

## The relationship between feeding patterns and growth of infants up to 6 months

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*Sri Lanka Journal of Child Health*, 2020; 49(2): 132-139

### Abstract

**Background:** Proper growth is one of the most reliable criteria for assessing the health status of infants. Nutrition is one of the factors affecting infant growth.

**Objectives:** To determine the relationship between the pattern of nutrition and growth of infants up to 6 months of age.

**Method:** A cohort study was conducted on 210 infants ranging from 3-5 days old to 2 months old from July 2016 to August 2017. Data were collected by using a demographic collective form, and measurement of growth indices from 2 to 6 months in three food patterns. Data analysis was done using ANOVA, repeated measures, Chi-square, Pearson correlation coefficient by SPSS software version 18.

**Results:** The results showed that infants fed breast milk or mixed feeding were heavier and taller at 2, 4 months old than infants fed formula. There was no significant difference in 6 month variation in weight in all three dietary patterns ( $p=0.405$ ). These changes were significant in the case of height ( $p<0.001$ ) and were higher in formula feeding group. No significant difference was found in the mean head circumference from 2 to 6 months and its changes during 6 months in all three dietary patterns.

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(Received on 28 June 2019; Accepted after revision on 16 August 2019)

The authors declare that there are no conflicts of interest

Personal funding was used for the project.

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**Conclusions:** The results of this study indicated that exclusive breastfeeding and mixed feeding patterns in comparison with formula feeding can have more favourable effect on the growth of weight and height in infants between the ages of 2-4 months.

DOI: <http://dx.doi.org/10.4038/sljch.v49i2.8960>

(Key words: Exclusive breastfeeding, formula feeding, mixed feeding, growth, infant)

### Introduction

The increase in physical size is called growth<sup>1,2</sup>. Growth in childhood is one of the most important components of health in life<sup>3</sup>. Nutrition has the strongest effect on regulating growth, especially during the first year of life<sup>4</sup>. Growth is assessed by measuring changes in weight, height and head circumference. The change in weight reflects changes in muscle mass, fat tissue, bones and water in the body, and therefore is a non-specific growth index. Height measurement is the best indicator of skeletal growth. Changes in the head circumference reflect the growth of the brain as well as the growth of the entire body<sup>1</sup>.

Growth is affected by various factors including genetics, environmental factors, cultural factors, economic conditions, sex, age, nutrition, and internal metabolism<sup>2,4-8</sup>. The dietary pattern has a special effect on the anthropometric measurements of infants. Oginska A, *et al.* reported that the weight, height, and head circumference of breast-fed infants were higher than formula-fed infants in the first months of life, and lower in the second half of their first year of life<sup>9</sup>. Formula-fed infants have a different growth pattern, especially at 3 to 6 months of age when they have more weight and fat and after this time, they have higher concentrations of serum amino acids, insulin, and blood urea nitrogen than breast-fed infants<sup>10</sup>. At one year of age, the weight of formula-fed infants is usually 500-600g more than that of breast-fed infants<sup>11</sup>. Probably the difference in protein intake between breast-fed and formula-fed infants is one reason for the differences in growth pattern of these infants<sup>4</sup>.

In one study no significant effect of the duration of lactation on infants' weight in the first 6 months was detected<sup>12</sup>. Another study reported that breast milk, formula, and a mixture of the two have similar effects on weight and height at 4, 8 and 12 months<sup>13</sup>. The results of several studies have shown that breast-fed infants had a higher growth rate in early

life than formula-fed infants. Another group of studies, however, has suggested that the weight gain of formula-fed infants is greater than that of breast-fed infants during the first months of growth<sup>11-19</sup>.

### Objectives

To determine the relationship between the dietary pattern and the growth of infants up to 6 months of age.

### Method

This cohort study was conducted on 210 singleton, term, normal weight at delivery, appropriate for gestational age, and healthy infants, ranging from 3-5 days to 2 months old, consuming multivitamin or vitamins A and D supplement with a dietary pattern of breast feeding, formula feeding, or breast and formula feeding, who were referred to health centres of Jam in Bushehr Province in Iran, from July 2016 to August 2017. Babies with birth weights less than 2500g at birth were excluded from the study. Samples were selected based on a targeted convenience sampling. Infants were excluded in the event of any changes in the type of nutritional group after recruitment or infection with diseases intervening with their nutrition. The most appropriate sampling in a cohort study is multi-stage sampling. Jam is a county with 70,051 population in Bushehr Province in Iran<sup>20,21</sup>. There are only 4 health centres and 22 Health homes. Due to limited population of eligible Infants of 3-5 days to 2 months old who referred to these centres, convenient sampling from all centres was selected as the sampling method.

*Sample size:* Based on previous studies<sup>12,22</sup>, and assuming 5% error, 80% power and effect size 30% and using the formula

$$n = \frac{2p(1-p)(t_{\alpha,v} + t_{\beta(1,v)})^2}{(d)^2}$$

63 people in each group were estimated. Given the longitudinal study and repeated measurement of variables and a 10% drop, the sample size was finally 70 in each group and a total of 210 children were determined. Therefore according to determined sample size, 70 infants were recruited in each group.

First, the objectives of the study were explained to the parents who were referred for the health care of their 3-5 days to 2 months old infants. Then, the eligible infants of the parents who filled in the written consent form for participation in the study were recruited. Subsequently, based on the answers of the parents to the researcher about the nutrition of the infants, they were divided into 3 groups of nutrition, including exclusive breastfeeding,

formula feeding, and mixed feeding (formula and breast feeding).

According to the parents' answers, a demographic collective form was filled by the researcher including characteristics of the parents such as age, education, gestational age, mother's disease history, and characteristics of the infant including sex, birth order, birth date, type of delivery, type of nutrition and infants' diseases. Information on infants' weight, height, and head circumference at birth was retrieved from their health record and growth monitoring card. The nutritional status of the infants was then monitored in terms of continuity of dietary pattern from the beginning of the study to 6 months and the height, weight and head circumference of the infants were measured at the age of 2, 4, and 6 months. The height was measured while the infants were lying supine using the stadiometer board, and the following measures were taken to ensure correct measurement. The head was kept in line with the body's middle line, the knees were simultaneously and slowly straightened, and the feet were pulled until the legs were perfectly straight.

The weight was measured with a standard SECA scale that was calibrated during the study at a specified time period (once a week) and had a  $\pm 20$ g accuracy. The infant had to have minimum clothing for weight measurement. A non-elastic paper or cloth meter was used to measure the head circumference which passed above the eyebrows, auricle, and inion. Head circumference and height were measured with standard tape meter with a  $\pm 0.2$  cm accuracy. Eighteen infants were excluded from the study due to a change in the type of dietary pattern and 2 infants due to their absence at the designated time for follow up. They were replaced with other infants.

Data analysis was performed using descriptive statistical methods, ANOVA, repeated measures, Chi-squared, Pearson correlation coefficient at a significance level of 5%. Data were analysed by SPSS-18 software.

### Results

In this study, 210 infants were divided into 3 groups based on the type of feeding: 70 subjects in breast-fed group, 70 subjects in formula-fed group, and 70 subjects in mixed-fed (breast milk and formula) group. Of the total infants, 50.5% were female. Most of them were first born. The demographic characteristics of the subjects and their parents in the three groups are summarized in Table 1.

**Table 1: Comparison of the demographic characteristics of infants and their parents in the three groups of breast-fed, formula-fed, and mixed-fed infants**

Variable	Nutritional pattern			Total n (%)	p-value
	Breastfeeding n (%)	Formula feeding n (%)	Mixed feeding n (%)		
<i>Sex</i>					
Girl	37 (52.9)	37 (52.9)	32 (45.7)	106 (50.5)	0.654
Boy	33 (47.1)	33 (47.1)	38 (54.3)	104 (49.5)	
<i>Parity</i>					
First	30 (42.9)	59 (84.3)	28 (40.0)	117 (55.7)	< 0.001
Second	28 (40.0)	06 (08.6)	34 (48.6)	68 (32.4)	
≥3	12 (17.1)	05 (07.1)	08 (11.4)	25 (11.9)	
<i>Mother's age</i>					
20 or less	03 (04.3)	02 (02.9)	0 (0)	05 (02.4)	0.304
21-25	17 (24.3)	18 (25.7)	15 (21.4)	50 (23.8)	
26-30	26 (37.1)	27 (38.6)	33 (47.1)	86 (41.0)	
31-35	17 (24.3)	12 (17.1)	18 (25.7)	47 (22.4)	
36-40	06 (08.6)	05 (07.1)	02 (02.9)	13 (06.2)	
>40	01 (01.4)	06 (08.6)	02 (02.9)	09 (04.3)	
<i>Mother's education</i>					
Primary school	05 (07.1)	06 (08.6)	07 (10.0)	18 (08.6)	0.075
Secondary school	08 (11.4)	0 (0)	05 (07.1)	13 (06.2)	
High school	31 (44.3)	28 (40.0)	31 (44.3)	90 (42.7)	
University	26 (37.1)	36 (51.4)	27 (38.6)	89 (42.4)	
<i>Mother being employed</i>	04 (05.7)	04 (05.7)	04 (05.7)	12 (05.7)	0.999
<i>Housing situation</i>					
Personal	30 (42.9)	42 (60.0)	40 (57.1)	112 (53.3)	0.116
Rent	39 (55.7)	28 (40.0)	30 (49.9)	97 (46.2)	
With parents	01 (01.4)	0 (0)	0 (0)	01 (0.5)	
<i>Father's education</i>					
Primary school	01 (01.4)	08 (11.5)	0 (0)	09 (04.3)	0.002
Secondary school	08 (11.4)	0 (0)	05 (07.1)	13 (06.2)	
High school	29 (41.4)	31 (44.3)	29 (41.4)	89 (42.4)	
University	32 (45.7)	31 (44.3)	36 (51.4)	99 (47.1)	

Based on the Chi-squared test results, the distribution of birth order and father's educational level were statistically different among the three groups. Other variables were not statistically significant different among the three groups and were assumed to be the same. Results of one-way ANOVA showed a significant difference between the three groups in terms of weight at birth, at 2 months, and at 4 months of age. Tukey's test showed that this difference was due to the difference of

breast milk with formula ( $P < 0.05$ ), so that breast-fed and mixed-fed infants had higher weights at birth, 2 months, and 4 months old. We used Repeated Measure Analysis of Covariance (RMANCOVA)<sup>23</sup> for controlling the birth weight. Results showed that weight changes were significant in all three groups. On the other hand, weight gain over 6 months was the same in all three groups and did not have a significant statistical difference (Table 2).

**Table 2: Comparison of changes in the mean weight of the infants at birth, 2 months, 4 months, and 6 months of age in the three groups of breast-fed, formula-fed, and mixed-fed infants**

Variable	Nutrition pattern			Total Mean ± SD	p-value
	Breast feeding Mean ± SD	Formula feeding Mean ± SD	Mixed feeding Mean ± SD		
<i>Weight (kg)</i>					
Birth	3.21 ± 0.43	2.74 ± 0.58	3.36 ± 0.39	3.10 ± 0.55	< 0.001
2 months	5.27 ± 0.58	4.62 ± 0.90	5.36 ± 0.71	5.08 ± 0.81	< 0.001
4 months	6.68 ± 0.75	6.26 ± 0.94	6.93 ± 0.78	6.62 ± 0.87	< 0.001
6 months	7.73 ± 0.93	7.50 ± 0.99	7.91 ± 1.62	7.71 ± 1.23	0.136
<i>Changes over 6 months</i>	4.51 ± 0.88	4.75 ± 0.77	4.54 ± 1.61	-	0.405
p-value	< 0.001	< 0.001	< 0.001	-	

Results of one-way ANOVA showed a significant difference between the three groups in terms of height at birth, at 2 months, and at 4 months of age ( $p < 0.05$ ). In the intra-group analysis, the changes were significant in all three groups, but there was a

significant difference between the three groups in terms of changes over 6 months so that the mean changes in height were higher in the formula-fed group ( $p < 0.05$ ) (Table 3).

**Table 3: Comparison of changes in the mean height in the three groups of breast-fed, formula-fed, and mixed-fed infants**

Variable	Nutrition pattern			Total	p-value
	Breast feeding Mean ± SD	Formula feeding Mean ± SD	Mixed feeding Mean ± SD		
Height (cm)					
Birth	50.27 ± 2.98	47.97 ± 2.72	50.52 ± 1.68	49.59 ± 2.76	< 0.001
2 months	57.53 ± 3.31	55.56 ± 2.40	56.88 ± 2.27	56.65 ± 2.81	< 0.001
4 months	63.04 ± 2.52	61.44 ± 2.46	63.24 ± 2.32	62.5 ± 2.56	< 0.001
6 months	66.91 ± 2.67	66.89 ± 2.34	67.18 ± 2.26	67.00 ± 2.42	0.748
Changes over 6 months	16.67 ± 0.88	18.92 ± 2.13	16.65 ± 2.38	-	< 0.001
p-value	< 0.001	< 0.001	< 0.001	-	

There was no significant difference in mean head circumference among the three groups at any of the measurement times. However, the changes in each of the three groups were significant and showed a

linear upward trend. Also, there were no significant differences between the three groups in terms of changes over 6 months ( $p = 0.196$ ) (Table 4).

**Table 4: Comparison of changes in the mean head circumference in the three groups of breast-fed, formula-fed, and mixed-fed infants**

Variable	Nutrition pattern			Total	p-value
	Breast feeding Mean ± SD	Formula feeding Mean ± SD	Mixed feeding Mean ± SD		
Head circumference (cm)					
Birth	34.92 ± 1.93	34.65 ± 1.48	35.11 ± 1.06	34.89 ± 1.54	0.202
2 months	39.13 ± 2.56	38.27 ± 1.43	38.59 ± 1.22	38.37 ± 3.72	0.836
4 months	41.16 ± 1.18	40.77 ± 1.38	41.02 ± 1.24	40.98 ± 1.27	0.175
6 months	42.95 ± 1.18	43.00 ± 1.33	42.92 ± 1.42	42.96 ± 1.31	0.937
Changes over 6 months	8.03 ± 2.19	8.35 ± 1.61	7.80 ± 1.46	-	0.196
p-value	< 0.001	< 0.001	< 0.001	-	

The weight gain and changes in height and head circumference over 6 months were calculated to investigate the relationship between infants' growth and socioeconomic status. Also, an overall score for the socioeconomic status variable was calculated for families by combining the factors of parents' educational level, parents' occupation, and housing status with appropriate scoring. The relationship between this socioeconomic status variable and the infants' growth was measured using the Pearson correlation coefficient. Based on this analysis, there was no significant association between infant's growth indicators and the socioeconomic status ( $p > 0.05$ ).

**Discussion**

There was a significant difference among the three groups in birth weight at the beginning of the study. According to E.L. Fancher thesis entitled

"Comparison of methods of analysis for pre-test and post-test data", if the two groups were truly equivalent at pre-test, one-way analysis of variance (ANOVA) on post-test scores should be a sufficient method to evaluate differences between the control and treatment groups. Analysis of covariance (ANCOVA), using pre-test scores as a covariate, can be used to remove the effect of pre-test scores and fairly compare post-test scores between groups<sup>23</sup>. Therefore ANCOVA was done in the current study. It seems that the difference in birth weight among three groups has not affected the results.

Current study showed that there was a significant difference between infants' weight at birth, 2 months, and 4 months old among the three groups of breast-fed, formula-fed, and mixed-fed infants. On the other hand, weight gain over 6 months had no significant statistical difference in all three groups.

Similar to present study, Li SC *et al.* in Taiwan (2010), did not find a significant difference between the three dietary groups in terms of weight at 6 months of age<sup>12</sup>. However, in their study, height and weight of infants at birth, 4, 6, 12 and 18 months old were obtained using data recorded in the household health records, while in this study, in addition to the above indicators, the head circumference at birth, 2, 4 and 6 months of age were evaluated, and data on growth indices were obtained based on the researcher's measurements with the exception of measurements at birth. Allahgholi L *et al.* (2011), in a study in West Tehran, found no significant relationship between duration of breastfeeding and weight of the child at 6 and 12 months of age, but they found a significant inverse relationship between the duration of breastfeeding and the weight of the child at 24 months of age ( $p=0.001$ )<sup>15</sup>. Their result about weight at 6 months of age is consistent with the current study. Results of Mohammad Beigi A, *et al.* (2009) examining the effect of breastfeeding on the growth pattern of infants under 6 months old in Arak in Iran, about the weight of infants at 2 and 4 months of age and head circumference of infants at 2, 4 and 6 months of age were in line with the current study<sup>24</sup>. Although the weight gain of infants was compared in two dietary patterns of breastfeeding and breastfeeding with complementary nutrition in their research, it was consistent with the present study, which was considered in formula feeding in addition to the two above-mentioned patterns.

In a study by Gunnarsdottir I, *et al* (2010), infants exclusively breastfed for 2 months and less than 2 months had more weight gain than infants that were exclusively breastfed for 3-4 months at 2 to 6 months old<sup>25</sup>. Their results are inconsistent with the present study. Gunnarsdottir I, *et al* only explored the effects of breastfeeding duration on two growth indices (weight and BMI) in two different countries while the present study explored the effect of 3 nutrition patterns (breastfeeding, formula feeding, and mixed feeding) on growth indices (weight, height, and head circumference) in one of the cities of Iran. Imai CM, *et al.* (2014) in a study in Iceland showed that infants, formula-fed during the first 5 months of their life, especially between 2-6 months old, had a faster after-birth weight gain than exclusively breast-fed infants. In addition, a group that started taking solid food along with formula at the age of 5 months also had a much faster weight gain compared to exclusively breast-fed infants. Thus, there was less difference between the group that started taking solid foods together with breastfeeding, compared to exclusively breast-fed infants<sup>16</sup>. Their results are not consistent with the present study. This difference may be due to a different type of dietary pattern of

infants in their study since in addition to the exclusive breast feeding and formula feeding, intake of solid food along with breast milk and formula were also explored.

There were significant differences between the mean heights of the three groups in this study at birth, 2 months and 4 months of age. The changes were significant in all three groups. There were also significant differences between the three groups in terms of changes over 6 months so that the mean changes in height were greater in the formula-fed group. In the present study, at 6 months of age, no difference was found in the mean height between the three groups. This finding was consistent with the results of Li SC *et al.* (2010) on the effect of breastfeeding duration on the height of the infants at 6 months old<sup>12</sup>. However, from the age of 7 months on, breast-fed infants had a shorter height than formula-fed infants. Han Y, *et al.* (2011) carried out a study to determine the relationship between the type of infant nutrition in the general population and the growth and stool characteristics of infants. They found that type of food did not have a significant effect on the height and weight of infants of any ages (at birth, 4, 8 and 12 months old)<sup>13</sup>. The results of our study were not consistent with the results of Han Y, *et al.* in relation to the mean height and weight of infants at 4 months of age. In the study of Han Y, *et al.*, there were 4 dietary patterns (breast milk, cow milk formula, goat milk formula, and mixed breast milk and formula). They evaluated height and weight from birth to 12 months of age, while in our study the effect of dietary patterns on growth indices was evaluated from birth to 6 months of age.

In the present study, there were no significant differences among the three groups of breast-fed, formula-fed, and mixed-fed infants in terms of the mean head circumference at any of the measurement times. Similar to the present study, Agrasada G, *et al.* (2011) found no significant difference between the mean head circumference in different dietary patterns at 6 months old and over 6 months. In their study, infants were divided into 3 groups of exclusively breastfed, formula-fed, and relative feeding with breast milk<sup>26</sup>.

In line with the present study, there were no significant differences in the mean head circumference between the two nutritional groups at birth, 2, 4, and 6 months old in a study by Mohammad Beigi A, *et al.* (2009)<sup>24</sup>. They compared 2 dietary patterns of breast feeding and breast feeding with complementary nutrition, while in this study we compared mixed feeding (breast milk and

formula) and exclusive feeding with breast milk or formula.

The results showed that there was no significant relationship between the socioeconomic status index and growth indices at the age of 2, 4 and 6 months. In a study by Allahgholi L, *et al* (2011), there was no significant relationship between the infants' weight at 6, 12, and 24 months of age and the education and occupation of the mother<sup>15</sup>. Also, there was no significant relationship between income and education of the mother and the weight gain of infants up to the age of six months in a study by Li R, *et al.* (2012)<sup>18</sup>. Their results are consistent with the present study. In a study by Wijlaars LPMM, *et al.* (2011), there was a significant relationship between the socioeconomic index and a greater weight at 3 months of age, higher changes in weight during 3 months of age, and a higher prevalence of rapid weight gain, which is not consistent with this study<sup>27</sup>.

The strength of this study was its prospective nature and follow up of the growth and development status of infants in different feeding groups from 2 to 6 months of age. The limitation of this study was lack of longer follow up of infants' growth until their childhood regarding the dietary patterns of the first and second 6 months of life after the birth due to time constraints in conducting the research.

### Conclusions

The results of this study showed that differences in the type of dietary pattern could affect the growth factors of weight and height of infants up to 6 months of age. It appears that two dietary patterns of exclusive breastfeeding and mixed feeding can be more effective than exclusive formula feeding in terms of weight and height growth in 2 to 4 months of age. In this respect, mixed feeding could be more beneficial than formula feeding for growth of infants who cannot feed by breastfeeding. However, differences in dietary patterns did not make a significant difference in the size of the head circumference of the infants up to 6 months of age.

### Acknowledgments

This article was extracted from the master's thesis of Saadat Amouei with the registered code of 95-11480. The authors herby thank the Research Deputy of Shiraz University of Medical Sciences for funding this project and all those who helped us in this study.

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