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Comparison Of Growth Patterns In Exclusively Breastfed Vs Formula Fed Infants In First Year Of Life

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ABSTRACT

Background: The influence of early feeding practices on infant growth trajectories has been a subject of increasing interest due to potential associations with long-term health outcomes. This study aimed to compare growth patterns between exclusively breastfed and formula-fed infants during the first year of life.

Methods: A prospective cohort study was conducted with 50 healthy term infants (25 exclusively breastfed, 25 exclusively formula-fed) enrolled within the first week of life. Anthropometric measurements including weight, length, and head circumference were obtained at enrollment and at 1, 2, 4, 6, 9, and 12 months of age. Body composition was assessed using bioelectrical impedance analysis at 3, 6, and 12 months. Growth parameters were converted to z-scores using WHO Child Growth Standards. Growth velocity and centile crossing patterns were also analyzed.

Results: The feeding groups showed comparable baseline characteristics except for maternal education, which was higher among breastfeeding mothers ($p=0.042$). Formula-fed infants exhibited significantly higher weight from 4 months onward ($p<0.05$) and higher weight-for-age and weight-for-length z-scores from 6 months onward ($p<0.05$), whereas length and head circumference remained comparable between groups. Growth velocity analysis revealed higher weight gain rates in formula-fed infants, particularly during 0-2 months (36.5 vs. 31.8 g/day, $p=0.004$). Body composition differed significantly, with formula-fed infants showing greater fat mass at all assessment points and higher body fat percentage at 6 and 12 months ($p<0.01$). Notably, 40.0% of formula-fed infants crossed upward by ≥2 weight-for-length centile lines compared to only 4.0% of breastfed infants ($p=0.003$).

Conclusions: Exclusive formula feeding was associated with accelerated weight gain, higher fat mass accumulation, and more frequent upward centile crossing despite comparable linear growth when compared to exclusive breastfeeding. These distinct growth trajectories highlight the importance of feeding mode as a determinant of early body composition development, with potential implications for future metabolic health.

Keywords: Infant nutrition; Breastfeeding; Formula feeding; Growth patterns; Body composition; Weight gain velocity; Infant development; Anthropometry; Bioelectrical impedance analysis; Growth standards.

INTRODUCTION

Infant nutrition during the first year of life represents a critical period for growth, development, and establishment of metabolic pathways that may have lifelong health implications. The World Health Organization recommends exclusive breastfeeding for the first six months of life, followed by continued breastfeeding alongside appropriate complementary foods for up to two years or beyond [1]. Despite these recommendations, global breastfeeding rates remain suboptimal, with formula feeding being a common alternative [2].

Growth patterns during infancy have gained significant attention as potential indicators of future health outcomes. Evidence suggests that differences in growth trajectories between breastfed and formula-fed infants may contribute to variations in long-term health outcomes, including obesity risk, metabolic programming, and immune system development [2,8].

Several studies have documented that exclusively breastfed infants typically exhibit different growth patterns compared to formula-fed infants. Breastfed infants tend to gain weight more rapidly in the first 2-3 months of life but then demonstrate slower weight gain in the latter part of the first year, while formula-fed infants often show more consistent weight gain throughout infancy [3]. These distinct growth patterns have prompted researchers to question whether traditional growth standards, often developed using data from predominantly formula-fed populations, accurately reflect optimal growth for all infants [10].

The composition of breast milk differs substantially from infant formula in several aspects, including macronutrient profiles, bioactive compounds, hormones, and immune factors [5]. Human milk contains unique bioactive components such as lactoferrin, secretory IgA, oligosaccharides, and various growth factors that are difficult to replicate

in formula [4,9]. These components not only provide nutrition but also influence gut microbiota composition, immune function, and metabolic pathways, potentially contributing to the distinct growth patterns observed [6].

Sociodemographic factors, including maternal education, socioeconomic status, and cultural practices, may confound the relationship between feeding method and growth outcomes. Additionally, maternal characteristics such as pre-pregnancy BMI, gestational weight gain, and health behaviors may influence both feeding choices and infant growth trajectories [8]. Understanding these potential confounders is crucial for accurately interpreting differences in growth patterns.

This study aims to comprehensively compare growth patterns between exclusively breastfed and formula-fed infants during the first year of life, controlling for relevant confounding factors. By examining multiple anthropometric measures including weight, length, head circumference, and body composition, this research will provide valuable insights into the nuanced differences in growth trajectories associated with different feeding methods [10]. The findings will contribute to the ongoing refinement of infant growth standards and inform evidence-based guidance for healthcare providers and parents regarding expected growth patterns associated with different feeding choices [7].

METHODOLOGY

This prospective cohort study was conducted at the Department of Pediatrics, Regional Medical Center, between January 2023 and January 2024. A total of 50 healthy term infants (gestational age ≥37 weeks) with birth weight ≥2500g were enrolled within the first week of life. The sample comprised 25 exclusively breastfed and 25 exclusively formula-fed infants. Written informed consent was obtained from parents or legal guardians prior to enrollment. The study protocol was approved by the Institutional Ethics Committee and was conducted in accordance with the Declaration of Helsinki.

Infants were included if they were born at term with normal birth weight and had an uncomplicated perinatal period (Apgar score ≥7 at 5 minutes). Infants with congenital anomalies, chromosomal disorders, intrauterine growth restriction, or any medical condition requiring hospitalization at birth were excluded. Mothers with significant medical conditions including gestational diabetes, hypertensive disorders of pregnancy, or conditions that might affect breastfeeding capability were also excluded. Multiple births were not included in the study population.

Feeding type was classified according to WHO definitions. "Exclusively breastfed" was defined as infants who received only breast milk with no other liquids or solids except for vitamins, minerals, and medications. "Exclusively formula-fed" was defined as infants who received commercial infant formula without any breast milk. Feeding status was verified at each visit through detailed feeding questionnaires. Infants who changed feeding methods during the study period were excluded from the final analysis to maintain the integrity of the feeding groups.

Trained research nurses performed all anthropometric measurements following standardized procedures. Measurements were taken at enrollment (0-7 days), and at 1, 2, 4, 6, 9, and 12 months of age (±7 days). Weight was measured using a calibrated electronic infant scale (Seca 354, Hamburg, Germany) to the nearest 5g with the infant fully undressed. Length was measured using an infantometer (Seca 416, Hamburg, Germany) to the nearest 0.1cm. Head circumference was measured using a non-stretchable tape (Seca 212, Hamburg, Germany) at the maximum occipitofrontal circumference. Each measurement was taken twice, and the average was recorded. If the two measurements differed by more than the predetermined tolerance (10g for weight, 0.5cm for length and head circumference), a third measurement was taken, and the mean of the closest two was used.

Body composition was assessed at 3, 6, and 12 months of age using bioelectrical impedance analysis (BIA) with the ImpediMed SFB7 device (ImpediMed Ltd., Brisbane, Australia). Measurements were performed after a minimum 3-hour fast, with the infant supine and limbs slightly abducted. Disposable electrodes were placed on the right hand and foot after cleaning the skin with alcohol. The analysis provided estimates of fat mass (FM) and fat-free mass (FFM). Body fat percentage (BF%) was calculated as (FM/body weight) × 100%.

Maternal demographic and anthropometric data were collected at enrollment, including age, pre-pregnancy weight and height, gestational weight gain, education level, and socioeconomic status. Information regarding pregnancy, delivery, and neonatal history was extracted from medical records. Infant feeding practices were documented at each visit using a structured questionnaire that assessed feeding type, frequency, and introduction of complementary foods. For formula-fed infants, the type of formula and preparation methods were recorded. Introduction of complementary foods was documented including timing of introduction, types of foods, and feeding frequency.

The primary outcome measures were weight-for-age z-score (WAZ), length-for-age z-score (LAZ), weight-for-length z-score (WLZ), and head circumference-for-age z-score (HCAZ) calculated using WHO Child Growth Standards. Secondary outcomes included growth velocity (g/day and cm/month), body composition parameters (FM, FFM, and BF%), and the proportion of infants crossing major centile lines (±2 major centile lines) during the 12-month follow-up.

Statistical analyses were performed using SPSS version 27.0 (IBM Corp., Armonk, NY). Normality of data distribution was assessed using the Shapiro-Wilk test. Baseline characteristics were compared between feeding groups using independent t-tests for continuous variables and chi-square or Fisher's exact tests for categorical variables. Repeated measures analysis of variance (ANOVA) was used to compare growth parameters between feeding groups over time, with post-hoc Bonferroni correction for multiple comparisons. Linear mixed-effects models were constructed to evaluate the association between feeding type and growth parameters, adjusting for potential confounders including maternal BMI, education, socioeconomic status, and timing of complementary food introduction. Missing data were handled using multiple imputation techniques. Statistical significance was set at $p<0.05$, and all tests were two-tailed.

RESULTS

Baseline Characteristics

Table 1 presents the baseline characteristics of the study cohort, demonstrating comparable demographic and anthropometric parameters between exclusively breastfed and formula-fed infants at birth. No significant differences were observed in gestational age, birth weight, birth length, head circumference, or sex distribution between the two groups. Among maternal characteristics, maternal age, pre-pregnancy BMI, gestational weight gain, and delivery mode were similar between groups. However, a significant difference was noted in maternal education level, with mothers of exclusively breastfed infants having higher educational attainment (72.0% with college/university education) compared to mothers of formula-fed infants (44.0% with college/university education) ($p=0.042$).

Table 1: Baseline Characteristics of Study Participants

	Exclusively	Exclusively	
	39.2 1.1	38.9 1.2	
	3320 412	3285 390	
	50.1 1.8	49.8 1.9	
	34.2 1.2	34.0 1.3	
	13 (52.0)	14 (56.0)	
	12 (48.0)	11 (44.0)	
	29.7 4.5	27.3 5.1	
	23.4 3.5	25.2 4.1	
	12.3 3.6	13.5 4.2	
	7 (28.0)	14 (56.0)	
	18 (72.0)	17 (68.0)	11 (44.0)
		14 (56.0)	

*$p<0.05$ indicates statistical significance

Anthropometric Measurements and Growth Parameters

Table 2 illustrates the anthropometric measurements across the first year of life. Weight measurements between the two feeding groups began to diverge noticeably from 4 months onwards, with formula-fed infants showing significantly higher weights at 4, 6, 9, and 12 months of age ($p=0.028$, $p=0.006$, $p=0.003$, and $p=0.001$, respectively). By 12 months, the mean weight difference between groups reached approximately 890g, with formula-fed infants weighing an average of 10,520g compared to 9,630g for breastfed infants. While formula-fed infants consistently demonstrated slightly greater length measurements throughout the study period, these differences did not reach statistical significance at any time point. Similarly, head circumference measurements were comparable between the two groups throughout the 12-month follow-up period.

Table 2: Anthropometric Measurements and Growth Parameters Over Time

Parameter	Age	Exclusively Breastfed (n=25)	Exclusively Formula-Fed (n=25)	p-value
Weight (g)	1 month	4210 ± 395	4325 ± 412	0.314

Parameter	Age	Exclusively Breastfed (n=25)	Exclusively Formula-Fed (n=25)	p-value
	2 months	5250 ± 485	5490 ± 510	0.087
	4 months	6520 ± 570	6890 ± 605	0.028*
	6 months	7680 ± 640	8240 ± 710	0.006**
	9 months	8740 ± 785	9450 ± 820	0.003**
	12 months	9630 ± 860	10520 ± 910	0.001**
Length (cm)	1 month	54.2 ± 1.7	54.5 ± 1.8	0.541
	2 months	57.9 ± 1.9	58.3 ± 2.1	0.475
	4 months	63.1 ± 2.2	63.8 ± 2.3	0.274
	6 months	67.5 ± 2.4	68.4 ± 2.5	0.193
	9 months	72.3 ± 2.6	73.5 ± 2.7	0.115
	12 months	76.1 ± 2.8	77.4 ± 2.9	0.108
Head Circumference (cm)	1 month	37.1 ± 1.2	37.3 ± 1.3	0.566
	2 months	39.2 ± 1.3	39.5 ± 1.4	0.434
	4 months	41.6 ± 1.4	42.1 ± 1.5	0.225
	6 months	43.7 ± 1.5	44.3 ± 1.5	0.164
	9 months	45.6 ± 1.5	46.2 ± 1.6	0.176
	12 months	46.9 ± 1.6	47.5 ± 1.7	0.193

*p<0.05, **p<0.01 indicate statistical significance

Growth Z-Scores

Table 3 presents the WHO growth standard z-scores for both groups. Weight-for-age z-scores (WAZ) began to diverge significantly at 6 months, with formula-fed infants showing progressively higher WAZ values through 12 months (p=0.012, p=0.003, and p=0.001 at 6, 9, and 12 months, respectively). By 12 months, the mean WAZ for formula-fed infants was 0.98 compared to 0.07 for breastfed infants. A similar pattern was observed for weight-for-length z-scores (WLZ), with significant differences emerging at 6 months and persisting through 12 months (p=0.008, p=0.002, and p<0.001 at 6, 9, and 12 months, respectively). At 12 months, formula-fed infants had a mean WLZ of 0.94, while breastfed infants had a mean WLZ of -0.02, suggesting higher relative adiposity in the formula-fed group. In contrast, length-for-age z-scores (LAZ) and head circumference-for-age z-scores (HCAZ) remained comparable between the two groups throughout the study period, indicating that linear growth and head growth were less affected by feeding mode than weight gain.

Table 3: Z-Scores Based on WHO Growth Standards

Parameter	Age	Exclusively Breastfed (n=25)	Exclusively Formula-Fed (n=25)	p-value
WAZ	1 month	0.21 ± 0.82	0.35 ± 0.87	0.552
	2 months	0.27 ± 0.84	0.54 ± 0.91	0.274

Parameter	Age	Exclusively Breastfed (n=25)	Exclusively Formula-Fed (n=25)	p-value
	4 months	0.25 ± 0.87	0.72 ± 0.95	0.067
	6 months	0.18 ± 0.88	0.86 ± 0.93	0.012*
	9 months	0.11 ± 0.89	0.93 ± 0.96	0.003**
	12 months	0.07 ± 0.91	0.98 ± 0.98	0.001**
LAZ	1 month	0.15 ± 0.89	0.22 ± 0.90	0.780
	2 months	0.19 ± 0.91	0.28 ± 0.93	0.726
	4 months	0.22 ± 0.92	0.36 ± 0.94	0.583
	6 months	0.24 ± 0.93	0.41 ± 0.95	0.512
	9 months	0.21 ± 0.94	0.43 ± 0.97	0.405
	12 months	0.18 ± 0.95	0.45 ± 0.98	0.317
WLZ	1 month	0.19 ± 0.86	0.32 ± 0.89	0.595
	2 months	0.23 ± 0.87	0.48 ± 0.92	0.310
	4 months	0.20 ± 0.89	0.68 ± 0.94	0.062
	6 months	0.11 ± 0.90	0.82 ± 0.96	0.008**
	9 months	0.03 ± 0.91	0.90 ± 0.98	0.002**
	12 months	-0.02 ± 0.92	0.94 ± 0.99	<0.001**
HCAZ	1 month	0.25 ± 0.84	0.32 ± 0.86	0.764
	2 months	0.29 ± 0.85	0.38 ± 0.88	0.704
	4 months	0.31 ± 0.86	0.42 ± 0.89	0.653
	6 months	0.33 ± 0.87	0.45 ± 0.90	0.625
	9 months	0.31 ± 0.88	0.46 ± 0.91	0.542
	12 months	0.29 ± 0.89	0.47 ± 0.92	0.470

*p<0.05, **p<0.01 indicate statistical significance; WAZ = weight-for-age z-score; LAZ = length-for-age z-score; WLZ = weight-for-length z-score; HCAZ = head circumference-for-age z-score

Growth Velocity

Table 4 demonstrates differences in growth velocity between the two feeding groups. Formula-fed infants exhibited significantly higher weight gain velocity during the 0-2 month period (36.5 vs. 31.8 g/day, p=0.004), 4-6 month period (22.5 vs. 19.3 g/day, p=0.007), and 6-12 month period (12.6 vs. 10.8 g/day, p=0.021). The most pronounced difference was observed in the earliest period (0-2 months), where formula-fed infants gained weight 14.8% faster than breastfed infants. In contrast, length gain velocity was comparable between the two groups across all time intervals, consistent with the non-significant differences observed in absolute length measurements and length-for-age z-scores.

Table 4: Growth Velocity

Parameter	Time Interval	Exclusively Breastfed (n=25)	Exclusively Formula-Fed (n=25)	p-value
Weight Gain (g/day)	0-2 months	31.8 ± 5.2	36.5 ± 5.8	0.004**
	2-4 months	21.2 ± 4.3	23.3 ± 4.7	0.098
	4-6 months	19.3 ± 3.8	22.5 ± 4.2	0.007**
	6-12 months	10.8 ± 2.5	12.6 ± 2.8	0.021*
Length Gain (cm/month)	0-2 months	3.9 ± 0.7	4.2 ± 0.8	0.156
	2-4 months	2.6 ± 0.5	2.8 ± 0.6	0.193
	4-6 months	2.2 ± 0.4	2.3 ± 0.5	0.410
	6-12 months	1.4 ± 0.3	1.5 ± 0.3	0.238

*p<0.05, **p<0.01 indicate statistical significance

Body Composition

Table 5 reveals important differences in body composition between breastfed and formula-fed infants. Fat mass was significantly higher in formula-fed infants at all three assessment time points (3, 6, and 12 months), with the difference becoming more pronounced with age (p=0.021, p=0.004, and p<0.001, respectively). By 12 months, formula-fed infants had accumulated 22.2% more fat mass than breastfed infants (2860g vs. 2340g). Fat-free mass was comparable between groups at 3 and 6 months but became significantly higher in formula-fed infants by 12 months (7660g vs. 7290g, p=0.031). Body fat percentage was similar at 3 months but became significantly higher in formula-fed infants at both 6 months (26.3% vs. 23.7%, p=0.008) and 12 months (27.2% vs. 24.3%, p=0.005), suggesting that formula feeding was associated with not only greater overall growth but also a relatively higher proportion of fat mass accumulation.

Table 5: Body Composition Analysis

Parameter	Age	Exclusively Breastfed (n=25)	Exclusively Formula-Fed (n=25)	p-value
Fat Mass (g)	3 months	1280 ± 215	1430 ± 235	0.021*
	6 months	1820 ± 275	2170 ± 310	0.004**
	12 months	2340 ± 320	2860 ± 375	<0.001**
Fat-Free Mass (g)	3 months	4310 ± 390	4450 ± 405	0.218
	6 months	5860 ± 475	6070 ± 495	0.132
	12 months	7290 ± 540	7660 ± 575	0.031*
Body Fat (%)	3 months	22.9 ± 3.2	24.3 ± 3.4	0.139
	6 months	23.7 ± 3.3	26.3 ± 3.5	0.008**
	12 months	24.3 ± 3.4	27.2 ± 3.6	0.005**

*p<0.05, **p<0.01 indicate statistical significance

Centile Crossing

Table 6 demonstrates significant differences in growth trajectory patterns between the feeding groups. For weight-for-age, a significantly higher proportion of formula-fed infants crossed upward by ≥2 centile lines compared to breastfed infants (36.0% vs. 8.0%, p=0.008). An even more pronounced difference was observed for weight-for-length, where 40.0% of formula-fed infants crossed upward by ≥2 centile lines compared to only 4.0% of breastfed infants (p=0.003). These findings suggest that formula feeding was associated with accelerated weight gain relative to expected growth trajectories based on WHO standards. In contrast, centile crossing for length-for-age showed no significant differences between feeding groups, consistent with the earlier observations that linear growth was less affected by feeding mode than weight gain.

Table 6: Centile Crossing During First Year of Life

Parameter	Exclusively Breastfed (n=25)	Exclusively Formula-Fed (n=25)	p-value
Weight-for-age			0.008**
Crossed ≥2 centile lines upward	2 (8.0%)	9 (36.0%)	
Remained within ±1 centile line	21 (84.0%)	15 (60.0%)	
Crossed ≥2 centile lines downward	2 (8.0%)	1 (4.0%)	
Length-for-age			0.583
Crossed ≥2 centile lines upward	3 (12.0%)	5 (20.0%)	
Remained within ±1 centile line	20 (80.0%)	19 (76.0%)	
Crossed ≥2 centile lines downward	2 (8.0%)	1 (4.0%)	
Weight-for-length			0.003**
Crossed ≥2 centile lines upward	1 (4.0%)	10 (40.0%)	
Remained within ±1 centile line	22 (88.0%)	14 (56.0%)	
Crossed ≥2 centile lines downward	2 (8.0%)	1 (4.0%)	

*p<0.05, **p<0.01 indicate statistical significance

DISCUSSION

This prospective cohort study comparing growth patterns between exclusively breastfed and formula-fed infants during the first year of life revealed significant differences in weight gain trajectories, body composition, and growth velocity patterns while finding comparable linear growth between the two feeding groups.

Our findings demonstrated that formula-fed infants exhibited significantly higher weight measurements from 4 months onward, with the differences becoming more pronounced with age. By 12 months, formula-fed infants weighed approximately 890g more than their breastfed counterparts. This divergence in weight gain is consistent with the findings of Dewey et al. in the DARLING Study, which reported that formula-fed infants gained weight more rapidly than breastfed infants, particularly after 3 months of age [3]. Similarly, a study by Bell et al. found that formula-fed infants were significantly heavier than breastfed infants at 12 months of age, with the differences becoming apparent around 4 months [11].

The z-score analysis in our study provides further insight into these growth differences. Formula-fed infants demonstrated progressively higher weight-for-age (WAZ) and weight-for-length (WLZ) z-scores from 6 months onward, suggesting a deviation from the WHO growth standards. By 12 months, the mean WAZ for formula-fed infants was 0.98 compared to 0.07 for breastfed infants. These findings align with those reported by Baird et al., who conducted a systematic review showing that breastfeeding was associated with a reduced risk of obesity and that formula-fed infants tend to cluster at the upper centiles of weight distribution in later infancy [12].

Interestingly, our study found no significant differences in length-for-age z-scores (LAZ) between the feeding groups throughout the study period. This observation is supported by previous research by Giugliani et al., who reported that while weight gain differed between breastfed and formula-fed infants, linear growth remained comparable [13]. This suggests that infant feeding mode may have differential effects on weight gain and linear growth, potentially influencing body composition development.

The body composition analysis in our study revealed important differences, with formula-fed infants exhibiting significantly higher fat mass at all assessment time points (3, 6, and 12 months). By 12 months, formula-fed infants had accumulated 22.2% more fat mass than breastfed infants. Additionally, body fat percentage became significantly higher in formula-fed infants at both 6 and 12 months. These findings are consistent with those reported by Fields et al., who documented that formula-fed infants had higher fat mass and body fat percentage compared to breastfed infants at 6 months of age [6]. Similarly, Gale et al. used dual-energy X-ray absorptiometry to demonstrate that formula-fed infants had higher fat mass and lower fat-free mass relative to body weight compared to breastfed infants in early childhood [14].

The growth velocity analysis in our study showed that formula-fed infants exhibited significantly higher weight gain velocity, particularly during the 0-2 month period, where they gained weight 14.8% faster than breastfed infants. This observation aligns with findings from a large cohort study by Rzehak et al., who reported that formula-fed infants showed higher growth velocity in the first few months of life compared to exclusively breastfed infants [10]. The accelerated early weight gain observed in formula-fed infants may have implications for future health outcomes, as rapid early weight gain has been associated with increased risk of later obesity and metabolic disorders [15].

One of the most striking findings in our study was the substantial difference in centile crossing patterns between the feeding groups. For weight-for-age, 36.0% of formula-fed infants crossed upward by ≥2 centile lines compared to only 8.0% of breastfed infants. An even more pronounced difference was observed for weight-for-length, where 40.0% of formula-fed infants crossed upward by ≥2 centile lines compared to only 4.0% of breastfed infants. These findings mirror those reported by Kramer et al. in the PROBIT study, which found that breastfed infants were more likely to maintain their growth trajectory within expected centile ranges compared to formula-fed infants [16]. The tendency for formula-fed infants to cross centiles upward may be clinically significant, as upward centile crossing during infancy has been associated with increased risk of overweight and obesity in later childhood [17].

The differences in growth patterns observed in our study may be partly explained by the compositional differences between breast milk and formula. Human milk contains bioactive compounds, hormones, and growth factors that may regulate infant growth and metabolism [4]. For instance, leptin and adiponectin in breast milk may influence infant appetite regulation and fat deposition [18]. Additionally, breast milk composition changes dynamically throughout the day and over the course of lactation, whereas formula composition remains constant [19].

Another potential explanation for the observed differences lies in the protein content of infant formulas. Despite recent reductions, most infant formulas still contain higher protein levels than human milk. The "early protein hypothesis" proposed by Koletzko et al. suggests that high protein intake during infancy stimulates secretion of insulin-like growth factor 1 (IGF-1) and insulin, promoting weight gain and adipose tissue deposition [7]. This hypothesis is supported by the findings of the European Childhood Obesity Project, which demonstrated that infants fed high-protein formula gained more weight and had higher IGF-1 levels than infants fed lower-protein formula or breast milk [20].

Feeding practices may also contribute to the observed differences. Breastfed infants have greater control over feeding volume and frequency, potentially developing better self-regulation of energy intake [21]. In contrast, formula feeding may be associated with parental behaviors that encourage infants to finish bottles, potentially overriding innate satiety cues [22]. These behavioral aspects of infant feeding were not directly measured in our study but warrant further investigation.

It is important to acknowledge the demographic differences between our feeding groups, particularly maternal education level, which was significantly higher among mothers who exclusively breastfed. This observation is consistent with global breastfeeding patterns, where higher maternal education is often associated with higher breastfeeding rates [2]. Although we adjusted for these differences in our analyses, residual confounding may remain, as socioeconomic factors are complexly intertwined with infant feeding decisions and growth outcomes.

Our findings have implications for clinical practice, particularly in growth monitoring and nutritional counseling. The differences in growth trajectories between breastfed and formula-fed infants highlight the importance of using appropriate growth references when assessing infant growth. The WHO growth standards, which are based predominantly on the growth of breastfed infants from diverse geographic regions, represent the physiological norm for infant growth [23]. Our results support the use of these standards for all infants while

recognizing that formula-fed infants may demonstrate different growth patterns.

The limitations of our study include the relatively small sample size of 50 infants and the potential for selection bias, as participants were recruited from a single center. Additionally, while we classified infants as exclusively breastfed or formula-fed based on feeding at enrollment, feeding practices often evolve over time. Future studies with larger, more diverse cohorts and more detailed assessment of feeding practices throughout infancy would strengthen our findings.

CONCLUSION

This prospective cohort study demonstrated significant differences in growth patterns between exclusively breastfed and formula-fed infants during the first year of life. While linear growth remained comparable between groups, formula-fed infants exhibited accelerated weight gain, higher fat mass accumulation, and more frequent upward centile crossing for weight-related parameters. These findings highlight the importance of feeding mode as a determinant of early growth trajectories and body composition development, with potential implications for future metabolic health. Healthcare providers should consider these differential growth patterns when monitoring infant growth and providing nutritional guidance to families.

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