

Carola Saure*, Marisa Armeno, Consuelo Barcala, Vanesa Giudici and Carmen Silvia Mazza

Excessive weight gain in exclusively breast-fed infants

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Keywords: exclusive breastfeeding; first year of life; obesity; weight gain.

Abstract

Background: Breastfeeding is recommended as the best source of nutrition in the first months of life and observational studies have associated exclusive breastfeeding with decreased weight gain and a protective effect against obesity in childhood. The objective of this study was to describe the characteristics of a cohort of exclusively breastfed obese infants to determine factors that may lead to this unusual weight gain.

Methods: Infants seen between 2003 and 2015 who were exclusively breastfed and showed excessive weight gain in the first year of life were followed with a focus on features of the mother, the child, feeding patterns and the presence of concomitant factors that influence nutritional status. Additionally, in a subset of the sample, macronutrients of the maternal breast milk were analyzed. A descriptive, prospective cross-sectional study was conducted.

Results: Of 73 patients, 63% were girls. At 3 months of life, 64% had a weight-for-height standard deviation score (SDS) >2. At 6 and at 12 months, 100% of the patients had a weight-for-height >2 SDS. The mean age at semisolid-food introduction was 7 months. The mean age at weaning was 15.8 months. The babies were fed on demand and no hunger-satiety pattern was observed. In the breast milk samples analyzed, a significantly lower fat content was found.

Conclusions: The results of our study lead to the assumption that inter-individual variations in mother's milk composition may affect the growth patterns of children.

Introduction

Strong evidence supports breast feeding as the optimal source of nutrition for infants, favoring normal growth and development as well as long-term health [1]. Indeed, breast milk has been recommended as the sole source of nutrition in the first 6 months of life and as an important complement in the first 2 years (<http://www.who.int/topics/breastfeeding/es/>). Breast milk has been described to have a protective effect against excessive weight gain and the development of obesity, and the effect appears to be dose-dependent [2, 3], supporting the hypothesis of a causal relationship between weight gain and the development of obesity. Nevertheless, the results of individual studies are controversial and some of them were not able to show significant long-term effects [4, 5].

Over the past decades, obesity has become an epidemic. Longitudinal studies show a marked decrease in age at obesity diagnosis and the appearance of secondary metabolic disorders, with a considerable carry-over effect into adulthood. The composition of breast milk varies according to diet, lifestyle, genetic factors and duration of breastfeeding [6–9]. Nevertheless, it remains unknown if inter-individual differences in breast milk composition may have relevant effects on the outcome of infant growth and health [10–12]. Compared to formula feeding, breastfeeding has been associated with a lower risk of future obesity [13, 14]. Traditionally, infant formulas are significantly higher in protein content than breast milk. In infancy, protein-rich feeding in excess of the metabolic needs has been proposed as a factor that increases plasma insulin concentration leading to increased insulin-like growth factor 1 (IGF-1) secretion and consequently higher early weight gain and later obesity [15, 16]. Several studies in recent years show that high protein intake accelerates weight gain while decreased protein levels lower it [17, 18].

In a 12-year clinical experience at a tertiary care hospital, we observed a considerable number of exclusively

*Corresponding author: Carola Saure, Department of Clinical Nutrition, Hospital Nacional de Pediatría J. P. Garrahan, Combate de los Pozos 1881, CP 1245 Ciudad Autónoma de Buenos Aires, Argentina, Phone: +54 9114087605, E-mail: gocarola@icloud.com

Marisa Armeno, Consuelo Barcala and Carmen Silvia Mazza: Department of Clinical Nutrition, Hospital Nacional de Pediatría J. P. Garrahan, Buenos Aires, Argentina

Vanesa Giudici: Laboratory for Physical-chemical Food Analysis, Department of Food Sciences, Universidad Nacional Entre Ríos, Entre Ríos, Argentina

breastfed babies who showed very high weight gain since the first month of life and throughout the breastfeeding period. In this study, we describe the clinical features of this population to explore possible factors that may have influenced this unusual weight gain. We also analyze macronutrients in the breast milk of the mothers in a subgroup of this cohort.

Subjects and methods

A prospective, descriptive, observational and longitudinal study was conducted. Some anthropometric data from the mother and the child were taken retrospectively. All patients who met the following inclusion criteria were consecutively and prospectively enrolled in the study:

- Infants younger than 6 months of life with a weight-for-age >2 standard deviation score (SDS), who were exclusively breastfed since birth.
- Infants older than 6 months of life, with a weight-for-age >2 SDS, and who were still being breastfed at the first visit to the Department of Clinical Nutrition of Pediatric Hospital J.P. Garrahan in Buenos Aires, Argentina, between June 2003 and June 2015.

Infants with a weight-for-age >2 SDS who were fed any type of formula or who were not being exclusively breastfed at the moment of the first evaluation were excluded from the study. The study was approved by the Ethics Committee of the Garrahan Pediatric Hospital and informed consent of the parents was obtained.

Maternal and infant anthropometric variables

Newborn weight (g) and height (cm) from birth were taken retrospectively during the first visit at our department. The same parameters were measured prospectively during follow-up.

Standard deviation Z-Scores for weight-for-age, height-for-age and weight-for-height were calculated according to the standards of the World Health Organization (WHO) (<http://www.who.int/childdgrowth/software/en/>; <http://www.sap.org.ar/prof-percentilos.php>).

The following equations were used for calculations: mean Δ weight from birth to 6 months of age = (SDS Z-Score at 6 months – SDS Z-Score at birth)/6; mean Δ weight from birth to 12 months of age = (SDS Z-Score at 12 months – SDS Z-Score at birth)/12; mean Δ weight from 6 months to 12 months = (SDS Z-Score at 12 months – SDS Z-Score at 6 months)/6.

Maternal weight gain during pregnancy measured in kg was reported by the mother and/or registered in the clinical chart. Excessive weight gain was defined as a weight gain of more than 18 kg during pregnancy [19].

Factors considered with possible influence on nutritional status

Weight gain >18 kg during pregnancy; bed-sharing; high or low birth weight for gestational age; suspected or confirmed genetic syndrome

associated with macrosomia (qualitative); frequency of daily and nightly breastfeeding (quantitative).

Biochemical variables of the breast milk

In a subgroup of patients, a sample of breast milk was taken halfway through feeding at the first consultation age (8.6 months $\pm$ 27 SD). All samples were frozen immediately after collection. Proteins were determined in g% (Method: 991.20 AOAC 2005 [20], using a semi-automated protein analyzer [a Foss Tecator Kjeltac A2200 auto distillation (MD, USA) unit with a 2006-Digestor]) and fats in g% (Method: 2000.18 AOAC 2005 [21] (MD, USA). A Presvac centrifuge was used for butyrometers and a Gerber butyrometer for milk).

Statistical analysis

For statistical analysis, the STATA/SE11 software program was used. Descriptive and analytical analyses were performed. The behavior of each variable was analyzed and reported as means and SDs for normal variables and as medians and ranges for variables with skewed distributions. Numerical and normal variables were analyzed using the Student's t-test and skewed variables with the Wilcoxon rank-sum test. Categorical variables were analyzed using the χ^2 -test or Fisher's exact test. A two-tailed test was performed and $p < 0.05$ was considered significant. Means and SDs of the breast milk proteins and fat were compared with those in mature milk of the general population and were dichotomized into less than and more than 6 months, using a t-test with a statistical significance of $p < 0.05$. As we did not have a control group, we compared our results with the normal population [22].

Results

Between June 2003 and June 2015, 73 infants that were exclusively breastfed during the first 6 months and gained weight excessively during the first year of life were enrolled in the study; 46 were girls (63%). All patients except one were term neonates (median of 39.1 weeks, range: 37–42), of whom six patients (8.2%) had a high birth weight and seven (9.5%) were long at birth. Two of these were boys who had macrosomia (weight-for-height >2 SDS). None of the patients had a low weight-for-height. The mean age at the first consultation was 8.6 months (range: 2–12 months). All patients were being breastfed at the moment of evaluation. An underlying disease was found in eight patients (11%) during the study period: disorders such as corpus callosum agenesis, hydrocephalus and West syndrome were diagnosed in six patients; Beckwith syndrome was confirmed in one and one patient is being studied for fragile X syndrome. For these reasons, we decided to exclude this group of patients from the general analysis.

Table 1: Anthropometric data of the study population at birth and at 3, 6 and 12 months of life.

	Weight, kg	Weight SDS	Height, cm	Height SDS	Weight-to-height SDS
Birth	3.66 (2.65–4.82)	0.75 (−1.77/+3.3)	50.1 (45.5–54)	0.44 (−2.23/+3.1)	0.74 (−1.75/+2.88)
3 Months	8.33 (6.34–10.8)	2.76 (+0.19/+6.34)	62.1 (56–67)	0.94 (−1.8/+3.41)	2.59 (−1.19/+4.56)
6 Months	11.7 (9.45–15)	4.60 (+2.26/+8.1)	69 (65–79)	1.22 (−0.75/+5.3)	4.43 (+2/+7.26)
12 Months	16.25 (11.3–23.7)	5.97 (+2/+12.5)	79.1 (75–85.5)	1.17 (−0.07/+4.25)	5.5 (+2.13/+9.47)

Data are expressed as medians and ranges.

We also compared the history and anthropometric characteristics of these patients and did not find any difference that was statistically significant between both groups. Sixty-five infants were finally included in the study.

In Table 1, the anthropometric data at birth and at 3, 6 and 12 months of life are shown for the whole population. At 3 months of life, 64% of the children presented with a weight of more than 2 SDS and 18% had a height of >2 SDS above the median. At 6 months, 100% of the infants had a high weight-for-age and weight-for-height SDS, and 15% were long. At 12 months of age, 100% of the patients had weight and weight-for-height of >2 SDS above the median and 28% were long. Weight gain velocity between birth and 3 months of life was 1.53 ± 0.36 kg per month (0.82–2.28), 1.36 ± 0.22 kg per month (0.83–1.85) between birth and 6 months, 1.24 kg per month (0.20–2.98) between 6 months and 1 year and 1.05 kg per month (0.6–1.66) overall between birth and 12 months. Weight gain by sex (expressed in kg) over the first year of life is shown in Figure 1 compared to the 50th percentile weight gain in the normal population (WHO references) (<http://www.unicef.org/argentina/spanish/Nutricion>).

The mean age at introduction of semisolid food was 6.56 months (range: 4–12 months). The mean age at weaning was 15.8 months (range: 9–26 months) and the mean weight at that moment was 17.29 kg (range: 11.85–25 kg) with a weight SDS of +5.2 (+1.85/+11.28 SDS).

The mean age of the mothers was 23.1 years (range: 15–41 years); 13% smoked during the pregnancy. Data on weight gain during pregnancy were available for 61 mothers (83.5% of the sample). The mean weight gain of these mothers was 16.7 ± 8.24 kg (range: 3–40 kg). Weight gain was >18 kg in 44% of the mothers, with a mean gain of 24.6 kg (range: 18.5–40 kg). No significant differences were found between maternal age and weight gain during pregnancy (23.2 ± 4.9 vs. 22.6 ± 5.6 years, respectively, $p=0.64$). No correlation was observed between mothers' weight gain during pregnancy and absolute weight and

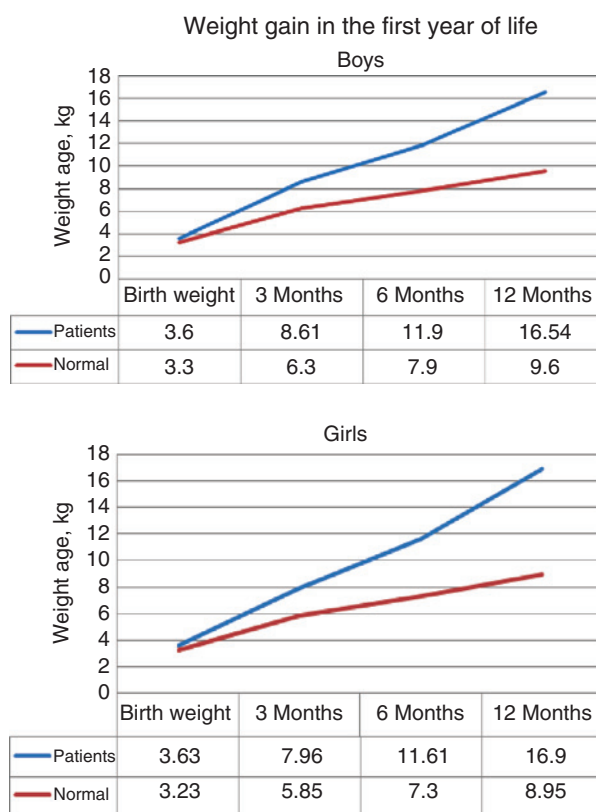


Figure 1: Weight gain (presented in kg) during the first year of life in our series (patients) compared with the 50th percentile in the general population (normal) (WHO tables) according to sex. Weight age = weight for age.

weight-for-height SDS for the children at birth and at 3, 6 and 12 months in a linear regression analysis, showing these items to be independent variables, even when separating the children by sex.

Regarding feeding patterns, 89% of the mothers could not specify the number of daily or nightly feeds and followed no hunger-satiety cues. Bed-sharing was reported in 100% of the mother-infant dyads at the first consultation.

In a subgroup of mother-infant dyads, the composition of a single sample of breast milk could be determined. Of the 31 samples obtained, two were too small and 29 samples were studied. Only proteins (mean in our total population 0.91 ± 0.2 g%; range: 0.4–1.5 g%) and fats (mean in our total population 2.98 ± 1.84 g%; range: 0.5–6.6 g%) could be assessed; we could not quantify carbohydrates. A non-significant difference in proteins ($p = 0.11$) but a significant difference in fat ($p < 0.00$) was found when comparing the values in the study group with those in the general population, as we did not have a control group.

When the infants were grouped into older and younger than 6 months at the moment the sample was taken, the correlation with the protein and fat levels in the breast milk of the general population remained the same: not statistically significant for proteins (0.96 ± 0.1 vs. 0.84 ± 0.28 g%, respectively; $p = 0.061$) and significantly less for fat in our series (2.37 ± 1.62 vs. 3.7 ± 2.08 g%, respectively; $p < 0.00$).

Discussion

The aim of this study was to describe the characteristics of a series of infants who were exclusively breastfed and showed excessive weight gain since birth, focusing on specific factors such as features of the mother and the child as well as feeding patterns, with the intention of explaining possible causes of this unusual weight gain and not to show causality between the factors that may have contributed with the unusual weight gain. We agree with the WHO recommendations on the benefits of breastfeeding in the protection against future obesity. We know this is a unique cohort and we were surprised for the exceptional growth pattern they had during breastfeeding; we, thus, encourage these patients to continue exclusive breastfeeding during the first 6 months, despite the weight gain.

The positive-protective effects of breastfeeding are controversial, and some studies have suggested that it indeed might not exist at all [23]. Weight gain velocity was much higher in our series of infants than in the general population, considering that these children were term newborns with adequate birth weight. The only case report published of an infant with similar characteristics as our population was a baby that had macrosomia and a similar weight gain velocity [23]. In the present series, the duration of breastfeeding was prolonged, with a mean age at weaning of 15.8 months ([http://www.msal.gob.ar/situacion de lactancia maternal en Argentina](http://www.msal.gob.ar/situacion-de-lactancia-maternal-en-Argentina), 2011), and 90% of the mothers could not specify the number of feeds given

either during the daytime or at night, using an on-demand feeding pattern without hunger-satiety cues. Bed-sharing was found in 100% of the mother-infant dyads. Although few articles have been published in the literature, a positive association has been described between bed-sharing and obesity in children aged 3 and 4 years [24], possibly related to shorter sleep rhythms and not to increased food intake. An association with on-demand feeding patterns and a higher frequency of bed-sharing has also been described [21], coinciding with the findings in our study. When the food registry was made, the introduction of semisolid food had been regular or bad at 6 months in 39% of the cases. Although the relation between the mother and the infant is bidirectional, some characteristics of the infant, such as temperament, may lead to certain responses in the mother and, conversely, the babies may respond to different attitudes of the mother [25]. In our series, four in every 10 babies were started on semisolid food late.

In our group of infants with early-onset obesity, 11% were found to have a congenital abnormality and to be associated with a rare genetic disorder. We think that this abnormal proportion is due to the specific characteristics of the sample because this is not a normal population where polygenic obesity is more prevalent [26]. The infants in this cohort did not show clinical genetic features at the beginning of the recruitment, so we included them as an early-onset obesity population. In the follow up, we realized that they had some different features that needed further investigation, so we had to exclude them from the total cohort in the final analysis.

In the subgroup where samples of breast milk were analyzed, we found protein levels that were similar to those in the general population for age and sex, but fat levels were lower. This is in disagreement with the hypothesis that a higher protein content in the breast milk leads to a higher risk of accelerated weight gain and the future development of obesity as in the entire subgroup, weight gain was far above the normal patterns. This may suggest that in addition to the macronutrients and related to the current lines of research [27], there are hormonal variations in human milk that regulate adipogenesis independently from the total protein and fat contents (IGF-1, adiponectin, leptin). On the other hand, it is well known that infants adjust milk intake according to calorie density. Therefore, it may also be hypothesized that, as the breast milk of these mothers has less fat, the babies drink more and thus receive a larger quantity of proteins. This hypothesis is consistent with the feeding pattern found in our population.

The strength of our study is that for the first time, it provides a description of a large cohort of children with excessive weight gain associated with exclusive

breastfeeding, with complete data from the neonatal period and information on the macronutrients in the breast milk of the mothers of these infants. One of the weaknesses of the study is that not all children were enrolled before 6 months of life, and although all were exclusively breastfed and had gained more weight than would be expected in the first months, in some, semisolid food had already been introduced. Additionally, we did not have a control group either for the cohort or for the analysis of the breast milk samples.

Conclusions

Although observation of these cases does not confirm causality, it led us to hypothesize that inter-individual variations in the composition of the mother's milk may affect growth patterns of the children and increase the risk of obesity. Further studies will be necessary to confirm this assumption.

We plan to prospectively study this hypothesis through the analysis of human milk composition in mother-infant dyads in a research project within the framework of early nutrition.

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