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Complementary feeding practices and their association with adiposity indicators at 12 months of age

Ameyalli M. Rodríguez-Cano, Jennifer Mier-Cabrera, Carolina Rodríguez-Hernández, Ana L Allegre-Dávalos, Cinthya Muñoz-Manrique and Otilia Perichart-Perera

Departamento de Nutrición y Bioprogramación, Instituto Nacional de Perinatología "Isidro Espinosa de los Reyes", Ciudad de México, Mexico

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Address for Correspondence: Dra. Otilia Perichart-Perera, Departamento de Nutrición y Bioprogramación, Subdirección de Investigación en Intervenciones Comunitarias, Torre de Investigación, Instituto Nacional de Perinatología "Isidro Espinosa de los Reyes", Montes Urales 800, Col. Lomas Virreyes, Alcaldía Miguel Hidalgo, Ciudad de México, Mexico. Email: otiliaperichart@inper.gob.mx

Abstract

Nutrition during the first 1000 days of life represents a window of opportunity to reduce the risk of metabolic dysfunctions later in life. Exclusive breastfeeding (EBF) and adequate introduction of solid foods are essential to promote metabolic and nutritional benefits. We evaluated the association of infant feeding practices from birth to 6 months (M) with adiposity indicators at 12 M. We performed a secondary analysis of 106 healthy term infants born from a cohort of healthy pregnant women. Type of breastfeeding (exclusive or nonexclusive), the start of complementary feeding (CF) (before (<4 M) or after (≥4 M)), and adiposity (body mass index – BMI, body mass index-for-age – BMI/A, waist circumference – WC, and waist circumference–length ratio – WLR) were evaluated at 12 M using descriptive statistics, mean differences, X^2, and linear regression models. During the first 6 M, 28.3% ($n = 30$) of the infants received EBF. Early CF (<4 M) was present in 26.4% ($n = 28$) of the infants. Children who started CF < 4 M were less breastfed, received added sugars as the most frequently introduced food category, and showed higher BMI, BMI/A, WC, and WLR; those who consumed added sugars early (<4 M) had a higher WC. Starting CF < 4 M was the main factor associated with a higher WC at 12 M. Unhealthy infant feeding practices, such as lack of EBF, early CF, and early introduction of sugars, may be associated with higher adiposity at 12 M.

Introduction

Nutrition during the first 1000 days of life represents a window of opportunity to reduce the risk of metabolic dysfunctions leading to obesity, diabetes, and cardiovascular diseases in later stages of life.[1,2] Exclusive breastfeeding (EBF) and adequate introduction of solid foods are essential to promote metabolic and nutritional benefits.[3,4]

International recommendations clearly state that all infants should be exclusively breastfed for the first 6 months (M) of life and it is advisable to continue breastfeeding for up to 2 years.[5] The benefits of EBF have been widely described in the literature, positively influencing immunological, nutritional, and clinical outcomes, and showing a reduction in the risk of developing overweight and obesity later in life.[6–9]

Experts recommend a timely introduction of complementary feeding (CF) between 4 M and 6 M, and the inclusion of different food groups, prioritizing iron intake and delaying the consumption of added sugars and sugary drinks until 24 M.[10,11] Some studies have shown that starting CF before 4 M (<4 M) is associated with an increased risk of overweight or obesity, although others have not observed this association.[2,12–14] The association between the type of food initially introduced and the risk of obesity is even less clear.

Recent estimates suggest that 38.2 million infants <5 years old and more than 158 million children aged 5–19 years old are overweight or obese and it is predicted to reach 254 million by 2030.[15,16] In Mexico, from 1998 to 2012, the prevalence of overweight and obesity in children <5 years old increased[17] from 7.8% to 9.7% and by 2018, 22.2% of infants 0–4 years old were at risk of overweight.[18]

Although not well documented, the start of CF in Mexican infants has been reported to happen around 4.3–5 M of life, where fruit is probably the most commonly offered first food.[19,20] However, in Mexico, as in Latin America, it is a common cultural practice to start CF with foods that do not provide the nutrients that infants require for optimal growth and development, such as atole (sweetened rice/corn-based beverage), herbal teas, broths, fermented dairy products, and Swiss-type flavored/sweetened cheese. Likewise, mothers avoid offering foods such as citrus fruits, strawberry/kiwi, pork, chocolate, egg, beans, and "hot/cold" foods.[21] In addition, inadequate dietary practices have been documented in Mexican children.[22] It has been recently reported that 83.3% of the infants (1–4 years old) consume sugary drinks, 63.6% consume sweets, snacks, and desserts, and 48.6% consume sweetened breakfast cereals.[18] The intake of added sugars in children of this age is estimated to be 40.5 g daily,[23] which is excessive. On the other hand, only 48.8% of them consume fruits, 37.5% legumes, and 20.2% vegetables.[18]

The objective of this longitudinal study was to evaluate the association of infant feeding practices (breastfeeding, timing of introduction of CF, and starting CF with sugars) from 0 to 6 M with adiposity indicators at 12 M.

Method

Settings

This is a secondary analysis from a cohort of healthy pregnant women and their infants, which was conducted at Instituto Nacional de Perinatología "Isidro Espinosa de los Reyes" (No. 212250-49511).[24] Women's participation was voluntary and all of them signed an informed consent. In adolescents (<19 years old), both parents and participants gave consent. Women were followed up until the end of their pregnancy and accepted that their children were nutritionally assessed during the 12 M of life.

Study population

For the purpose of this analysis, we only included data collected from healthy term infants (≥37 weeks). We eliminated data from babies whose mothers had gestational diabetes and/or preeclampsia or when nutritional/anthropometric information was missing/incomplete at 6 M and 12 M.

All clinical and sociodemographic information from the mothers such as age, parity, education level, and pregestational body mass index (BMI) were obtained from the cohort's records. Pregestational BMI was classified as normal (18.5–24.9 kg/m^2), overweight (25–29.9 kg/m^2), or obesity (≥30 kg/m^2) according to WHO criteria.[25]

Adiposity indicators

At birth, we obtained all clinical (gestational age – weeks) and anthropometric infant data (weight, length, and head circumference) from the institute's medical record. BMI was computed and BMI-for-age (BMI/A), and length-for-age (L/A) z-scores were evaluated.

At 12 M, an experienced, well-trained nutritionist took all anthropometric measurements following the techniques described by Lohman.[26] She did one-time measures of weight (1582 Baby/Mommy digital scale, Tanita Corporation of America, Inc., IL, USA), length (SECA 207 portable infantometer, SECA Corp., MD, USA), and waist circumference (WC) (anthropometric tape; Gulick II, Country Technology, WI, USA) while infants were dressed in the minimum of clothing. Waist circumference–length ratio (WLR) was computed. Sex-specific z-scores were calculated using the Anthro software v. 3.0.1 (WHO, Geneva, Switzerland). We evaluated the infants' nutritional status as wasted (< −2 SD), normal (> −2 SD), risk of overweight (> +1 SD), overweight (> +2 SD), or obesity (> +3 SD) by means of BMI/A, according to WHO's references.[27]

Feeding practices

During the follow-up visits (1 M, 3 M, and 6 M), mothers were asked about their babies feeding practices, including information regarding breastfeeding patterns and CF. Questions included whether infants were breastfed, formula-fed, or both, as well as if they had ever been fed any other food/liquid (e.g. water, juices, herbal teas, other types of milk, semi-solid, or solid food) during their first 6 M of life.

We classified breastfeeding practices during the first 6 M as (1) exclusive (EBF) or (2) nonexclusive (non-EBF). For the purpose of the study, EBF included breast milk, tap water, non-sweetened herbal teas, oral rehydration solution, drops, and syrups. Non-EBF category included infants that received any amount of formula or received both breast milk and formula or were only formula-fed. We also recorded the month when CF was started, as well as the type of food offered. We evaluated the intake of cereals, vegetables, fruits/natural juices, legumes, animal products, dairy, and added sugars. The latter category included food sweetened with table sugar, brown sugar, honey, or syrup, industrialized juices, soda, gelatin, jam, condensed milk, flavored milk, and soft/hard candy. When CF started <4 M, we classified it as early CF.

At 12 M, a 24-Hour Food Recall (24 HR) was administered to mothers in order to assess their children's diet. We used the Food Processor SQL program (version 10.4, ESHA Research, OR, USA) to analyze the collected information, obtain the energy intake (kcal/d, kcal/kg), as well as the percentage of energy (%E) of macronutrients.

Statistical analysis

We used descriptive statistics (mean ± SD) to describe continuous variables and frequencies (n (%)) to describe categorical variables. Using Student's t-/Mann–Whitney U tests, we evaluated differences in weight, length, BMI, BMI z-score, WC, and WLC at 0 M and 12 M between boys and girls; as well as, adiposity (BMI, BMI z-score, WC, and WLC) indicators at 12 M according to parity, start of CF and EBF. One-way ANOVA/Kruskal–Wallis was used to evaluate differences in adiposity indicators at 12 M according to mothers' age (<18, 18–35, and >35 y), education level (basic, medium, and high), and pregestational BMI (normal, overweight, and obesity). To assess differences between categories of BMI/A (wasted, normal, risk of overweight, overweight, and obesity) at 0 M and at 12 M, we used the chi-square test. These analyses were performed using SPSS (v. 22, SPSS Statistics/IBM Corp, NY, USA).

To test the association of feeding practices with adiposity indicators (BMI, BMI/A, WC, and WLR) at 12 M, we used adjusted linear regression models. Infant predictor variables included BMI at birth, actual age (days), energy intake (kcal/kg), protein intake (as %E), sex, EBF during 6 M (yes or no), and the start of CF <4 M (yes or no). Maternal predictor variables included in the models were pregestational BMI (kg/m^2), age (y), category of educational level (basic, medium, and high), and nulliparity (yes or no). A value of $P < 0.05$ was considered statistically significant. All models were performed using STATA software (v. 12, StataCorp, Texas, USA).

Results

Of the 263 newborns from the cohort, 233 were born at term and were eligible to follow-up. One-hundred and sixty-six mothers accepted to continue and returned with their infants for nutritional and anthropometric assessment up to 12 M (dropout rate: 28.7%). For the purpose of this analysis, we eliminated data from 60 children due to lack of nutritional information at 6 M or anthropometric assessment at 12 M ($n = 54$) or because they were born from mothers who developed preeclampsia/gestational diabetes ($n = 6$). We analyzed data collected from 106 infants.

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At birth, the mean gestational age was 39.0 ± 1.1 weeks. Low birth weight was present in 12.2% ($n = 12$) of the newborns and only three (2.8%) weighed >3500 *g*. Most of them had a normal BMI/A; only one had low BMI/A. Stunting (L/A <–2 SD) was present in 38.9% ($n = 37$) of the infants. Boys had greater weight and length at birth and 12 M ($P < 0.05$). We found no differences in BMI/A, WC, nor WLR according to sex at any follow-up visit. At 12 M, most of the infants continued with a normal BMI/A, although there was an increase in infants classified at risk of being overweight and as overweight. There were no cases of obesity or differences by sex at any follow-up visit. Descriptive anthropometric data is shown in Table 1.

Regarding feeding practices, 28.3% ($n = 30$) of the children received EBF during the first 6 M. At 12 M, only 33.3% ($n = 35$) continued receiving breast milk. The mean age when CF started was 4.2 ± 1.2 M; nevertheless, the earliest onset registered was 1 M. Those infants who did not receive EBF started CF earlier (3.9 ± 1.2 M vs. 4.6 ± 1.1 M; $P = 0.031$). We found no difference in the start of CF with food group categories according to breastfeeding classification.

In addition, 26.4% ($n = 28$) of the children started CF <4 M. The food category which mothers used most frequently to start CF was fruits/natural juices (72.2%, $n = 70$), followed by added sugars (52.6%, $n = 51$), and vegetables (49.5%, $n = 48$) (Fig. 1). Added sugars (71.4% vs. 44.9%, $P = 0.025$) was the most frequently introduced food category in children who started CF <4 M; meanwhile, in those who started CF >4 M, vegetables (32.1% vs. 52.5%, $P = 0.043$) and fruits/natural juices (57.1% vs. 78.3%, $P = 0.047$) categories were the most frequent (Fig. 1).

The mean energy intake at 12 M was 1002 ± 416 kcal/d and the distribution of macronutrients was 17 ± 5% from protein, 27 ± 7% from fat, and 57 ± 9 % from carbohydrates.

At 12 M, those who received EBF showed a tendency to have a lower BMI/A ($P = 0.081$). No other differences were observed in anthropometric indicators at 12 M according to breastfeeding classification (Table 2). Children who started CF <4 M had a higher BMI, BMI/A, WC, and WLR (Table 2). Those who started CF early and with sugars had a higher weight (8807.0 ± 999.7 kg vs. 9486.6 ± 1226.4 kg; $P = 0.007$) and WC (41.1 ± 3.2 cm vs. 42.7 ± 2.5 cm; $P = 0.012$) at 12 M.

Adjusted regression linear models showed that early CF (<4 M) and energy intake (kcal/kg) influenced WC at 12 M. On the other hand, a mother's high education level had a statistically significant effect on BMI (kg/m^2). No other independent maternal–infant variables showed an effect on BMIA, BMI/A, WC nor WLR (Table 3).

Discussion

This longitudinal analysis shows important associations between feeding practices during the first 6 M of life and adiposity indicators at 12 M in Mexican infants. We observed that an early start of CF is associated with a higher WC, even after adjusting for relevant maternal and infant characteristics, including EBF exposure during the first 6 M of life. We found that added sugars are common as one of the first foods introduced in CF, especially in those who start <4 M.

The National Nutrition and Health Survey in Mexico[18] showed that 28.6% of the infants receive EBF during the first 6 M and only 46.9% of the infants still received breast milk at 12 M. This data is comparable to those findings in our sample. The effect of breastfeeding on the prevention of obesity has been challenging to confirm for various reasons, including methodological issues[12,28] and confounding factors.[29,30] Our results show a tendency of BMI to be lower in those children who received EBF during the first 6 M, but the association is lost when adjusting for confounding variables. Studies have found a lower BMI and body fat in children between 2 and 10 years old exposed longer to EBF/BF.[28,30–32] When adjusting for maternal variables (age, pregestational BMI, education level, and parity), these associations are maintained, although their attenuation is important.

The absence of EBF has been associated with an early onset of CF.[4,33–35] Barrera *et al.*, found that never breastfed infants or those who stopped at <4 M were more likely (odds ratio 2.27; 95%CI 1.62–3.18) to be introduced to CF early than infants who breastfed ≥4 M.[36] We also observed this outcome in infants who did not receive EBF for 6 M. In addition, 25% of children started CF < 4 M, being this an inadequate practice.[10,11] We found some reports showing similar prevalence, evidencing that it is still a fairly common practice. The BeeBOFT study in the Netherlands ($n = 2157$) found that 21.4% of infants had received early CF.[34] Data from the Nurture study observed that almost one-third of infants had an inadequate practice (31.7%).[37] In a recent NHANES analysis, 16.3% of infants had an early CF introduction.[36]

We observed that an early start of CF was associated with a higher WC. Other studies have reported a possible effect of this early start on the risk of obesity.[14,38] However, results are still inconsistent.[28,39] Most studies have assessed adiposity using BMI, without direct measurements of fat mass. The start of CF <4 M has been associated with a higher risk of a higher BMI between the first and second year of life,[4,40] greater adiposity at 7 years,[41] larger increase of subscapular skinfold thickness at 9 M in premature children,[42] and increased risk of overweight, obesity, and altered WC in adulthood.[43]

A meta-analysis found that the introduction of complementary foods <4 M is associated with an increased risk of overweight or obesity (by means of BMI) during childhood.[44] Huh *et al.* analyzed this association in separate models for breastfed or formula-fed infants, finding that the risk of obesity increased in the latter and not in the former.[45]

Gingras and cols. found that starting CF < 4 M was associated with higher WC and higher trunk fat mass (measured by DXA) in school-aged children and adolescents, for both breastfed and formula-fed children (with a larger effect in the latter) and adjusted for infant and maternal variables.[46]

In our study, we did not observe any associations of feeding variables (EBF, CF) with BMI. In some European countries, it has been documented that the increase in WC greatly exceeded that of BMI, leading to the assumption that the prevalence of obesity in children has been underestimated. Fredriks *et al.* suggest that central body fat accumulation has increased more abruptly than total body mass as a result of height and weight.[47] Therefore, the prevalence of overweight and obesity may have been underestimated, since BMI does not distinguish between fat and fat-free mass. Probably, BMI is less accurate when estimating metabolic risk than FM.[39,48] There is a strong correlation between total body fat and risk of obesity-related diseases in adults.[49,50] Good correlations have been reported in school-aged children[51,52] with weaker correlations for preschoolers[52] and even more for neonates.[53] Within the first year of life, BMI could be limited as a surrogate for adiposity and adiposity changes.[54] Obesity in children (>7 years old) could be misclassified when using BMI that when using fat mass.[55,56] The screening ability of BMI varied on the extremes of fat mass and across ethnic groups.[56]

WC could be a better indicator for the detection of metabolic risk. WC, a simple measurement which is part of the characteristic criteria for metabolic syndrome, has been recognized as a useful marker of risk in adults, independent of BMI. It could be considered a good

Table 1. Baseline anthropometric data at birth and at 12 M

	Newborns			12 M		
	Total	Boys	Girls	Total	Boys	Girls
Weight (kg)	2.88 ± 0.36	2.96 ± 0.36*	2.79 ± 0.34	8.95 ± 1.08	9.22 ± 1.06^{+}	8.66 ± 1.04
Length (cm)	46.9 ± 2.0	47.4 ± 1.8$^{\$}$	46.3 ± 2.0	72.7 ± 3.1	73.3 ± 2.8$^{\#}$	72.0 ± 3.2
BMI (kg/cm^2)	13.1 ± 1.1	13.0 ± 1.1	13.1 ± 1.0	16.9 ± 1.4	17.1 ± 1.6	16.7 ± 1.2
BMI/A classification (*z*-score)	−0.26 ± 0.85	−0.32 ± 0.88	−0.19 ± 0.83	0.23 ± 1.00	0.20 ± 1.14	0.25 ± 0.83
Wasted	1 (1.1%)	1 (2%)	0 (0%)	3 (2.8%)	3 (5.4%)	0 (0%)
Normal	89 (93.7%)	47 (94%)	42 (93.3%)	82 (77.4%)	41 (73.2%)	41 (82%)
Risk of overweight	5 (5.3%)	2 (4%)	3 (6.7%)	17 (16%)	9 (16.1%)	8 (16%)
Overweight	0 (0%)	0 (0%)	0 (0%)	4 (3.8%)	3 (5.4%)	1 (2%)
Obesity	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
WC (cm)	29.0 ± 2.0	29.1 ± 2.2	28.9 ± 1.8	41.5 ± 3.1	41.7 ± 3.5	41.2 ± 2.6
WLR (cm/cm)	0.62 ± 0.04	0.61 ± 0.04	0.63 ± 0.04	0.57 ± 0.04	0.57 ± 0.04	0.57 ± 0.03

Data are shown as mean ± SD; *n* (%). Student's *t*-test, $^{*}P < 0.05$, $^{+}P < 0.01$; Mann–Whitney U test, $^{\#}P < 0.05$, $^{\$}P < 0.01$.
BMI, Body Mass Index; BMI/A, Body Mass Index-for-Age; M, Months; WC, Waist Circumference; WLR, Waist circumference–length ratio.

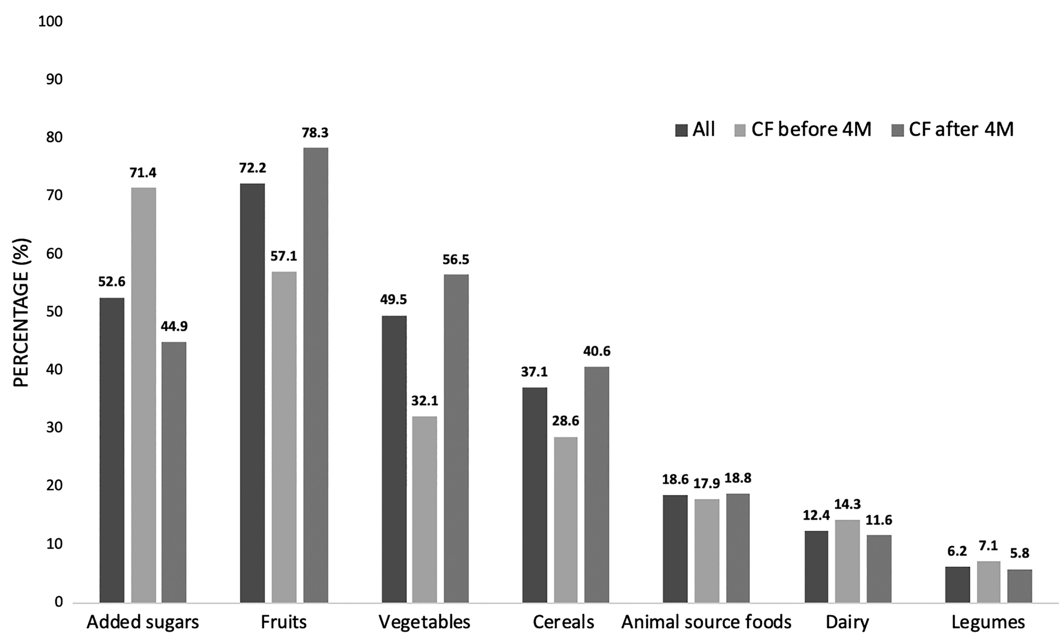

Fig. 1. Food categories used by mothers to start complementary feeding (CF) in infants.

predictor of visceral adipose tissue, such as BMI is for subcutaneous adipose tissue, even in the pediatric population.[57] In children, WC has shown a good correlation with visceral adiposity.[58] Taylor *et al.* found that WC correctly discriminated children (3–5 years old) with low- and high-fat mass in approximately 90% of the cases.[59] On the other hand, WLR identified children (4–17 years old) with adverse cardiovascular risk factors (heart rate, LDL cholesterol, triglycerides, and total cholesterol) better than BMI.[60] Greater gain in WC, particularly within the first 6 M and between 24 and 36 M of life, was more positively associated with blood pressure at 36 M than gains in other anthropometric measures (such as skinfolds).[61] Obese children (7–11 years old) with a WC ≥ 90° are at a greater risk of dyslipidemia and insulin resistance than obese children with WC < 90°.[58] These results could support the assessment of WC as a routine practice in infants in order to identify those with a higher metabolic risk.[47]

Another relevant aspect for consideration is the type of food offered when starting CF. It is recommended to avoid added sugars and sugary drinks, delaying its introduction until after 2 years.[10,62,63] However, a common practice in early childhood is the prompt introduction of sugar. Different studies have reported that juices and other sugary drinks are consumed frequently at this stage of life.[35,64] Data from 2011 to 2014 NHANES showed that 10% of the infants (<6 M) consumed any amount of 100% juice.[65] On the other hand, the BeeBOFT study found that at 6 M, infants consumed sweet beverages daily (20.2%) or at least once a week (41%).[34] Results from the Nurture Cohort Study indicated that 6% (0–6 M) and 38% (6–12 M) of babies were consuming juice.[66] In toddlers (12–24 M), according to the FITS study and 2005–2012 NHANES, juice was the second and third most commonly consumed beverage, respectively.[67,68]

Table 2. Adiposity indicators at 12 M according to maternal and infant variables

	Adiposity indicators at 12 M			
	BMI (kg/m^2)	BMI/A (*z*-score)	WC (cm)	WLR (cm/cm)
Maternal variables				
Age (years)				
<18 (*n* = 24)	16.8 ± 1.4	0.23 ± 0.88	41.4 ± 2.9	0.57 ± 0.04
18–35 (*n* = 59)	17.0 ± 1.5	0.25 ± 1.10	41.3 ± 3.5	0.57 ± 0.04
>35 (*n* = 23)	16.9 ± 1.2	0.15 ± 0.89	41.9 ± 2.3	0.57 ± 0.02
Pregestational BMI (kg/m^2) classification				
Normal (*n* = 63)	16.8 ± 1.4	0.20 ± 0.99	41.6 ± 2.9	0.57 ± 0.03
Overweight (*n* = 23)	17.1 ± 1.6	0.26 ± 1.19	41.8 ± 4.0	0.57 ± 0.05
Obesity (*n* = 16)	17.1 ± 1.4	0.33 ± 0.94	41.1 ± 2.5	0.57 ± 0.04
Education level				
Basic (*n* = 34)	16.8 ± 1.6	0.13 ± 1.19	41.4 ± 3.0	0.57 ± 0.04
Medium (*n* = 39)	16.6 ± 1.1	0.04 ± 0.82	41.1 ± 3.0	0.56 ± 0.03
High (*n* = 25)	17.5 ± 1.5	0.61 ± 0.94	42.1 ± 3.8	0.58 ± 0.05
Parity				
Nulliparous (*n* = 67)	16.9 ± 1.4	0.23 ± 0.96	41.5 ± 3.0	0.57 ± 0.03
Multiparous (*n* = 31)	17.0 ± 1.4	0.20 ± 1.11	41.3 ± 3.6	0.57 ± 0.05
Infant variables				
BMI classification at birth				
Normal (*n* = 89)	16.8 ± 1.4	0.17 ± 1.00	41.4 ± 3.2	0.57 ± 0.04
Overweight risk (*n* = 5)	17.7 ± 1.1	0.85 ± 0.95	43.1 ± 2.9	0.58 ± 0.03
Start of complementary feeding				
≥4 M (*n* = 78)	16.7 ± 1.4	0.10 ± 1.02	40.9 ± 2.7	0.57 ± 0.04
<4 M (*n* = 28)	17.4 ± 1.4*	0.57 ± 0.90*	43.0 ± 3.5$^{\&}$	0.58 ± 0.04*
Exclusive breastfeeding during 6 M				
No (*n* = 76)	17.0 ± 1.4	0.33 ± 0.93	41.7 ± 3.1	0.57 ± 0.04
Yes (*n* = 30)	16.6 ± 1.5	−0.5 ± 1.15	40.9 ± 3.0	0.57 ± 0.04

Data are shown as mean ± SD. Student's *t*-test, *$P < 0.05$; Mann–Whitney U test, $^{\&}P < 0.05$.
BMI, Body Mass Index; BMI/A, Body Mass Index-for-Age; M, Months; WC, Waist Circumference; WLR, Waist circumference–length ratio.

In Brazil, Dallazen found that the prevalence of introduction of sugar <4 M was 35.5% in counties with low socioeconomic status.[69] Our results showed that 53.6% of children started CF with some type of sugar and, if CF started early, the probability of being exposed to it was greater. It has been documented that with an early start of CF, there is an increased exposure to added sugars as age increases[34,70–72] and a decrease in the consumption of fruits and vegetables, among other healthy foods.[35,61,72,73] This is of utmost relevance due to the fact that these early feeding practices are factors influencing an infant´s current and future health.

Our results showed that a higher education level is associated with BMI. Socioeconomic characteristics have been an important confounding issue when studying obesity, although mixed results have been documented. In low- and middle-income countries, such as Mexico, it has been observed that children from more educated families have higher levels of childhood obesity.[74] In Brazil, Victora reported that children from the highest income families were heavier at birth and weighed 20% more than those from the lowest income families.[75] On the contrary, Grjibovski did not find association between maternal education and weight-for-length *z*-scores at birth and at 12 M in Russian infants.[76]

We found a relatively high prevalence of stunting at birth in our sample, this could be related to the fact that birth length was obtained from the medical record, which could represent an element of bias, since neonatal measurements cannot always be performed by a well-trained professional. Subsequent data (1 M, 3 M, and 6 M) shows a prevalence of stunting below 4% (data not shown). Furthermore, the adjusted linear regression models performed in this analysis included birth weight (measured using a digital scale, requires less training) as a way of controlling for the infant's health status at birth, where it was nonsignificant.

Among the strengths of this study, we highlight its longitudinal design. This allowed for a better definition and classification of BF exposure during the first 6 M, based on the information collected from their mothers at 1 M, 3 M, and 6 M of life. We also document the type of food introduced when starting CF, data which is very scarce in the literature. The fact that the sample is derived from a cohort, allowed to eliminate important factors associated with neonatal and infant adiposity (gestational diabetes, preeclampsia, and prematurity) and to control for confounding variables (pregestational BMI, parity, education level, birth weight, EBF, energy intake, or protein).

Some limitations of this analysis include a small sample size considering the multifactorial etiology of obesity. Although the dropout rate (28.7%) was acceptable for a long-term cohort study, there is a possibility that this could have resulted in bias. Nevertheless, we did not find any significant differences in maternal/infant (at birth) variables between those who continued and those who did not. Even though there was an association between energy intake and WC, children's diet at 12 M was evaluated with a single 24 HR; ideally, several 24 HR are required to decrease the error due to the high variability (intra/inter) in consumption. It was not possible to define the exact time (weeks) of introduction of specific food groups in CF, it was only feasible to report if it happened before or after 4 M, with no data after 6 M.

Conclusions

We found inadequate infant feeding practices in this group of Mexican infants, such as low percentage of EBF, early start of CF, and early introduction of sugars. These practices may be associated with increased adiposity. Starting solid foods <4 M of age was associated with increased abdominal fat at 12 M. It is imperative that families receive appropriate healthy eating education and counseling during the first months of their children´s life to promote behavioral change and achieve a healthy diet from early stages.

Acknowledgments. None.

Table 3. Association of maternal/infant variables and feeding practices with adiposity indicators at 12 M

Predictor variables	Outcome variables							
	BMI (kg/m^2)		BMI/A (*z*-score)		WC (cm)		WLR (cm/cm)	
Maternal variables	B (95% CI)	*P*	B (95% CI)	*P*	B (95% CI)	*P*	B (95% CI)	*P*
Mother's age (years).	−0.01 (−0.04, 0.03)	0.74	−0.004 (−0.032, 0.023)	0.75	−0.01 (−0.10, 0.08)	0.81	0.00 (−0.00, 0.00)	0.48
Pregestational BMI (kg/m^2)	0.03 (−0.31, 0.09)	0.31	0.022 (−0.023, 0.068)	0.34	−0.05 (−0.20, 0.10)	0.50	−0.01 (−0.01, 0.03)	0.20
Education level								
Basic	Reference	–	Reference	–	Reference	–	Reference	–
Medium	0.30 (−0.44, 1.04)	0.43	−0.006 (−0.028, 0.017)	0.62	0.21 (−1.53, 1.95)	0.81	−0.01 (−0.03, 0.12)	0.62
High	0.99 (0.09, 1.88)	**0.03**	0.018 (−0.009, 0.045)	0.19	1.69 (−0.41, 3.79)	0.11	0.02 (−0.01, 0.05)	0.19
Parity								
Multiparous	Reference	–	Reference	–	Reference	–	Reference	–
Nulliparous	0.10 (−0.60, 0.80)	0.78	0.082 (−0.43, 0.59)	0.75	0.20 (−1.44, 1.84)	0.81	0.01(−0.01, 0.32)	0.30
Infant variables								
BMI at birth (kg/m^2)	0.22 (−0.06, 0.51)	0.13	0.15 (−0.054, 0.361)	0.15	0.32 (−0.35, 0.99)	0.95	0.01 (−0.01, 0.01)	0.38
Actual age (days)	−0.01 (−0.01, 0.00)	0.31	−0.0005 (−0.006, 0.005)	0.86	0.01 (−0.01, 0.03)	0.18	−0.00 (−0.00, 0.00)	0.13
Sex								
Boys	Reference	–	Reference	–	Reference	–	Reference	–
Girls	−0.06 (−0.72, 0.60)	0.85	0.28 (−0.20, 0.76)	0.24	−0.88 (−2.43, 0.67)	0.26	0.01 (−0.01 to 0.03)	0.28
Exclusive breastfeeding during 6 M								
No	Reference	–	Reference	–	Reference	–	Reference	–
Yes	0.17 (−0.55, 0.88)	0.64	0.97 (−0.42, 0.61)	0.71	−0.20 (−1.87, 1.47)	0.81	0.01 (−0.01, 0.03)	0.44
Start of complementary feeding								
≥4 M	Reference	–	Reference	–	Reference	–	Reference	–
<4 M	0.32 (−0.37, 1.02)	0.35	0.22 (−0.28, 0.73)	0.40	2.08 (0.45, 3.71)	**0.01**	0.01 (−0.01, 0.03)	0.20
Energy intake at 12 M (kcal/kg)	−0.01 (−0.01, 0.00)	0.13	−0.003 (−0.008, 0.001)	0.16	−0.02 (−0.03, 0.21)	**0.04**	−0.00 (−0.00, 0.00)	0.21
Protein intake at 12 M (% Energy)	0.01 (−0.06, 0.79)	0.84	0.008 (−0.044, 0.060)	0.75	0.05 (−0.12, 0.21)	0.59	0.00 (−0.01, 0.00)	0.98

BMI, Body Mass Index; BMI/A, Body Mass Index-for-Age; M, Months; WC, Waist Circumference; WLR, Waist circumference-length ratio.
Bold numbers indicate statistical significance.

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Ethical standards. The authors assert that all procedures contributing to this work comply with the ethical standards of *Ley General de Salud en Materia de Investigación para la Salud* and with the Helsinki Declaration of 1975, as revised in 2008, and has been approved by the Institutional Review Board and Ethics Committee (reference number: 212250-49511).

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