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Does Breastfeeding Shape Food Preferences? Links to Obesity

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Key Messages

- **The first 2 years of life are a critical window for the development of flavor and food preferences.**
- **The flavors of the mothers' diet are transmitted through the amniotic fluid and breast milk, and young infants develop preferences for flavors to which they are repeatedly exposed within familiar contexts.**
- **Breastfeeding plays a role in promoting infants' acceptance of and preference for healthy foods during weaning, which is an important foundation for efforts to promote healthier dietary intakes and growth trajectories during childhood.**

Keywords

Breastfeeding · Food preferences · Flavor preferences · Formula feeding · Obesity · Infant

Abstract

The first 2 years of life have been recognized as a critical window for obesity prevention efforts. This period is characterized by rapid growth and development and, in a relatively short period of time, a child transitions from a purely milk-based diet to a more varied solid-food diet. Much learning about food and eating occurs during this critical window, and it is well-documented that early feeding and dietary exposures predict later food preferences, eating behaviors, and dietary patterns. The focus of this review will be on the earliest feeding experiences – breast- and formula-feeding – and the unique role of breastfeeding in shaping children's food preferences. Epidemiological data illustrate that children who were breastfed have healthier dietary patterns compared to children who were formula-fed, even after controlling for relevant sociodemographic characteristics associated with healthier dietary and lifestyle patterns. These dietary differences are underlined, in part, by early differences in the opportunities for flavor learning and preference development afforded by breast- versus formula-feeding. In particular, the flavors of the mothers' diet are transmitted from mother to child through the amniotic fluid and breastmilk. The flavors experienced in these mediums shape later food preferences and acceptance of the solid foods of the family and culture onto which the infant is weaned. All infants learn from flavor experiences in utero, but only breastfed infants receive the additional reinforcement and flavor learning provided by continued repeated exposure to a wide variety of flavors that occurs during breastfeeding. Given the numerous benefits of breastfeeding, promotion of breastfeeding during early infancy is an important focus for primary prevention efforts and should be combined with efforts to ensure that mothers consume healthy, varied diets during pregnancy and lactation, and expose their infants to a wide array of foods during weaning and solid-food feeding.

Introduction

The American Academy of Pediatrics recommends infants be exclusively breastfed for about the first 6 months, followed by the introduction of complementary foods and beverages, and continued breastfeeding through at least the first year [1]. This recommendation reflects that the first year of life is characterized by rapid growth and development during which infants transition from a purely milk-based diet to a more varied solid-food diet over a relatively short period of time [2]. Dietary patterns emerge during this period and track from infancy into later childhood [3] and adulthood [4], and it is widely recommended that both children and adults consume diets high in fruits, vegetables, whole grains, low-fat dairy, and lean protein sources, and low in added sugar, saturated fats, and sodium [5].

Many families are not meeting recommendations for early feeding practices and dietary patterns. Eighty-one percent of mothers initiate breastfeeding at birth, but only 22% of infants are exclusively breastfed through 6 months of age [6]. An additional 30% of infants are fed a mix of breast milk and formula by 6 months, with the remaining 48% of 6-month-old infants exclusively formula-fed [6]. Adherence to recommendations does not improve once infants are fed a predominantly solid-food diet. Data from the Feeding Infants and Toddlers Study (FITS) illustrate that 26% of young children fail to consume at least 1 serving of fruit on a given day and 28% do not consume at least 1 serving of vegetables [7]. Only 11–24% of young children consume at least 1 serving of nutrient-dense, dark green or deep yellow vegetables per day. In contrast, over 30% of young children consume white or fried potatoes daily, and 63% consume at least 1 serving of desserts, sweets, or sweetened beverages daily. These dietary patterns continue to worsen throughout later childhood and adolescence [7, 8].

Given the importance of high-quality, nutrient-dense diets for promoting healthy developmental and cardiometabolic outcomes, improvement of young children's dietary patterns is a critical focus for health promotion and primary prevention efforts. Parents and caregivers are largely in charge of which foods are offered to young children, but children's food preferences are a major driver of the types of foods offered, as well as the types of foods that are actually consumed. Thus, the focus of this review will be on how these preferences develop during infancy to highlight possible targets for health promotion efforts. As will be discussed below, young children's preferences are initially hedonically driven, but can be shaped by early exposures and experiences. This review will focus on the earliest feeding experiences – breast- and formula-feeding – and the unique role of breastfeeding in shaping children's food preferences.

Preference Development during the Prenatal Period

The development of sensory preferences begins in utero; gustatory and olfactory systems emerge during the first trimester and these systems achieve functional maturity by the end of gestation [9]. The functional capacity of these systems in utero provides the opportunity for early sensory learning that prepares the fetus to be attracted to tastes, flavors, and foods that are safe, will promote growth, and are available within the postnatal environment.

It is well-established that gustatory and olfactory stimuli are transferred from mother to fetus through the amniotic fluid [10], and this experience is an initial step in the development of later flavor and food preferences. The fetus can detect chemosensory stimuli present in the amniotic fluid, and repeated exposure to these stimuli influences neonates' later behavioral responses to those same stimuli. For example, during the first few days after birth, neonates show preference for the odor of their own mother's amniotic fluid when compared to the odor of distilled water [11] or the amniotic fluid of another parturient mother [12]. Additionally, mothers who regularly consumed garlic [13] or anise [14] during the third trimester of pregnancy had neonates who showed greater preference for the odor of garlic or anise, respectively, compared to neonates of mothers who did not regularly consume those foods. Experimental work has illustrated that prenatal exposure to carrot flavor leads infants to prefer carrot-flavored to plain cereal during weaning, indicating that prenatal exposures impact later food preferences [15].

An early benefit of prenatal sensory learning was demonstrated in a series of studies by Marlier and colleagues [12, 16]. They noted that 2-day-old newborns could not discriminate between the odor of their mothers' amniotic fluid and colostrum, which suggests continuity exists for the chemosensory properties of amniotic and lacteal fluids [12]. This continuity likely supports the infant's attraction to breast milk as a nutrient source in the early postpartum period. By day 4, infants showed a preference for the odor of their mothers' transitional milk over the odor of their mothers' amniotic fluid, likely due to the repeated exposure to the lacteal fluids and changing properties of these fluids as they transition from colostrum to

mature breast milk [12]. In contrast, infants who were formula-fed at birth showed preference for the odor of their mothers' amniotic fluid compared to the odor of the formula they were fed, and this preference persisted through the first 4 days postpartum [16]. Four-day-old newborns showed clear preferences for the odor of human milk (whether from their own mother or not) compared to formula [17]. Thus, neonates prefer stimuli of biological origins and significance (e.g., breast milk) to those of synthetic origin or without immediate biological significance (e.g., synthetic milk).

Preference Development during the Postnatal Period

At birth, infants exhibit innate preferences for sweet and savory and aversion to bitter and sour [18]; a preference for salt emerges around 4 months [19]. These innate taste preferences are thought to be adaptive, ensuring the infant is attracted to the initial food that will sustain growth (breast milk, which is high in lactose, a source of sweet taste, and free amino acid glutamate, a source of savory taste). Given that poisons are bitter and rancid foods are sour, these taste preferences also ensure that infants are less willing to consume foods that may induce harm.

Consideration of these initial preferences provide some insight into why many children eat diets that are high in desserts, sweets, sweetened beverages, and fried potatoes, and low in nutrient-dense, dark green and other vegetables: these are the diets to which they are innately attracted and readily prefer. However, infants exhibit high levels of plasticity and are responsive to the food-related stimuli to which they are exposed and the social cues that surround food and eating. Thus, a major developmental task during the first years of life is for the child to learn both how and what to eat, as well as to develop preferences for a wide array of healthy foods.

Flavors in breast milk and/or formula are a primary postnatal influence on infants' developing flavor and food preferences. Although formula brands differ in their sensory profiles, formulas provide a more monotonous experience relative to breast milk. In particular, breast milk is similar to the amniotic fluid in that a wide array of flavor compounds that are transferred to and detectable in human milk, including garlic [20], carrot [21], vanilla [22], tobacco [23], alcohol [24], and lipophilic flavor compounds with molecular structures and sensory properties similar to those found in fruits, vegetables, sweets, and spices [25]. The appearance of these compounds in breast milk peaks approximately 2–3 h after consumption and, in some cases, are detectable for up to 8 h after consumption [25]. Thus, breastfeeding is unique from formula feeding in that it provides a "flavor bridge" between the flavors to which the infant was exposed in the womb and the flavors of the foods to which the infant will eventually be exposed during weaning [26].

Experimental research examining how infants' preferences develop during the introduction of complementary foods and beverages has illustrated 3 mechanisms by which preferences emerge: repeated exposure, variety exposure, and associative conditioning. At the most basic level, infants who are merely repeatedly exposed to a novel food show increased intake and positive behavioral responses (e.g., positive facial expressions) to that food [27]. However, infants who are repeatedly exposed to a variety of foods (e.g., a rotating schedule of peas, potatoes, squash) show increased acceptance of the foods to which they are exposed, as well as to novel foods [28]. Infants also show greater acceptance of a novel food when it is paired with a familiar, preferred flavor or food compared to when it is presented alone [27].

Breastfeeding provides a "flavor bridge" between the flavors to which the infant was exposed in the womb and the flavors of the foods to which the infant will eventually be exposed during weaning

These key components of preference development – repeated exposure, variety exposure, and associative conditioning – characterize the experience afforded by human milk. Because the flavors of the mother's diet are transmitted from mother to child through the milk, the infant is repeatedly exposed to a wide variety of flavors, and novel flavors are paired with the familiar sweetness and flavors already present within the milk. Given this experience, it is no surprise that a large body of research illustrates that infants are responsive to the flavors contained within human milk and these early experiences are associated with later preferences and dietary patterns.

In particular, the varied sensory properties of human milk influence infant behavior, but, in the short term, the way in which the flavor of the milk impacts infant behavior depends on whether the infant has had recent experience with the flavor. For example, when breastfeeding mothers were instructed to consume a bland,

low-garlic diet for 3 days prior to testing, their 4- to 6-month-old infants spent a significantly longer time attached to the nipple and showed an increased number of sucks during a test feeding that occurred 1.5–3 h after their mothers ingested a garlic capsule compared to a control group of infants whose mothers consumed a placebo capsule [20]. Thus, infants are attracted to and stimulated by novel flavors in the milk [15, 20, 29]. In contrast, when breastfeeding mothers consumed a target flavor (e.g., garlic [29], carrot [21], or caraway [30]) in the days prior to testing (i.e., their infants were repeatedly exposed to these flavors in the breast milk), their infants showed no preference for the flavor relative to a plain control during a test feeding, which may be a form of sensory-specific satiety [21, 29]. In contrast to these short-term studies, longer-term studies of both breast- and formula-fed infants illustrate that, during solid-food feeding, infants and young children show greater preferences for the flavors to which they have been exposed through the amniotic fluid [15], breast milk [15], or formula [31]. Effects of early experience on taste and flavor preferences has been shown to last until at least 10 years of age [32, 33].

Infants are attracted to and stimulated by novel flavors in the milk

Although infants learn from their early flavor exposures during milk feeding regardless of whether fed breast milk or formula, the exposure to a wide variety of flavors afforded by breastfeeding appears to be advantageous during later weaning. During the introduction of solid foods (when infants are 4–6 months of age), parents generally report that their infants react positively to the vast majority of foods to which they are introduced [34]. However, reactions to novel foods vary according to the taste of the food, with salted vegetables more accepted than plain vegetables [34] and fruits or sweeter vegetables more readily accepted than more bitter vegetables [35].

It has also been documented in some [30, 36], but not all [27, 34, 35], studies that breastfed infants are initially more accepting of novel foods and that repeated exposure to a novel food leads to greater increases in intake for breastfed compared to formula-fed infants. Similarly, breastfed infants exhibit a greater response to variety exposure than formula-fed infants [37], and the effect of variety exposure, either through breastfeeding or offering a variety of flavors, is still evident at 3 and 6 years of age [38]. During later childhood, children who were breastfed exhibit lower levels of neophobia (or fear of new foods) [39] and are less picky [40] compared to children who were formula-fed.

Associations between Breastfeeding and Later Dietary Patterns

Globally, a growing body of epidemiological studies suggest that the early effects of breastfeeding on acceptance of and preferences for healthy foods may translate into healthier dietary patterns during later life. For example, in a cohort of Australian children, longer breastfeeding durations were associated with intakes of greater varieties of healthy foods and greater varieties of fruits and vegetables when children were 2 years old, independent of family demographics [41]. In a recent analysis of 4 European cohorts of children aged 2–4 years living in the United Kingdom, France, Greece, and Portugal, longer breastfeeding durations predicted higher fruit and vegetable intakes during later childhood, even after adjusting for maternal intakes and relevant sociodemographic variables [42]. Similarly, a study of Canadian children illustrated that 4-year-old children who were exclusively breastfed for 3 or more months had significantly higher adjusted odds of consuming 2 or more servings of vegetables per day when compared to children who were formula-fed or partially breastfed [43]. Other studies of US, Brazilian, and Dutch cohorts have demonstrated similar associations between breastfeeding through the first year [44–46] and/or exclusive breastfeeding for ≥3 months [45, 47] and higher consumption of fruits and vegetables when children are 4–7 years old.

Associations between Breastfeeding and Risk for Obesity

The etiology of obesity is multifactorial with a number of important risk factors occurring prior to birth (Fig. 1) [48]. However, during the postnatal period, the first 2 years have been recognized as a critical period for development, especially as it relates to health outcomes and risk for obesity [49] and dietary patterns have been highlighted as important contributors to the development of obesity [50]. Given the evidence for effects of breastfeeding on early food preferences and associations between breastfeeding and later dietary patterns, it is plausible to

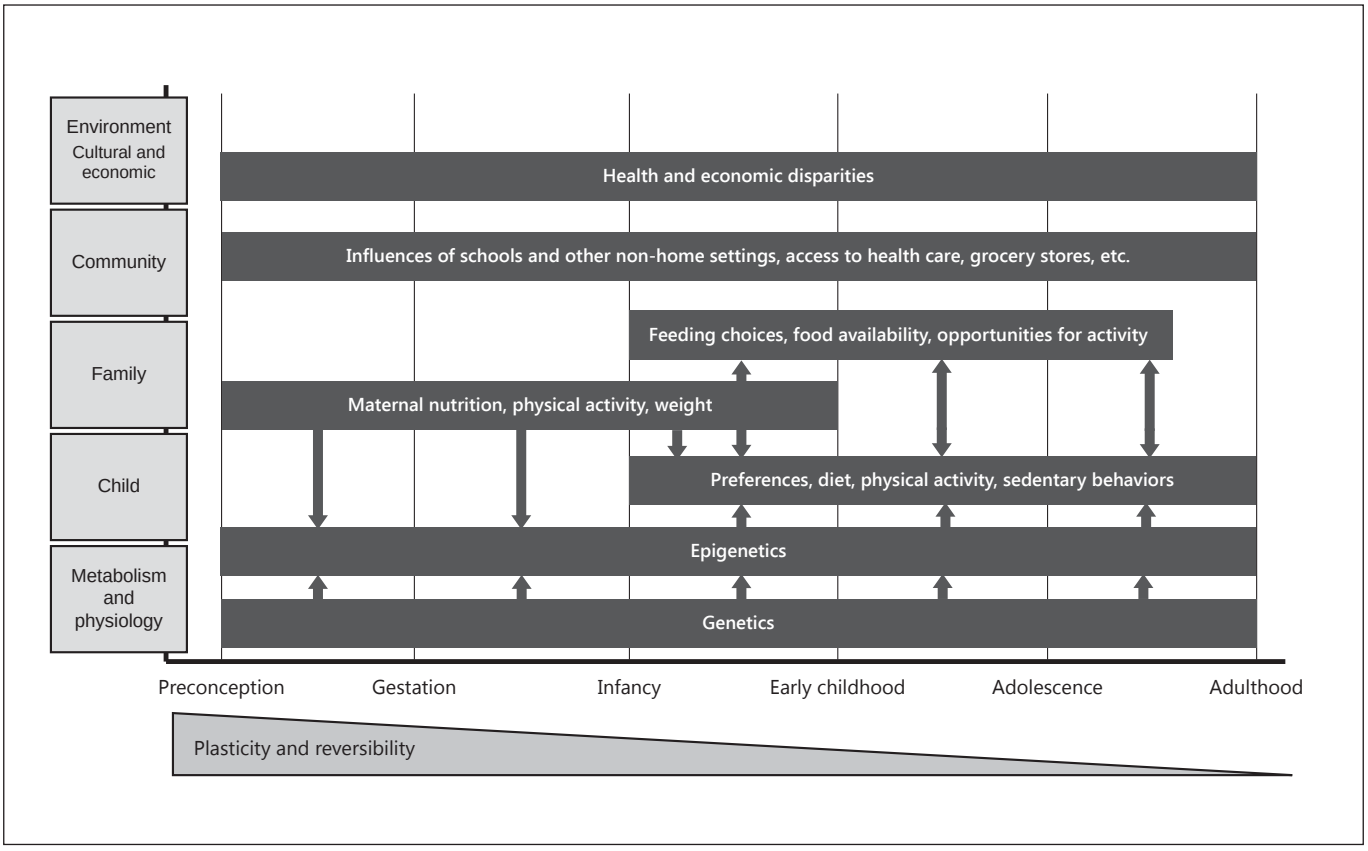

Fig. 1. Early origins of obesity. Factors at multiple levels (ranging from genetics to environments) interact to influence a child's risk for obesity. Note that this is not a complete representation of all factors influencing obesity, but it illustrates how influences begin during the preconception period and continue throughout the life course. Children exhibit high levels of plasticity – or abilities to change – during early life, but exposures during this period also have more significant impacts of long-term health outcomes. Adapted from Pray et al. [48].

consider promotion of breastfeeding as a component of obesity prevention efforts and examine possible effects of breastfeeding on later growth patterns and obesity risk.

During early infancy, breastfeeding is associated with healthier growth patterns. Breastfed infants consume a lesser volume during each feeding and over the course of a day compared to formula-fed infants [51] and infants fed breast milk are significantly lighter by 9 months of age [52]. Breastfed infants also gain healthier amounts of weight during the first year postpartum and are less likely to show patterns of rapid weight gain during infancy compared to their formula-fed peers [53]. Excess weight gain among formula-fed infants is not offset by equally greater gains in length and appears to be attributable to higher levels of fat mass (as opposed to fat-free mass) in formula-fed infants [54].

Whether these early growth differences translate to later weight outcomes is unclear given somewhat equivocal findings for associations between breastfeeding and later risk for obesity. Some studies suggest that the effects of breastfeeding on promoting healthy weight gain trajectories and weight status are long lasting, extending into later childhood, adolescence, and adulthood, even after controlling for sociodemographic characteristics. Indeed, several meta-analyses of published research have consistently illustrated modest associations between breastfeeding (when compared to formula-feeding) and reduced risk of obesity later in life [55–60], as well as a significant dose-response effect of breastfeeding duration on reduced risk for later obesity [55, 59]. However, a recent cluster-randomized trial (the Promotion of Breastfeeding Intervention Trial [PROBIT]), within which mothers who initiated breastfeeding participated in a

breastfeeding promotion intervention or standard care, did not find differences in the prevalence of obesity for children of mothers in the intervention versus control groups, despite significant effects of the intervention on increasing the duration and exclusivity of breastfeeding [61, 62]. These findings may suggest that the links between breastfeeding and obesity are due to confounding factors, but this conclusion is limited by the fact that all mothers in this sample initiated breastfeeding and a comparison of outcomes for infants who were breastfed versus those who were exclusively formula-fed was not possible.

Implications and Recommendations

A child's first 1,000 days – defined as the period from conception to the age of 2 years – are a critical period for obesity prevention efforts [49]. Although the etiology of obesity is complex, 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 [63] and has been recognized as a prime target for prevention and intervention efforts [64]. Early feeding exposures are central when considering influences on risk for rapid weight gain and obesity, and it is well-documented that these early feeding and dietary exposures are significant predictors of later food preferences, eating behaviors, and dietary patterns.

Although breastfeeding is not a panacea, a large body of research illustrates that breastfeeding can facilitate the development of preferences for healthy foods during a critical period of development. Specifically, it appears that children who are breastfed get a "jump start" on developing preferences for a wide array of healthy foods when compared to children who are formula-fed, mainly because breastfeeding allows children to be repeatedly exposed to a wide array of novel flavors that are paired with the familiar flavors already contained within the milk. This experience may lead infants to be more accepting of foods during weaning, because they are already familiar with and have developed a preference for the flavors of these foods well before they experience them in solid-food form. Given the numerous benefits of breastfeeding, promotion of breastfeeding during early infancy is an important focus for primary prevention efforts and should be combined with efforts to ensure mothers consume healthy, varied diets during pregnancy and lactation and expose their infants to a wide array of healthy foods during weaning and complementary feeding.

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