ORIGINAL ARTICLE

Breastfeeding and complementary feeding practices and nutritional status through anthropometric and biochemical indicators among preschoolers. A comparison with national health indicators

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ABSTRACT

Objective: To assess and compare breastfeeding and complementary feeding practices and the nutritional status of preschoolers attending various child development centers in a municipality of Mexico City.
Materials and methods: An analytical, cross-sectional study which analyzed a sample of 444 preschoolers who underwent anthropometric measurements and hemoglobin determination. Additionally, information on breastfeeding and complementary feeding practices was gathered from mothers. The children were categorized into two age groups (13 to 59 months and 13 to 80 months).
Results: The average age was 48.4 months, with 90 % having been breastfed for an average of 7.7 months and 63 % having started complementary feeding before six months of age. Significant linear correlations were observed in height-for-age (r = 0.88) and weight-for-age (r = 0.72), and 6.5 % exhibited stunting. According to the nutritional status by body mass index-for-age (BMI-for-age), 3.8 % were classified as underweight, 66 % as normal weight, 22.4 % as overweight and 7.8 % as obese. The distribution of these categories was consistent between sexes (p = 0.90). Moreover, 13 % were classified as at risk of malnutrition based on upper arm circumference. Girls exhibited higher percentages of body fat (BF) (p = 0.008) and total fat (TF) (p = 0.01); 4 % of the children presented anemia, being more prevalent in girls (p = 0.02). There was an average annual weight gain of 2.3 kg across age categories, except for those over six years old, who averaged 11.36 kg.
Conclusions: Malnutrition is a growing public health problem. Preschool age is the ideal stage to carry out interventions that stimulate and promote healthy dietary habits and physical activity. Prolonged exclusive breastfeeding for at least six months is crucial for newborns and infants. In conclusion, it is imperative to refrain from using breast milk substitutes and to delay the introduction of complementary feeding before this period.

Keywords: Child, Preschool; Nutritional Sciences; Nutritional Status; Lactation; Infant Nutritional Physiological Phenomena (Source: MeSH NLM).

INTRODUCTION

During the preschool years (which follow infancy), growth and development are continuous and linear processes characterized by changes in body composition. For many years, extensive evidence has shown that dietary patterns established in childhood significantly influence weight, height, lean mass, physical performance and intellectual development during school age, adolescence and adulthood. These patterns are also associated with the risk of developing chronic diseases [1-3]. Nutritional assessment involves measuring weight, height, circumferences, skinfold thickness and, in some cases, additional clinical parameters. These parameters are analyzed in relation to age and to each other, and they are compared against current standards to assess the nutritional status and provide a comprehensive diagnosis.

The risk of nutritional deficiencies is particularly prevalent in pediatric populations, with height and weight being the primary indicators. These deficiencies often result from multiple factors, including inadequate exclusive breastfeeding or complementary feeding practices, infections during the first two years of life and socioeconomic conditions, posing a significant public health problem [4-6].

Breastfeeding is essential for human survival immediately after birth; without it, medical intervention would be necessary. Beyond its benefits for mothers, breastfeeding has a greater impact on child survival than any other preventive measure. It significantly reduces the risk of

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mortality in the first months of life due to respiratory and gastrointestinal infections, regardless of socioeconomic status (compared to those who were not breastfed), and also lowers the incidence of other infectious diseases during the first five years of life [7]. Research indicates disparities in breastfeeding prevalence, with shorter durations observed among populations with greater access to healthcare, food security, improved sanitation, urban services and higher socioeconomic status [8,9]. Despite the World Health Organization (WHO) recommending breastfeeding for at least the first six months of life, followed by continued breastfeeding alongside complementary feeding for an additional 18 months, breastfeeding has unfortunately been losing importance and showing a declining trend. This decline is concerning, as the use of breast milk substitutes—an unnecessary practice—imposes an economic burden and negatively affects infant health [8,10].

Since the late 1980s, Mexico experienced a decline in low weight and stunting (chronic undernutrition) rates among children under five years of age, a trend that persisted for 34 years. However, by 2019, these rates began to increase again by 2 and almost 1 percentage point (pp) (4.8 % and 14.2 %), respectively [11]. In contrast, overnutrition—comprising overweight and obesity—declined by 3 pp (6.8 %) during the same period. Unfortunately, acute malnutrition (wasting) has remained at 1.4 % [12], with even higher rates among children under one year of age [13].

Anemia, a major global public health problem, predominantly affects children under five years of age and pregnant women. Primarily caused by iron deficiency, anemia negatively impacts mental, cognitive and psychomotor development and serves as a key indicator of a country's development and overall health. According to WHO criteria, prevalence rates between 20 % and 39 % indicate a moderate public health problem [14]. In Mexico, anemia rates among children have declined due to a combination of health interventions, including high-dose vitamin supplementation, deworming programs, improved access to clean water and increased consumption of nutrient-rich foods. These efforts have primarily targeted vulnerable populations, with 39.1 % being screened for anemia [12,15]. However, by 2019, national anemia prevalence among children under five years of age increased significantly by 9.2 pp, surpassing the 1999 rate of 31.6 % by nearly 1 pp [11].

Despite the well-documented benefits of breastfeeding for both infants and mothers, as well as its role in improving quality of life, further research is needed to better understand breastfeeding and complementary feeding practices and their relationship with key nutritional indicators. Therefore, this study aims to assess and compare breastfeeding and complementary feeding practices with the anthropometric and biochemical indicators of preschoolers attending child development centers (CENDIs) in a municipality of Mexico City.

MATERIALS AND METHODS

Study design and population

This cross-sectional, analytical study involved administering a questionnaire to the mothers of preschoolers attending various CENDIs. Additionally, anthropometric measurements of the children were taken following internationally accepted procedures [16], as part of preventive health activities conducted in collaboration with the medical and social services of the municipality. Hemoglobin (Hb) levels were also assessed. All measurements were performed by trained and standardized personnel, following the participants' informed consent.

Variables and measurements

One of the study variables was the preschooler's age, obtained through maternal interviews. The total sample comprised 444 children aged 13 to 80 months, from which a subsample of 321 children aged 59 months or younger (under five years of age) was analyzed separately. Additional variables included the child's sex, breastfeeding history, breastfeeding duration (in months) and age of complementary feeding initiation (before or after six months of age). Anthropometric measurements included weight (assessed using a Tanita Body Fat Monitor/Scale TBF-611 and Seca 354/364 baby scale) and height (measured with a Seca 207 stadiometer and infantometer), taken in duplicate. These measurements were used to assess growth patterns and nutritional status based on the following indicators: weight-for-age, height-for-age, weight-for-height and body mass index-for-age (BMI-for-age, calculated as weight in kilograms divided by the square of height in meters). International child growth standards from the WHO, the National Center for Health Statistics (NCHS) and the Centers for Disease Control and Prevention (CDC) [17] were used for classification.

According to WHO criteria, a child is considered undernourished when their measurements fall below two standard deviations (SD) from the NCHS reference mean. Acute malnutrition is defined as weight-for-height –2 SD, while stunting is classified as height-for-age –2 SD. BMI-for-age is categorized as underweight (–2 SD), overweight (+1 SD) and obese (+2 SD) [17]. Body density (BD) was first determined according to Brook's method [19], based on the sum of skinfold thicknesses at four sites (biceps, triceps, subscapular and suprailiac) measured with a Lange caliper (1 mm resolution). The BD equations used were: boys' BD = 1.1690 - 0.0788 $\log_{10}$ Σ skinfolds; girls' BD = 1.2063 - 0.0999 $\log_{10}$ Σ skinfolds [20]. Body fat (BF) percentage was then estimated using Siri equation [18]: [(4.95/BD) - 4.5] x 100. Total fat (TF) in kilograms

was calculated as TF = weight x %BF/100. Brachial circumference (BC) was measured with a non-stretchable millimeter tape. All anthropometric measurements were taken in triplicate.

Hb levels were assessed via spectrophotometry using the HemoCue®201+ system, with fasting capillary blood samples. Anemia classification was based on WHO cut-off values: Hb < 11 g/dL for children aged 1–5 years and Hb < 12 g/dL for children older than 5 years [21].

Statistical analysis

Descriptive statistics were computed for all study variables, including measures of central tendency and dispersion. Bivariate analysis and simple linear regression analysis were performed to evaluate correlations. Statistical significance was set at $p < 0.05$, with a 95 % confidence interval (CI).

Ethical considerations

As part of the municipality's preventive healthcare programs targeting preschoolers, health and nutritional assessments were conducted. Caregivers were invited to participate and provided with a clear explanation of the study's objectives and benefits. Upon agreement, they signed a consent form before proceeding with the interview and measurements. All collected data were anonymized, ensuring the confidentiality of the participants' personal information. The study exclusively analyzed numerical data.

RESULTS

A total of 444 children attended the CENDIs between January and February 2019. The mean age was 48.4 ± 15.4 months for the entire group and 41.1 ± 11.8 months for children under five years of age. The sex distribution was comparable between groups, with 48.8 % of participants being male. The average duration of breastfeeding was 7.7 ± 6.3 months for the entire group and 7.5 ± 6.3 months for children under five years of age. In both groups, 10 % of preschoolers were not breastfed. Among those who were, half were breastfed for more than six months and two-thirds initiated complementary feeding before six months of age (Table 1).

An analysis of the association between breastfeeding history and breastfeeding duration among children under five years of age revealed no significant differences by sex ($p = 0.81$ and $p = 0.78$, respectively), height-for-age ($p = 0.68$ and $p = 0.90$, respectively) and BMI-for-age ($p = 0.55$ and $p = 0.36$, respectively).

Table 1. Distribution of the characteristics of preschoolers attending the municipality's CENDIs

Variables	Children under five years of age		Entire group	
	(*n* = 321)	%	(*N* = 444)	%
Age (years)				
1-2	18	5.49	18	3.99
2-3	81	25.25	81	18.27
3-4	111	34.63	111	25.00
4-5	111	34.63	111	25.00
5-6			91	20.53
> 6			32	7.21
Sex				
Female	166	51.71	230	51.81
Male	155	48.19	214	48.19
Breastfeeding history				
Yes	286	89.12	401	90.30
No	35	10.88	43	9.70

Variables	Children under five years of age		Entire group	
	(*n* = 321)	%	(*N* = 444)	%
Breastfeeding duration (months)				
≤ 6	141	44.07	202	45.07
> 6	145	44.81	199	45.00
Not breastfed	35	11.12	43	9.93
Age at complementary feeding initiation (months)				
≤ 6	205	63.81	278	62.61
> 6	116	36.19	166	37.39

The mean weight and height for the entire group were 16.7 ± 4.4 kg and 100 ± 1 cm, respectively, while for children under five years of age, these values were 15.2 ± 3.2 kg and 96 ± 0.8 cm. The correlation between age and height was $r = 0.88$ ($p < 0.0001$) for the entire group and $r = 0.84$ ($p < 0.0001$) for children under five years of age. Similarly, the correlation between age and weight was $r = 0.72$ ($p < 0.0001$) and $r = 0.67$ ($p < 0.0001$), respectively.

The prevalence of stunting among children under five years of age was 6.5 %, with four cases classified as severe. In the entire group, five children had severe stunting. Regarding BMI-for-age, 97 children under five years of age (30.32 %) were classified as overweight or obese. No significant sex-based differences were observed in either group (Table 2).

Table 2. Distribution and classification of preschoolers attending the municipality's CENDIs based on height-for-age, weight-for-age, weight-for-height and BMI-for-age

Variables	Children under five years of age			Entire group		
	(*n* = 321)	%	*p*	(*N* = 444)	%	*p*
Height-for-age			0.15§			0.23§
Normal height	300	94.50		417	93.89	
Stunting	21	6.50		27	6.11	
Weight-for-age			0.002*			0.07*
Underweight	1	0.32		3	0.69	
Normal weight	286	89.11		380	85.59	
Overweight	30	9.35		50	11.24	
Obese	4	1.39		11	2.48	
Weight-for-height			0.0001*			0.06*
Underweight	1	0.32		3	0.72	
Normal weight	281	87.49		372	83.80	
Overweight	33	10.31		56	12.61	
Obese	6	1.88		13	2.87	

Variables	Children under five years of age			Entire group		
	(*n* = 321)	%	*p*	(*N* = 444)	%	*p*
BMI-for-age			0.90§			0.88§
Underweight	12	3.83		19	4.24	
Normal weight	212	65.85		280	63.11	
Overweight	72	22.38		102	22.97	
Obese	25	7.94		43	9.68	

§ Pearson's chi-square test with sex.
***** Fisher's exact test with sex.

The mean BC was 16.3 ± 1.9 cm for the entire group and 15.9 ± 1.6 cm for children under five years of age. Among the latter, 13 % (*n* = 42) were classified as at risk of malnutrition (1–2 SD below the mean), while 1.2 % (*n* = 4) presented moderate malnutrition (2–3 SD below the mean). The highest proportion (85.8 %, *n* = 275) had an adequate nutritional status (1 SD of the mean).

The median percentages of BF and TF were 21.5 ± 6.6 % and 3.7 ± 1.9 kg, respectively, for the entire group, and 20.9 ± 6.5 % for children under five years of age. Significant sex differences were found in both groups, with girls presenting higher percentages of BF (p = 0.008 for the entire group; p = 0.003 for children under five years of age) and TF (p = 0.01 for the entire group; p = 0.0009 for children under five years of age). The percentages of BF by weight-for-height and BMI-for-age in children under five years of age revealed significant sex differences in the normal weight category, with higher values in boys for weight-for-height (p = 0.004) and in girls for BMI-for-age (p = 0.0001). In the entire group, the percentage of BF by weight-for-height and BMI-for-age was higher in girls (p = 0.02 and p = 0.0002, respectively), particularly in the overweight category (p = 0.001) (Table 3).

Table 3. Percentage of BF and TF among preschoolers attending the municipality's CENDIs according to weight-for-height and BMI-for-age

Variables	BF (%) Children under 5 years of age (*n* = 321)				TF (kg) Children under 5 years (*n* = 321)		BF (%) Entire group (*N* = 444)				TF (kg) Entire group (*N* = 444)	
	n	Median	Range	*p**	Median	Range	*n*	Median	Range	*p**	Median	Range
Weight-for-height												
Underweight	1	13.6	-	-	1.6	-	3	14.8	13.6-22.7	0.22	2.0	1.6-3.4
Normal weight	281	18.8	11.7-33.4	**0.004§**	2.7	1.2-6.3	372	19.1	11.7-33.4	**0.02**	2.9	1.2-6.5
Overweight	33	24.3	15.7-35.0	0.18	4.6	1.9-9.6	56	25.3	15.7-35.0	**0.001**	5.3	1.9-10.6
Obese	6	31.0	14.2-37.3	0.64	7.0	1.6-12.2	13	32.7	14.2-37.3	0.88	9.6	1.6-13.8
BMI-for-age												
Underweight	12	15.3	11.7-29.5	**0.01**	1.8	1.4-4.1	19	15.1	11.7-29.5	**0.001**	2.0	1.4-4.1
Normal weight	212	15.4	11.8-25.8	**0.0001**	2.6	1.2-6.0	280	18.6	11.8-30.4	**0.0002**	2.7	1.2-6.0
Overweight	72	21.9	14.5-29.7	0.20	3.5	1.6-5.9	102	22.2	14.5-29.8	0.57	4.1	1.6-7.4
Obese	25	28.2	14.2-37.3	0.20	5.9	1.6-12.2	43	29.9	14.2-37.3	0.06	7.4	1.6-13.8

* Kruskal-Wallis test by sex. All significant values were higher in girls, except for §, which was higher in boys.

Average annual weight gain among age groups, as determined by linear regression analysis, is as follows:

- Children ≥ 1 year old: 2.26 kg (p = 0.01; CI: 0.47–4.06).
- Children ≥ 2 years old: 2.41 kg (p = 0.003; CI: 0.84–3.98).
- Children ≥ 3 years old: 2.36 kg (p = 0.004; CI: 0.79–3.93).
- Children ≥ 4 years old: 3.12 kg (p = 0.007; CI: 0.87–5.37).
- Children ≥ 5 years old: 1.63 kg (p = 0.23; CI: -1.09–4.37).
- Children ≥ 6 years old: 11.36 kg (p = 0.07; CI: -1.01–23.7) (Figure 1).

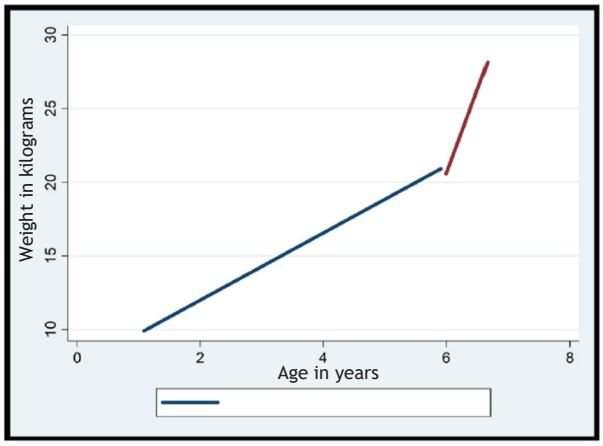

Figure 1. Linear regression analysis of age and annual weight gain among preschoolers attending the municipality's CENDIs

The mean Hb level in both groups was 12.6 ± 1.0 g/dL. Anemia was present only in 4.12 % of the entire group, with a higher prevalence in girls (p = 0.02). In children under five years of age, 5.23 % had anemia, with no significant difference between boys and girls (p = 0.09).

DISCUSSION

Maintaining a desirable body composition, as well as an optimal physical and mental performance, is achieved through an adequate daily diet. Daily dietary requirements depend on factors such as age, sex, body frame, and physical and metabolic activity levels. To maintain nutritional health, energy intake must be balanced with energy expenditure; when intake exceeds expenditure, body weight increases, leading to overweight and obesity, whereas calorie deficit results in weight loss. Both conditions can have short- and long-term health impacts. Some determinants of malnutrition arise from birth, and during the initiation, continuation and completion of exclusive breastfeeding [22]. Exclusive breastfeeding is defined as an infant consuming only breast milk, without any supplementation (e.g., water, juice, non-human milk or other foods), except for vitamins, minerals and medications [23].

Over time, the prevalence of early initiation of breastfeeding has significantly declined (from 47.7 % to 39.4 %). As infants grow, breastfeeding rates tend to decrease; however, nearly half of all children continue to be breastfed until their second year of life, with higher prevalence in rural areas [12,24].

Exclusive breastfeeding offers multiple benefits. For mothers, it promotes faster recovery from pregnancy and postpartum, reduces fertility, and lowers the risk of osteoporosis and breast cancer. For infants, it significantly reduces mortality risk; protects against infections, allergies and chronic diseases such as childhood diabetes; and decreases the likelihood of obesity. Additionally, breast milk is a rich source of essential nutrients and microbiota, promotes better cognitive development and fosters emotional bonding [8,9,25]. However, the implementation of exclusive breastfeeding remains inconsistent. According to recent data, 64.1 % of infants under five months do not receive exclusive breastfeeding [12], a figure that has dropped by 21.5 pp since 2012 [13]. The WHO recommends exclusive breastfeeding from birth until at least four to six months of age, meaning that all infants under four months (< 120 days) should receive only breast milk [10]. Although the prevalence reported in the present study for children under five years of age and the entire group (11.12 % and 9.93 %, respectively) is lower than in previous reports, it was not possible to determine whether breastfed children were exclusively breastfed, which may explain the lower prevalence.

Nevertheless, the findings align with reports indicating that 4.7 % of children under two years of age were never breastfed [12]. Previous studies suggest that the decision to discontinue breastfeeding is influenced—but not determined—by sociodemographic factors such as maternal occupation, education level and marital status. Young mothers with inadequate knowledge of exclusive breastfeeding benefits are more likely to stop breastfeeding early. The most commonly reported reasons for discontinuing breastfeeding include the mother's lack of time, employment, breast-related discomfort (e.g., engorgement, cracking), perceived insufficient milk production, concerns about inadequate milk supply, and lack of awareness of its nutritional benefits, as well as concerns about the infant's poor weight gain or refusal to be breastfed. However, mothers who continue breastfeeding—particularly in rural areas—recognize its benefits for both themselves and their children [8,26,27]. Among the two age groups analyzed that had been breastfed (89.12 % and 90.30 %), half of the children in each group were breastfed for more than six months, while only 25.17 % of the entire group were breastfed for 12 months. For the remaining cases, it was not possible to estimate breastfeeding duration, as mothers either did not accurately recall the duration beyond six months or reported inconsistent and uncertain intervals. Similarly, no significant differences were found when assessing the association between sex and breastfeeding history and duration.

Infants under six months who are breastfed do not require any complementary feeding. However, two main factors contribute to early weaning, i.e., the replacement of breast milk with animal-derived milk. The first is aggressive marketing, particularly in mass media, which promotes bottle-feeding with breast milk substitutes. These products are often misleadingly labeled with variations of the term "dairy," creating the false perception that they are equivalent to milk and avoiding explicit classification as "processed milk." This marketing strategy exerts social pressure—particularly in urban areas—leading families to introduce non-maternal feeding at an early stage. Fortunately, this trend has declined by 17 pp in both urban and rural areas [11,12]. The second contributing factor is the increasing number of mothers who must return to work just weeks after childbirth [8,28].

One of the most common issues associated with bottle-feeding with breast milk substitutes is the lack of parental guidance regarding appropriate feeding quantities, particularly for young infants. Overfeeding is a frequent occurrence and, in many cases, healthcare professionals themselves—often lacking the necessary expertise to accurately determine appropriate intake—recommend such practices by distributing or selling formula samples [8]. This is concerning given the well-documented fact that breast milk substitutes have high calorie content in their primary formulations. Such practices contribute to unhealthy eating habits, which are among the leading risk factors for overweight, obesity and non-communicable chronic diseases from an early age. Furthermore, these dietary patterns can have repercussions on dental health, including early childhood caries [29].

As previously discussed, breastfeeding provides numerous benefits. Beyond supporting optimal growth and development, it plays a crucial role in regulating future eating behaviors. Research has shown that preschoolers and school-age children whose mothers adhere more strictly to breastfeeding tend to develop healthier dietary habits. Mothers who prioritize breastfeeding are more likely to adopt a nutritious diet for both themselves and their children, thereby discouraging the consumption of unhealthy foods and shaping dietary preferences throughout life. This early-life intervention is essential, as dietary habits established during infancy can significantly reduce the risk of developing certain diseases in adulthood [30]. In this study, it was not possible to evaluate the quantity of breast milk consumed by children from both groups or to determine whether breastfeeding was combined with other feeding methods (complementary foods or breast milk substitutes). However, it is evident that most infants who were breastfed for less than six months—or were not breastfed at all—began weaning and/or supplemented their diet with breast milk substitutes, in addition to consuming small amounts of water.

To meet nutritional requirements, complementary feeding (or weaning) should be introduced gradually over a transition period of approximately two months. Therefore, nearly all infants older than six months should receive nutritious complementary foods alongside breast milk. The use of breast milk substitutes is not recommended, as the gradual introduction of complementary foods helps ensure a balanced diet. Infants should be breastfed for at least one year, with a recommended duration of up to two years or more [10]. Ideally, weaning should begin gradually around six months of age, transitioning to non-human milk (animal-derived milk) and complementary foods. It is important to classify breast milk substitutes as part of complementary feeding rather than as a form of non-human milk feeding. Both transitions should be undertaken without coercion, as forcing these changes may contribute to feeding and eating disorders later in life. In the present data, approximately 63 % of children began complementary feeding before six months of age, indicating a high prevalence of early introduction. No significant differences were observed based on sex ($p = 0.99$), height-for-age ($p = 0.97$) and BMI-for-age ($p = 0.37$).

Malnutrition remains a global challenge, with children being particularly vulnerable due to their rapid growth and

reliance on caregivers. There is broad consensus regarding the multiple determinants of malnutrition among children under five years of age, including infectious diseases; socioeconomic, demographic and environmental influences; healthcare access and childcare practices [28], with food insecurity being the most critical determinant.

Undernutrition or overnutrition in preschoolers is assessed using anthropometric indicators according to age. These include weight, height, BMI, circumferences (head, arm, leg, abdomen) and skinfold thickness measurements, among others, which provide valuable insights into nutritional status [31]. Measurements conducted in this study among children under five years of age revealed that approximately 6.3 % exhibited stunting—6.3 pp lower than the national prevalence of 12.6 %, which is more pronounced in rural areas but similar to the prevalence observed in Mexico City (5.9 %) [12]. Notably, this prevalence has decreased by 7.7 pp over the past 33 years [13]. Based on weight-for-age and weight-for-height indicators, 10.74 % and 12.19 % of children under five years of age, respectively, were classified as overweight and obese. Significant differences were observed among boys, who were more affected than girls (p = 0.002 and p = 0.0001, respectively). However, when including children over five years of age (n = 123), this condition was equally distributed between both sexes (p = 0.07 and p = 0.06, respectively). Regarding the diagnosis of nutritional status using the BMI-for-age indicator, the prevalence of overweight and obesity was 30.32 %, a figure comparable to national data yet 22.52 pp higher [12], with 7.8 % occurring in children under five years of age (9 % in Mexico City). When including the 123 preschoolers, the prevalence increased to 32.65 %, which is 3.75 pp lower than the 36.4 % reported for children aged six years [12]. These statistics align with the WHO's warning that childhood obesity has reached alarming levels, referring to it as "the epidemic of the 21st century" [30]. These figures remain concerning for children attending the municipality's CENDIs. Notably, the prevalence of overweight and obesity was equally distributed between both sexes in both age groups (p = 0.90 and p = 0.88, respectively).

Currently, given the high and rising prevalence of childhood obesity, estimating body composition in children has become increasingly important. In most cases, BMI is employed as a practical, useful and cost-effective tool for field studies to estimate prevalence. However, it is an imprecise measure, as it does not distinguish between bone, muscle and fat tissues or account for their distribution during periods of continuous growth and development, as body composition changes. Additionally, age and sex introduce significant variations that can act as predictors in adulthood. Consequently, in this study, BMI served a statistical rather than a screening function [32]. Additionally, BMI does not consider physical activity levels, which play a crucial role in bone and muscle mass development. Estimating muscle mass is essential, as it determines functional capacity through energy expenditure, making it more relevant than fat mass in this context.

BC serves as an indicator of nutritional status in children, which comprises calorie (subcutaneous tissue) and protein (muscle) reserves. It is particularly useful in cases of undernutrition, as its reduction implies the depletion of these reserves [31]. Nutritional assessment based on this sensitive and specific indicator during childhood yields results comparable to weight-for-age and weight-for-height indicators, which reflect notable short-term changes in nutritional status [33]. Moreover, BC is minimally influenced by edema, making it a practical, cost-effective and universally applicable measure, independent of sex and valuable for identifying at-risk groups with acute clinical malnutrition [31,34]. An analysis of this indicator revealed a low prevalence of malnutrition (1.22 %) among children under five years of age, a finding consistent with low weight values observed in weight-for-age and weight-for-height measurements. However, 42 preschoolers were identified as at risk of malnutrition. Since BC is primarily an indicator for detecting risk of undernutrition, it is not suitable for diagnosing overnutrition, nor can it act as a diagnostic tool for past clinical malnutrition [31].

Weight and height gains gradually declined between 15 and 48 months of age, stabilizing from this stage until six years of age. Moderate and continuous increases in muscle mass were recorded in both sexes. In terms of fat accumulation, girls exhibited greater increases, though this trend balanced out between four and a half and six years of age. Notably, muscle and body fat were the most variable components in cases of protein and calorie imbalances [31,35].

The estimation of fat mass and its relationship with chronic diseases—particularly abdominal fat—allows for a more precise and direct assessment of health risks. In contrast, BMI presents a significant limitation, as it does not differentiate between the components contributing to weight status (whether appropriate, deficient or excessive). This limitation can lead to an underestimation or overestimation of obesity, given that the primary concern in obese individuals is excess fat rather than overweight per se [32]. The measurement of BD through skinfold thickness, which is influenced by the number and location of skinfold measurements, provides an indirect estimation of fat mass for evaluating overweight and obesity [32,35], as direct measurements require sophisticated techniques [35,36]. However, predictive equations for BF exhibit systematic errors in preschoolers, underestimating BF percentages especially in girls. One of the most widely used equations is that of Brook [19], which was derived from a sample of 30 children aged one to eleven years with short stature

and obesity. Consequently, assessing body composition using equations developed for populations with different epidemiological profiles—especially in growing children—is inadequate. Ideally, new equations should be created and validated to reflect the specific characteristics of our target population [35]. In this study, significant differences were found in the percentages of BF and TF, both of which were higher in girls. Additionally, when analyzing BF in children under five years of age within the BMI-for-age normal weight category, a consistent trend was observed; however, a higher prevalence was found when using the weight-for-height indicator. Moreover, total body water (TBW) was higher in boys, indicating that an increased BF percentage corresponds to a decrease in BD and TBW, highlighting significant differences based on sex and nutritional status. In girls, the association between the percentages of BF and TF was stronger [35]. Furthermore, it is essential to establish reference values that define obesity based on data from the literature, as well as statistical criteria linking these parameters to metabolic complications [36]. Another important consideration in body composition and nutritional status analysis—particularly in estimating the percentages of BF and TF—is the inclusion of thigh and leg measurements, which are relevant to motor function. These aspects are crucial in assessing physical fitness and serve as key tools for the prevention, monitoring and management of children's health [32]. Finally, in cases of extreme obesity, calculating BF percentage through skinfold measurements is unnecessary, as the condition is visibly evident, allowing for an accurate diagnosis through direct observation [36].

During the process of growth and development, numerous changes occur in body composition. In general terms, from birth through childhood and puberty, there is a sustained period of intense metabolic activity, with continuous development of muscle and bone mass until adulthood. This process includes phases of equilibrium or increase, influenced by multiple factors such as age, heredity, physical activity, diet, environment and overall health [31,35]. Linear regression analysis indicates that the average annual weight increases observed in children under five years of age align with mean reference values for weight-for-age [16]. It is common for a slightly overweight child to experience rapid weight gain, leading to obesity due to nutritional imbalances and a lack of physical activity. Notably, in this study, children over six years of age gained an average of 11.36 kg, a figure significantly higher than the average annual increase observed in their earlier years, during which they had only gained an average of 2.3 kg per year. This value is also nearly equivalent to the total sum of all prior yearly increases (11.78 kg). Consequently, 61 children in the total study population fell into the overweight or obese category, with equal sex distribution. As children grow older and gain independence, they have greater autonomy in selecting and accessing food, often consuming highly processed products with high calorie content, both at home and outside. In this regard, it is important to note that the term "food" should not be used indiscriminately to describe such products. Although the WHO defines food as any substance intended for human consumption, this broad classification may be misleading for consumers and could infringe upon their rights. Another point of concern is that children increasingly engage in leisure activities that do not encourage physical activity, promoting sedentary lifestyles and excessive calorie intake. Although the weight increase in children over six years of age was not statistically significant in this study, this trend may explain why only a small portion of the sample fell into this category.

Anemia, a nutritional condition diagnosed by measuring blood iron levels, is primarily caused by insufficient iron intake and adversely affects mental, cognitive and psychomotor development, particularly in children under five years of age [37]. Over the past 13 years, anemia prevalence initially declined from 31.6 % [11] or 31.7 % [13] in 1999 to 26.8 % [11] or 26.1 % [13] in 2006, and further to 23.3 % [11] or 24.4 % [13] in 2012. However, over the following six years, the prevalence increased by 9.2 or 8.1 pp, reaching 32.5 %—nearly rising 1 pp and almost returning to 1999 levels [11]. In this study, anemia prevalence among children under five years of age was low (5.23 %) compared with recent national health data, which reported higher prevalence rates across different geographic regions, such as Mexico City (31.1 %) [11]. No significant differences were found between boys and girls (p = 0.09). Among children under five years of age, the highest prevalence and risk of iron deficiency was observed in the second year of life [11,13,21,38,39]. At this age, the national prevalence reaches its peak within this age group, at 48.2 %, which is more than twice the prevalence in four-year-olds, who have the lowest rate at 20.6 % [11]. Anemia prevalence declined as age increased. When including children over five years old in the analysis, the overall prevalence dropped to 4.12 %, with a higher rate in girls (p = 0.02). The most affected group consisted of children aged one to two years, with a prevalence of 33.33 %, accounting for one-third of the entire study group. However, association analysis found no significant correlations between anemia and the weight-for-height (p = 0.31), height-for-age (p = 0.07) or BMI-for-age (p = 0.44) indicators.

In conclusion, despite multiple interventions, infant malnutrition remains one of the most challenging public health problems, with long-term outcomes that are often discouraging and only marginally satisfactory, ultimately impacting health in adulthood. Prolonged exclusive breastfeeding for at least six months is the optimal form of nutrition for newborns and infants. Therefore, it is

essential to avoid the use of breast milk substitutes and to refrain from introducing complementary foods before this period.

Preschool age is a critical stage for developing healthy behaviors related to nutrition and physical activity, which contribute to proper growth and an adequate nutritional status. Addressing nutritional issues in preschoolers requires a twofold approach: reducing excessive calorie intake through a well-balanced diet and increasing physical activity. CENDIs could serve as ideal settings for implementing specialized programs focused on nutrition and physical activity, as these centers oversee meal preparation. Furthermore, introducing such programs at an early age would not only benefit children directly but also facilitate parental education on proper nutrition and the importance of incorporating regular physical activity, creativity and engagement into their children's daily routines.

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