

Research Article

# The Effect of Breast and Formula Feeding on Infant Obesity

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## Abstract

Childhood obesity has emerged as a major global public health concern due to its increasing prevalence and the limited effectiveness of available treatment strategies. Consequently, greater emphasis has been placed on preventive approaches early in life, particularly infant feeding practices. This narrative review examines the impact of breastfeeding and formula feeding on infant and childhood obesity, with a focus on growth trajectories, body mass index development, and long-term metabolic outcomes from infancy through adolescence. A structured literature search was conducted using PubMed, Scopus, and Google Scholar databases to identify relevant studies published between 1980 and 2024, including meta-analyses, systematic reviews, cohort studies, and population-based observational studies. Evidence from multiple studies consistently suggests that breastfeeding is associated with a reduced risk of overweight and obesity during early childhood, potentially through mechanisms related to metabolic programming, adipose tissue development, and gut microbiome composition. However, findings across studies remain heterogeneous, and several analyses did not adequately adjust for important confounding factors such as parental body mass index. Overall, while breastfeeding appears to confer a protective effect against early excessive weight gain, its long-term impact on obesity risk remains inconclusive, highlighting the need for well-designed studies with appropriate control of confounding variables.

## Keywords

Breastfeeding, Formula Feeding, Infant Obesity, Body Mass Index, Childhood Growth

## 1. Introduction

Customs and traditions differ from one people to another, from one country to another, and from one village to another, and the common factor between them remains the way infants obtain their nutrition, which is milk. A child can get his food, whether from formula or breastfeeding, depending on his composition, but this is what is available. We find that this food provides a child with what he needs of micronutrients and macronutrients, in addition to other components, and because of these components, the child grows. But the question is, is this behavior what will determine the future diseases that this child will suffer from when he reaches an old age? Because the modern

disease is obesity, our topic today will be about the difference between feeding through breastfeeding and feeding through formula.

## 2. Digestive System Design

The design of the digestive system allows for the assimilation of environmental nutrients for the purposes of growth, maintenance, and reproduction. The digestive tract has an incredibly complex physiological and mechanical design, with a significant but limited capacity to assimilate nutrients. The carrying ca-

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capacity of the intestine is a function of multiple variables, including surface area, digestion, facilitative and active translocation, motility, perfusion, microbiota, and metabolism. Ultimately, the intestinal capacity to absorb nutritional load is designed to meet the energy requirements for growth and metabolism. The study of the evolution of biological function reveals powerful evolutionary concepts and remarkable adaptations for the purposes presented.

### 3. Childhood Obesity

Although the prevalence of childhood obesity is high in industrialized countries, the causes of obesity are not well defined. The negative consequences of childhood obesity are significant, including its.

#### 3.1. Causes and Consequences

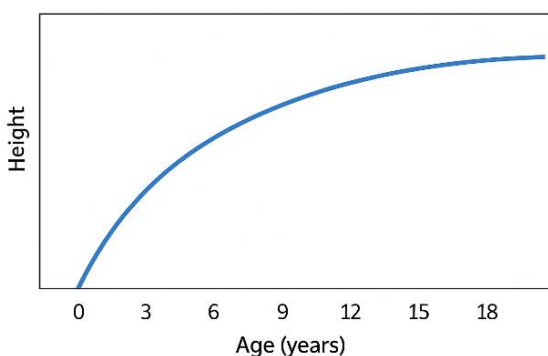
persistence into adulthood and associated morbidity, such as impaired glucose tolerance, type 2 diabetes, hypertension, dyslipidemia, and psychosocial stress. [1].

#### 3.2. Genetic and Environmental Interactions

Obesity is a multifactorial disease that arises from complex interactions between genes and environment. Prenatal and postnatal development may play a role in the later development of obesity.

##### 3.2.1. Role of Early Infant Nutrition

Early infant nutrition is one of the most powerful environmental factors determining early growth and development, and may also influence gene expression.



**Figure 1.** Growth Trajectory from 0 to 18 Years.

This figure illustrates the typical height growth curve from infancy through adolescence, highlighting the rapid growth during the first two years of life, the steady progression throughout childhood, and the second major growth acceleration during puberty. Early nutrition including exclusive breastfeeding, mixed feeding, or formula feeding can influence the

slope and timing of this trajectory through metabolic programming, hormonal regulation, and differences in adipose tissue composition. Understanding these growth patterns is essential when assessing the long-term impact of early feeding practices on obesity risk and developmental outcomes.

##### *Long-Term Growth and Metabolic Outcomes*

Growth trajectories from infancy through adolescence demonstrate that rapid early weight gain is associated with increased obesity and insulin resistance later in life. [13] Breastfed infants typically show more regulated growth patterns, whereas formula feeding has been linked to accelerated growth velocity and higher fat mass.

Adolescence represents a critical period during which early metabolic programming may manifest as obesity, de-layed muscle development, or insulin resistance. [8].

##### **Figure 1.** Growth Trajectory from Infancy to 18 Years.

This figure illustrates typical height and growth velocity patterns from birth through adolescence, highlighting early infancy growth, steady childhood progression, and pubertal acceleration. Early feeding practices may influence the slope and timing of these trajectories through metabolic and hormonal programming.

#### 3.2.2. Breastfeeding Hypothesis

The researchers hypothesized that breastfeeding may be protective against obesity. [2].

### 4. Human Milk

The relationship between the function of the lactating breast and the function of the neonatal stomach and intestines is an example of the parallel development of two organs that together, after birth, perform functions previously performed by the placenta. Human milk contains the nutrients a newborn needs for energy and metabolism and non-nutritive components that promote the baby's health, growth and development.

##### *Nutritional and Non-Nutritional Components*

Non-nutritive components include: antimicrobial agents, digestive enzymes, hormones, nutritional factors, and growth units.

##### *Adipose Tissue Development and Gut Microbiome*

Early infant nutrition influences obesity risk through effects on adipose tissue biology and gut microbiota. Brown adipose tissue contributes to thermogenesis and energy expenditure, while white adipose tissue serves as energy storage. Breastfed infants may maintain higher brown adipose tissue activity, whereas formula-fed infants tend to accumulate greater white adipose tissue mass. [10, 11].

Breastfeeding is also associated with a gut microbiome enriched in Bifidobacterium species, supporting improved metabolic regulation and insulin sensitivity. [12] These mechanisms may partially explain long-term differences in obesity risk. [13].

They include energy, nutrients, metabolic fuels (body, fat, protein, and carbohydrates), free water, and raw materials

needed for tissue growth and growth, such as long-chain acids: essential amino acids, and minerals. Vitamins and trace elements. For most infants, nutrients derived from breast milk become increasingly insufficient after 4 to 6 months of age, and other foods must be added to the diet. More than 98% of the fat in human milk is in the form of triglycerides, which are synthesized within the mammary glands from medium- and long-chain fatty acids. Oleic acid (18:1) and palmitic acid (16:0) are the most abundant fatty acids, with palmitic acid occupying the central position of the glycerol molecule in most human milk triglycerides, a property that increases its overall digestibility. [3].

Likewise, high proportions of essential fatty acids such as linoleic acid (18:2 w-6) and alpha-linolenic acid (18:3 w-3) and other long-chain polyunsaturated fatty acids, such as arachidonic acid (20:4 w-3), eicosapentaenoic acid (22:5w-3), and docosahexaenoic acid (22:6w-3), are also present.

3, DHA), are also present.

Proteins make up about 75% of the nitrogen-containing compounds in breast milk.

Nonprotein nitrogen substances include urea, nucleotides, peptides, free amino acids, and DNA. The proteins of human milk can be divided into 2 categories: micellar caseins and aqueous whey proteins, present in the ratio of about 40:60. [4].

Predominant casein of human milk is beta-casein, which forms micelles of relatively small volume and produces a soft, flocculent curd in the infant's stomach. Certain human milk proteases, such as plasmin, which is highly active against casein, increase infant capacity for protein digestion. A major protein found in human milk is alpha-lactalbumin which secretor in IgA and Serum albumin. [5].

In the following table are the components of human milk:

## 5. Table of Human Milk Components

The composition of human milk, including macronutrients, vitamins, minerals, and trace elements, is summarized in Tables 1–4 [6].

**Table 1.** Representative Values for Constituents of Human Milk.

Constituent per liter	Energy	Lactose (g)	Oligosaccharides (g)	Total nitrogen (g)	Nonprotein nitrogen (% total N)	Protein nitrogen (% total N)
Mature milk (after 2 weeks lactation)	650–700	67–70	12–14	1.9	23	77

Constituent per liter	Total protein (g)	Total lipids (g)	Triglyceride (% total lipids)	Cholesterol (% total lipids)	Phospholipids (% total lipids)
Mature milk (after 2 weeks lactation)	9	35	97–98	0.4–0.5	0.6–0.8

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**Table 2.** Water-Soluble Vitamins in Human Milk.

Constituent per liter	Ascorbic acid (mg)	Thiamin (µg)	Riboflavin (µg)	Niacin (mg)	Vitamin B6 (µg)	Folate (µg)	Vitamin B12 (µg)	Pantothenic acid (mg)	Biotin (µg)
Mature milk (after 2 weeks lactation)	100	200	400–600	1.8–6.0	90–310	80–140	0.5–1.0	2.0–2.5	5–9

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**Table 3.** Fat-Soluble Vitamins and Minerals in Human Milk.

Constituent per liter	Retinol (mg)	Carotenoids (mg)	Vitamin K (µg)	Vitamin D (µg)	Vitamin E (mg)
Mature milk (after 2 weeks lactation)	0.3–0.6	0.2–0.6	2–3	0.33	3–8

Constituent per liter	Calcium (mg)	Magnesium (mg)	Phosphorus (mg)	Sodium (mg)	Potassium (mg)	Chloride (mg)
Mature milk (after 2 weeks lactation)	200–250	30–35	120–140	120–250	400–550	400–450

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**Table 4.** Trace Elements in Human Milk.

Constituent per liter	Iron (mg)	Zinc (mg)	Copper (mg)	Manganese (µg)	Selenium (µg)	Iodine (µg)	Fluoride (µg)
Mature milk (after 2 weeks lactation)	0.3–0.9	1–3	0.2–0.4	3	7–33	150	4–15

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## 6. Table of Energy and Protein Requirements

Estimated energy and protein requirements for infants are presented in Table 5 and were adapted from Krause's Food & the Nutrition Care Process [7].

Energy

**Table 5.** Energy and Protein Requirements for Infants.

Here we must mention the equation through which calories can be calculated:

Infants	0 to 3 months	$(89 \times \text{Weight [kg]} - 100) + 175 \text{ kcal}$	Protein 9.1 gram per day
	4 to 6 months	$(89 \times \text{Weight [kg]} - 100) + 56 \text{ kcal}$	Protein 9.1 gram per day
	7 to 12 months	$(89 \times \text{Weight [kg]} - 100) + 22 \text{ kcal}$	Protein 11 gram per day
	13 to 36 months	$(89 \times \text{Weight [kg]} - 100) + 20 \text{ kcal}$	Protein 13 gram per day

Mahan, L. Kathleen, and Janice L. Raymond. Krause's food & the nutrition care process-e-book. Elsevier Health Sciences, 2016.

**Table 6.** Typical Composition of Standard Infant Formula (0–1 Month).

Constituent per 100 mL	Standard Infant Formula (0–1 month)
Energy (kcal)	65–70 kcal
Carbohydrates (g)	7.0–7.5 g (mainly lactose)
Protein (g)	1.3–1.5 g (whey: casein ratio ~60:40)
Total Fat (g)	3.3–3.6 g
DHA (% total fatty acids)	0.2–0.3%

Constituent per 100 mL	Standard Infant Formula (0–1 month)
ARA (% total fatty acids)	0.35–0.45%
Linoleic Acid (mg)	500–600 mg
$\alpha$ -Linolenic Acid (mg)	50–55 mg
Calcium (mg)	45–55 mg
Phosphorus (mg)	25–35 mg
Iron (mg)	0.5–1 mg
Sodium (mg)	15–20 mg
Potassium (mg)	70–80 mg
Vitamin D (IU)	40–60 IU
Vitamin A ( $\mu$ g)	60–70 $\mu$ g
Vitamin C (mg)	8–10 mg
Prebiotics (GOS/FOS)	0.2–0.4 g (if added)

American Academy of Pediatrics (AAP). Infant Formulas: Nutritional Requirements and Standards. Pediatric Nutrition Handbook, 8th Edition. American Academy of Pediatrics; 2020.

As shown in Table 6, standard infant formula for the first month of life is formulated to approximate the caloric density and macronutrient balance of human milk. Although commercial formulas provide adequate amounts of carbohydrates, proteins, fats, and fortified micronutrients, they lack the dynamic bioactive components naturally present in breast milk, such as immunoglobulins, hormones, and live beneficial cells. The inclusion of DHA and ARA supports neurodevelopment, but their bioavailability in formula remains lower compared to human milk. Overall, while standard formulas meet nutritional requirements recommended by pediatric authorities, they do not replicate the immunological and physiological benefits observed in breastfed infants. [9].

## 7. Breastfeeding and Its Impact on Infant Obesity

Some studies included in this systematic review reported results showing that BF is inversely associated with overweight and obesity in children, but only at certain ages.

For example, infants who are exclusively breastfed for more than 6 months have been shown to have a slimmer body shape at age 5. However, this association did not appear to persist into adolescence or adulthood and was dependent on recollection by mothers of adult children. [8].

From 1 to 8 years of age, infants who were breastfed for 4 months or less were at increased risk of being overweight. [14].

While children who are breastfed for longer than 12 months have a lower BMI at 1 year of age than those who are breastfed for less than 4 months, the effect disappears by 8 years of age. [14].

Found a non-significant effect between BF and BMI between 1 and 7 years of age. However, they showed that higher BMI at age 1 is associated with higher BMI between ages 1 and 7 years. They hypothesized that because breastfed children have a lower BMI at 1 year of age, they may have a lower risk of being overweight in childhood. However, researchers were unable to show a statistically significant relationship between BF and BMI at age 7. [15].

An inverse relationship was found between duration of BF and exclusivity with increasing rates of growth in height, weight and BMI between the ages of 3–6 months. However, this association was not true at ages 1, 2, and 3 years. No associations were found between duration of BF and exclusivity and risk of obesity before 3 months of age. [16].

In contrast, a 2010 study conducted by Metzger and McDade compared siblings where only one had been breastfed. Their findings revealed that the breastfed adolescent had a body mass index that was 0.39 standard deviations lower than their non-breastfed sibling, even after accounting for child-specific confounding factors. Moreover, breastfeeding has been associated with a decreased likelihood of children falling into the highest range of the BMI scale. [17].

Findings from a 2008 study by Beyerlein, Toschke, and von Kries suggest that the observed relationship between breastfeeding and childhood obesity may depend heavily on the statistical approach used. When analyzed using a logistic regression model, breastfeeding appeared to significantly reduce BMI levels in children. However, this association was not evident when a linear regression model was applied. Through quintile regression analysis, the impact of breastfeeding was seen primarily among children at the lower and upper ends of the BMI spectrum, helping to normalize their BMI values.

These results imply that breastfeeding may help prevent excessive weight gain rather than alter the overall BMI distribution. [18]. Araujo, Victora, Hallal, and Gigante (2006) found that the lowest prevalence of overweight was in children breastfed for more than 11 months (6.5% compared to total over-weight children 10.2% of children breastfed less than 11 months). However, no linear trends were identify-able in the duration of BF compared to the occurrence of overweight. [19] Breastfeeding and the length of time it was practiced did not show a statistically significant impact in lowering obesity rates. [20, 21], and exclusive BF was not shown to reduce obesity at 5 years of age. [22].

## Abbreviations

BF	Breastfeeding
BMI	Body Mass Index
ARA	Arachidonic Acid
DHA	Docosahexaenoic Acid
IgA	Immunoglobulin A
DNA	Deoxyribonucleic Acid
µg	Microgram
mg	Milligram
g	Gram
kcal	Kilocalorie

## Author Contributions

Mohamed Samir Elkoush is the sole author. The author read and approved the final manuscript.

## Conflicts of Interest

The author declares no conflicts of interest.

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