Original Article

Growth Indices of Exclusively Breastfed Until 6 Months Age and Formula-Fed Infants in Southwest of Iran

Abstract

Background: Formula milk is prepared as a nutritional substitution for human breast milk, but because of biologic and constituent differences, it might cause obesity and growth disorders in infants. In this study, we compared the growth pattern of formula-fed and breastfed infants living in Yasuj, southwest of Iran. **Methods:** Infants 7–14 months of age in southwest of Iran were classified as exclusively breastfed (n = 200) and formula-fed (n = 200) in their first 6 months of life. Growth velocity and Z-scores of weight for age, length for age, weight for length, and head circumference were estimated using WHO Anthro Plus software (2010) and SPSS Version 19 (SPSS Inc., Chicago, IL, USA) using World Health Organization reference for growth data. **Results:** The study showed that Z-score of length for age and head circumference for age at the birth were significantly lower in formula-fed group than exclusively breastfed group ($P < 0.05$), but the Z-score of weight for length did not differ significantly. At the sixth month of age, Z-score of weight for length was significantly higher in formula-fed group ($P < 0.05$), but Z-score of length for age had no significant difference and Z-score of head circumference was higher in exclusively breastfed group yet ($P < 0.05$). Growth velocity, prevalence of obesity, wasting, underweight, and stunting did not differ between two groups. **Conclusions:** Our findings suggest that formula feeding can lead to greater weight gain and may help the catch up of length, but evidences are not convincing enough to suggest the formula as an obesogenic feeding in the studied area. To make a conclusion, we suggest comparing the privileged and unprivileged areas and controlling for confounding variables including family hygiene and infant feeding practices between formula-fed and breastfed infants.

Keywords: *Breastfeeding, formula feeding, growth velocity*

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Introduction

Nutrition during infancy could program lifelong risk of obesity and chronic diseases such as hypertension, type 2 diabetes, nonalcoholic fatty liver, and cardiovascular disease.[1-3] Human breast milk and formula are the main infantile feeding during the first year of life and have important effects on a child's nutritional status. Some studies reported that breastfeeding is associated with lower adiposity and higher stature in children.[4,5]

According to the accelerated postnatal weight gain hypothesis, formula feeding increases the fat mass of infants and may be the cause of metabolic disorders in later life;[3] however, the reports are controversial. While in some studies formula feeding is associated with risk of obesity,[6-8] others did not report significant difference in body mass index of formula-fed and breastfed infants.[4,9]

Human breast milk provides all dietary requirements of children until 6 months of age[10-12] and its composition changes proportionate to the child's requirements through the infant feeding duration.[13,14] However, formula milks are significantly different from human milk in the kinetics of a child's growth.[15] Growth patterns are evaluated through comparing growth indices at a specific age with a reference chart (prospective assessment) or measuring and comparing the growth indices within a time interval expressed as growth velocity. Growth velocity measurement is a dynamic process, which takes a period of growing child's life and is a useful index in evaluating nutrition effects and growth monitoring.[16,17]

Differences in nutritional content and characteristics of human milk and formula milk may affect infant growth.[18-20] On the other hand, the growth difference between formula-fed and breastfed infants

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may be related to behavioral effects of feeding type or related to developmental situation of society.[13] To compare the effects of formula feeding and breastfeeding on the growth pattern of infants living in Yasuj, we compared anthropometric indices between two groups of exclusively breastfed or formula-fed infants that were matched based on gender and socioeconomic status.

Methods

We conducted this historical cohort study in Yasuj County, southwest of Iran. In all, 400 children 7–14 months of age (200 exclusively breastfed and 200 infant with only formula feeding during the first 6 months of life) referring to health centers were selected. The infants' gender matched in both groups. The infants' mothers reported the type of feeding consumed by their children. Inclusion criteria for the breastfed group were exclusively breastfeeding during the first 6 months of life and breast-feeding afterward until weaning. Inclusion criteria for the formula-fed group were formula feeding from the first month of life without breast-feeding. Infants that have fed both breast milk and formula are not included in the comparison. Ethical Committee of Yasuj University of Medical Science approved all the study procedures (ethical code: IR. YUMS. REC.1395.223). Only the children with Iranian ethnicity, born healthy, singleton, and after 37 weeks of gestation, without apparent congenital anomaly, were enrolled in the study. Infants' demographic information were recorded asking their mothers. Child growth data at birth and 6 months of age were achieved through medical records in healthcare clinics. Weight, length, and head circumference at birth, feeding type until 6 months of age, delivery type, gender, and children birth order were obtained from medical records. Trained health staff measured weight, height, and head circumference for each infant and recorded them in related household file. Weight was measured to the nearest 100 g with the lightest clothing. Length was measured to the nearest 0.5 cm on an infant length board. *Z*-scores of weight for age, length for age, and head circumference for age were calculated based on World Health Organization reference growth data[21] using Anthro software version 3.2.2. Weight-for-age *Z*-score (WAZ), weight-for-length *Z*-score (WLZ), and length-for-age *Z*-score (LAZ) below −2 were identified as underweight, wasting, and stunting, respectively. Weight-for-length *Z*-score (WLZ) higher than two was regarded as obesity.[17] Weight growth velocity (GV, g/kg/day) was computed for each child. Actual or accurate standard GV (g/kg/day) was calculated using the following formula:[5,22]

$$weight\ velocity = \frac{1000(wi - w0)}{180(\frac{wi + w0}{2})}$$

where w_0 = weight in gram at birth and wi = weight in gram at 6 months of age.

The following procedure was applied to calculate the *Z*-score of weight velocity for an individual child with weight increment *y* at the visit age *t* (17):

$$Z_{ind} = \frac{[\mathrm{Y} / \mathrm{M}(t)]^{\mathrm{L}(t)} - 1}{\mathrm{S}(t)\mathrm{L}(t)}$$

The above formula was applied to calculate the *Z*-score for velocity of length and head circumference for a child with increment *y* at the visit age *t*. Detailed explanation and each value of *M (t)*, *L (t)*, *S (t)*, and δ coefficient for both genders at 6 months of age were provided elsewhere.[21]

Statistical analysis

We analyzed the continuous variables for normality distribution and did not find any serious deviation from normality. Continuous variables were compared using independent samples *t*-test between formula-fed and breastfed groups. *Z*-score indices in each group were compared at the birth with 6 months of age using paired samples *t*-test. Qualitative variables were compared using Chi-square test. SPSS version 19 (SPSS Inc., Chicago, IL, USA) was used for statistical analysis.

Results

Tables 1 and 2 summarize the sociodemographic and anthropometric characteristics of infants, respectively. Chi-square test did not show any statistical difference between demographic characteristics of two groups [Table 1].

Birth head circumference in breastfed group was significantly higher than that of formula-fed group ($P < 0.001$). Birth length was also significantly higher in exclusively breastfed group ($P = 0.02$), but the birth weight of both groups was not statistically different.

Table 1: Sociodemographic data of study population

Variable	Breastfed, *n* (%)	Formula-fed, *n* (%)	*n* (%)	*P*
Infant rank (order)				
1	58 (29)	64 (32)	122 (30.5)	0.51
2	76 (38)	65 (32.5)	141 (35.2	
≥3	66 (33)	71 (35.5)	137 (34.2)	
Mother education (years)				
0-5	34 (17)	34 (17)	68 (17)	0.94
6-12	105 (52.5)	102 (51)	209 (523)	
>12	61 (30.5)	64 (32)	123 (30.8)	
Father education (years)				
1-5	20 (10)	13 (6.5)	33 (8.2)	0.56
6-12	110 (55)	98 (48)	208 (52)	
>12	70 (35)	69 (34.5)	159 (39.8)	
Gender				
Boy	100 (50)	100 (50)	200 (50)	1
Girl	100 (50)	100 (50)	200 (50)	

NS=Not significant

According to Table 3, birth LAZ and birth HCZ in exclusively breastfed group were significantly higher than formula-fed group (P = 0.005 and P = 0.012, respectively). HCZ of exclusively breastfed group was also significantly higher than formula-fed group at 6 months of age (P = 0.016). WLZ of formula-fed group was significantly higher than exclusively breastfed group at the sixth month of age (P = 0.02).

Table 4 shows the *Z*-score changes from birth to sixth month of age in both groups. In the formula-fed group, WAZ, WLZ, and LAZ increased more than breastfed group; however, the increment was just significant for WAZ (P = 0.021).

LAZ was significantly lower in boys than girls ($P \leq 0.01$); also, boys had more LAZ at birth and 6 months of age and HCZ at 6 months of age than girls. In addition, the prevalence of obesity, underweight, wasting, and stunting did not differ between exclusively breastfed and formula-fed groups [Figure 1].

Discussion

In spite of similar weight for age and WLZ at birth in both groups, we observed that WLZ was significantly higher in formula-fed group at 6 months of age, indicating that formula feeding can lead to a higher weight gain than breast milk in infants. Similar to our findings, Agostoni *et al*. in an Italian population showed that formula-fed groups had higher weight for length at 12 months of age.[22] In another cohort study, Dewey *et al*. showed that the mean weight of formula-fed infants was significantly higher than breastfed infants between 6 and 18 months of age.[23] In accordance with our study, other studies also confirmed that formula-fed infants have more weight gain than breastfed infants.[24-27]

These differences may be due to different nutritional contents of human milk and formula milk such as the ratio of omega 3 and omega 6 fatty acids[18] and insulin response to higher amount of protein in formula.[19,20] Furthermore, the growth difference between formula-fed and breastfed infants may also be related to behavioral effects of feeding type or related to developmental situation of society.[13] In spite of higher LAZ in breastfed group at birth, we did not observe the same significant difference among groups at 6 months of age. It means that length for age is compensated in formula-fed group during the first 6 months of life. Comparing the *Z*-score changes at the sixth month of age showed greater increase in WAZ, LAZ, and WLZ in formula-fed group, but just WAZ was significantly changed. Similar to our study results on LAZ, Bell *et al*. also reported similar LAZ between formula-fed and breastfed groups.[25] In contrast, in an American study, weight *Z*-scores of breastfed infants decreased slightly

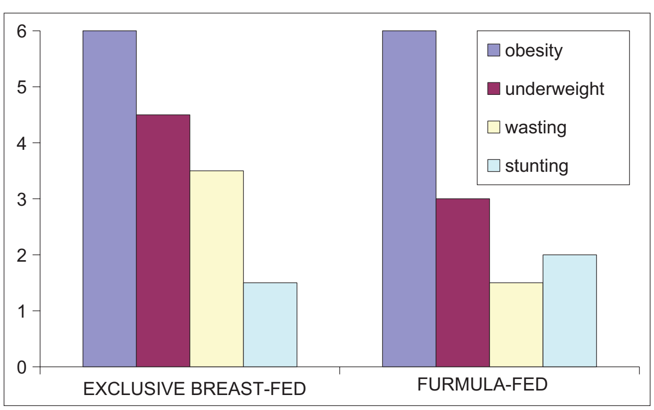

Figure 1: Obesity, underweight, wasting, and stunting among group

Table 2: Anthropometric data of the study population

	Mean±SD		Total (n=400)	P
	Breastfed (n=200)	formula-fed (n=200)		
Birth weight (kg)	3.2±0.4	3.2±0.5	3.2±0.5	0.19
Birth length (cm)	49.5±2	48.5±2.8	49±2.6	0.001
BHC (cm)	34.6±1.2	34.3±1.5	34.5±1.4	0.023
Sixth month weight (kg)	7.9±1	7.9±1	7.9±1	0.9
Sixth month length (cm)	67.4±2.5	66.92.8	67.1±2.1	0.05
Sixth month head circumference (cm)	43.3±1.3	43±1.4	43.2±1.4	0.02
Prepregnancy mother weight (kg)	67±12	65.7±10.3	66.3±11.2	0.25
Pregnancy during weight gain (kg)	11±3.7	11.3±3.8	11.1±3.7	0.26

Continuous variables between formula-fed and exclusive breastfed infants were compared using independent sample *t*-tests, respectively SD=standard deviation, BHC=birth head circumference

Table 3: *Z*-score and velocity of growth indices population of study

	Mother milk fed (n=200)	Formula-fed (n=200)	Total (n=400)	P
Birth WAZ	−0.18±0.9	−0.3±1.1	−0.3±1	0.06
Birth WLZ	−0.25±1.3	0.01±1.4	−0.2±1.4	0.13
Birth LAZ	0.07±1.1	−0.25±1.2	0.1±1.1	0.005
Birth HCZ	0.38±0.94	0.11±1.2	0.24±1.1	0.012
Sixth month WAZ	0.25±1.3	0.31±1.1	0.27±1.2	0.26
Sixth month WLZ	0.12±1.26	0.41±1.21	0.27±1.2	0.020
Sixth month LAZ	0.3±1	0.25±1.3	0.28±1.1	0.56
Sixth month HCZ	0.5±1	0.3±1.2	0.4±1.1	0.016
Weight velocity *Z*-score	0.4±1.2	0.5±1.1	0.45±1.1	0.35
Height velocity *Z*-score	1.7±0.3	1.8±0.3	1.75±0.3	0.91
Head circumference velocity *Z*-score	0.03±1	0.1±1	0.0.6±1	0.49
Weight velocity (g/kg/day)	4.7±0.6	4.8±0.7	4.76±0.3	0.21

WAZ=weight-for-age *Z*-score, NS=not significant, LAZ=length-for-age *Z*-score, HCZ=head circumference-for-age *Z*-score, WLZ=weight-for-length *Z*-score

Table 4: Mean and standard deviation of *Z*-score changes from birth to 6 months of age in formula-fed and breastfed groups

Z-scores feeding type	*n*	Mean±SD	Significant
HCZ_{diff}			
Breast milk	199	0.1564±1.16379	0.99
Formula	199	0.1566±1.19101	
WLZ_{diff}			
Breast milk	196	0.3779±1.62587	0.87
Formula	199	0.4046±1.54846	
WAZ_{diff}			
Breast milk	195	0.3898±1.34863	0.021
Formula	198	0.7035±1.32489	
LAZ_{diff}			
Breast milk	200	0.2432±1.40351	0.07
Formula	200	0.5020±1.44594	

SD=standard deviation, HCZ=head circumference-for-age *Z*-score, WLZ=weight-for-length *Z*-score, WAZ=weight-for-age *Z*-score, LAZ=length-for-age *Z*-score

over first 7 months, whereas WLZ of formula-fed infants increased.[25]

In this study, HCZ was significantly higher in breastfed than formula-fed group at birth and at 6 months of age. However, the change in HCZ is the same in both the groups and the observed difference could be due to baseline difference in HCZ in the two groups. Brain tissue is a rapidly synthesizing tissue during the last pregnancy trimester and neonatal period. Infant mental development and brain growth need docosahexaenoic acid (DHA) and arachidonic acid (AA). Because of incomplete enzymatic activity, the synthesis of AA and DHA from their precursor fatty acid is negligible in fetus and infants. Therefore, the AA and DHA requirements must be provided from the mothers' diet during prenatal period or breastfeeding postnatal.[28] From the sixth week of lactation to the sixth month, the fat and polyunsaturated fatty acid content of human milk increases, thus breastfeeding in this period is significant to child's nutrition.[11]

Researchers propose that because of late assessment the consequences of human milk fatty acids on brain development are unknown. Although breast milk has lower protein than formula milks, overall amino acid profile of human milk fulfills needs of developing infant systems. For instance, glutamine, the most abundant free amino acid in human milk, might play a neurotransmitter role in the brain.[11] Most of the formula milks are manufactured from milk of mammalians such as cow; however, these milk fats cannot substitute human milk.[29] Even human breast milk in mothers delivering preterm babies contains higher DHA and AA than milk from mothers delivering full-term babies.[30] In this study, growth velocity indices did not significantly differ based on feeding type at first 6 months of age; it may be because of research design in our study or the small sample size. These indices are used in longitudinal studies for assessing the growth patterns.[16,17]

Conclusions

Our findings show that formula feeding may increase body weight more than human breast milk. In addition, it may compensate for the length growth retardation that is frequently seen in unprivileged children. In addition, it may make formula-fed infants prone to overweight and obesity in privileged children. However, because of small sample size and cross-sectional design of our study, we must interpret these findings with caution. For a conclusion, we suggest implementing the study as cohort group comparing privileged and unprivileged areas and controlling for infants hygiene and other feeding practices.

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Conflicts of interest

There are no conflicts of interest.

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