Prospective Associations of Eating Behaviors with Weight Gain in Infants

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Objective: To examine whether maternal reports of infant eating behaviors are stable over time and whether eating behaviors are prospectively associated with weight gain.

Methods: In an ongoing study of infant growth, weight and length were measured at 2 weeks, 3 months, and 5 months of age. Food responsiveness (FR), satiety responsiveness (SR), enjoyment of feeding (EF), and slow eating (SE) were assessed with the Baby Eating Behavior Questionnaire. Repeated measures ANOVA was used to examine changes in eating behaviors from 2 weeks to 5 months. Simple Pearson correlations examined associations among eating behaviors across time and associations of eating behaviors with subsequent change in weight-for-length z-scores.

Results: Among 31 infants studied from 2 weeks to 3 months, FR and SR remained consistent ($P < 0.05$), and among 21 infants studied from 3 to 5 months, FR, EF, and SE were consistent ($P < 0.01$). Infants ate more quickly ($P < 0.01$) and tended to have greater SR with age ($P = 0.09$). Only SE at 3 months was associated with subsequent gain in weight-for-length ($P < 0.05$).

Conclusions: Consistent with previous research, SE was predictive of weight gain during infancy. Given that eating behaviors were largely consistent after 3 months of age, it may be important to encourage the development of healthy eating behaviors during early infancy.

Introduction

Almost 17% of children in the United States have a body mass index (BMI) greater than the 95th percentile, characterizing them as obese (1). Minority children are particularly burdened by obesity, with 20% prevalence in African American children and 22% prevalence in Hispanic children, compared to 14% among Caucasians (1). Childhood obesity is associated with serious metabolic health conditions such as high blood pressure, type 2 diabetes, and non-alcoholic fatty liver disease (2). Furthermore, deleterious psychological consequences, such as low self-esteem, depression, anxiety, and behavior problems, are also associated with obesity (3). Children with obesity have a much greater risk of having obesity as adults, as well as having more severe obesity than those who did not have obesity during childhood (4,5). It is important, therefore, to identify potential contributors to obesity early in life.

One of the most consistent predictors of childhood obesity is rapid infant weight gain. Studies have consistently shown that rapid weight gain in the first 6 months is associated with overweight and obesity during childhood (6-9), adolescence (10,11), and adulthood (10,12). One study found that children who had rapid weight gain in infancy were nearly 10 times more likely to have obesity at 4 years old than children who had not experienced rapid infant weight gain, irrespective of children’s ethnicity or history of breast- versus formula-feeding (13). Furthermore, excess weight gain during the first, but not the second, 6 months of life, has been associated with relatively greater trunk fat among 1-year-olds (14) and among 4- to 20-year-old individuals (15). This is particularly important given the association between abdominal obesity and adverse metabolic health [for review see (16,17)]. Less is known about the more immediate consequences of rapid weight gain during infancy, but at least one study has shown an association between activity level and fat mass during infancy (18), which may suggest that infants who have experienced a rapid rate of weight gain may be less active, which could potentially contribute to more weight gain thereafter. Additionally, ethnic minority infants are at an increased risk for rapid infant weight gain, and this may be at least partially attributable to a shorter duration of exclusive breastfeeding and the earlier introduction of solid foods (19).

Eating behavior may play a role in rapid infant weight gain and subsequent obesity. In studies of older children, those who have obesity show less responsiveness to internal satiety signals (20,21), eat more quickly during meals (22,23), and show greater sensitivity to food...
cues than healthy weight children (24). There are few studies among infants, but in a longitudinal study, parent-reported infant response to food cues and enjoyment of food were associated with subsequent weight gain (25,26). However, one limitation of this study was that parents were asked when their children were 8 months of age to report the feeding behavior of their infants for the first 3 months of life, and so it is possible that the parents’ recall was influenced by the child’s current weight status. In an observational study of infants, Stunkard et al. (27) found that infants with vigorous sucking subsequently gained more weight up to 3 years of age. Together these findings suggest that infant eating behaviors may be an important predictor of subsequent weight gain.

The overall objectives of this study were first, to examine whether maternal reports of infant eating behaviors are consistent across infancy, and second, to examine whether maternal reports of infant eating behaviors are predictive of subsequent weight gain. We hypothesized that mothers would report their infants eating faster and becoming more responsive to food cues as they got older. Furthermore, we hypothesized that maternal reports of low satiety responsiveness, rapid eating, and greater food responsiveness and enjoyment at 2 weeks and 3 months of age would be associated with greater weight gain thereafter. These hypotheses were tested in data collected from a cohort of primarily African American bottle-feeding mother-infant dyads enrolled in an ongoing growth study.

**Methods**

**Participants**

Mothers were recruited in the third trimester of pregnancy as part of a study to investigate metabolic health during pregnancy and infant growth to 3 months of age. Those who completed the 3-month visit were invited to attend another follow-up visit at 5 months of age. Women were excluded from participation in the parent study if they had pre-existing diabetes, had previously delivered a preterm (i.e., <37.0 weeks) or growth restricted (i.e., <2500 g) infant, or had any medical condition during pregnancy that is believed to interfere with normal fetal growth. Infants were excluded if they were born prior to 37.0 weeks’ gestation or were exclusively fed directly from the breast for the first 3 months of life. Only data from infants who attended at least two follow-up visits were included.

**Protocol**

Mothers and infants attended three study-related visits at 2 weeks (17 ± 6 days), 3 months (93 ± 4 days), and 5 months (153 ± 3 days) of age. At each visit, infant length (cm) and weight (g) was obtained using standard clinical procedure, and the Baby Eating Behavior Questionnaire (BEBQ; [28]) was administered to examine infant eating behaviors. Additional data retrieved from prenatal records included: maternal date of birth, race, BMI in early pregnancy, gestational weight gain, infant sex, gestational age at delivery, birth weight, and birth length.

**Baby Eating Behavior Questionnaire**

The BEBQ was adapted from the Child Eating Behavior Questionnaire used for older children, which was originally validated against objective behavioral measures (28,29). The BEBQ asks parents to rate 18 statements on a 5-point scale of never, rarely, sometimes, often or always. Items load onto four subscales: Enjoyment of Eating (EF; e.g., My baby enjoys feeding time); Food Responsiveness (FR; e.g., My baby frequently wants more milk than I have given him/her); Slowness in Eating (SE; e.g., My baby finishes feeding quickly); Satiety Responsiveness (SR; e.g., My baby sucks/drinks more and more slowly during a feed). There is also a fifth subscale, General Appetite, which consists of one item (GA; e.g., My baby has a big appetite). The BEBQ was verbally administered to mothers during the study visits.

**Results**

Forty-seven mothers enrolled in the parent study. Two infants were excluded from follow-up because they were born preterm, and data from one infant who was exclusively fed from the breast was removed. Three infants did not return for any post-partum follow-up visits, and six attended only one visit. Final analyses for the 2-week to 3-month assessments were conducted on data from 31 infants who attended both of these study visits. This number reflects 70% retention of eligible infants from the parent study. There was no difference in birth weight-for-length z-score or gestational age among infants retained for the 2-week to 3-month analyses versus those who were lost to follow-up. Further loss to follow-up was experienced after 3 months, which may be partly due to the fact that this extra follow-up was not part of the original study. Data from 21 infants were included in the 3- to 5-month assessments, which represents 64% of the sample who were informed of this follow-up study. There were no differences in weight-for-length z-scores at birth, 2 weeks, or 3 months among those who were included in the 3- to 5-month analyses as compared to those lost to follow-up. These groups also did not differ in terms of gestational age at delivery and BEBQ scores at 2 weeks and 3 months or feeding mode at 2 weeks. Characteristics of the study participants are shown in Table 1. All except one infant was African American and 61% of the sample was male. The majority of the infants received formula only across the duration of the study, but at 2 weeks of age, 12 were receiving some breastmilk and 1 received rice cereal. By 3 months of age, 1 infant was still receiving some breastmilk and 12 infants were receiving complementary foods (e.g., cereal, baby food, or other table foods). The type of formula used at 2 weeks was reported for all but six of the mothers, with the majority using Similac Advance® (N = 12) or Similac Sensitive® (N = 6). The remainder used another type of Similac formula or did not specify which type it was. Two mothers reported that they had changed formula by the 3-month visit.
and were now using Similac Advance instead of Similac For Spit-Up or Similac Sensitive. The majority of the infants were healthy, with only 5 (16%) mothers reporting use of medication for common gastrointestinal disturbances, such as reflux or gas, at some point in the study.

Table 2 shows associations among the infant eating behaviors from 2 weeks to 3 months and from 3-5 months of age. From 2 weeks to 3 months, maternal reports of FR and SR, but not EF and SE, remained consistent ($P < 0.05$), and there was a trend for general appetite to also be consistent ($P = 0.06$). Partial correlations were also run to examine whether these associations were independent of the exclusivity of formula feeding at 2 weeks and results were similar (not shown). From 3 months to 5 months, maternal reports of FR, FE, SE, and general appetite, but not SR, remained consistent ($P < 0.05$), indicating that the infants ate more quickly as they got older (Figure 1A). Among the 21 infants who attended the first two visits, there was no significant change reported for FR, EF, SR, or general appetite. However, mothers reported a decrease in infant SE over time ($F (30, 1) = 10.01, P \leq 0.01$), indicating that the infants ate more quickly as they got older (Figure 1A). Among the 21 infants who attended the 3rd-5th month visits, mothers reported that SR increased as the infants got older ($F (20, 1) = 5.18, P < 0.05$; Figure 1B), but the other variables did not change significantly.

Table 1 Characteristics of the study sample ($N = 31$ unless noted)

| Variable | Mean ± SD |
|----------|-----------|
| Maternal BMI in early pregnancy (kg/m²) | 29.57 ± 9.11 |
| Gestational age at delivery (weeks) | 39.46 ± 1.20 |
| Birth weight (kg) | 3.22 ± 0.36 |
| Birth length (cm) | 50.19 ± 2.05 |
| Birth weight-for-length z-score | −0.63 ± 1.17 |
| 2 weeks | | |
| Weight (kg) | 3.57 ± 0.37 |
| Length (cm) | 51.44 ± 1.94 |
| Weight-for-length z-score | −0.39 ± 1.28 |
| 3 months | | |
| Weight (kg) | 6.08 ± 0.69 |
| Length (cm) | 60.49 ± 1.90 |
| Weight-for-length z-score | −0.03 ± 0.94 |
| 5 months | | |
| Weight (kg) | 7.14 ± 1.85 |
| Length (cm) | 64.27 ± 5.36 |
| Weight-for-length z-score | 0.36 ± 1.15 |

*$N = 21$.

Discussion

The overall goals of this study were to explore whether maternal reports of infant eating behaviors were consistent over time and whether infant eating behaviors, as reported by the mothers, were predictive of subsequent weight gain. With the exception of SR, maternal reports of their infants’ eating behaviors were more consistent between 3 and 5 months than they were from 2 weeks to 3 months. However, mothers reported that their infants ate more quickly by 3 months of age, as compared to 2 weeks, and they became more responsive to satiety from 3 to 5 months. Although reported eating behaviors at 2 weeks were not predictive of subsequent gain in weight-for-length z-score to 3 months of age, SE at
3 months was inversely associated with weight-for-length z-score gain to 5 months of age.

In this cohort, mothers reported that their infants’ eating behaviors become relatively stable after the neonatal phase, although exactly when and how this occurs is not clear. To our knowledge, there are no other studies that have examined the stability of maternal reports of infant eating behaviors over time, but a study of older children showed that eating behaviors were established by the time children were 4 years of age and remained relatively consistent through 10 years of age, albeit with modest associations ($r = 0.29 – 0.55$; 31).

In this study, the correlation coefficients among most of the eating behaviors were relatively robust (i.e., $0.66 – 0.83$) between 3 and 5 months of age, but it is not known whether this pattern will persist over a longer duration of time, particularly in light of the food transitions that occur during the first few years of life. It is possible that greater consistency is seen among infants in comparison to older children because of the more limited diet of infants. However, given that this association was independent of whether the children were receiving complementary foods at 3 months of age, results from this cohort suggest that, at least during infancy, the mode of feeding may not influence how consistently mothers perceive their children’s feeding behavior to be. It would be of interest in the future to examine whether eating behaviors remain stable into early childhood despite transitioning to table food.

Maternal report of infant SR was the only eating behavior that was not consistent from 3 to 5 months of age, with mothers reporting increased SR with age. Although little is known about SR among very young infants, there is evidence from previous research that satiety regulation is established after the first month or two of life. In survey data from a nationally representative cohort, 4- to 5-month-old infants consumed smaller meals when they had a greater frequency of meals (32). Another study found that by 7 to 14 weeks of age, infants are able to regulate the amount of milk they drink in response to the amount of time that has passed since the previous meal (33). To our knowledge, however, no previous studies have examined whether younger infants respond to internal satiety cues from the first days of life.

Mothers in this cohort also reported that infants ate more quickly as they got older. It is perhaps not surprising that infants would become more efficient at eating as they mature. It is interesting to note, however, that despite the overall change in speed of eating, infants who were reported to be relatively quick at eating at a young age remained so as they aged. Speed of eating among adults has been associated with obesity (34,35), and this is consistent with the Stunkard et al. finding that infants with more vigorous sucking had a greater body weight at 3 years of age (27). We found a similar trend in the current study for greater weight gain from 3 to 5 months of age among those who were reported to be more rapid eaters at 3 months of age. If these findings are confirmed in a larger prospective cohort, it may be interesting in the future to examine whether an intervention to slow infant intake could reduce the risk for rapid weight gain.

In this study, there was also a trend for FR at 3 months to be prospectively associated with greater gain in weight-for-length. Although our sample is small, this finding is consistent with previous research among infants (25,26) and with studies among adults and older children showing that FR is associated with obesity (20,24,36-39). In addition, given that FR was reported to be relatively consistent across the ages examined, these data suggest that

| Eating behavior               | 2 weeks × 3 months$^a$ | 3 months × 5 months$^b$ |
|-------------------------------|------------------------|-------------------------|
| Enjoyment of food             | 0.16                   | 0.72***                 |
| Food responsiveness           | 0.63**                 | 0.83***                 |
| Slowness in eating            | 0.21                   | 0.64**                  |
| Satiety responsiveness        | 0.38*                  | 0.30                    |
| General appetite              | 0.34$^c$               | 0.66**                  |

$^aN = 31$.  
$^bN = 21$.  
$^c0.05 < P < 0.10$.  
$^*P < 0.05; **P < 0.01; ***P < 0.001$.  

Figure 2 Weight-for-length z-score gain from 3 to 5 months was greater for infants who were reported to be quicker eaters at 3 months of age (A: $r = –0.51$, $P < 0.05$) and tended to be greater among infants who were reported to be relatively more responsive to food cues at 3 months of age (B: $r = 0.39$, $P = 0.08$).
FR may be established during the early neonatal phase. It will be of interest in the future to examine reasons for individual differences in infant FR and mechanisms that underlie the generalization of this behavior from breast to bottle and to cues associated with table food.

There are several limitations of this study that should be addressed. First, this study was conducted in a small, homogenous sample, and as such, it is not known whether the results will generalize to breastfed infants and to those of other racial or ethnic groups. Further, significant loss to follow-up was experienced across the duration of this study which, although not uncommon in studies of low income families, raises questions about whether data from the later visits was biased. In exploratory analyses, however, those who remained versus those who dropped out of this study did not differ in terms of their feeding behavior scores or weight-for-length prior to drop-out. Another limitation of this study is the use of a parent-report measure rather than objective behavioral measurements, which raises the possibility that parental perception of infant feeding behavior became more consistent with time, rather than there being an actual change in infant feeding behavior. However, the child version of the questionnaire that was used to develop the BEBQ has shown good validity when compared with behavioral measures (29), suggesting that parental report does reflect actual feeding behavior. This study was strengthened by the use of a prospective, longitudinal design, which to our knowledge, has not previously been undertaken.

Together with previous research, the results of this exploratory study suggest that potentially obesogenic feeding behaviors, such as rapid eating, may be established at a very young age and may play an important role in the development of obesity. These implications warrant further study in a larger, less homogenous sample. It will also be of interest in the future to examine whether interventions can change these feeding behaviors during infancy and possibly reduce the risk for overeating and subsequent obesity.

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