DOI: 10.1590/1413-81232017228.18182015

Determinants of the mean growth rate of children under the age of six months: a cohort study

Poliana Cristina de Almeida Fonseca [1]
Carolina Abreu de Carvalho [2]
Sarah Aparecida Vieira Ribeiro [3]
Luciana Neri Nobre [4]
Milene Cristine Pessoa [5]
Andreia Queiroz Ribeiro [1]
Silvia Eloiza Priore [1]
Sylvia do Carmo Castro Franceschini [1]

Abstract *This study aimed to investigate some factors that contributed to higher or lower growth rate of children up to the sixth month of life. This is a cohort study with 240 children evaluated in four stages. Variables of birth, eating habits of the child, mothers' breast-feeding difficulty and pacifier use were investigated. Children's weight gain rate (grams/day) and size gain (cm/month) were measured in all assessments and compared according to the variables of interest. In the first month, weight gain rate of children born by cesarean section was smaller. By the second month, the growth rate (weight and size gain) was higher among children who were exclusively or predominantly breastfed and lower among those who consumed infant formula. Children of mothers who reported difficulty to breastfeed showed a lower growth rate until the second month. Children age four months who consumed porridge had lower weight and size gain rate. Pacifier use was associated with lower weight gain rates up the first, second and fourth month.*

Key words *Weight gain, Growth, Breastfeeding, Infant*

[1] Departamento de Nutrição e Saúde, Centro de Ciências Biológicas e da Saúde, Universidade Federal de Viçosa. Av. Peter Henry Rolfs s/n, Campus Universitário. 36570-900 Viçosa MG Brasil. poliana.nutri_ufv@yahoo.com.br
[2] Instituto Federal do Maranhão Campus Barreirinhas. Barreirinhas MA Brasil.
[3] Departamento de Nutrição, Universidade Federal do Espírito Santo. Vitória ES Brasil.
[4] Programa de Pós-Graduação em Saúde Coletiva, Universidade Federal do Maranhão. São Luís MA Brasil.
[5] Departamento de Nutrição, Escola de Enfermagem, Universidade Federal de Minas Gerais. Belo Horizonte MG Brasil.

Introduction

Child growth is influenced by maternal, environmental, genetic and hormonal factors[1]. Proper infant nutrition is one of the most important factors for growth, maturation and maintenance of bodily functions, as well as disease prevention. One of the main reasons for children growth deficit is malnutrition[1-3].

The first six months of life are considered a critical period, since it is the moment of greater growth rate[4]. According to the World Health Organization (WHO)[5], exclusive breastfeeding (EBF) up to the sixth month is the ideal food to promote adequate growth at this stage.

Among the most important child health indicators is the monitoring of their physical growth, which reflects their current and intra-uterine life conditions, and can be assessed by simple measures such as weight and size[2,6,7]. These measures performed repeatedly in a given period provide better consistency in the assessment of the growth period[8].

The growth rate corresponds to increased weight, size or other anthropometric parameter in a given time interval (days or months, for example), representing the current growth dynamics. Anthropometric indices, in turn, reflect pre and postnatal cumulative growth attained at a given age[3,7,9].

In a paper published in 2009, WHO showed a growth rate pattern based on the Multicentre Growth Reference Study, but it strengthens the need to establish limits to which growth rate intervals specific disorders can be observed. The study on growth rate has a hypothetical advantage of early identification of growth problems. However, studies for this purpose are difficult to conduct due to scarce appropriate longitudinal data.[10]

It has been interesting to evaluate growth in early childhood and its associated factors, considering changes reflected in this process in the medium and long term[11]. However, few studies have proposed to evaluate the rate of weight and size growth, as well as its determinants[9]. Some Brazilian studies[3,4,8,12,13] have investigated the relationship between breastfeeding (BF) and child growth. Studies that evaluate infant growth rate according to the variables analyzed in this study are not common in Brazilian literature, whose objective is to investigate some factors that contributed to a higher or lower growth rate of infants up to the sixth month of life.

Methods

This is a cohort study with children monitored from birth until the six months of life of the municipality of Viçosa, Minas Gerais. The city is located in the Zona da Mata Mineira, has an area of 299.418 km^2 and estimated population in 2014 of 76,745 residents with a per capita Gross Domestic Product (GDP) of 11,256.07 reais[14].

Children born in Viçosa from October 2011 to October 2012, who resided in the municipality, were invited to take part in the study. The invitation to mothers occurred at childbirth at the maternity hospital where all the children of the municipality are born. A member of the project team was on call at the hospital awaiting hospitalization of pregnant women to carry out the invitation to participate in the research and scheduling the next consultations. Children were evaluated in the first, second, fourth and sixth month at the Municipal Polyclinic of Viçosa, according to the vaccination schedule.

Newborns with birth weight > 2,500 grams, gestational age > 37 weeks, single delivery and healthy children living in Viçosa-MG were included in the study. Children who did not meet the inclusion criteria were also followed up, but were not included in this study because they evidenced growth specificities.

The team responsible for data collection was composed of six nutritionists, a nurse and nutrition and nursing academics from the Federal University of Viçosa, with rotation among team members during the two years of data collection. A pilot study was conducted at the same location where data were collected, with children in the same age group and characteristics of those belonging to the study, which were not included. Prior to the onset of data collection, all team members were trained in the application of questionnaire and anthropometry techniques.

According to information from the board of the São Sebastião hospital (maternity hospital), 806 children were born during the data collection period at the hospital. Of these, 15 cases of congenital malformation or syndromes, 52 double pregnancies or more, and 72 children hospitalized in the Neonatal Intensive Care Unit were excluded. There were 117 losses due to early hospital discharge or refusal and 90 mothers accepted to participate in the first hospital contact, but did not attend the first visit. Thus, the mothers of 460 children were located and accepted to participate in the first consultation, of which 3.9%

(18) were preterm, 2.4% (11) were born preterm and with low birth weight and 3.0% (14) were born with low birth weight, leaving out 417 eligible children. In the second month, 390 children were evaluated. In the fourth month, 336 children attended, and in the sixth month, 240 children were counted, who participated in all four scheduled evaluations. Losses were analyzed for a possible selection bias, as described in the results of this study.

A semi-structured questionnaire was applied with sociodemographic, birth and child feeding practices. The type of delivery (vaginal and cesarean) and children's weight and size at birth were investigated. Birth weight and size were obtained on the child's card in the first evaluation (1 month of age). Children born with a weight greater than 2,500 and less than 3,000 grams were considered to be underweight at birth, and greater than 4,000 grams with high birth weight.

The breastfeeding type, infant formula intake (yes or no), cow milk (yes or no) and porridge (yes or no) were surveyed in all evaluations. The breastfeeding type classification used WHO's definitions recommended by the Ministry of Health, which classifies it as exclusive, predominant, mixed or partial and supplemented breastfeeding[15]. Mothers were questioned regarding the intake of infant formula and cow milk, and these were counted regardless of breastfeeding, and it is possible to evaluate the introduction of these types of milk in infant feeding. Mothers were also asked about porridge consumption (cow milk with added sugar and flour) separately. Mothers' breastfeeding difficulty and children's use of pacifiers were also evaluated. Mothers were questioned in all consultations regarding the early introduction of liquids and other food, such as water, tea and juice.

In all assessments (1st, 2nd, 4th and 6th month), children's weight and size were measured by previously trained nutritionists and interns of the Nutrition course of the Federal University of Viçosa, following standard WHO guidelines[16]. Weight was measured using an electronic and digital pediatric scale, with a capacity of 15 kg and a 10-gram precision, always without clothes or diaper. Size was measured with the naked child, using a wooden infant anthropometer, with a ruler graduated from zero to 100 cm, with 1 mm-accuracy.

Children's weight gain rate (grams/day) and size gain rate (centimeters/month) were calculated from birth to the first, second, fourth and sixth month, as follows:

Weight gain rate (g/day) = (weight in the 1st, 2nd, 4th and 6th month – birth weight) / age in days

Size gain rate (g/day) = (size in the 1st, 2nd, 4th and 6th months – size at birth) / age in days

Considering that the initial sample size was not predicted to evaluate the relationship between growth rate (weight and size gain) and the variables of interest, the sample power was calculated *a posteriori* to compare means in all evaluated months, with 95% confidence interval. Considering the difference between weight gain rate means, power ranged from 90.8% to 99.8%. Regarding the difference between size gain rate, power ranged from 73.2% to 99.9%. Calculations were made in the OpenEpi program.

Regarding ethical aspects, mothers of the children signed the informed consent form ICF and were properly instructed regarding all the procedures, objectives and advantages of their participation. The Research Ethics Committee, Federal University of Viçosa, approved this study under protocol number 051/2012/CEPH, and the study was funded by the State of Minas Gerais Research Support Foundation.

Statistical analyses

Data was entered on a Microsoft Office Excel 2010 data sheet and all statistical analyses were conducted in Stata statistical software, version 10.0. For descriptive analysis, explanatory variables (gender, delivery type, low birth weight, high birth weight, breastfeeding type, difficulty in breastfeeding, formula, cow milk, water, tea, juice and porridge consumption and use of pacifiers) were described in percentages in the tables.

Follow-up losses are common in cohort studies. Thus, some child-related variables (gender, delivery type and birth weight) were compared between the monitored and non-monitored groups in order to evaluate possible selection bias using Pearson's chi-square test and Student's t-test.

The distribution of weight gain rate (WGR1, WGR2, WGR4 and WGR6) and size gain rate (SGR1, SGR2, SGR4 and SGR6) variables were analyzed with the Shapiro-Wilk test. For the analysis of the differences between the weight and size and the explanatory variables, statistical tests were used to compare mean/median values according to the growth rates' distribution. When parametric, mean and standard deviation were shown, and non-parametric values were shown in medians and minimum and maximum values.

Student's t-test or ANOVA (post-hoc test: Bonferroni) was used to compare the mean of

parametric variables (WGR2, WGR1 and SGR6) when the response variable showed more than three groups (breastfeeding type). Non-parametric variables (WGR1, WGR 4, WGR6, SGR2, SGR2 and SGR 4) were compared using the Mann-Whitney or Kruskal-Wallis test (post-hoc test: Dunn) when there were more than three groups in the qualitative variable (breastfeeding type). The level of rejection for the null hypothesis was $p < 0.05$.

Results

Table 1 shows the comparison between monitored and not monitored children, and it was observed that there was no statistical difference ($p < 0.05$) between the groups. Therefore, the results of this study are unlikely to evidence selection bias due to follow-up losses.

Of the 240 children evaluated up to six months, 52.5% were boys, whose mean age of mothers was 26 years (± 6 years), with a median family income of 1,244 reais. Regarding birth, 72.9% were born from cesarean section, 25.4% with low weight and 5.4% with high weight.

Table 2 shows the growth rate (weight and size gain) of infants in the four evaluations, by gender, type of delivery and birth weight. The weight and size gain rate was higher in boys in all evaluations ($p < 0.05$) and there was a slowdown of weight-size gain as from the second month in both genders. Only up to the first month, the weight gain rate (WGR1) of children born from cesarean section was lower ($p = 0.022$) and there was no difference in the size gain rate. It was observed that the weight gain rate did not differentiate between children who were born underweight and overweight. The mean size gain rate up to six months (SGR6) was higher among infants born with low weight ($p = 0.035$) and lower among those born with high birth weight ($p = 0.006$).

As observed in Table 3, the growth rate up to the first month was influenced by the child feeding practices in this period. Regarding breastfeeding type, children who were exclusively or predominantly breastfed had a higher median WGR1 ($p < 0.001$). Children whose mothers reported some difficulty in breastfeeding, who used infant formula and consumed water showed lower WGR1 ($p < 0.001$, $p < 0.001$ and $p = 0.049$). The mean SGR1 of children who consumed infant formula was also lower ($p = 0.006$).

Up to the second month, WGR2 and SGR2 were higher among infants exclusively or predominantly breastfed ($p < 0.001$ and $p = 0.015$, respectively), and lower among children consuming infant formula ($p < 0.001$ and $p < 0.001$) and water ($p = 0.019$ and $p = 0.033$). Children of mothers who reported difficulty in breastfeeding had a lower average of WGR2 and SGR2 ($p = 0.004$ and $p = 0.047$). These data are shown in Table 4.

Table 5 shows the results for WGR and SGR up to the fourth and sixth month. There were no significant differences in growth rate means by breastfeeding type in the fourth and sixth month, as observed in the first two months. Four-month-old children who consumed porridge had lower values of WGR4 ($p = 0.014$) and SGR4 ($p = 0.003$). In the sixth month, only infant formula intake was associated with lower WGR6 values ($p = 0.047$). There were no associations between growth rate up to the fourth and sixth month with consumption of water, tea and fruit juice (the results of these analyses are not shown in Table 5).

There were no differences in the growth rate of children who consumed cow milk in any of the evaluations. Those who used pacifiers had the lowest WGR values up to the first ($p = 0.023$), second ($p < 0.001$) and fourth ($p = 0.006$) month, as observed in Tables 2, 3 and 4.

Discussion

This study aimed to evaluate the growth rate of children in the first six months of life, by gender and birth variables, as well as feeding practices, difficulty in breastfeeding reported by the mother and child's use of pacifiers. We observed relevant results, not very common in literature, which can certainly contribute to a better understanding of some factors associated with child growth.

In all evaluations, weight and size gain rate was higher among boys. Augusto e Souza et al.[13], studying 347 children, observed a higher rate of daily weight gain in boys during the first quarter. In the study by Spyrides et al.[8] with children up to nine months of age, lower weight and size gain rates were also observed among girls. A study[4] that analyzed data from 181 children on exclusive breastfeeding (EBF) up to the sixth month of age found that boys' weight gain was higher only in the first quarter. The study by Mihrshahi et al.[17] observed that male gender was a non-modifiable factor for rapid weight gain among children. Boys tend to have a higher birth weight and a faster weight gain rate[8]. A discussion is presented by

Ciência & Saúde Coletiva, 22(8):2713-2726, 2017

Table 1. Characteristics of children monitored and not monitored from the first to the sixth month of life. Viçosa, Minas Gerais, 2011-2013.

Sample characterization	Monitored (n = 240)	Not monitored (n = 177)	p-value**
Gender	**% (n)**	**% (n)**	
Male	55.3 (114)	44.7 (92)	0.366
Female	59.7 (126)	40.3 (85)	
Type of delivery			
Normal	56.5 (65)	43.5 (50)	0.792
C-section	57.9 (175)	42.1 (127)	
Low birth weight (> 2500 < 3000 g)			
No	56.6 (179)	43.4 (137)	0.507
Yes	60.4 (61)	39.6 (40)	
High birth weight (> 4000 g)			
No	57.6 (227)	42.4 (167)	0.918
Yes	56.5 (13)	43.5 (10)	
Size at birth (cm)			
Mean ± Standard Deviation	49.2 ± 1.8	49.1 ± 1.9	0.671

* Totals may not add up to 417 (monitored and not monitored) across all variables due to some missing values;

** Pearson's chi-square test or Student's t-test.

Table 2. Growth rate (weight and size gain) by gender and variables of birth of children evaluated up to the first, second, fourth and sixth month of life of the municipality of Viçosa, Minas Gerais, 2011-2013.

Variables (%)	WGR1 (g/day)		WGR2 (g/day)	
	Median (Min - Max)	p-value[1]	Mean ± SD	p-value[2]
Gender				
Male (52.5)	33.6 (-8.3 – 69.3)	**< 0.001***	34.2 ± 8.1	**<0.001***
Female (47.5)	26.5 (-35.3 – 69.3)		28.8 ± 7.9	
Type of delivery				
Normal (27.1)	32.8 (1.3 – 63.7)	**0.022***	32.1 ± 8.2	0.624
C-section (72.9)	29.2 (-35.3 – 69.3)		31.5 ± 8.6	
Low BW				
Yes (25.4)	31.0 (-6.7 – 69.3)	0.965	31.6 ± 8.0	0.979
No (74.6)	29.8 (-35.5 – 66.8)		31.6 ± 8.6	
High BW				
Yes (5.4)	29.1 (-35.3 – 57.3)	0.969	30.6 ± 14.3	0.633
No (94.6)	30.8 (-8.3 – 69.3)		31.7 ± 8.1	
Variables (%)	**SGR1 (cm/month)**		**SGR2 (cm/month)**	
	Mean ±SD	**p-value[2]**	**Median (Min - Max)**	**p-value[1]**
Gender				
Male (52.5)	4.0 ± 1.5	**0.016***	3.9 (2.3 – 18.0)	**0.001***
Female (47.5)	3.5 ± 1.5		3.5 (1.1 – 5.5)	
Type of delivery				
Normal (27.1)	3.9 ± 1.6	0.245	3.5 (1.6 – 18.0)	0.879
C-section (72.9)	3.7 ± 1.5		3.8 (1.1 – 5.6)	
Low BW				
Yes (25.4)	3.7 ± 1.5	0.743	3.8 (1.6 – 5.9)	0.564
No (74.6)	3.8 ± 1.5		3.6 (1.1 – 18.0)	
High BW				
Yes (5.4)	3.0 ± 1.5	0.070	3.5 (1.1 – 18.0)	0.224
No (94.6)	3.8 ± 1.5		3.7 (1.6 – 5.9)	

it continues

Table 2. continuation

Variables (%)	WGR4 (g/day)		WGR6 (g/day)	
	Median (Min - Max)	p-value[1]	Median (Min-Max)	p-value[1]
Gender				
Male (52.5)	29.5 (17.4 – 54.6)	< **0.001***	25.3 (15.7 – 47.4)	**0.001***
Female (47.5)	25.4 (7.2 – 43.4)		22.2 (12.2 – 36.7)	
Type of delivery				
Normal (27.1)	26.8 (17.5 – 45.5)	0.315	22.7 (16.8 – 42.8)	0.144
C-section (72.9)	28.1 (7.3 – 54.6)		24.7 (12.2 – 47.4)	
Low BW				
Yes (25.4)	28.4 (18.7 – 43.4)	0.566	24.0 (15.7 – 41.2)	0.964
No (74.6)	27.3 (7.3 – 54.6)		24.1 (12.2 – 47.4)	
High BW				
Yes (5.4)	25.4 (11.6 – 41.3)	0.671	21.8 (12.2 – 35.2)	0.619
No (94.6)	27.7 (7.3 – 54.6)		24.2 (15.7 – 47.4)	
Variables (%)	**SGR4 (cm/month)**		**SGR6 (cm/month)**	
	Median (Min - Max)	**p-value[1]**	**Mean ± SD**	**p-value[2]**
Gender				
Male (52.5)	3.4 (2.4 – 4.6)	<**0.001***	2.9 ± 0.3	< **0.001***
Female (47.5)	3.1 (1.4 – 4.6)		2.7 ± 0.3	
Type of delivery				
Normal (27.1)	3.2 (2.2 – 4.6)	0.354	2.8 ± 0.4	0.222
C-section (72.9)	3.3 (1.3 – 4.6)		2.8 ± 0.3	
Low BW				
Yes (25.4)	3.3 (2.3 – 4.6)	0.373	2.9 ± 0.3	**0.035***
No (74.6)	3.3 (1.4 – 4.5)		2.8 ± 0.4	
High BW				
Yes (5.4)	3.1 (1.8 – 3.7)	0.152	2.6 ± 0.5	**0.006***
No (94.6)	3.2 (1.3 – 4.6)		2.8 ± 0.3	

WGR: Weight Gain Rate; SGR: Size Gain Rate; g: gram; cm: centimeter; min: minimum; max: maximum; ± SD: Standard Deviation; BW: birth weight. [1] Mann-Whitney's test; [2] Student's t-test; * p value < 0.05.

Jaldin et al.[4], which is based on other studies and justifies this difference between genders by anatomical and physiological characteristics, where boys have larger body structures and muscle tissue and girls have lower birth weight. In view of the above, one would expect that higher growth rates be observed among boys. WHO[10] shows distinct growth rate curves for girls and boys.

Growth rate was progressive until the second month, gradually decelerating up to the sixth month in both genders, regardless of the breastfeeding type. This slowdown in weight gain is also in line with previous studies[2-4,13]. In the study by Longo et al.[3], children on EBF and predominant BF showed a higher growth rate up to three months, slowing down to five month of age. According to Marques et al.[2], regardless of sex, after the fourth month, children on EBF showed a reduction of about 50% in daily weight gain and in the monthly mean size increase. According to Rzehak et al.[18], weight and size gain rates are higher until the first three months after birth and decrease at different rates in the following periods. When it comes to breastfed infants, this rapid growth is due to the large volume of milk ingested and its recognized nutritional value and sufficiency in this initial phase[19]. A normal growth deceleration is expected, regardless of the duration of breastfeeding. This decreased pace should not be confused with growth problems, for example, giving scope for the hypothesis that breastfeeding is insufficient and that there is a need for early introduction of other food[4,13].

We observed that the cesarean section had a negative influence on weight gain, since children born from this type of delivery had lower rate of

Table 3. Growth rate (weight and size gain) by feeding practices, difficulty in breastfeeding and use of pacifiers of children evaluated up to the first month of life of the municipality of Viçosa, Minas Gerais, 2011-2013.

Variables (%)	WGR1 (g/day)		SGR1 (cm/month)	
	Median (Min - Max)	p-value[1]	Mean ± SD	p-value[2]
Breastfeeding type				
Exclusive (47.8)	32.8 (7.6 – 65.3)[a]		3.9 ± 1.4	
Predominant (30.3)	31.0 (-35.3 – 66.8)[a]	< **0.001***	3.9 ± 1.6	0.050
Mixed (16.6)	24.5 (-8.3 – 52.5)[b]		3.3 ± 1.4	
Artificial (5.3)	19.0 (10.5 – 38.5)[b]		3.2 ± 1.6	
Difficulty in breastfeeding				
No (79.0)	31.7 (-3.0 – 69.3)	< **0.001***	3.8 ± 1.5	0.086
Yes (21.0)	25.2 (-35.3 – 51.8)		3.4 ± 1.4	
Formula consumption				
No (78.5)	31.8 (-7.0 – 69.3)	< **0.001***	3.9 ± 1.5	**0.006***
Yes (21.5)	24.3 (-35.3 – 52.5)		3.3 ± 1.5	
Cow milk consumption				
No (98.0)	30.6 (-35.3 – 69.3)	0.129	3.8 ± 1.5	0.065
Yes (2.0)	22.3 (15.0 – 32.7)		2.5 ± 1.6	
Water consumption				
No (87.8)	31.0 (-7.0 – 65.3)	**0.049***	3.8 ± 1.5	0.100
Yes (12.2)	27.0 (-8.3 – 45.0)		3.3 ± 1.8	
Tea consumption				
No (63.2)	29.7 (-6.7 – 65.3)	0.427	3.8 ± 1.4	0.982
Yes (36.8)	30.7 (-8.3 – 66.8)		3.8 ± 1.6	
Use of pacifier				
No (54.3)	31.7 (2.8 – 66.8)	**0.023***	3.8 ± 1.4	0.926
Yes (45.7)	28.3 (-8.3 – 65.3)		3.8 ± 1.6	

WGR1 = weight gain rate in the first month of life; SGR1 = size gain rate in the first month of life; g = gram; cm = centimeter; min = minimum; max = maximum; SD = standard deviation. [1] *Mann-Whitney*/*Kruskal-Wallis* Test (post-hoc test: Dunn); [2] Student's t-test /ANOVA Test (post-hoc test: Bonferroni). *a/b: equal letters mean that there was no difference.

weight gain until the first month. It is possible that post-surgery maternal condition had a negative influence on breastfeeding in the first days of the child's life, reflecting lower weight gain. Delayed first mother-to-child contact, postanesthetic effect and incisional pain of cesarean section appear to hamper first breastfeeds and the establishment of breastfeeding, leaving newborns susceptible to the introduction of early lactational formulas[20].

According to Weiderpass et al.[21], in a population-based cohort study in Pelotas, Brazil, mothers submitted to elective cesarean sections showed a greater risk (OR = 3.09) of complete interruption of lactation in the first month of life, evidencing that this type of delivery is an important risk factor for not initiating lactation or stopping it in the first days of the child's life. This finding can be explained in part by postoperative hospital practices that may hamper cohabitation and on-demand breastfeeding or the early introduction of another type of milk, in addition to lower breastfeeding incentive to these mothers in the postpartum period[21]. A study[22] with recent mothers from Rio de Janeiro showed that caesarean section reduced by half the prevalence of breastfeeding in the first hour.

Contrary to our results, Spyrides et al.[8] observed that children born with cesarean delivery tended to have greater weight gain rates than those born vaginally. These authors point out that literature has investigated the relation between cesarean deliveries with breastfeeding, but the influence of this type of delivery on growth in the first months of the infant's life is not known.

As for the relationship between growth rate and birth weight, up to the sixth month, children born with low weight showed a higher size gain rate and those born with high weight, a lower size gain rate. In the study by Spyrides et al.[12], birth

Table 4. Growth rate (weight and size gain) by feeding practices, difficulty in breastfeeding and use of pacifiers of children evaluated up to the second month of life of the municipality of Viçosa, Minas Gerais, 2011-2013.

Variables (%)	WGR2 (g/day)		SGR2 (cm/month)	
	Mean ± SD	p-value[1]	Median (Min - Max)	p-value[2]
Breastfeeding type				
Exclusive (51.8)	33.5 ± 7.6[a]		3.8 (2.1 – 5.4)[a]	
Predominant (22.3)	31.8 ± 8.7[a]	< **0.001***	3.8 (1.1 – 18.0)[a]	**0.015***
Mixed (17.0)	27.3 ± 9.1[b]		3.5 (2.1 – 5.9)[b]	
Artificial (8.9)	29.0 ± 7.8 [(a,b)]		3.4 (2.3 – 5.3)[b]	
Difficulty in breastfeeding				
No (85.0)	32.3 ± 8.2	**0.004***	3.8 (1.6 – 5.6)	**0.047***
Yes (15.0)	27.9 ± 9.2		3.4 (2.3 – 5.9)	
Formula consumption				
No (75.7)	32.9 ± 8.1	< **0.001***	3.8 (1.6 – 5.9)	< **0.001***
Yes (24.3)	27.9 ± 8.8		3.4 (2.1 – 5.3)	
Cow milk consumption				
No (95.9)	31.7 ± 8.6	0.517	3.7 (1.6 – 5.6)	0.544
Yes (4.1)	29.9 ± 6.3		3.8 (2.9 – 5.9)	
Porridge consumption				
No (97.6)	31.6 ± 8.6	0.564	3.7 (1.6 – 5.7)	0.960
Yes (2.4)	33.6 ± 4.7		3.8 (2.3 – 4.2)	
Water consumption				
No (76.5)	32.4 ± 8.4	**0.019***	3.8 (1.6 – 5.7)	**0.033***
Yes (23.5)	29.4 ± 8.3		3.5 (1.6 – 18.0)	
Tea consumption				
No (71.3)	32.1 ± 8.5	0.220	3.7 (2.0 – 5.7)	0.677
Yes (28.7)	30.6 ± 8.5		3.6 (1.0 – 5.9)	
Juice consumption				
No (94.7)	31.7 ± 8.6	0.555	3.8 (1.6 – 5.7)	0.254
Yes (5.3)	30.3 ± 6.8		3.5 (2.3 – 5.9)	
Use of pacifier				
No (52.2)	33.4 ± 7.6	< **0.001***	3.7 (1.6 – 5.6)	0.326
Yes (47.8)	29.8 ± 9.0		3.6 (1.9 – 5.7)	

WGR1 = weight gain rate in the first month of life; SGR1 = size gain rate in the first month of life; g = gram; cm = centimeter; min = minimum; max = maximum; SD = standard deviation. [1] *Mann-Whitney/Kruskal-Wallis* Test (post-hoc test: Dunn); [2] Student's t-test /ANOVA Test (post-hoc test: Bonferroni). *a/b: equal letters mean that there was no difference.

weight was one of the strong predictors of size development in the first nine months of life.

The study by Eickmann et al.[11] compared growth of term infants born with low birth weight and adequate weight in the first two years of life and observed that there was a more evident initial acceleration of growth in low birth weight children, since there was a greater increase in the size/age rate mainly in the first months of life. This compensatory growth acceleration may have occurred in infants born in this study who were delivered with low weight, as suggested by the higher size gain rate at six months of age. However, literature already points to the negative effects of low birth weight on pre-school growth, implying lower growth and greater risk of failure in this process[23]. Regarding the relationship between high birth weight and lower size gain rate, further studies are required to better understand this finding.

This study showed a higher rate of weight gain among infants on EBF and predominant breastfeeding compared to mixed and artificial BF until the first and second month. It was possible to observe that size gain rate was also higher up to the second month. In children who consumed formulas showed lower growth rate (weight and size gain) during the first and second month,

Table 5. Growth rate (weight and size gain) by feeding practices and use of pacifiers of children evaluated up to the fourth and sixth month of life of the municipality of Viçosa, Minas Gerais, 2011-2013.

Variables (%)	WGR4 (g/day)		SGR4 (cm/month)	
	Median (Min - Max)	p-value[1]	Median (Min - Max)	p-value[1]
Breastfeeding type				
Exclusive or Predominant (49.8)	28.3 (17.9 – 44.5)		3.3 (2.3 – 4.4)	
Mixed (17.8)	27.1 (7.3 – 41.3)	0.178	3.2 (1.4 – 4.4)	0.449
Artificial (8.9)	29.1 (18.2 – 45.5)		3.3 (2.6 – 4.6)	
Supplemented (23.5)	26.4 (11.6 – 42.1)		3.4 (1.8 – 4.6)	
Formula consumption				
No (69.2)	28.1 (17.5 – 45.5)	0.301	3.3 (2.3 – 4.5)	0.938
Yes (30.8)	26.8 (7.2 – 43.4)		3.2 (1.3 – 4.6)	
Cow milk consumption				
No (87.5)	27.9 (16.0 – 43.4)	0.105	3.3 (2.2 – 4.5)	0.476
Yes (12.5)	25.3 (17.5 – 45.5)		3.2 (2.3 – 4.2)	
Porridge consumption				
No (93.5)	27.9 (16.0 – 43.4)	**0.014***	3.3 (2.2 – 4.5)	**0.003***
Yes (6.5)	23.3 (18.0 – 45.5)		3.0 (2.3 – 3.4)	
Use of pacifier				
No (55.1)	29.0 (17.4 – 44.4)	**0.006***	3.3 (2.2 – 4.3)	0.234
Yes (44.9)	26.6 (11.6 – 43.4)		3.2 (2.3 – 4.6)	
Variables (%)	**WGR6 (g/day)**		**SGR6 (cm/month)**	
	Median (Min - Max)	**p-value[1]**	**Mean ± SD**	**p-value[2]**
Breastfeeding type				
Breastfeeding and SF (45.3)	24.2 (15.9 – 36.7)		2.8 ± 0.3	
Mixed and SF (32.4)	23.9 (12.2 – 41.2)	0.675	2.8 ± 0.3	0.820
Artificial and SF (22.3)	23.3 (15.7 – 42.8)		2.8 ± 0.3	
Formula consumption				
No (68.8)	24.4 (15.9 – 42.7)	**0.047***	2.8 ± 0.3	0.445
Yes (31.2)	23.1 (12.2 – 41.2)		2.8 ± 0.3	
Cow milk consumption				
No (72.1)	24.0 (15.8 – 41.2)	0.940	2.8 ± 0.3	0.637
Yes (27.9)	24.2 (12.2 – 42.7)		2.8 ± 0.4	
Porridge consumption				
No (81.0)	24.2 (15.8 – 38.9)	0.324	2.8 ± 0.3	0.179
Yes (19.0)	23.4 (12.2 – 42.8)		2.7 ± 0.3	
Use of pacifier				
No (53.8)	24.3 (15.9 – 37.4)	0.107	2.8 ± 0.3	0.982
Yes (46.2)	23.4 (15.7 – 41.2)		2.8 ± 0.3	

WGR4 and WGR6 = weight gain rate in the fourth and sixth month of life; SGR4 and SGR6 = size gain rate in the fourth and sixth month of life; g = gram; cm = centimeter; min = minimum; max = maximum; SD = standard deviation; SF = Supplementary Feeding; [1] *Mann-Whitney*/*Kruskal-Wallis* Test (post-hoc test: Dunn); [2] Student's t-test /ANOVA Test (post-hoc test: Bonferroni).

and until the sixth month, only weight gain was lower. There were no differences in growth rates between the breastfeeding types until the fourth and sixth month, probably because other factors not evaluated by this study must have exerted greater influence on the growth of infants.

Similar results were also observed in the study by Longo et al.[3] with 3,172 children, who evaluated the growth rate in different categories of breastfeeding, finding a positive association between the weight and size gain rate with EBF and predominant BF in the first months of life and lower weight and size increase in artificially breastfed infants. Children on EBF of the Marques et al. study[2] reached 6 months with mean weight above the 50th percentile of the curves of the National Center for Health Statistics (NCHS), based on formula-fed infants. According to the study

by Augusto e Souza[13], in the first quarter, the daily rate of weight gain among girls was higher and was related to longer duration of EBF. In the second quarter, the daily rate of weight gain was not influenced by the duration of EBF, as was the case in this study. According to Johnson et al.[24], infants weaning after 6 months show lower growth rate and shorter size. The protective role of EBF against excessive weight gain during the second half of life of the children is also highlighted, as observed by Gonçalves et al.[25]. These findings reinforce that it is undisputed that EBF and predominant BF are fundamental for better weight and size gain among infants.

This study did not identify differences in the influence of exclusive or predominant breastfeeding on the growth rate of the studied children, evidencing that predominant breastfeeding contributed in a similar way to EBF in the best growth rate until the second month. A similar result was observed in the study by Spyrides et al.[8], who observed that infants in the first months of life had a higher growth rate, although at the end of the study weight and size were lower when compared to children who consumed formulas. A study conducted in Australia with infants in the age group 4-7 months showed that one of the risk factors for rapid weight gain was infant formula intake[17]. Literature shows evidence that the consumption of infant formulas predisposes children to overweight and obesity in the future, due to their high protein composition in relation to breast milk. Studies conclude that childhood feeding practices are determinant for long-term health impact and the composition of infant formulas should be reviewed[26,27].

WHO growth curves[28] published in 2006 and considered a growth pattern for healthy children show that size-weight growth is characterized differently in the first and second semester of children's lives. Those exclusively breastfed during the first half show greater weight gain, but a lower weight gain is observed after this period when compared to growth of children who consume infant formulas[29].

As described above, the importance of breastfeeding in the growth rate of infants is well-documented in literature, especially when breastfeeding occurs in the first months, as observed in this study, which showed a slower growth rate among children on mixed and artificial feeding. Studies on growth rate and types of breastfeeding are still rare in literature, but our results and studies shown here strengthen the hypothesis that breastfeeding is nutritionally sufficient for optimal growth up to six months and there is no need to introduce other milks. Therefore, intake of infant formulas should only be recommended to children under one year of age when breastfeeding is not possible[30].

Regarding the consumption of cow milk, no differences were found in the growth of the children in this study in all evaluations, probably due to their low frequency in the first months and their consumption associated with breastfeeding, and a possible negative effect on the growth rate was not observed. On the other hand, the intake of cow milk-based porridge was related to lower growth rate (weight and size gain) up to the fourth month. Different results were found in the study by Gonçalves et al.[25] with children in the first year, who did not observe an association between the consumption of cow milk with sugar and flour added (porridge) with weight gain up to six months. Cow milk is not recommended in the diet of children under one year due to its high protein content, which is difficult to digest[15,31] and promotes changes in insulin secretion and decreased secretion of growth hormone, predisposing the child to overweight[25]. The early introduction of cow milk alone or combined with other food in child feeding is common and worrying, according to data from a national survey, where 62.4% of children under six months consumed cow milk[32].

Among the difficulties related to breastfeeding reported by mothers were nipple lesions, breast pain, breast engorgement, incorrect breastfeeding technique, breast milk's reduced production, waking up at dawn, among others. This implied a lower rate of weight gain in children until the first and second month of life. Thus, it is of great importance to follow-up and instruct recent mothers on alternatives to solve these hardships during this period, considering that these difficulties reflected in children's growth rate. Literature indicates that reports of breastfeeding problems are associated with the lack of EBF[33]. According to Rocci and Fernandes[34], support to mothers in overcoming these breastfeeding issues determines mother breastfeeding's success or abandonment.

Among inappropriate practices, which usually occur in the studied age range, water intake was related to a slower growth rate (weight and size gain) of infants up to the second month. Water consumption in the first month also implied a lower weight gain rate. Mothers offer other liquids to infants because they feel it necessary to satisfy a child's physiological need for thirst, but

this practice should be disregarded even on hot days[33,35]. There is evidence that one of the factors associated with early weaning is the supplementation of infant breastfeeding with other liquids, since they reduce the volume of breastfeeding[35]. Thus, it is necessary to instruct mothers regarding the early introduction of fluids, reinforcing EBF's sufficiency up to six months, since such inappropriate practices jeopardize child growth, as observed in this study.

The use of pacifiers by infants in this study was related to lower weight gain rate until the first, second and fourth month. This relationship was due to the fact that children using pacifiers were more susceptible to breastfeeding abandonment, which meant less weight gain. Studies have shown that pacifier use is an important risk factor for the interruption of breastfeeding[33,36]. Campagnolo et al.[37] emphasize that children using pacifiers seem to have less efficient breast suction. This evidence may explain why pacifier use was a limiting factor for weight gain in children of this study, and initiatives are required to make mothers aware of the risks of pacifiers to child growth, discouraging their use mainly in the first few months of life.

The longitudinal nature of this study allowed the monitoring of the growth rate of infants during the first six months of life in four stages, showing important factors, most of them modifiable that contributed to a higher or lower rate of children's weight and size gain. It is important to highlight the importance of this study to evaluate children's growth rate in a critical period, identifying early the interfering factors of this process and how they operate. As a limitation, it has been observed that follow-up losses were higher than 20%. However, the analysis of the differential loss between the monitored and non-monitored children showed that there was no difference between them, leading to the conclusion that the results of this study were not compromised by this selection bias.

EBF and predominant BF were related to higher growth rates up to the first two months, and predominant BF contributed in a similar way to the EBF in this process. Risk factors for slower growth rates were cesarean delivery, high birth weight, difficulty in breastfeeding, formula intake, early introduction of liquids (water), porridge consumption and use of pacifiers. These results point to the need for interventions aimed at quality prenatal care, as well as encouraging vaginal delivery and EBF until the sixth month, regardless of inherent difficulties, instructing mothers on inadequate feeding practices during this period and discouraging them to use pacifiers.

Collaborations

PCA Fonsêca worked on design, setting objectives, data analysis and interpretation, as well as writing the manuscript. CA Carvalho and SAV Ribeiro assisted in data analysis and critical review of the manuscript. LN Nobre, MC Pessoa, AQ Ribeiro and SE Priore assisted in work co-orientation, data interpretation and critical review of the manuscript. SCC Franceschini worked on work orientation, assisting in the design, outline of the study and definition of objectives, as well as data interpretation, critical review of the manuscript and approval of its final version.

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Article submitted 15/09/2015
Approved 22/02/2016
Final version submitted 24/02/2016