

# Differential Maternal Feeding Practices, Eating Self-Regulation, and Adiposity in Young Twins

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## KEY WORDS

pediatrics, psychosocial, genetics, adiposity, parenting practices

## ABBREVIATIONS

%BF—percent body fat

CFQ—Child Feeding Questionnaire

COMPX%—caloric compensation

DXA—dual energy x-ray absorptiometry

DZ—dizygotic

MZ—monozygotic

NSE—nonshared environment

Ms Tripicchio carried out the initial analyses and drafted the initial manuscript; Dr Keller conceptualized and designed the study, and collected data; Ms Johnson contributed to the writing of the initial manuscript; Dr Pietrobelli conceptualized and designed the study; Dr Heo conceptualized and designed the study, and reviewed the data analyses; Dr Faith conceptualized and designed the study, collected data, contributed to the initial writing of the manuscript, and reviewed the data analyses; and all authors critically reviewed and revised the manuscript and approved the final manuscript as submitted.

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**WHAT'S KNOWN ON THIS SUBJECT:** Restrictive feeding by parents is associated with poorer eating self-regulation and increased child weight status. However, this association could be due to confounding home environmental or genetic factors that are challenging to control.



**WHAT THIS STUDY ADDS:** Differential maternal restrictive feeding is associated with differences in twins' caloric compensation and BMI z score. Controlling for the shared home environment and partially for genetics, these findings further support a true (ie, unconfounded) association between restriction and childhood obesity.

## abstract



**OBJECTIVE:** Restrictive feeding is associated with childhood obesity; however, this could be due to other factors that drive children to over-eat and parents to restrict (eg, child genetics). Using a twin design to better control for confounders, we tested differences in restrictive feeding within families in relation to differences in twins' self-regulatory eating and weight status.

**METHODS:** Sixty-four same-gender twin pairs (4–7 years old) were studied with their mothers. Child caloric compensation ability (COMPX% index) was assessed by using a laboratory-based protocol. The Child Feeding Questionnaire assessed mothers' self-reported feeding styles toward each twin. Child BMI (kg/m<sup>2</sup>) and BMI z score were calculated by using measured weight and height; percent body fat and waist circumference were also assessed. Partial correlations examined within-twin pair differences in Child Feeding Questionnaire subscales in relation to within-twin pair differences in anthropometry and caloric compensation (COMPX%).

**RESULTS:** Differences in maternal restriction were significantly associated with within-pair differences in child COMPX% and BMI z score. Mothers reported more restriction toward the heavier and more poorly compensating twin. Additionally, within-pair differences in parental pressure to eat were associated with significant differences in BMI z score, percent body fat, and waist circumference. Mothers were more pressuring toward the lighter twin.

**CONCLUSIONS:** Mothers vary in their feeding practices, even among same-gender twin pairs, which might influence differences in adiposity. Future research needs to elucidate cause-and-effect and intervention implications regarding parental restriction and pressure-to-eat prompts. *Pediatrics* 2014;134:e1399–e1404

One of the major discoveries in the field of child development is that siblings, despite living in the same household, have their own “nonshared” environments (NSEs).<sup>1–3</sup> NSEs include unique interactions with parents and peers and influence behavioral outcomes, including growth and development.<sup>4,5</sup> NSEs also impact children’s adiposity,<sup>6–8</sup> as well as their dietary patterns,<sup>9</sup> eating rate,<sup>10</sup> food preferences,<sup>11</sup> appetite,<sup>12,13</sup> and food neophobia.<sup>14</sup> A challenge, however, has been to identify specific factors in NSEs that drive pediatric obesity. Study designs necessary to discover NSEs typically require biologically related children (eg, siblings, adoptees, twins) who can be compared with respect to unique life exposures, while controlling for shared genetic and environmental factors. Despite this barrier, the study of siblings is a powerful research strategy for identifying environmental determinants of behavior.<sup>15,16</sup> Might certain parental feeding practices (in particular, restrictive feeding) be an NSE driver of child overconsumption and obesity? Restrictive feeding, or controlling children’s access to and intake of certain foods, is associated with child overeating and obesity,<sup>17,18</sup> and might disrupt children’s ability to self-regulate food intake.<sup>19</sup> Restriction may also interact with poorer self-control to exacerbate excess weight gain in children.<sup>20</sup> However, few family studies have addressed this question and most study designs are limited to the use of sibling pairs. Payne et al<sup>21</sup> reported that differential restrictive feeding toward siblings was related to differential levels of concern about child weight rather than objective differences in weight. Farrow et al<sup>22</sup> reported that, within families, mothers were more restrictive toward children who reportedly were fussier and had a greater desire to drink beverages compared with their siblings. On the other hand, Saelens et al<sup>23</sup> reported no differences in maternal control between

obese and nonobese siblings who were 7 to 12 years old. Other parental feeding practices of interest include pressure to eat, characterized by parental force to consume food, and monitoring, or oversight of child eating behavior by parents.

The main purpose of this study was to test whether mothers’ differential restrictive feeding was associated with differences in children’s self-regulatory eating, specifically, caloric compensation ability (COMPX%, defined below) and weight status, within same-gender twins (4–7 years). We hypothesized that differential restrictive feeding would be associated with differences in children’s COMPX% and weight status. Specifically, we predicted that greater maternal restrictive feeding toward one twin, relative to his or her cotwin, would be associated with poorer self-regulatory eating behavior (favoring overconsumption) and higher BMI z scores for the restricted twin. To fully characterize parent-feeding practices and understand their associations with child eating behavior and weight status, we also examined within-family differences in the 2 other feeding practices assessed by the Child Feeding Questionnaire (CFQ): pressure to eat and monitoring. As with restriction, we examined whether within-family differences in these traits were associated with differential child weight status and COMPX%. Previous research has linked pressure to eat prompts with reduced child weight status,<sup>24,25</sup> but associations with monitoring generally have not been found.

## METHODS

### Sample

A total of 69 same-gender twin pairs participated in Project Grow-2-Gether,<sup>26,27</sup> including 40 monozygotic (MZ) and 29 dizygotic (DZ) pairs. Participants were recruited through twins’ clubs, *Twins Magazine*, general newspaper advertisements, targeted mailings, and word-of-mouth.

Participants were compensated \$175 for participation in appreciation of their time and travel. Children 4 to 7 years old and their mothers visited the New York Obesity Research Center, St Luke’s–Roosevelt Hospital, for 4 assessments over 2 weeks. Visits were 1 to 2 weeks apart and each visit lasted ~60 to 75 minutes. The energy compensation protocol was performed on the first 2 visits and body composition assessments were collected on the third or fourth visit. On the third and fourth visits, we video-recorded mother-child interactions during structured laboratory lunch meals to objectively assess feeding dynamics. Mothers ate separately with each twin during these visits, which was replicated across visits 3 and 4 to evaluate reliability. Further details of these procedures are provided elsewhere.<sup>14,26</sup>

For the present report, we examined 64 twin pairs (39 MZ, 25 DZ pairs) who had complete data for the compensation protocol, the CFQ, and child weight and height measures. Twin assignment within families (eg, twin 1 vs 2) was randomly designated before the first assessments occurred. Parental consent was obtained at the beginning of the first visit, and the study received full approval from the institutional review board of St Luke’s–Roosevelt Hospital.

## Measures

### Self-Regulatory Eating

We used an established preloading paradigm<sup>28,29</sup> to assess children’s caloric compensation. In brief, parents were instructed not to feed their children any meals or snacks for at least 2 hours before their visit. We did not assess children’s full dietary intake for the morning of or 24 hours before the visit because of concerns of participant burden. During the first 2 laboratory visits, children were randomly assigned to receive cherry-flavored carbohydrate drink preloads (173 g) on arrival that were either low

calorie (3 kcal) or high calorie (159 kcal). Whichever treatment (eg, low-calorie or high-calorie preload) was assigned on the first visit was reversed on the second visit. After drinking the preload, the twins were given a 25-minute play period. Preloads were weighed during the play period to calculate consumption. After the play period, twins were served a multi-item lunch; they could eat as much as they wanted and were able to request additional servings. Food items included macaroni and cheese (133 g), canned string beans (57 g), string cheese (30 g), graham crackers (25 g), green grapes (113 g), baby carrots (35 g), and whole milk (513 g). The total caloric value of all the food items and milk, collectively, was approximately 935 kcal. Meal intake following each preload (high and low) was calculated for each twin and used to determine compensation ability.

Compensation ability was operationalized as the percentage compensation index (COMPX%):

$$\text{COMPX}(\%) = \frac{\text{Meal}_{\text{low}} - \text{Meal}_{\text{high}}}{\text{Preload}_{\text{high}} - \text{Preload}_{\text{low}}} (100),$$

where  $\text{Meal}_{\text{low}}$  is the energy intake from the lunch meal after the low-energy preload,  $\text{Meal}_{\text{high}}$  is the energy intake from the lunch meal after the high-energy preload,  $\text{Preload}_{\text{high}}$  is the energy consumed from the high-energy preload intake (ie, 159 kcal, assuming the entire drink was consumed), and  $\text{Preload}_{\text{low}}$  is the energy consumed from the low-energy preload intake (ie, 3 kcal assuming the entire drink was consumed). Better compensation indicates the ability to adjust caloric intake in a meal relative to the calories in the preload. Specifically, COMPX% is a continuous measure scaled such that 100% reflects “perfect” compensation. This is achieved when the difference in the child’s lunch intake over the 2 sessions is equal to the difference in the amount of energy between the 2 respective preloads consumed (high and low).

To illustrate this formula, consider a child who consumes exactly 456 kcal at lunch after the low-energy preload and 300 kcal at lunch after the high-energy preload. Plugging these values into the formula yields  $([456 - 300]/[159 - 3]) * 100$ , or  $\text{COMPX}\% = 100\%$ . Had this child consumed 800 kcal rather than 300 kcal after the high-energy preload (with all else the same), this would have yielded  $([456 - 800]/[159 - 3]) * 100$ , or  $\text{COMPX}\% = -220.51\%$ . But had this child consumed only 150 kcal after the high-energy preload (with all else the same), this would have yielded  $([456 - 150]/[159 - 3]) * 100$ , or  $\text{COMPX}\% = 196.15\%$ . Thus, 100% is perfect compensation, with progressively lower, negative scores reflecting the tendency to overeat after the high-energy preload relative to the low-energy preload (“undercompensation”). Progressively higher scores reflect the tendency to undereat after the high-energy relative to the low-energy preload (“overcompensation”). Undercompensation, leading to overconsumption, has been associated with overweight status.<sup>28</sup>

### Parental Feeding Practices

The CFQ<sup>30</sup> was administered to mothers to assess self-reported feeding practices (eg, restriction, pressure to eat, and monitoring). Restriction indicates the extent to which parents limit their child’s access to foods, pressure to eat assesses parents’ propensity to try to force their children to consume more food, and monitoring is used to determine the degree to which parents oversee their child’s eating.

### Anthropometry

Each child’s height and weight were measured and converted to weight and adiposity indexes. BMI, BMI z scores, and percentiles were calculated by using appropriate age- and gender-specific cut-offs for height and weight.<sup>31</sup> Each child’s waist circumference was measured and dual energy x-ray absorptiometry (DXA)<sup>32</sup>

was used to assess percent body fat (%BF). Of the 128 children (from the 64 families) analyzed in this report, only 105 had waist circumference measures and 95 had DXA measures.

### Data Analytic Plan

Descriptive statistics are presented as means and SDs. To test our hypotheses, differences between each twin pair were calculated to create a within-pair difference score for each variable. Differential parental practices also were calculated to create a differential parent score within each twin pair. Partial correlations (adjusting for child gender and zygosity; eg, MZ or DZ) tested whether within-family differences in CFQ subscales were associated with within-family differences in child anthropometric measures and COMPX%. All statistics were analyzed by using SPSS (version 22; IBM SPSS Statistics, IBM Corporation, Chicago, IL).

## RESULTS

Descriptive statistics are presented for each twin (Table 1). The mean child age was 58.4 (17.7) months and the race/ethnicity breakdown was 52% white, 17% African American, 15% Hispanic, 3% Asian, and 13% other or mixed background. Most mothers were college educated or higher (59%), married (75%), and currently employed (58%).

Pearson correlation coefficients represent the associations between within-pair differences in maternal feeding practices and within-pair differences in child adiposity and self-regulatory eating measures (Table 2). Within-pair differences in restrictive feeding were associated with within-pair differences in BMI z score ( $r = 0.31$ ,  $P = .014$ ). As predicted, mothers reported being more restrictive toward their relatively heavier twin compared with the lighter cotwin. Additionally, the within-pair difference in self-reported pressure to eat was negatively associated with within-pair

**TABLE 1** Descriptive Statistics for Child Age, Child Anthropometric Measures, and Parental Feeding Practices, Presented by Twin Number

	Twin 1 Mean (SD)	Twin 2 Mean (SD)	Mean Differential Score (SD)
Age, mo	58.37 (17.67)	58.37 (17.67)	N/A
Height, m	1.07 (0.10)	1.06 (0.11)	0.00 (0.03)
Weight, kg	18.30 (4.05)	18.66 (5.84)	-0.37 (4.09)
COMPX%	101.01 (120.44)	76.57 (121.82)	24.43 (148.75)
CFQ-Restriction	2.83 (0.80)	2.89 (0.83)	-0.06 (0.68)
CFQ-Pressure to Eat	2.69 (1.03)	2.68 (1.08)	0.01 (0.98)
CFQ-Monitoring	3.64 (1.08)	3.43 (1.15)	0.21 (0.62)
BMI, kg/m <sup>2</sup>	15.85 (1.48)	16.02 (2.42)	-0.18 (2.34)
BMI z score	0.11 (1.07)	0.11 (0.94)	0.001 (0.92)
BMI%	53.97 (28.07)	52.88 (26.42)	1.09 (23.81)
%BF	15.36 (5.31)	14.91 (6.09)	0.40 (5.42)
Waist circumference, cm	51.85 (4.14)	52.33 (7.30)	-0.12 (1.10)

Data presented are means ( $\pm$ SDs) for each of the variables. Anthropometric measures were obtained in a body composition laboratory and feeding measures were obtained from the CFQ.<sup>30</sup> The means for twins 1 and 2 did not significantly differ for any of the measures ( $P > .05$ );  $n = 64$  families (128 children) for measures of child age, height, weight, COMPX%, CFQ-Restriction, CFQ-Pressure to Eat, CFQ-Monitoring, BMI, BMI z score, and BMI%;  $n = 47$  families (94 children) for measures of child %BF;  $n = 50$  families (100 children) for measures of child waist circumference. BMI%, BMI percentile; N/A, not applicable.

differences in BMI z score ( $r = -0.40, P = .001$ ), %BF ( $r = -0.38, P = .009$ ), and waist circumference ( $r = -0.40, P = .004$ ). Mothers encouraged greater food intake by the lighter twin relative to the heavier cotwin. There were no significant associations for monitoring.

Compensation ability (COMPX%) was negatively associated with parental restriction ( $r = -0.27, P = .034$ ), as predicted. Mothers were more restrictive toward the twin showing poorer compensation (favoring overconsumption) relative to the cotwin showing better compensation. No other significant associations were shown for compensation ( $P > .05$ ).

## DISCUSSION

We found that mothers differed in their feeding practices toward children, even

though they were same-gender twin pairs, and these differences related to child weight status. Mothers reported more restrictive feeding practices toward their heavier compared with their lighter twin; additionally, mothers were more restrictive toward the twin with poorer compensation favoring overconsumption. The long-term outcomes of restriction and compensation ability cannot be assessed in this study, although other studies have linked poorer compensation to increased weight status over time.<sup>20,33</sup> Additionally, our findings align with a related body of literature on self-regulation and childhood obesity. Specifically, poorer self-control and delay of gratification in early childhood are associated with a higher weight status or greater weight gain later in life.<sup>34-38</sup> Future research should examine whether restrictive feeding

impedes children's delay of gratification and impulsivity.

We also found that differential pressure to eat within families was associated with differences in twins' adiposity. Specifically, the children receiving increased pressure to eat had a lower BMI, BMI z score, %BF, and waist circumference compared with their cotwins. Previous studies have shown this association between pressure to eat and lower child weight status across families,<sup>39,40</sup> and experimental studies have found that pressuring children to eat (eg, "Finish your soup, please") can have counterproductive effects on a child's eating and food preferences.<sup>41</sup> Pressuring a child to eat beyond satiety might also contribute to excess weight gain.<sup>42</sup> Interestingly, unlike restriction, differential pressure to eat was not related to differential caloric compensation in our sample, suggesting an alternative mechanism other than disrupted eating regulation.

Our findings should be considered in light of study limitations. First, as this was cross-sectional research, the causal direction of associations cannot be determined. Second, as we used same-gender twin pairs, we could not test for gender differences in feeding practices within families. The use of opposite-gender DZ twin pairs could be a powerful strategy for addressing this question. Third, we did not explore other feeding styles that have been examined in the literature, such as indulgent feeding, which have been linked to obesity in lower-income families.<sup>43-46</sup> Finally, this study was conducted in a laboratory setting and drawing conclusions to eating behavior in the home setting should be done conservatively.

One of the strengths of this study was the use of same-gender twins to control for a shared home environment, which is perfectly correlated among MZ and DZ twin pairs. The design also partially controls for genes, as MZ twin pairs are

**TABLE 2** Pearson Correlation Coefficients Representing the Associations Between Within Twin-Pair Differences in Maternal Feeding Practices and Within Twin-Pair Differences in Child Adiposity and Self-Regulatory Eating Measures

	$\Delta$ Restriction	$\Delta$ Pressure to Eat	$\Delta$ Monitoring
$\Delta$ COMPX%	-0.27*	-0.04	-0.20
$\Delta$ BMI, kg/m <sup>2</sup>	0.16	-0.42**	-0.09
$\Delta$ BMI z score	0.31*	-0.40**	-0.06
$\Delta$ %BF	0.23	-0.38*	0.08
$\Delta$ Waist circumference, cm	0.05	-0.40*	-0.08

Weight and height measures were assessed in a body composition laboratory. Parental feeding practices were assessed by the Child Feeding Questionnaire.<sup>30</sup>  $\Delta$  refers to the difference score (ie, twin 1 minus twin 2) within twin pairs for each respective measure.  $n = 64$  families (128 children) for measures of COMPX%, BMI, and BMI z score;  $n = 47$  families (94 children) for measures of child body fat;  $n = 50$  families (100 children) for measures of child waist circumference;  $n = 64$  families (128 children) for measures of CFQ-Restriction, CFQ-Pressure to Eat, and CFQ-Monitoring. \* $P < .05$ ; \*\* $P \leq .001$ .

genetically identical and DZ twin pairs share 50% of their genetic variation on average. This provides stronger evidence for true (eg, unconfounded, population-level) associations among the CFQ subscales, anthropometrics, and COMPX%. Another study strength was that children's body composition assessment included DXA and waist circumference. Pediatric obesity treatment and prevention studies are increasingly focusing on feeding practices as intervention targets.<sup>47</sup> In a family-based obesity treatment study, decreases in child weight status were associated with decreases in parental concern and parental restriction.<sup>48</sup>

More recently, a family-based intervention targeting "division of responsibility" feeding decreased parental pressure-to-eat prompts and restriction (girls only) in parents of children at risk for obesity.<sup>49</sup> More controlled trials are needed to evaluate how changes in restrictive feeding impact child eating and weight control. Additionally, parents should be cautious about overly restrictive feeding practices that might disrupt children's self-regulation. Instead, parents might use covert rather than overt control strategies to limit access to energy-dense foods at home.<sup>50</sup>

## CONCLUSIONS

Even mothers of twins differentially encourage and restrict their children's eating behaviors. Differential restrictive parenting was associated with differences in twins' caloric compensation ability and BMI z score. Mothers also differentially pressured twins to eat, which was inversely associated with differences in twins' adiposity. Feeding practices may be part of the NSEs contributing to pediatric obesity. These relationships should be further explored to establish directionality and to guide intervention development.<sup>49</sup>

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