

# Associations between Breastfeeding and Maternal Responsiveness: A Systematic Review of the Literature<sup>1,2</sup>

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## ABSTRACT

Recent recommendations and prevention programs have focused on the promotion of responsive feeding during infancy, but more research is needed to understand best practices for fostering responsive feeding during early life. The objective of this systematic review was to synthesize the accumulating bodies of evidence aimed at understanding associations between mothers' feeding experiences and responsive feeding in an attempt to clarify the nature of associations between feeding mode and responsive feeding. A literature search was conducted between January and October 2016; articles were collected from PsychINFO, Medline, and CINAHL, as well as from references in published research and reviews. Article inclusion criteria were as follows: 1) empirical research, 2) included a measure of infant feeding, 3) included a measure of maternal responsiveness, 4) study conducted in human participants, 5) available in English, and 6) study conducted in a developed and/or high-income country. Forty-three studies were identified. Cross-sectional observational studies consistently reported greater responsiveness among breastfeeding mothers than among formula-/bottle-feeding mothers. In addition, longitudinal studies showed that longer breastfeeding durations predicted lower use of nonresponsive feeding practices during later childhood, and some, but not all, found that breastfeeding mothers showed greater increases in responsiveness across infancy than did formula-/bottle-feeding mothers. However, a limited number of longitudinal studies also reported that greater responsiveness during early infancy predicted longer breastfeeding durations. A common limitation among these studies is the correlational nature of their designs and lack of prenatal measures of maternal responsiveness, which hinders our understanding of causal mechanisms. Although 2 randomized clinical trials aimed at promoting maternal responsiveness did not find effects of the intervention on breastfeeding outcomes, these findings were limited by the way in which breastfeeding outcomes were assessed. In sum, although there is consistent evidence for an association between breastfeeding and responsive feeding, more research is needed to better understand the mechanisms underlying this association. *Adv Nutr* 2017;8:495–510.

**Keywords:** breastfeeding, responsive feeding, bottle-feeding, mothers, infants, rapid weight gain, obesity prevention

## Introduction

Evidence-based prevention strategies are needed to reduce the persistently high prevalence of childhood obesity (1). In response to this need, major public health and governmental organizations have begun to recognize infancy as a critical period for determining the risk of obesity and establishing preventive strategies (2–4). Rapid weight gain during infancy has been highlighted as one of the earliest postnatal risk factors for the development of later obesity and metabolic dysfunction and has been recognized as a prime target for prevention and intervention efforts (5–9).

Responsive feeding has been a focal point for current recommendations (2, 3, 10, 11) and prevention programs (12–17) aimed at reducing the risk of rapid weight gain and obesity during early childhood. Responsive feeding is defined as caregivers' recognition and sensitive responsiveness to children's behaviors during feeding interactions (18) and is a facet of responsive caregiving, wherein caregivers recognize and understand children's developmental needs and cues and contingently respond in ways that are predictable and developmentally appropriate (19). Feeding practices that are nonresponsive are characterized by a lack of awareness, understanding, or appreciation of children's needs and/or cues (e.g., encouraging an infant to finish a bottle despite the infant's communication of satiation). In addition, whereas responsive feeding is characterized by an appropriate balance between caregiver and child

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control within the caregiver-child interaction, nonresponsive feeding is characterized by an imbalance, either in the direction of excessive caregiver control (e.g., restrictive feeding practices) or excessive child control (e.g., indulgent feeding practices) (18). Previous research has consistently shown that caregivers' use of nonresponsive feeding practices is associated with the development of poor self-regulation skills, such as tendencies to eat in the absence of hunger, and a higher risk of obesity (18, 20, 21); thus, the promotion of responsive feeding during early infancy holds promise as an effective obesity-prevention strategy.

Despite evidence for benefits of responsive feeding, more research is needed to understand optimal approaches for promoting responsive feeding during early childhood (3, 18, 21). One facet of this field has focused on the potential of feeding mode (breastfeeding compared with bottle-feeding) for influencing mothers' feeding behaviors and mother-infant interactions. In particular, a number of researchers have attempted to understand how mothers' experience with breastfeeding or bottle-feeding may influence the development of feeding practices, thereby influencing infants' eating behaviors and growth outcomes. A prevailing hypothesis within this body of research is that one of the numerous benefits of breastfeeding is that it supports the development of responsive feeding because the inability of a breastfeeding mother to assess infant consumption may help her learn to trust her infant's developing abilities to self-regulate intake and feed in response to satiation cues (22–27). In contrast, it is hypothesized that a bottle-feeding mother's greater ability to assess and control how much her infant consumes may facilitate nonresponsive feeding during infancy and lead to the development and continued use of nonresponsive feeding practices during later childhood (23, 24, 28). If this hypothesis is true, then efforts to promote responsive feeding should primarily focus on breastfeeding promotion, with the understanding that instillation of responsive feeding practices will be a desirable side effect.

Although plausible, this hypothesis does not consider the possibility that certain mothers choose to bottle-feed because they prefer the higher level of control it affords (29, 30). For example, maternal characteristics, such as higher levels of dietary restraint and external eating (30) and anxiety (31) and lower levels of extraversion, emotional stability, and conscientiousness (31), are all predictive of initiation of formula-feeding at birth and shorter durations of breastfeeding. Thus, mothers who choose to formula-/bottle-feed may desire a more structured approach to parenting that is guided by parent-led routines (32), and nonresponsive feeding may not develop from bottle-feeding per se, but rather, drives decisions related to infant feeding. If this alternative hypothesis is true, then efforts to promote responsive feeding should primarily focus on directly promoting maternal responsiveness with the understanding that increasing maternal responsiveness will be an important support for mothers' motivation and ability to breastfeed.

In response to these differing perspectives on the nature of the association between feeding mode and responsive feeding, the objective of the present review is to synthesize the

accumulating bodies of evidence aimed at understanding associations between mothers' feeding experiences and responsive feeding and parenting. This review aims to elucidate whether or how feeding mode influences responsiveness, or vice versa, and to highlight potential areas for future research. To this end, this review attempts to answer the question, does the experience of breastfeeding lead to responsive mothers or do responsive mothers choose to breastfeed?

## Methods

### Literature search

A literature search was conducted between January and October 2016. Articles were collected from PsycINFO (American Psychological Association), MEDLINE via PubMed (US National Library of Medicine), and CINAHL (EBSCOhost). No limits were placed on the publication date of the articles found. The search was repeated in October 2016 to verify that no additional articles had been published. A snowball search strategy was also used to identify additional relevant articles from references in published research and reviews and to cross-check citations in these articles for any missed articles. Study inclusion criteria were as follows: 1) empirical research published in peer-reviewed journals or edited books, 2) included a measure of infant feeding (e.g., breastfeeding, formula-feeding, bottle-feeding, breastfeeding duration), 3) included a measure of maternal responsiveness or nonresponsiveness (within both feeding and nonfeeding contexts), 4) used human participants, 5) article available in English, and 6) study was conducted in a developed and/or high-income country (18). Studies that focused on preterm infants or samples within developing countries were beyond the scope of this review.

Literature searches were conducted by using various combinations of keywords related to feeding mode (breastfeeding or formula-feeding or bottle-feeding or infant feeding or feeding mode) and key words related to maternal responsiveness (19, 33, 34) (responsiveness, responsive feeding, responsive parenting, sensitivity, synchrony, mutuality, emotional support, positive attitude, positive affect, negative attitude, negative affect, stimulation, feeding interaction, feeding practices, controlling feeding practices, restrictive feeding practices, encouragement to eat, pressure to eat, scheduled infant feeding, demand infant feeding, maternal feeding style, maternal parenting style, authoritarian, authoritative, permissive, indulgent, uninvolved).

### Conceptualization of feeding mode and maternal responsiveness

Variation exists within the published literature for the conceptualization and measurement of feeding mode and maternal responsiveness. These constructs are clarified here to allow for consistent terminology throughout the remainder of this review.

**Feeding mode.** The term *feeding mode* is used throughout this review to refer to the method by which breast milk or formula is delivered to the infant (i.e., breast or bottle). This is distinct from *milk type*, which refers to what is being fed (i.e., breast milk or formula). Although consideration of milk type is important given the evidence for effects of milk composition on infant outcomes (35–38), the focus of the present review is on feeding mode.

Many previous studies that examined associations between infant feeding and maternal responsiveness classify infants as formula-fed or breastfed without further describing whether infants were exclusively or partially breastfed or the extent to which infants received breast milk from the breast or a bottle. Thus, feeding mode and milk type are typically confounded for “formula-fed” infants and the extent to which “breastfed” infants consume breast milk from a breast or breast milk from a bottle is unclear, making it difficult to delineate effects of feeding mode from effects of milk type. To best convey the previous literature, the terms formula-/bottle-fed and breastfed are used throughout this review with these caveats in mind. Additional information about whether breastfeeding was exclusive or partial and the extent to which breast milk was fed from a breast or a bottle is included, whenever possible.

**Maternal responsiveness.** As discussed above, responsive feeding and parenting practices and styles can be conceptualized as caregiver sensitivity

and contingent response to children's cues (18, 19, 33, 34). The term *maternal responsiveness* will be used throughout this review to encompass a number of different aspects and variants of this concept that are discussed in related literature, including sensitivity, mutuality, synchrony, emotional support, positive attitude, or responsive stimulation (see references 18, 19, 33, and 34 for a review). Nonresponsive feeding and parenting practices are also considered and conceptualized as control, restriction, encouragement or pressure to eat, feeding an infant on a schedule, and negative attitudes or affect during dyadic interactions (18, 20).

## Results

A total of 43 studies were identified and included in this review. **Tables 1–5** summarize the studies by study design and research question to allow for an evaluation of the strength of the evidence for mechanisms underlying associations between feeding mode and maternal responsiveness.

### Studies describing cross-sectional associations between current feeding mode and maternal responsiveness

Sixteen correlational studies comparing breastfeeding and formula-/bottle-feeding mothers on both observational and self-report measures of maternal responsiveness in feeding and nonfeeding contexts were found (**Table 1**). The consensus among studies that used observational measures of maternal responsiveness during feeding is that mothers show greater sensitivity to infant cues and more responsive feeding practices during breastfeeding than formula-/bottle-feeding. For example, during the first 10 d postpartum, breastfeeding mothers were found to be more likely to give their infants positive attention (39, 41) and to talk affectionately to their infants during feeding gaps than were formula-/bottle-feeding mothers (41). In addition, breastfeeding mothers showed greater sensitivity to (43) and behavioral synchrony with (41) infant feeding cues than did formula-/bottle-feeding mothers.

Studies that used self-report measures of both responsive and nonresponsive feeding show that breastfeeding mothers report more demand- or infant-led feeding and termination of feeding in response to early satiation cues, whereas formula-/bottle-feeding mothers report more scheduled or mother-led feeding and termination of feeding in response to the late satiation cues (22, 29, 30, 40–42, 45). Mothers who breastfed during the first 6 mo also report lower levels of restricting and limiting milk feedings (29, 44), as well as less encouragement of milk feedings (29). However, in one somewhat contradictory study, Rametta et al. (45) reported that, at 4 mo, breastfeeding mothers reported greater use of food to calm their infants and lower awareness of infant cues. In addition, a recent study showed that, among mothers who perceived their infants to have large appetites, those who were formula-/bottle-feeding reported higher levels of restriction than those who were breastfeeding (44), suggesting that mothers' perceptions of infant characteristics may be an important consideration when studying mechanistic associations between feeding mode and mothers' use of responsive and nonresponsive feeding practices (72).

Cross-sectional findings for differences between breastfeeding and formula-/bottle-feeding mothers on measures of maternal responsiveness in nonfeeding contexts have been equivocal. However, these studies had small sample sizes and little consistency in the measure of maternal responsiveness used (**Table 1**). Some studies found that breastfeeding and formula-/bottle-feeding mothers did not differ in their attachment behaviors (e.g., affection, proximity-maintaining) (47) or levels of responsiveness to their infants (52). In a unique study that used psychophysiological measures of maternal responsiveness to infant emotional states during a laboratory-based protocol, Wiesenfeld et al. (46) reported that breastfeeding mothers showed lower cardiac response to their infants' display of positive, neutral, or negative emotions than did formula-/bottle-feeding mothers, as well as lower electrodermal response, in general, to being in the laboratory. In addition, breastfeeding mothers in this study reported greater desire to pick up their infants after viewing the infant's emotional display than did formula-/bottle-feeding mothers, although there were no differences in mothers' self-reported levels of empathy (46).

In support of associations between breastfeeding and maternal responsiveness, others have found that breastfeeding mothers report higher levels of mother-infant mutuality with their infants (48) and exhibit more affectionate touch during a free-play session (49) than do formula-/bottle-feeding mothers. In addition, 2 studies reported that pregnant mothers' intentions to breastfeed during the third trimester were significantly and positively associated with mothers' perceived maternal-fetal attachment (defined as engaging in behaviors that represent affiliation, interaction, and personification of the unborn child) (51, 52).

In sum, the majority of cross-sectional studies support associations between breastfeeding and maternal responsiveness within feeding contexts, with the most consistent support for greater use of demand- or infant-led feeding for breastfeeding mothers and scheduled or mother-led feeding for formula-/bottle-feeding mothers. Whether mothers who breastfeed also show greater levels of responsiveness in nonfeeding contexts is unclear. However, given the correlational nature of these data, they cannot inform as to the direction of the association between feeding mode and maternal responsiveness or provide us with an understanding of the mechanisms underlying these associations.

### Studies exploring whether breastfeeding duration during infancy predicts maternal responsiveness during later childhood

**Table 2** summarizes the 12 studies that used retrospective or longitudinal approaches to test the hypothesis that longer breastfeeding durations are associated with more responsive feeding and parenting practices and styles. The majority of these studies were based on mothers' self-reported duration of any breastfeeding and nonresponsive child-feeding practices [typically the Restriction and Pressure to Eat subscales of the Child Feeding Questionnaire (CFQ) (73)]. Although these

**TABLE 1** Studies examining cross-sectional associations between feeding mode and maternal responsiveness within feeding and nonfeeding contexts<sup>1</sup>

Authors (ref)	Year	Sample size (n dyads)	Infant age	Primiparous, %	Measure of feeding mode	Measure of responsiveness	Results
Measures of responsiveness within feeding contexts							
Bernal and Richards (39)	1970	20 breastfeeding	2 d	NR	Observed	Observed during feeding; coding system: developed by authors	Breastfeeding mothers interacted more and had better synchrony with their infants during feeding. Bottle-fed infants were more often held in a way that allowed for eye contact. Breastfeeding mothers were more likely to report demand-feeding. Bottle-feeding mothers more often reported stopping feeding in response to late satiation cues.
Crow (40)	1977	11 bottle-feeding 50 breastfeeding	3 d	NR	Self-reported	Qualitative interviews	Breastfeeding mothers showed more affection and were more likely to talk during breaks in sucking. Bottle-feeding mothers more often ended sucking bouts by removing the teat. Greater proportion of mothers who breastfed $\geq 4$ mo reported demand infant feeding compared with other groups. Breastfeeding mothers scored significantly higher on NCAFS Sensitivity to Cues subscale. Any breastfeeding was associated with lower levels of encouraging and limiting milk feeds; exclusive breastfeeding was associated with less scheduled feeding and monitoring.
Dunn and Richards (41)	1977	50 bottle-feeding 33 breastfeeding	Birth to 10 d	0	Observed	Observed during feeding; coding system: developed by authors	Mothers who were breastfeeding were more likely to report use of an infant-led routine.
Gubbels et al. (42)	2011	409 exclusively bottle-fed, 878 breastfed <3 mo, 1347 breastfed $\geq 4$ mo	4 mo	NR	Self-reported	Single question about demand vs. scheduled infant feeding	
Singletery and Horodyski (43)	2012	129 <sup>2</sup>	1–12 wk	NR	Observed	Observed during feeding; coding system: NCAFS	
Brown and Lee (29)	2013	140 exclusively breastfeeding, 65 mixed feeding, 185 exclusively bottle-feeding	1–36 wk	54	Self-reported	Self-reported; questionnaire: modified CFQ	
Brown (30)	2014	650 breastfeeding, 81 bottle-feeding	6–12 mo	71	Self-reported	Single question about mother- vs. infant-led feeding routine	

(Continued)

**TABLE 1** (Continued)

Authors (ref)	Year	Sample size (n dyads)	Infant age	Primiparous, %	Measure of feeding mode	Measure of responsiveness	Results
Fildes et al. (44)	2015	574 breastfeeding 1346 bottle-feeding	8 mo	54	Self-reported	Retrospectively-reported; questionnaire: drawn from review of measures (e.g., IFQ, CFQ)	Breastfeeding was associated with lower levels of restrictive feeding. Mothers who perceived their infants to have a greater appetite restricted their infants more if they were bottle-feeding. Exclusive breastfeeding was associated with greater use of food to calm their infants and a lower awareness of infant cues. Mixed or exclusive bottle-feeding was associated with greater concern for infant under-eating and scheduled infant feeding.
Rametta et al. (45)	2015	288 exclusive breastfeeding 195 mixed or exclusive bottle-feeding	4 mo	58	Self-reported	Self-reported; questionnaire: modified IFQ	
Measures of responsiveness within nonfeeding contexts							
Wiesenfeld et al. (46)	1985	24 breastfeeding, 24 bottle-feeding	3–5 mo	50	Self-reported	Physiologic reaction to infant emotion	Breastfeeding mothers exhibited lower cardiac reactivity, were more relaxed under laboratory conditions, and reported greater desire to pick up their infant.
Martone and Nash (47)	1988	15 breastfeeding, 15 bottle-feeding	2 d	NR	Observed	Observed during feeding; coding system: Avant's Maternal-Infant Attachment Tool	There were no differences between groups for display of attachment behaviors.
Viriden (48)	1988	33 exclusive breastfeeding, 13 bottle-feeding, 14 mixed feeding	4–6 wk	100	Self-reported	Self-reported; questionnaire: MAS	Exclusively breastfeeding mothers reported the highest mother-infant mutuality.
Kuzela et al. (49)	1990	11 breastfeeding, 16 bottle-feeding	3–12 mo	85	Self-reported	Observed during free-play session; coding system: adapted from Mahoney 1989 (50)	Breastfeeding mothers affectionately touched their infants more frequently.

(Continued)

**TABLE 1 (Continued)**

Authors (ref)	Year	Sample size (n dyads)	Infant age	Primiparous, %	Measure of feeding mode	Measure of responsiveness	Results
Foster et al. (51)	1996	38 <sup>2</sup>	32–38 wk gestation	NR	Self-reported intention	Self-reported; questionnaire: MFAS	Women who intended to breastfeed reported significantly higher maternal-fetal attachment.
Huang et al. (52)	2004	110 breastfeeding intention, 63 mixed feeding intention, 22 bottle-feeding intention	32–38 wk gestation	NR	Self-reported intention	Self-reported; questionnaire: MFAS	Higher maternal-fetal attachment predicted mothers' intention to breastfeed or mixed feed.
Drake et al. (53)	2007	105 breastfeeding, 72 bottle-feeding	2–4 mo	64	Self-reported	Self-reported; questionnaire: MIRI	There was no association between feeding mode and maternal responsiveness.

<sup>1</sup> CFQ, Child Feeding Questionnaire; IFQ, Infant Feeding Questionnaire; MAS, Maternal Attitudes Scale; MFAS, Maternal-Fetal Attachment Scale; MIRI, Maternal Infant Responsiveness Instrument; NCAFS, Nursing Child Assessment-Parent-Child Interaction Feeding Scale; NR, not reported; ref, reference.  
<sup>2</sup> n for breastfed vs. bottle-fed groups not reported.

studies consistently showed that longer durations of breastfeeding predicted lower levels of some aspects of nonresponsive feeding, discrepancies among studies exist. For example, some studies showed that longer breastfeeding duration predicted lower levels of restriction (26, 27, 54) but not pressure to eat (27) when infants were 12 mo of age, whereas other studies showed that longer breastfeeding duration predicted lower levels of pressure to eat (55, 56) but not restriction (55, 56) at 12 mo. Others found that associations between breastfeeding duration and restriction did not emerge until infants were 24 mo of age (57). It should be noted, however, that several of these studies used a modified version of the CFQ, wherein single questions were used to represent the Restriction and Pressure to Eat subscales (27, 54).

Studies that included other self-report measures of maternal feeding practices showed that mothers who reported longer durations of breastfeeding also reported less scheduled infant feeding and less encouragement of milk feedings during the first 6 mo (29, 57). During the latter part of infancy (7–24 mo), longer breastfeeding durations were associated with higher reported responsive feeding practices and styles (25, 59), greater reported use of structure-related feeding practices during solid-food feedings (e.g., structured meal settings, family meal settings, covert restriction) (59), and lower reported pressuring feeding style (25).

Three studies used observational measures of maternal responsiveness during milk and/or solid-food feeding interactions when infants were 7–24 mo of age and found that longer breastfeeding durations were associated with mothers' greater sensitivity (55, 60) and responsiveness (58) to child cues, less verbal control (55, 60), and more positive behaviors (55, 60). Similar findings for associations between longer breastfeeding durations and greater levels of observed maternal sensitivity to infant cues have also been shown during free-play sessions when infants were 12–14 mo of age (60, 61). In the only study to examine whether longer breastfeeding durations predicted self-reported parenting styles during the first 12 mo, Brown and Arnott (32) reported that mothers who fed breast milk at birth or for longer durations reported a more responsive parenting style (characterized by lower adherence to parent-led infant feeding routines and higher levels of nurturance) than mothers who exclusively formula-fed their infants.

In sum, these studies indicate that mothers who breastfeed for longer durations show greater sensitivity and responsiveness to infant cues during later maternal-child interactions in both feeding and nonfeeding contexts. A strength of this collection of studies is their consistent adjustment for relevant covariates, such as infant sex and mothers' sociodemographic, economic, and anthropometric predictors of breastfeeding continuation. However, major limitations of all of these studies were the correlational nature of their designs and the inclusion of only one post-test measure of maternal responsiveness during the end of infancy. Thus, although this subset of studies can provide support for an association between breastfeeding duration and later maternal responsiveness, they cannot



**TABLE 2** Retrospective or longitudinal studies examining whether breastfeeding duration during infancy predicts mothers' responsiveness within feeding and nonfeeding contexts during later childhood<sup>1</sup>

Authors (ref)	Year	n	Age of infants at assessments	Primiparous, %	Measure of breastfeeding duration	Measure of responsiveness	Results
Measures of responsiveness within feeding contexts							
Fisher et al. (26)	2000	55	12–13 mo, 18 mo	NR	Self-reported	Self-reported at 12 mo; questionnaire: CFQ	Mothers who breastfed for $\geq 12$ mo reported lower levels of control during feeding at 12–13 mo
Taveras et al. (27)	2004	1160	Prenatal, birth, 6 mo, 12 mo	49	Self-reported	Self-reported at 12 mo; questionnaire: modified CFQ	Longer breastfeeding durations were associated with lower restriction, but not pressure to eat; greater concern for child's under- or overeating during the prenatal assessment was associated with shorter breastfeeding duration.
Taveras et al. (54)	2006	1012	Prenatal, birth, 6 mo, 12 mo, 3 y	49	Self-reported	Self-reported at 12 mo; questionnaire: modified CFQ	The negative association between breastfeeding duration and child BMI z score at 3 y was partially mediated by maternal restriction.
Farrow and Blisset (55)	2006	87	12 mo	63	Self-reported	Self-reported; questionnaire: CFQ	Longer breastfeeding duration was associated with lower pressure to eat, but not restriction.
Blisset and Farrow (56)	2007	62	Birth, 6 mo, 12 mo, 24 mo	79	Self-reported	Self-reported at 12 and 24 mo; questionnaire: CFQ	Mothers who did any breastfeeding were less verbally controlling and more positive and displayed more appropriate behavior and higher sensitivity.
Brown et al. (57)	2011	502	6–12 mo	NR	Self-reported	Self-reported; questionnaire: modified CFQ	Longer breastfeeding duration was associated with lower pressure to eat at 12 mo and lower restriction at 24 mo.
DiSantis et al. (25)	2013	154	7–11 mo (n = 79) or 12–24 mo (n = 75)	49	Self-reported	Self-reported; questionnaire: IF-SQ	Mothers who breastfed $\geq 6$ mo reported less scheduled feeding and encouraging milk feedings than mothers who bottle-fed or breastfed $\leq 7$ d. Mothers who breastfed $\leq 7$ d reported less scheduled feeding and encouraging milk feedings than mothers who bottle-fed. In 7- to 11-mo-olds, longer breastfeeding durations were associated with higher responsiveness and lower pressure. In 12- to 24-mo-olds, mothers who breastfed $>6$ mo reported lower pressure than mothers who breastfed 3–6 mo and $<3$ mo.

(Continued)

**TABLE 2 (Continued)**

Authors (ref)	Year	n	Age of infants at assessments	Primiparous, %	Measure of breastfeeding duration	Measure of responsiveness	Results
Hodges et al. (58)	2013	144	7–11 mo or 12–24 mo	48	Self-reported	Observed maternal behaviors during a feeding; coding system: RCFCs	Longer breastfeeding duration was associated with greater responsiveness to infant fullness (but not hunger) cues. Longer breastfeeding duration was associated with lower use of nonresponsive feeding practices and greater use of structure-related feeding practices.
Jansen et al. (59)	2015	458	Birth to 4 mo, 14 mo, 24 mo	100	Self-reported	Self-reported at 24 mo; questionnaire: FPSQ	
Measures of responsiveness within both feeding and nonfeeding contexts							
Farrow and Blisset (60)	2014	74	6 mo, 12 mo	NR	Self-reported	Feeding-specific: observed at 12 mo; coding system: FIS General: observed at 12 mo; coding system: Ainsworth Sensitivity Scales	Longer breastfeeding duration was associated with greater feeding sensitivity and positive vocalizations. Longer breastfeeding duration was associated with greater general sensitivity.
Measures of responsiveness within nonfeeding contexts							
Tharner et al. (61)	2012	675	Birth, 2 mo, 6 mo, 14 mo	62	Self-reported	Observed at 14 mo; coding system: Ainsworth Sensitivity Scales	Longer breastfeeding duration was associated with greater sensitive responsiveness.
Brown and Arnott (32)	2014	508	0–12 mo	29	Self-reported	Self-reported; questionnaire: IPSQ	Mothers who fed breast milk (either from the breast or bottle) at birth and for longer durations reported lower levels of parent-led routine and higher levels of nurturance than mothers who fed formula.

<sup>1</sup>CFQ, Child Feeding Questionnaire; FIS, Feeding Interaction Scale; FPSQ, Feeding Practices and Structure Questionnaire; IPSQ, Infant Feeding Style Questionnaire; NR, not reported; RCFCs, Responsiveness to Child Feeding Cues Scale; ref, reference.



**TABLE 3** Prospective longitudinal studies examining whether breastfeeding predicts change in mothers' responsiveness in feeding and nonfeeding contexts<sup>1</sup>

Authors (ref)	Year	n	Age of infants at assessments	Primiparous, %	Measure of breastfeeding	Measure of responsiveness	Results
Measures of responsiveness in feeding contexts							
Wright et al. (62)	1980	60	3–5 d, 1 mo, 2 mo	NR	Observed at each assessment	Observed at each assessment; coding system: developed by authors	Breastfeeding mothers were less controlling of the feeding at all assessments.
Crow et al. (22)	1980	39	Monthly: birth to 6 mo	48	Observed at each assessment	Observed at each assessment; coding system: developed by authors	Breastfeeding mothers showed greater responsiveness and infant-led feeding at all assessments.
Pridham et al. (63)	2001	99	1 mo, 4 mo, 8 mo, 12 mo	NR	Self-reported at each assessment	Observed at each assessment; coding system: PCERA	Breastfeeding did not predict mothers' levels of or change in positive affective involvement, sensitivity and responsiveness.
Britton et al. (64)	2006	152	32 wk gestation, birth, 3 mo, 6 mo, 9 mo, 12 mo	32	Self-reported and observed; self-reported initiation and duration	Observed at 3 and 6 mo; coding system: NCAFS	Prenatal intentions to breastfeed and breastfeeding initiation were associated with higher sensitivity to infant cues at 3 mo. At 3 mo, breastfeeding mothers had higher sensitivity; at 6 mo, there was no association between NCAFS total score and feeding mode.
Li et al. (28)	2014	1117	Birth, ~monthly to 12 mo, 6 y	NR	Self-reported across 0–6 mo	Self-reported at 6 y; questionnaire: modified CFQ	High bottle-feeding intensity during first 6 mo predicted greater use of pressuring feeding practices at 6 y. No association was seen between bottle-feeding intensity and restrictive feeding practices.
Timby et al. (65)	2014	213	2 mo, 4 mo, 6 mo, 12 mo	NR	Self-reported at each assessment	Self-reported at 4 and 12 mo; questionnaire: modified CFQ	There was no association between feeding mode and restriction at 4 and 12 mo or pressure to eat at 4 mo. Breastfeeding was associated with higher pressure to eat at 12 mo.

(Continued)

**TABLE 3 (Continued)**

Authors (ref)	Year	n	Age of infants at assessments	Primiparous, %	Measure of breastfeeding	Measure of responsiveness	Results
Measures of responsiveness in feeding and nonfeeding contexts Else-Quest et al. (66)	2003	570	Birth, 4 mo, 12 mo	NR	Self-reported	Observed at 4 and 12 mo; coding system: PCERA	At 4 mo, there was no association between feeding mode and PCERA subscales.
							At 12 mo, any breastfeeding was associated with less negative affect, intrusiveness, insensitivity, and inconsistency.
Measures of responsiveness in nonfeeding contexts Pearson et al. (67)	2011	51	Prenatal, 3–6 mo	49	Self-reported at each assessment	Observed at each assessment; measure: attentional bias toward infant distress stimuli	There was no association between prenatal sensitivity and feeding mode at 3–6 mo. At 3–6 mo, breastfeeding mothers showed greater sensitivity to infant distress, even after controlling for prenatal sensitivity.
							At 2–4 wk, breastfeeding mothers showed greater activation.
Kim et al. (68)	2011	17	2–4 wk 3–4 mo	29	Self-reported at each assessment	At 2–4 wk: brain activation in response to own infants' cry; measure: fMRI scan At 3–4 mo: observed; coding system: CIBM	At 2–4 wk, breastfeeding mothers tended to show greater sensitivity to their infants; greater brain activation at 2–4 wk predicted greater sensitivity at 3–4 mo.
							At 3–4 mo, breastfeeding mothers tended to show greater sensitivity to their infants; greater brain activation at 2–4 wk predicted greater sensitivity at 3–4 mo.

<sup>1</sup> CFQ, Child Feeding Questionnaire; CIBM, Coding Interactive Behavior Manual; NCAFS, Nursing Child Assessment–Parent-Child Interaction Feeding Scale; NR, not reported; PCERA, Parent-Child Early Relational Assessment; ref, reference.

**TABLE 4** Retrospective and longitudinal studies examining whether mothers' responsiveness in feeding and nonfeeding contexts predicts breastfeeding duration<sup>1</sup>

Authors (ref)	Year	n	Age of infants at assessments	Primiparous, %	Measure of breastfeeding	Measure of responsiveness	Results
Measures of responsiveness in feeding contexts							
Brandt et al. (69)	1998	42	28–90 h, 6 wk	100	Self-reported	Observed at 28–90 h; coding system: NCAFS	Higher NCAFS scores at 28–90 h predicted breastfeeding at 6 wk.
Brown and Lee (29)	2013	390	1–36 wk	54	Self-reported	Self-reported; questionnaire: modified CFQ	Mothers who initiated breastfeeding but stopped reported higher levels of encouragement compared with mothers who continued to breastfeed.
Britton et al. (64)	2006	152	32 wk gestation, birth, 3 mo, 6 mo, 9 mo, 12 mo	32	Self-reported	Observed; coding system: NCAFS	Among those who initiated breastfeeding, higher sensitivity at 3 mo was associated with longer breastfeeding durations.
Measures of responsiveness in nonfeeding contexts							
Cernadas et al. (70)	2003	539	12–24 h after birth, at hospital discharge, 1 mo, 4 mo, 6 mo	50	Self-reported	Observed at 12–24 h; coding system: bonding rated by trained nurses	Duration of exclusive breastfeeding was significantly longer for dyads with very good bonding compared with those with good or fair bonding.

<sup>1</sup> CFQ, Child Feeding Questionnaire; NCAFS, Nursing Child Assessment–Parent–Child Interaction Feeding Scale; ref, reference.

inform as to whether longer breastfeeding durations lead mothers to develop greater levels of responsiveness.

Only one study included a prenatal measure of mothers' pre-existing concerns for their child's eating and weight as a covariate (27). This study showed that mothers' greater levels of pre-existing concerns for their child's over- or undereating predicted shorter breastfeeding duration (27), which is consistent with the possibility that mothers who choose to breastfeed and who breastfeed for longer durations have different attitudes about feeding before their experience with feeding their children. Although not directly tested in this study, one could speculate that these pre-existing ideas would also interact with infant birth weight and weight-gain trajectories to influence a mother's feeding practices, including both her choice to breastfeed or formula-/bottle-feed, as well as the level of restriction, pressure, and monitoring used during these different feeding modes (55). A growing body of research has begun to examine how mothers' responsive feeding and parenting styles may develop across infancy and in response to feeding and other interactions, as well as whether maternal responsiveness predicts breastfeeding success.

### Prospective longitudinal studies examining whether breastfeeding duration during infancy predicts change in maternal responsiveness across infancy

Nine prospective longitudinal studies with multiple measures of maternal responsiveness were found (Table 3). The longitudinal nature of these studies allows for insights related to whether change in maternal responsiveness across infancy is associated with early feeding experiences or whether maternal responsiveness predicts breastfeeding success. However, these studies used a wide variety of measures of maternal responsiveness (both between and within studies), making a concise summary of findings across studies difficult.

In 2 related studies, wherein the researchers observed feeding interactions of breastfeeding and formula-/bottle-feeding mothers and infants at 1, 4, and 8 wk (62) and monthly across the first 1–24 wk (22) postpartum, formula-/bottle-feeding mothers were more controlling than were breastfeeding mothers at all assessments. Little change was seen in the balance of mother-led compared with infant-led feeding observed during breastfeeding and formula-/bottle-feeding across the first 24 wk postpartum (22, 62).

Two studies that used the Parent-Child Early Relational Assessment to assess mothers' sensitivity and responsiveness during feeding or other interactions produced equivocal findings. In one study, mothers' levels of sensitivity and responsiveness were stable across observed feedings at 1, 4, 8, and 12 mo and breastfeeding duration was not predictive of mothers' levels of or change in sensitivity and responsiveness (63). In the other study, mother-infant interactions were observed at 4 and 12 mo during a feeding and a structured task (66). At 4 mo, there were no differences between mothers who breastfed during the first week postpartum and those

**TABLE 5** Experimental studies examining causal associations between mothers' responsiveness and feeding mode<sup>1</sup>

Authors (ref)	Year	n	Age of infants at assessments	Primiparous, %	Intervention	Outcome measures related to responsiveness or feeding mode	Results
Measures of responsiveness in feeding contexts							
Ventura and Golen (71)	2015	25	2–24 wk	32	Bottle-feeding mothers fed infants under 2 counterbalanced conditions: 1) while using a conventional clear bottle and 2) while using an opaque, weighted bottle	Observed maternal sensitivity and responsiveness during the feeding conditions; coding system: NCAFS	Mothers who reported high levels of pressuring feeding style showed greater responsiveness and fed their infants less formula when using opaque compared with clear bottles.
Paul et al. (14)	2011	160	2–3 wk, 16–24 wk, 12 mo	100	Responsive parenting intervention delivered at 2–3 and 16–24 wk	Percentage of mothers predominantly breastfeeding (≥80% of feedings) at 2–3 and 16–24 wk	There was no difference between intervention and control groups.
Daniels et al. (13)	2012	698	72 h, 16–24 wk, 13–15 mo	100	Responsive feeding intervention delivered at 16–24 wk	Percentage of mothers breastfeeding at 13–15 mo	There was no difference between intervention and control groups.

<sup>1</sup> NCAFS, Nursing Child Assessment–Parent–Child Interaction Feeding Scale; ref, reference.

who never breastfed, but at 12 mo, mothers who initiated breastfeeding showed less negative affect and less intrusiveness, insensitivity, and inconsistency during both the feeding and structured-task interactions (66).

Britton et al. (64) explored mothers' scores on the Nursing Child Assessment–Parent–Child Interaction Feeding Scale (NCAFS) Sensitivity to Infant Cues subscale at 3 mo and the NCAFS Total Scale at 6 mo and reported that mothers who expressed prenatal intentions to breastfeed and who initiated breastfeeding had higher sensitivity scores at 3 mo. In addition, mothers who were breastfeeding at 3 mo had significantly higher sensitivity scores than formula-/bottle-feeding mothers. At 6 mo, no association was seen between the NCAFS Total Scale scores and feeding mode (64).

Li et al. (28) found that higher bottle-feeding intensity during infancy (regardless of milk type) predicted greater levels of CFQ-measured pressure to eat when children were 6 y old, even after controlling for the extent to which mothers encouraged their infants to finish the bottle during infancy. Thus, bottle-feeding intensity predicted additional variance, over and above existing levels of encouragement, in pressure to eat when children were 6 y old (28). However, Timby et al. (65) reported potentially contradictory findings, showing that exclusively breastfeeding and formula-/bottle-feeding mothers did not differ on self-reported levels of pressure to eat when infants were 4 mo old, but that formula-/bottle-feeding mothers reported lower CFQ-measured pressure to eat than did breastfeeding mothers at 12 mo.

Two studies explored facets of responsiveness: mothers' brain activation to their infants' own cry and attentional bias to infant distress. Kim et al. (68) showed that mothers who exclusively breastfed during the first 2–4 wk postpartum had greater activation in limbic and cortical brain regions associated with caregiving behaviors and empathy when they heard their infants cry than did mothers who were exclusively formula-/bottle-feeding. At 3–4 mo, breastfeeding mothers tended to show greater sensitivity to their infants during a free-play session than did mothers who exclusively formula-/bottle-fed their infants; but across both groups, greater brain activation in response to infant crying at 2–4 wk was associated with higher levels of sensitivity to infant cues at 3–4 mo. In the only study with a prenatal measure of maternal responsiveness, Pearson et al. (67) assessed maternal attentional sensitivity to infant distress by using a computerized attention task. Identical attention tasks were given to mothers during late pregnancy (after 34 wk of gestation) and after birth (3–6 mo postpartum) and, although mothers who went on to breastfeed compared with formula-/bottle-feed showed no prenatal differences in their attentional sensitivity to infant distress, mothers who were breastfeeding at 3–6 mo showed greater attentional sensitivity to infant distress (67). Thus, breastfeeding was associated with increases in mothers' attentional bias to infant distress from the prenatal to early infancy periods.

In sum, the few longitudinal studies that included multiple measures of maternal responsiveness somewhat improve our understanding of the mechanisms underlying

associations between breastfeeding and maternal responsiveness, but they are limited by inconsistencies in how responsiveness was measured, as well as the general lack of prenatal measures of maternal responsiveness. Despite these limitations, there were some consistencies among several of these studies. First, when considering the first 6 mo postpartum, many of these studies reported relative consistency over time for mothers' levels of responsiveness to infant cues (62, 63), as well as higher levels of responsiveness for breastfeeding compared with formula-/bottle-feeding mothers (22, 62). Second, a few studies did show increases in responsiveness for breastfeeding mothers (66) or nonresponsive feeding for bottle-feeding mothers (28); some of those that did not had inconsistent measures of responsiveness (64). Third, the one study that included a measure of prenatal responsiveness (i.e., before the experience of breastfeeding) showed that breastfeeding was associated with increases in maternal responsiveness between the prenatal to postnatal periods (67), but it is also important to note that few studies considered parity (i.e., previous experience with breastfeeding another child), which limits the ability to fully understand whether previous experience with breastfeeding predicts greater maternal responsiveness or whether early differences in mothers' levels of responsiveness predicts breastfeeding initiation and success. A small subset of studies supports the latter possibility.

### **Retrospective and longitudinal studies exploring whether maternal responsiveness predicts breastfeeding duration**

Table 4 summarizes 4 studies that explored whether mothers' feeding-specific or general responsiveness during early infancy predicts breastfeeding success or longer breastfeeding durations. Two studies observed mother-infant interactions during the first 12–90 h after birth during the postpartum hospital stay and reported that mothers who exhibited greater responsiveness to their infants during this period were more likely to still be breastfeeding at 6 wk (69) and through 6 mo (70). Similarly, greater maternal sensitivity to infant cues at 3 mo was predictive of longer breastfeeding durations (64). In addition, when considering mothers who initiated breastfeeding, those who continued breastfeeding reported significantly lower levels of limiting, encouraging, and feeding to a routine during early infancy than did those who did not continue to breastfeed (29). Thus, these studies, albeit limited in number, provide support for the explanation that mothers who are more responsive during early infancy have more success with and longer durations of breastfeeding, but these studies are still limited by the correlational nature of their designs.

### **Experimental and randomized clinical trials that promoted breastfeeding or maternal responsiveness**

Experimental studies provide the strongest evidence for mechanisms underlying the associations between feeding mode and maternal responsiveness given the ability of

controlled experiments to highlight causal associations between 2 variables of interest. Although a number of intervention studies used experimental approaches to examine the effectiveness of promoting breastfeeding [e.g., (74–76)] or maternal responsiveness [e.g., (13, 14, 17, 77–80)], very few of these studies assessed whether the promotion of breastfeeding increases maternal responsiveness or whether the promotion of maternal responsiveness increases breastfeeding success. Interestingly, a recent Cochrane Review found no randomized or quasi-randomized trials evaluating the effect of demand- or infant-led feeding (compared with scheduled infant feeding) for promoting breastfeeding success (81). In the present review, only 3 experimental studies that could contribute to our understanding of associations between feeding mode and maternal responsiveness were found (Table 5).

One short-term experimental study directly tested the hypothesis that mothers' ability to assess the amount of milk in the bottle influences mothers' feeding behaviors (71). In this within-subject study, formula-feeding mothers were video-recorded while feeding their infants under 2 counterbalanced conditions: 1) while using a conventional, clear bottle and 2) while using an opaque, weighted bottle that removed the mothers' ability to assess how much formula was in the bottle. Mothers' self-reported typical level of pressuring feeding style was a significant moderator of the effect of bottle type on maternal responsiveness to infant cues and infant intake: mothers who reported higher typical levels of pressuring feeding showed greater responsiveness to their infants' cues and fed their infants less formula when using opaque compared with clear bottles, but no effect of bottle type on feeding behaviors was seen for mothers who reported lower levels of pressuring feeding. Although preliminary and not directly focused on breastfeeding mothers, this study may suggest that some mothers who bottle-feed rely on cues from the bottle and can readily rely on child cues when bottle-based cues are removed. This study may also suggest that the ability of bottle-feeding mothers to assess the amount the infant consumes facilitates, rather than promotes, nonresponsive feeding practices for mothers who already have a pressuring feeding style.

Two randomized clinical trials that focused on promoting responsive parenting to decrease infants' risk of rapid weight gain and later obesity also assessed whether the promotion of responsive parenting intervention influenced breastfeeding outcomes (13, 14). Within a behavioral intervention delivered at 2–3 and 16–24 wk postpartum, Paul et al. (14) reported that the prevalence of mothers who were predominantly breastfeeding (defined as  $\geq 80\%$  of feedings) did not differ between the treatment and control groups at 3 and 16 wk; however, effects of the intervention on total breastfeeding duration were not reported. It is also important to note that this intervention only included mothers with a prenatal intention to breastfeed, which may indicate that all mothers had some motivation to breastfeed. A larger follow-up of this study included a broader sample of mothers who intended to breastfeed as well as mothers



who intended to formula-feed; however, the authors did not report whether the intervention influenced mothers' success with or duration of breastfeeding (17).

Daniels et al. (13) conducted a behavioral intervention that began when infants were 16–24 wk old and that was delivered over 6 biweekly sessions. Although the intervention increased mothers' self-reported responsive feeding when infants were 13–15 mo old, no effect of the intervention on the proportion of mothers still breastfeeding at 13–15 mo was seen (13). However, a limitation of these findings is that the researchers did not examine whether the intervention affected total breastfeeding duration for mothers who were not still breastfeeding at 13–15 mo.

In sum, few experimental studies have attempted to explore whether breastfeeding promotes maternal responsiveness or vice versa. Available studies are either focused on short-term bottle-feeding interactions (71) or do not fully explore the possible impact of promoting responsive parenting on breastfeeding initiation or duration (13, 14). More studies that use experimental approaches that are specifically designed to assess possible causal mechanisms underlying associations between feeding mode and maternal responsiveness are needed.

## Discussion

The current body of research aimed at understanding the nature of the association between feeding mode and responsive feeding supports the presence of an association between breastfeeding and maternal responsiveness but still leaves us wondering why and how. Cross-sectional studies consistently supported associations between breastfeeding and maternal responsiveness within feeding contexts (22, 29, 32, 39–45). Retrospective and longitudinal studies consistently showed that longer breastfeeding durations predict greater levels of responsive feeding (25–27, 29, 54–60) and parenting (32, 60, 61) during later childhood. However, only one longitudinal study included a prenatal or neonatal measure of maternal feeding attitudes and beliefs (27), which limits our ability to understand whether longer breastfeeding was a driver or a result of greater maternal responsiveness. Although a number of longitudinal studies included >1 measure of maternal responsiveness (22, 28, 62–68), which would allow for an exploration of the codevelopment of feeding experiences and maternal responsiveness, inconsistency in the measurement of responsiveness hinders our ability to draw strong conclusions. A few prospective studies showed that mothers who exhibit higher levels of responsiveness during early infancy are more successful at breastfeeding (29, 69, 70), but these studies were also limited by the fact that none of them included a measure of maternal responsiveness that occurred before breastfeeding. Randomized clinical trials aimed at promoting maternal responsiveness did not show that the promotion of responsiveness affected breastfeeding (13, 14), but these trials did not fully explore breastfeeding outcomes, and thus are limited in their ability to elucidate causal relations between maternal responsiveness and breastfeeding.

In sum, this body of research provides relatively consistent, but methodologically weak, support for several possible explanations for the mechanisms underlying associations seen between breastfeeding and maternal responsiveness; these explanations are not mutually exclusive. One possible explanation is that the nature of breastfeeding compared with bottle-feeding leads mothers to be less or more controlling, respectively. In other words, it is possible that it is more difficult for a mother to control breastfeeding, even if she so desires, because the successful initiation of a breastfeeding requires a more active role for the infant, whereas bottle-feeding may be a more passive experience for the infant (82). Although this possibility was supported by the majority of cross-sectional, observational studies reviewed, whether this possibility is true and indeed influences the development of responsive feeding practices in the long term is an important area for future research.

A second explanation is that the experience of breastfeeding facilitates mothers' ability to learn and feed in response to infant cues because the mother cannot assess the amount the infant consumes, and thus must base her feeding decisions on infant-based cues rather than bottle-based cues. Only one experimental study provided partial support for this explanation, showing that the removal of bottle-based cues increased maternal responsiveness and decreased infant intake, but only for mothers with pressuring feeding styles (71). No other studies provided direct evidence to support this possibility, but the large number of prospective, longitudinal studies reviewed did show that breastfeeding predicted less controlling feeding practices later on (25–27, 29, 54–60). However, given the lack of prenatal or early measures of maternal responsiveness in the majority of these studies, an equally likely third explanation is that mothers who elect to breastfeed and who breastfeed for longer durations do so because they have a greater understanding of and motivation to feed in response to infant cues. Indeed, the few prospective, longitudinal studies that examined whether maternal responsiveness during early infancy predicted later breastfeeding success provided consistent evidence for this possibility (29, 69, 70).

Causal associations between breastfeeding and infant outcomes are inherently difficult to determine because we cannot randomly assign mothers to breastfeed or formula-/bottle-feed. Thus, much of our evidence relies on epidemiologic data or prospective or retrospective cohort studies. At times, the body of evidence from these studies is large and strong enough, even after controlling for relevant covariates, to confidently link breastfeeding to a benefit. Other times, the body of evidence is equivocal and causal mechanisms are hard to determine. This review shows that the state of this literature indicates the latter, but that there are a number of limitations within the current body of research that would be prime targets for future research efforts. In particular, future studies that use prospective, longitudinal designs and repeatedly assess maternal responsiveness across the prenatal, infancy, and early childhood periods would provide better ability to understand the codevelopment of mothers' feeding choices and responsiveness. Adopting



consistent and valid measures of feeding mode and maternal responsiveness—both within and between studies—is also imperative given the wide variability in the conceptualization of both of these variables within the studies reviewed. In addition, although many studies controlled for sociodemographic factors, such as maternal education and family income, very few considered broader characteristics of mothers (e.g., parity, previous breastfeeding experiences) and infants (e.g., temperament, eating behaviors) as potentially relevant covariates. Further exploration of how a broader array of factors may moderate or mediate associations between breastfeeding and maternal responsiveness would provide novel insights. Randomized clinical trials that aim to 1) promote breastfeeding [e.g., (74–76)] or responsiveness [e.g., (13, 14, 17, 77–80)] and 2) examine whether these interventions improved maternal responsiveness or breastfeeding success, respectively, would provide the strongest evidence on whether causal associations between breastfeeding and responsiveness exist. This understanding would provide an important foundation for interventions aimed at both supporting breastfeeding initiation and duration and promoting maternal responsiveness during early infancy, with the overall goal of reducing infants' risk of rapid weight gain and later obesity.

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