers were instructed to remain in the waiting room and not offer the child any meal-related instructions. The waiting room was in a separate portion of the laboratory that was out of sight and sound from the place where the child ate dinner. Children ate with one research assistant at their tables who read non-food related books during the meal as a neutral distraction. When possible, the same research assistant was used throughout the child's enrollment in the study. Children were presented with serving sizes, based on the reference quantities outlined in the Continuing Survey of Food Intake by Individuals (CSFII) (Smiciklas-Wright, Mitchell, Mickle, Cook, & Goldman, 2002). They were instructed to eat as much or as little as they like from each of the food items and to let the researcher know if they would like additional servings when finished.

Measures

The Child Feeding Questionnaire (CFQ)—Restrictive feeding practices were assessed by the 6-factor version of the CFQ (Birch et al., 2001) on the families' first visit to the laboratory. The CFQ is a self-report questionnaire and the version used in the present study measured 3 parental feeding practices (monitoring, restriction, and pressure to eat) and 3

parental feeding attitudes (perceived responsibility, perceived overweight, and concern). The restriction subscale is assessed by 8 questions, 6 of which assess the extent to which parents restrict access to palatable foods (e.g. *I have to be sure that my child does not eat too many high fat or his/her favorite foods*, etc.). The other 2 questions that make up this subscale measure the extent to which parents reward their children for good behavior with sweets and other favorite foods (e.g. *I offer my child his/her favorite foods in exchange for good behavior*, etc.). The psychometric properties of this subscale have been validated in Caucasians (Birch et al., 2001) and Hispanic and African-American families (Anderson, Hughes, Fisher, & Nicklas, 2005). In the latter mentioned study, the authors found better factor loading when 5 questions in the restriction subscale were dropped (the 2 reward-based questions, and 3 questions related to the restriction of “some” or “favorite” foods) (Anderson et al., 2005). In the present study, we ultimately decided to retain those items, although in some analyses, we separated the questions that specifically addressed restriction of access from those that addressed use of palatable food as reward to more clearly understand the impact of these different practices.

Anthropometric measures—Height and weight were measured by a trained researcher. Children were measured without shoes and in light clothing. Weight was measured to the nearest 0.5 lb by a balance scale and height to the nearest 0.5 in. by a stadiometer. Height and weight measurements were used to calculate BMI (kg/m^2) and BMI z-score using CDC cut-offs (Cole, Bellizzi, Flegal, & Dietz, 2000). Data are reported as BMI z-scores (Field et al., 2003). In addition to child weight measures, parents, the majority of whom were mothers, self-reported their own height, weight, and age.

Energy density calculations—Energy density was calculated by two methods, based on the strategies used by Kral et al. (2007). The two calculations used were ED for all food and beverages ($\text{ED}_{\text{food+drinks}}$) and for foods only (ED_{food}). Calculation of energy density can vary widely depending on whether beverages are included because they have relatively low energy densities (Ledikwe et al., 2005; Johnson, Wilks, Lindroos, & Jebb, 2009). Also, the effects on satiety for foods and beverages are different, with fluids passing more quickly through the gastrointestinal tract than foods (Johnson et al., 2009). However, because many of the beverages served had equal or greater ED than some of the foods (Table 1), we opted to use $\text{ED}_{\text{food+drinks}}$ as our primary outcome variable. However, for comparison, we also included values for ED_{food} , and all main analyses were completed for both variables.

For ED calculations, weight in grams (g) of all foods and beverages consumed at each meal were calculated as the difference between pre- and post-weights of each food/beverage consumed at the meals. Energy and macronutrient content of each food and beverage was determined from food label information. Using this information, SPSS statistical software (Version 16.0) was used to create scripts for total energy intake, $\text{ED}_{\text{food+drinks}}$, and ED_{food} for each child. Energy density was calculated by determining the average caloric intake of each meal and dividing that by the average weight of foods and/or beverages eaten at each meal. Neither energy intake nor ED (calculated in both ways) differed across the 4 meals (p -values ranged from 0.4 to 0.8), so a mean value for each was used in the final analyses.

Statistical analyses—Descriptive characteristics are presented as mean (SD) for continuous variables and frequencies for categorical variables. The dependent variables in this study were $ED_{\text{food+drink}}$, ED_{food} , and total energy intake. The independent variable was parentally reported restriction, assessed by the CFQ. Pearson's correlation coefficients were computed to assess the relationships between continuous variables (BMI z -score, average calorie intake, energy density, and feeding practices). Nonparametric correlations were done to assess relationships between dichotomous variables (e.g. sex, ethnicity). In linear regression models, sex and ethnicity were dummy coded. Multiple linear regressions were done to adjust the analyses for relevant covariates (e.g. BMI z -score, sex, ethnicity, etc). A cut-off of $p < 0.10$ was used to determine the covariates to include in regression models. Unless otherwise specified, all data are presented as adjusted values, because in most cases, the significance of the relationships did not change from the unadjusted. Data were analyzed using SPSS (version 16.0). All hypotheses were two-tailed and a p -value of < 0.05 was used for significance.

Power analysis—Using Power and Precision Software, V. 3, a post hoc power analysis was conducted based on the effect size observed in previous studies that have examined relationships between restrictive feeding and children's intake under laboratory conditions (Birch et al., 2003). At an $\alpha = 0.05$ and a 2-tailed hypothesis, we calculated that testing 70 subjects would yield 80% power.

Statement of ethics

We certify that all applicable institutional and governmental regulations concerning the ethical use of human volunteers were followed during this research.

Results

Descriptive statistics of the cohort are listed in Table 2. Over half (64.3%) were parentally reported as African-American or Hispanic. Body weight status of the children ranged considerably with about 3% classified as "underweight," while over 25% were obese, according to cut-offs defined by the Centers for Disease Control and Prevention (CDC). Mean BMI z -score was 1.1 (1.1), which corresponds to a BMI-for-age of 65.6 (28.9) %, slightly above the weight status of children reported in similar studies (Birch et al., 2003; Kral et al., 2007). Parents self-reported that they were, on average, overweight, BMI = 27.6 (6.2). Energy density calculated from foods only (ED_{food}) was significantly greater than ED calculated from foods and drinks ($ED_{\text{food+drink}}$), with means (SD) equal to 2.5 (0.8) and 1.8 (0.7), respectively ($t = 26.3$; $p < 0.01$). Values for ED were similar to those obtained from other studies (Bell & Rolls, 2001; Cox & Mela, 2000) (Table 2).

Approximately 20% of the families reported annual income of less than or equal to \$20,000, but reported income group was not associated with child BMI z -score ($p = 0.7$), energy intake ($p = 0.1$), $ED_{\text{food+drink}}$ ($p = 0.5$), or ED_{food} ($p = 0.6$). Reported income was not associated with overall reports of restriction ($p = 0.27$), but when questions that assessed parents use of palatable foods as rewards were analyzed separately, income level was negatively associated with this variable ($\rho = -0.3$, $p < 0.05$). By this relationship, parents

who reported lower incomes tended to report higher levels of rewarding their children with high-fat or palatable foods for positive behavior.

Child age was not associated with $ED_{\text{food+drink}}$ ($p = 0.6$), but there was a non-significant trend for age to be positively associated with ED_{food} ($r = 0.2$; $p = 0.09$). There were no relationships between $ED_{\text{food+drink}}$ or ED_{food} and sex of the child, ethnicity, or parental BMI (p -values ranging from 0.2 to 0.8).

Overall, there was no association between reported levels of restriction and child BMI z -score ($p = 0.6$). However, when restriction was separated into subtypes, the restricting access subtype was positively associated to child BMI z -score ($r = 0.3$; $p < 0.05$), such that parents reported higher levels of restricting access with children who weigh more. In contrast, use of food as a reward was negatively associated with child BMI z -score ($r = -0.3$; $p < 0.05$), suggesting that parents use foods as rewards less often for heavier children.

Self-reported parental BMI (collected on only 73% of the cohort) was positively associated with child BMI z -score ($r = 0.3$; $p < 0.05$). Parental reported BMI modified the relationship between restrictive feeding practices and child BMI z -score. For non-obese parents, restriction was positively associated with child weight status ($r = 0.6$; $p < 0.05$). For overweight and obese parents, there was a non-significant trend for restriction to be negatively associated with child BMI z -score ($r = -0.3$; $p = 0.07$). Restrictive feeding practices were not associated with parental BMI ($p = 0.2$).

Associations between restrictive feeding practices and energy density

There was a negative association between overall level of restriction and $ED_{\text{food+drink}}$ both before ($r = -0.3$; $p < 0.01$) and after ($\beta = -0.3$; $p < 0.01$) adjusting for covariates (age and BMI z -score) (Fig. 1). The pattern of association with $ED_{\text{food+drink}}$ was similar when the restriction subscale was separated into the restricting access ($r = -0.2$; $p = 0.08$) and use of food as reward ($r = -0.2$; $p = 0.09$) subtypes.

The two measures of ED used in this study were positively correlated to one another ($ED_{\text{food+drink}}$ and ED_{food}) ($r = 0.6$; $p < 0.001$). However, restrictive feeding was not associated with ED_{food} , either before ($r = -0.2$; $p = 0.20$) or after ($\beta = -0.14$; $p = 0.3$) adjusting for covariates (age and BMI z -score). In overweight and obese children only, there was a negative association between restrictive feeding and ED_{food} ($r = -0.54$; $p < 0.01$) (Fig. 2). When the restrictive feeding subscale was broken down, there was a non-significant trend for restricting access to foods to be negatively associated with ED_{food} ($r = -0.2$; $p = 0.07$), but no association was found with use of foods as rewards and ED_{food} ($p = 0.7$).

Associations between restrictive feeding practices and total energy intake

Restrictive feeding practices were not associated with total energy intake, both before ($p = 0.5$) and after ($p = 0.5$) adjusting for covariates. When the restriction subscale was broken down, only the use of food as a reward showed a negative association with total energy intake in the laboratory ($r = -0.3$; $p < 0.05$), but this relationship was no longer present after adjusting for covariates, ethnicity, age, and BMI z -score ($p = 0.2$).

Associations between energy intake, ED, and child BMI z-score

Total energy intake was positively associated with both ED_{food+drink} ($r = 0.6$; $p < 0.001$) and ED_{food} ($r = 0.4$; $p < 0.05$). Children with higher BMI z-scores tended to eat more at the meal, both total weight of food ($r = 0.38$; $p < 0.005$) and total energy ($r = 0.28$; $p < 0.05$). There was a non-significant trend for BMI z-score to be negatively associated with both ED_{food+drink} ($r = -0.2$; $p = 0.08$) and ED_{food} ($r = -0.2$; $p = 0.09$), such that children with higher BMI z-scores tended to select meals of lower ED.

Discussion

This study of primarily middle-to-lower income children from diverse ethnic backgrounds reveals that parents who report less restrictive feeding practices have children who eat meals with greater ED of food and beverages in a controlled laboratory feeding environment. The same relationship was found between restrictive feeding and ED of food only, but only in overweight and obese children. This is the first study to demonstrate associations between parental feeding practices and ED selection at meals by children under controlled laboratory conditions. It is important to note that restrictive feeding only explained about 10% of the variance in children's ED selection after adjusting for child age and BMI z-score. Other factors that were not measured in this study, such as energy expenditure and satiety hormones, may explain additional variance in this relationship. Short-term ED selection may have implications for total daily energy intake (Bell & Rolls, 2001) and obesity (Poppitt & Prentice, 1996). The idea that parental feeding practices such as restriction may be useful predictors of short and long-term energy intake should be investigated to establish the potential implications for childhood obesity prevention.

Another novel finding was that the pattern of results differed based on the type of "restrictive feeding" parents reported, as assessed by the CFQ (Birch et al., 2001). The CFQ is one of the most common measures of parental feeding attitudes and practices in the literature, and its psychometric properties are validated for Caucasian (Birch et al., 2001) and non-Caucasian (Anderson et al., 2005) populations. Of the 8 items that make up this subscale, 6 of the items reflect parents perceived need to restrict their child's access to sweets, snacks, high-fat foods, or his/her favorite foods. As pointed out in Anderson et al. (2005), these items most closely reflect the notion of "restriction", and parents who rate highly on such items can be assumed to carry out similar behaviors with respect to limiting their child's access to foods that are perceived as undesirable. The other 2 items reflect a parents use of sweet, high-fat, or favorite foods as rewards for the child's good behavior. When these variables were considered separately, we often found different relationships to the outcome variables. Most notably, parents reported increased levels of restricted access to palatable foods for children who weighed more, but, they reported decreased use of palatable foods as rewards for children who were heavier. There was also a trend for increased restriction of palatable foods to be negatively associated with ED from foods only, but no such relationship was found with reported use of palatable foods as rewards. These findings underscore the complex nature of "restrictive feeding" as assessed by the CFQ, and they suggest the need to separate this variable to better understand its relationship to childhood obesity.

A second objective of this study was to explore the association between ED and child weight status. Although the relationships we found were only trends and should be interpreted with caution, it is interesting to note that heavier children tended to select meals with lower ED. However, child weight status was positively associated with total energy intake, thus supporting the use of this meal paradigm for measuring and detecting hyperphagia in overweight children. We also found a trend for child age to be positively associated with ED_{food}, and these findings agree with reports from Kral et al. (2007). These findings further call into question the extent to which dietary ED is an important predictor of long-term excesses in energy balance, particularly in children.

Previous studies carried out in non-Hispanic white children from middle- to upper-income families have found that restrictive feeding practices may be associated with greater childhood overweight (Johnson & Birch, 1994) and higher rates of disinhibited eating (Birch et al., 2003; Fisher & Birch, 2002) in girls. Other studies in lower income and minority cohorts have not supported these findings (Baughcum et al., 2001; Powers, Chamberlin, van Schaick, Sherman, & Whitaker, 2006), and the relationship remains debated. A variety of environmental factors, including child gender, ethnicity and acculturation, income, and general parental feeding practices may influence the parent-child feeding relationship (Faith et al., 2003). Excess levels of restriction may be detrimental to the feeding relationships in some families, but may actually protect against the development of obesity in other families, depending on the individual family dynamics that are involved (Brown, Ogden, Vogeles, & Gibson, 2008). As evidenced in the present study, the impact of restricting children's access to palatable foods may be different from the impact of using these foods as rewards. Future investigations should aim to better understand the modifying variables that are involved in determining the outcomes of the parent-child feeding relationship.

We used two methods for calculating ED for the test-meal in the proposed study, though our main outcome measure included both foods and beverages. A comprehensive review by Johnson et al. (2009) offered convincing rationale for calculating dietary ED from foods only, because beverages dilute the overall ED and have different effects on satiety compared to foods. While we agree with this review, we opted to use both calculations in the present study, for the primary reason that the milks and sweetened beverages offered at the meal had similar EDs to some of the food choices. As expected, we found that ED from food only was significantly greater than ED from food and drink. However, both calculations shared similar associations with child BMI z-score, and total energy intake. Where the measures differed is in their relationships to restrictive feeding practices. For all children, higher reports of restrictive feeding were negatively associated with ED_{food+drink}, but not ED from foods only, which suggests that children from highly restrictive feeding environments may have consumed a greater proportion of their total meal calories from beverages. We did not see differences in total or individual beverage intake as a function of restrictive feeding in the present study (data not shown), however, the notion warrants further study. It is interesting to note that while ED from foods only was not associated with restrictive feeding for all children, there was a strong, negative association between ED_{food} and restrictive feeding in overweight children. It is possible that restriction in this subset of children may have a different impact on dietary selection but the reasons for this were not able to be ascertained by the present study.

As seen in several other studies (Faith et al., 2004b; Powers et al., 2006) maternal obesity modified the relationship between reported restriction and child weight status. However, in contrast to these previous studies that showed positive relationships in obese mothers between maternal restriction and child weight status, our findings showed just the opposite. For *non*-obese parents, greater restriction was associated with increased child weight status, and the relationship was highly significant. For overweight and obese mothers, the relationship was in the opposite direction, although it did not reach significance. Parental weight status did not modify the relationships between feeding practices and ED or total energy intake at the meal. At this time, it is not clear why the present findings are different from those reported by others (Faith et al., 2004b; Powers et al., 2006), but the small sample size and diverse ethnic backgrounds of the families in this study may provide some explanation.

There are several strengths and limitations to this study. Food intake was measured by direct observation across 4 meals, a method that is without the well-known biases inherent in dietary surveys. However, single meal intake in a laboratory may not reflect children's usual intake in the "real world". While we purposely chose foods that are familiar to most children, not all of the children had equal levels of exposure to these foods prior to the study. In addition, the palatable foods used in these test-meals may not have been the same foods that were highly restricted in the home environment, so the observed associations may have been weakened, or not reflective of the relationships observed in studies that have used palatable, highly restricted foods (Birch et al., 2003). Furthermore, because we did not conduct an exit interview with children after the study to determine how they believed their parents would have felt about their food selection, we cannot draw conclusions about the role that restrictive feeding played in consumption of the specific laboratory test foods. It is possible that increased reports of restrictive feeding were associated with different patterns of meal intake (e.g. greater intake of beverages) that consequently decreased the energy density of the meal, but additional studies are needed before these conclusions can be confirmed. Moreover, the cohort that participated in this study was ethnically diverse, with Caucasians representing less than 20% of the sample. This is both a strength and limitation. These research questions have not been previously explored in primarily non-Caucasian cohorts. However, interpretation of the findings can be limited because our sample size was not large enough to perform the primary analyses within each ethnic group. Additional limitations were that maternal education level was not collected and maternal BMI was collected by self-report instead of direct observation. This was an unintentional oversight in the study protocol. Finally, the study was cross-sectional, so it is not possible to determine if restriction is a causal factor in ED selection in children.

Conclusion

In this sample of ethnically diverse children from a major metropolitan area, greater restrictive feeding practices were associated with selection of lower energy density foods and beverages in a controlled feeding paradigm. In overweight children only, greater restrictive feeding practices were strongly associated with reduced energy density from food items at these meals. The notion that for some families, greater restriction of feeding may serve as a strategy to prevent overeating under certain conditions should be investigated.

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Fig. 1. Children's ($n = 70$) average $ED_{\text{food+drink}}$ consumed at the 4 laboratory test meals adjusted for child age and BMI z -score as a function of reported restrictive feeding practices. Increased reports of restrictive feeding are associated with lower adjusted $ED_{\text{food+drink}}$ scores ($r = -0.3$; $p < 0.05$).

Fig. 2.

In overweight and obese children only ($n = 24$), increased reports of restrictive feeding are associated with lower ED_{food} . These relationships remained after adjusting for child age.

Table 1

Energy densities and macronutrient breakdown of foods and beverages offered at *ad libitum* test-meals.

Food	Energy density(kcals/g)	% Fat	% Carbohydrate	% Protein
Macaroni and cheese	3.7	12.0	74.0	14.0
String beans	0.2	0.0	80.0	20.0
Baby carrots	0.4	11.0	81.0	8.0
Mozzarella cheese sticks	2.9	66.0	0.0	34.0
Graham crackers	4.2	23.0	71.0	6.0
Pudding	1.1	11.0	82.0	7.0
Whole milk	0.6	48.0	31.0	21.0
Fruit punch	0.5	0.0	100.0	0.0
Cola	0.4	0.0	100.0	0.0
Apple juice	0.4	0.0	100.0	0.0
Whole chocolate milk	0.8	22.0	62.0	16.0

Table 2

Characteristics of 4–6-year-old children ($n = 70$) in study.

Variable	Frequencies n (%)	Mean (SD)
Sex		
% Male	34 (48.6)	N/A
% Female	36 (51.4)	N/A
Ethnicity		
% African-American	24 (34.3)	N/A
% Hispanic	21 (30.0)	N/A
% Caucasian	14 (20.0)	N/A
% Asian	2 (2.9)	N/A
% “Other”	9 (12.8)	N/A
Weight Status		
% underweight	2 (2.9)	N/A
% normal weight	43 (61.4)	N/A
% overweight	7 (10.0)	N/A
% obese	18 (25.7)	N/A
Age (year)	N/A	5.2 (0.8)
BMI z -score	N/A	1.1 (1.1)
Energy intake (kcal)	N/A	543.0 (289.6)
ED _{food+drink} (kcal/g)	N/A	2.5 (0.8)
ED _{food} (kcal/g)	N/A	1.8 (0.7)
Restriction (range 1–5)	N/A	3.3 (0.9)