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ORIGINAL ARTICLE

Biochemical markers and anthropometric profile of children enrolled in public daycare centers

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Abstract
Objective: The nutritional status resultant from dietary habits along with socioeconomic conditions and the school environment are directly related to the individual's health condition not only in their childhood but also throughout adulthood. The aim of this study was to evaluate the effects of socioeconomic factors on the anthropometric profile and to analyze a probable association between this profile and biochemical markers in children attending public daycare centers.
Methods: It is a transversal study developed in a probability sample of clusters of children from 6 months to 5 years old. Anthropometric and socioeconomic data were gathered at the CMEIs, questionnaires on the nutritional status were applied and blood was collected at the Family Health Units (USFs).
Results: Female children are three times more likely to be underweight; in families with five members, it is 1/3 more likely that children of higher-educated parents are overweight. Among the results of the biochemical tests, hypervitaminosis A was a relevant aspect, positively correlating with copper (p=0.005) and zinc (p=0.008).
Conclusion: Therefore, since the influence of the family is an important predictor of overweight and its future outcomes related to nutritional deficiencies and inadequate dietary intake, educational interventions are vital as a way to pave the path to prevention.

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Introduction

Childhood is a determining stage in life for the introduction and development of adequate nutritional habits, which will bring about a strong impact on the individual later in life. Stimuli for the establishment of such habits should be shared in all the scenarios in which a child is inserted due to the fact preferences for, and interest in certain types of foods arise in childhood. Family members, caretakers, and educators are in daily contact with the child, so they should all take responsibility in this process of influencing their lifestyle. [1]

Daycare centers aim for the full development of children, and a healthy diet is part of it. To properly manage a balanced, nutritious, and tasty eating plan according to each age group and at the same time arouse the children's desire to discover new foods are challenges that, once successful, reduce the probability of nutritional deficiency and help in the maintenance of an adequate nutritional status with positive future repercussions.[2]

Within this context, the nutritional status of preschool children has been the target of research and a survey topic among the general population. Over the past few years, rates of protein-energy malnutrition have reached low levels; nevertheless, some specific deficiencies, such as iron, vitamin A and zinc, still remain as nutritional challenges since they are important factors for the linear growth of the individual and the aim of studies and routine follow-up.[1,3,4]

The last decade demonstrates that the deficiency of micronutrients (vitamins and minerals) was one of the main causes of death of around 1 million children worldwide. Additionally, this deficiency also contributed to the cognitive impairment of around 100 million and malformations in about 250 thousand children born at that time.[1,5] When it comes to nutritional deficiencies in childhood, the lack of the liposoluble vitamins A and D, iron and ferritin and the oligoelements zinc and copper stand out among the factors that mostly affect child growth and development. However, cases that associate the profile of micronutrients with child health in Brazil are scarce since the tests are costly and not available in public healthcare services.[5,6]

Another very relevant aspect that directly impacts the deficiencies mentioned above is the fact that processed and ultra-processed foods are more easily available for all social classes, especially the lower classes. Such foods contain high levels of saturated fat and simple carbohydrates and low levels of complex carbohydrates, fibers, vitamins, and minerals, so a higher prevalence of overweight and obesity can be observed in the general population, including children.[7]

In compliance with what is exposed above, the current study aims to evaluate the effects of socioeconomic factors on the anthropometric profile and to analyze a probable association between this profile and biochemical markers in children attending public daycare centers named CMEIs, an acronym for *Centro Municipal de Educação Infantil* in Portuguese, translated as Municipal Centers for Early Childhood Education in Lavras, a municipality in the state of Minas Gerais, Brazil.

Material and methods

This is a transversal study developed in a probability sample of clusters of children from 6 months to 5 years old. The sample was from 15 public daycare centers (Municipal Centers for Early Childhood - CMEIs) in Lavras, a municipality in the state of Minas Gerais, Brazil. The study was submitted and approved by the Human Research Ethics Committee of the Universidade Federal de Lavras (UFLA) (protocol number 80841917.0.0000.5148). Authorization was obtained from the Municipal Education and Health Departments prior to data collection. A total of 12 Family Health Units (USFs) and six nursing technicians for blood collection were made available to optimize and supply data for the Federal School Health Program (PSE) and to make immediate interventions in the municipality.[8] In order to obtain authorization from the parents, the project was presented in meetings sponsored by the CMEIs where daily school routine was discussed. After being explained about the aim of the study and its voluntary aspect, all the guardians were invited to sign the Free and Informed Consent Term (FICT).

Sampling

A 95% confidence interval with an error margin of 5% was considered for sample calculation in the universe of 1250 children in the established age group, which led to an n of 235 preschool children. Exclusion criteria comprised those children with clinical signs of neurological impairment and those whose parents refused to sign the FICT or did not consent to the performance of the tests. The final sample was composed of 219 children between 6 months and 5 years old enrolled, regularly attending, and proportionally distributed among all centers (Figure 1-Supplementary).

Data collection was divided into two stages and places. The first stage was conducted by a nutritionist previously trained for the task at the CMEIs. Anthropometric and socioeconomic data were obtained, and questionnaires on the nutritional status were handed out. The second stage comprised blood collection performed by six nursing technicians in 12 Family Health Units (USFs) distributed according to their proximity to each daycare center.

In the first stage, all the parents/guardians received a semi-structured questionnaire. There were questions on their socioeconomic level (monthly household income, number of people living in the same household, car and homeownership) as well as the variables related to pregnancy and past and current eating habits.[9]

Anthropometric measures were taken according to the guidelines established by the World Health Organization (WHO).[10] The children were minimally dressed and weighed using a 150kg mechanic anthropometric scale (G-life®), graduated every 100g. Children who were less than 24 months old were measured using a recumbent stadiometer with a precision of 1 cm. On the other hand, to those who were 24 months or older, height was measured barefoot, in a standing position, using an anthropometric stadiometer attached to the scale.

The anthropometric indices in this study were weight for age (W/A), height for age (H/A), and weight for height (W/H), which were measured with the WHO Anthro software (2010) using Z-score values according to the Center for Disease Control and Prevention reference curve.[11] In order to classify the nutritional status, the Z scores of the indices H/A and W/H were applied: Z score $<$ -2 referred to low height/malnutrition; Z score between -2 and -1 referred to the risk of height /nutritional impairment; Z score between -1 and +2 meant adequate height/eutrophy. Z score values ≥ +2 in regard to the W/H indicator ere defined as obesity. Data like cranial and arm circumferences were also obtained.[10]

At the units, the experienced nursing technicians from the Municipal Health Department drew 20 ml of blood from the children through peripheral venipuncture using disposable material. First, the serum was centrifuged at 3000 rpm for 10 to 15 minutes, and then the samples were frozen.

Serum concentrations of 25-hydroxyvitamin D (25(OH)D) were determined by electrochemiluminescence immunoassay; levels below 20ng/mL were considered deficient, and those above 20ng/mL were considered sufficient. Vitamin A was measured by high-performance liquid chromatography (HPLC), and values between 0.2 and 0.4 mg/L were considered normal. For iron, the colorimetric method was used, and the normal parameters ranged between 33 and 193 mcg/dL. Ferritin was measured by electrochemiluminescence with a normal range between 13 and 150 ng/mL. For the determination of serum zinc, the atomic absorption spectrometry method was used; deficiency levels were those below 30.0 μg/dL, and normal levels lay between 70.0 and 120.0 μg/dL. Finally, copper levels were measured by the atomic absorption method, and normal values were between 90.00 and 190.00 μg/dL. During the processing and storage processes, there were some losses of samples due to the instability in some of them.

Data analyses

Biochemical and anthropometric results were categorized and presented in absolute and percentage frequencies as well as the socioeconomic variables.

In order to study the association between socioeconomic factors and the anthropometric profile of the children, some logistic models were adjusted using the R program. The models were adjusted for the outcomes as follows: Weight/Age: 1 for low weight and 2 for adequate weight; Height/Age: 1 for low height and 2 for adequate; Body Mass Index/Age: 1 for adequate and 2 for overweight; Cephalic Perimeter/Age: 1 for lower and 2 for adequate; Arm Circumference/Age: 1 for adequate and 2 for above. The inclusion of explanatory variables in the models was based on the results of the Chi-square tests between the outcomes of each explanatory variable. Whenever a variable was statistically significant at a 20% level ($p < 0.20$), it was considered a logistic model. The associations found in the resultant models were then studied in terms of prevalence. In all the other inferential procedures, the significance level adopted was 5%.

Finally, to study the association between the biochemical test results and the anthropometric data, a correlation analysis was made using the Spearman's method. Absolute values were considered for the variables weight, height, body mass index (BMI), cranial circumference (CC), and arm circumference (AC) regarding the anthropometric profile, and the variables iron, ferritin, vitamin D, vitamin A, copper, and zinc for the biochemical profile of the sample.

Results

The final sample was composed of 121 boys (55.2%) and 98 girls (44.7%), totaling 219 children. Their ages ranged up to 5 years, and within the group, 29.8% were between 36 and 47 months old. Regarding the monthly household income, 47.03% of the families earned from 2 to 3 minimum wages. As to the parents' schooling level, 78 fathers (35.6%) and 108 mothers (49.3%) had finished high school or had an incomplete higher education. Concerning the head of the household's profession, 36.1% (n = 79) were at grade IV (Table 1).

The mean concentrations (standard deviation) of serum iron, ferritin, retinol levels in serum, vitamin D (25 hidroxi), zinc and copper in serum were 63.3mcg/dL (28.9), 41.4 ng/mL (37.1), 0.34 mg/L (0.13), 28.3 ng/mL (6.1), 86.8 μg/dL (16.0) and 123.7 μg/dL (24.9) respectively. A total of 16.8% of the children had sideropenia, and 8.3% had low ferritin levels; 14.2% had hypervitaminosis A, and 9.8% had hypovitaminosis D; zinc and copper deficiencies respectively corresponded to 12.6% and 7.0% of the sample. It could be observed that most of the children had weight and height adequate for age (85.9% and 74.0%, respectively); however, around 26.5% had a high body mass index (BMI) for their age, which was expressed in overweight or obesity (Table 2).

Table 3 shows the descriptive values of the socioeconomic characteristics of the sample and the results from the Chi-square tests for the association between sociodemographic variables and anthropometric outcomes. The variables sex, age, monthly household income, number of people living in the same household, the parents' schooling level, the head of the household's profession, and car ownership, all with p-value < 0.20, were included in the logistic regression model.

According to the results obtained from the terms of prevalence (Table 4) and the data from this study, the variable weight for age (W/A) revealed that girls are 3 times more likely to be underweight (W/A = 1) than boys. In families with five members, the terms of prevalence for low height in relation to age (H/A = 1) are 0.12 when compared with families with up to 2 members. The adjusted model for BMI/A indicated that overweight in children (BMI/A = 2) whose parents finished high school or had incomplete higher education are one-third-fold lower than in those whose parents did not finish primary or middle school. Finally, in regard to the variable cephalic perimeter for age, the conclusion is that the terms of prevalence for a child to have a smaller cephalic perimeter in relation to age (CP/A = 1) decrease as they grow older (Table 4).

Table 1 Means and deviations of dosages of Iron, Ferritin, Vitamin D, Vitamin A, Cuprum and Zinc.

	Iron	Ferritin	VITD	VITA	Cuprum	Zinc
Mean	63.3	41.4	28.3	0.3	123.7	87.0
SD	29.0	37.1	6.1	0.1	25.0	16.1

Table 2 Relative frequency of the anthropometric and biochemical data of the sample.

Biochemical tests	*N*	(%)	Anthropometric analysis	*n*	(%)
Serum iron			Weight for age (W/A)		
Sideropenia	18	16.8%	Very low weight for age	06	2.7%
Normal range	89	83.2%	Low weight for age	17	7.8%
			Adequate weight or eutrophic	188	85.8%
			High weight for age	08	3.6%
Ferritin			Height for age (H/A)		
Low ferritin	08	8.3%	Low height for age	57	26.0%
Normal range	86	89.6%	Adequate height for age	162	73.9%
High ferritin	02	2.1%			
Vitamin A (serum retinol)			Weight for height (W/H)		
Normal range	109	85.2%	Low weight-for-height for age	08	3.6%
Hypervitaminosis A	18	14.2%	Adequate weight or eutrophic	180	82.2%
			Adequate weight for height −	12 19	5.5% 8.7%
Vitamin D - 25 HIDROXI			Body mass index for age (BMI/A)		
Hypovitaminosis D	10	9.8%	Low BMI for age	09	4.1%
Normal range	92	90.2%	Adequate BMI or eutrophic	152	69.4%
			Overweight	44	20.1%
			Obesity	14	6.4%
Serum zinc			Cephalic perimeter for age (CP/A)		
Deficiency	22	12.6%	CP < p10	28	12.8%
Normal range	148	85.1%	CP > p10 e < p90	151	68.9%
Excess	04	2.3%	CP > p90 −	19 21	8.7% 9.6%
Copper			Brachial perimeter for age (BP/A)		
Deficiency	12	7.0%	BP< P5	05	2.3%
Normal range	158	92.4%	BP> p5 e < p95	185	84.5%
Excess	01	0.6%	BP > p95	09	4.1%
			−	20	9.1%
			−	20	9.1%

A correlation analysis between the anthropometric data and the absolute values of the biochemical tests was performed (Figure 2-Supplementary). Positive correlations between weight and height, waist circumference (WC), and arm circumference (AC) could be observed ($p < 0.001$). Height was positively correlated with BMI, WC and AC ($p < 0.001$) and iron ($p = 0.045$). Finally, AC was also positively correlated with WC ($p < 0.001$). Concerning the biochemical parameters, vitamin A positively correlated with copper ($p = 0.005$) and zinc ($p = 0.008$). On the other hand, negative correlations were found between BMI and AC ($p < 0.001$) and the micronutrients copper and zinc ($p = 0.020$).

Discussion

Over the past decades, there has been a global increase in overweight and obesity cases, especially in the Americas and Europe, where the increasing rates are quite significant. This tendency can also be observed in the other continents, with a clear increase throughout the past 35 years.[12] In preschool children, this increasing rate can also be seen. According to the World Health Organization (WHO, 2020), the global prevalence of overweight/obesity in children under 5 years of age is 38.9 million.[13] These are alarming figures since obesity in this age group leads to obesity in adulthood, an aspect that may trigger other non-transmissible chronic diseases resulting in the increase in morbimortality.

Such fact may occur due to the early introduction of processed and ultra-processed foods in children's dietary habits,[14] most probably because, despite their low nutritional value, these foods are financially more accessible. It is also known that most of the diseases related to overweight occur in adulthood; however, such diseases have gradually been emerging in childhood or adolescence, which points to the importance of establishing healthy eating habits from childhood with the essential support from parents.[15]

In the current study, according to the adjusted model for BMI/A, it could be observed that the odds for overweight in children whose parents have finished high school or have incomplete higher education are one-third-fold lower than in those whose parents did not finish primary or middle school. This may be because low-income families tend to have a higher BMI, and parents with lower incomes usually have a lower educational background.[16,17] Parents who have a higher BMI given their inappropriate eating habits and lifestyle tend to raise their children the same way, and their

Table 3 Relative frequency and Chi-square test results associating the anthropometric variables.

Variable	*N*	(%)	Weight/ Age *p* value	Height/ Age *p* value	Weight/ Height *p* value	BMI/ Age *p* value	Head circumference/ Age Valor-p	Arm Circumference/ Age Valor-p
			0.06[a]	0.75	0.24	0.65	1,00	0,65
Male	121	55.2%						
Female	98	44.7%						
Age[b]			0.98	0.45	0.68	0.51	0,012[a]	0,17
Children under 6 mo.	02	0.9%						
Children between 6 and 11 mo.	07	3.2%						
Children between 12 and 23 mo.	47	21.5%						
Children between 24 and 35 mo.	57	26.0%						
Children between 36 and 47 mo.	65	29.8%						
Children between 48 and 59 mo.	24	10.9%						
Children between 60 and 72 mo.	17	7.7%						
Monthly household income			0.06[a]	0.31	0.54	0.40	0,14	0,74
Up to 1 minimum wage	94	42.9%						
From 2 to 3 minimum wages	103	47.0%						
From 4 to 5 minimum wages	16	7.3%						
From 5 to 9 minimum wages	4	1.8%						
NA	2	0.9%						
Number of people per household			0.37	0.08	0.75	0.47	0,57	0,91
Up to 2 people	10	4.6%						
3 people	54	24.6%						
4 people	81	36.9%						
5 people	38	17.3%						
6 people	19	8.7%						
More than 6 people	12	5.5%						
NA	5	2.3%						
Schooling level			0.160/0.301	0.482/0.711	0.582/0.514	0.06[a]/0.851	0,440/0,862	0,422/0,102
Father/mother								
Incomplete primary school	15/11	6.8% / 5.0%						
Incomplete middle school	32/20	14.6% / 9.1%						
Incomplete high school	54/55	24.6% / 25.1%						
Complete high school and incomplete higher education	78/108	35.6% / 49.3%						
Complete higher education	19/24	8.7% / 10.9%						
NA	21/01	9.6% / 0.4%						
Home ownership			0.347	0.190	0.4953	0.7496	0,3994	0,7608
Fully paid off	55	25.1%						
Still being paid off	52	23.7%						
Borrowed from parents/relatives	33	15.1%						
Residence provided by the job	13	5.9%						
Rented	65	29.2%						
NA	01	0.4%						

Table 3 *(Continued)*

Variable	*N*	(%)	Weight/Age *p* value	Height/Age *p* value	Weight/Height *p* value	BMI/Age *p* value	Head circumference/Age Valor-p	Arm Circumference/Age Valor-p
Head of the household's profession			0.525	0.652	0.390	0.013[a]	0,145	0,611
Grade I	03	1.4%						
Grade II	14	6.4%						
Grade III	33	15.0%						
Grade IV	79	36.1%						
Grade V	66	30.1%						
NA	24	10.9%						
Car ownership			0.808	0.476	0.494	0.387	0,114	0,497
No car	99	45.2%						
1 car	97	44.2%						
2 or more cars	20	9.1%						
NA	03	1.3%						

[a] Variables with p value < 0.2 subjected to the logistic regression model.
[b] Age in months was standardized, and its association with each outcome was studied through logistic regression model.

low schooling background along with a low family income affect the food quality at home.[18] The data found in the current study comply with the ones provided by the National Health and Nutrition Examination Survey (NHANES), showing a significant inverse association of parents' schooling level and family income with the child's BMI.

A study showed how parents' schooling level, mothers' in particular, influences the development of childhood obesity.[19] Hence, it is of utmost importance to take a closer look at this portion of the population to prevent the risks brought by obesity in the long run.

Regarding the influence of family income, the per capita income in Brazil increased, especially between the years 2003 and 2009, with the rise of the C-class. Additionally, all sorts of food became more accessible to all social classes, including the lower ones. It is then possible to infer that this population increased the intake of processed or ultra-processed foods, which contain high levels of saturated fat and simple carbohydrates and low levels of complex carbohydrates, fibers, vitamins, and minerals, thus reflecting the higher prevalence of overweight and obesity.[20]

The deficiency of micronutrients is one of the major outcomes related to inappropriate eating habits, which leads to unpleasant effects and health issues in the child population and triggers an increase in morbimortality. Deficiency of some nutrients like iron, zinc and vitamin A may hinder a child's growth and development, compromise their cognitive development and immune system, leaving the child more susceptible to infections, many diseases, and metabolic changes.[21] Since the children from this study sample had iron, ferritin, vitamin D, zinc, and copper deficiencies as well as elevated serum retinol levels, their susceptibility to such outcomes are expected.

The results from the National Demographic and Health Survey[22] reveal that the prevalence rates of anemia and inappropriate levels of vitamin A in children under 5 years old are 20.9% and 17.4%, respectively. In the current study, similar rates were found regarding iron deficiency. However, when it came to vitamin A levels, hypervitaminosis was detected. Vitamin A is one of the essential micronutrients for proper human development and growth, but its excess may be harmful, and the following symptoms can be observed: nausea, jaundice, irritability, anorexia, vomiting, blurry vision, headaches, hair loss, muscular and abdominal pain, weakness, drowsiness and mental confusion.[23] In Brazil, the National Program of Vitamin A Supplementation was introduced in 2005, aiming to reduce and control vitamin A deficiency in children between 6 and 59 months old and mothers who have recently given birth immediately after the delivery.[24] Prophylactic supplementation is prescribed by many professionals, especially for children, and it consists of two doses, one of 100.000 UI and the other of 200.00 UI.[8]

These findings bring up for discussion the faulty access to information regarding the indiscriminate use of vitamin supplements, particularly those prescribed by health professionals. The municipality where this study was carried out, for example, is not included as an area of risk for vitamin A deficiency. Nevertheless, in this study sample, a great part of parents (67.5%) reported supplementing their children with megavitamins in their first two years of life.

Vitamin toxicity, whether due to formulation errors, prescription or administration, has already been reported in the

Table 4 Estimates and Wald tests for the parameters of the logistic models regarding the effects of socioeconomic variables on the anthropometric profile, odds ratio (OR) estimates and their respective 95% confidence intervals.

Variable	Estimate	Standard error	*p*-value	OR	95%CI (OR)
Weight/Age[1]					
Sex					
Female	0.9372	0.4610	0.042	2.5527	[1.0578; 6.6026]
Height/Age					
Home ownership					
Still being paid off	0.2391	0.4679	0.609	1.2702	[0.5083; 3.2189]
Borrowed from parents/relatives	-0.1947	0.5685	0.731	0.8230	[0.2588; 2.4644]
Residence provided by the job	0.8349	0.6740	0.215	2.3045	[0.6015; 8.7600]
Rented	-0.4888	0.4800	0.308	0.6133	[0.2366; 1.5764]
Number of family members					
3 people	-0.9491	0.7206	0.187	0.3870	[0.0911; 1.6284]
4 people	-0.8198	0.6983	0.2404	0.4404	[0.1085; 1.7848]
5 people	-2.0884	0.8569	0.0148	0.1238	[0.0212; 0.6479]
6 people	-1.6084	0.9222	0.0811	0.2001	[0.0291; 1.1658]
Over 6 people	-0.9987	0.9666	0.3015	0.3683	[0.0499; 2.3788]
Height/Age[2]					
Body Mass Index/Age					
Schooling level (father)					
Incomplete middle school	-0.3830	0.6506	0.5561	0.6818	[0.1898; 2.5119]
Incomplete high school	-0.1252	0.5977	0.8341	0.8823	[0.2758; 2.9733]
Complete high school and incomplete higher education	-1.2040	0.6083	0.0478	0.3000	[0.0911; 1.0250]
Complete higher education	-0.9163	0.7710	0.2347	0.4000	[0.0818; 1.7775]
Cephalic perimeter/Age					
Age	-0.5968	0.2367	0.011	0.550	[0.3385; 0.8605]
Arm circumference/Age[3]					

[a]The variables parent's education, schooling level and socioeconomic status were withdrawn due to convergence issues.
[b]Models were not adjusted because no variable had a p-value < 0.2 in the Chi-square test.
[c]In this model, the mother's schooling level was withdrawn due to convergence issues, and age did not have a significant effect.

literature. In Brazil, high levels of calcium in the blood, for example, are commonly detected by medical clinic workers in their daily routine. It is also important to point out that hypervitaminosis A is present in the early stages of chronic kidney disease, and it is associated with the increase in the dietary consumption of the vitamin, especially from supplementation.[25]

Some divergences were found in the literature in regard to serum concentrations of vitamin D (25 hidroxi) and child obesity. Actually, it may be related to childhood obesity that varies according to the seasons of the year and sex, the fact that hinders studies on the topic.[26] The other analyzed micronutrients did not show a clear correlation with overweight or obesity in the study sample. Therefore, it is possible to imply that the high caloric intake rather than a poor nutritional status may lead to obesity. However, the insufficient intake of essential nutrients may occur, which will bring about deficiencies.[27]

Concerning the cephalic perimeter, an anthropometric indicator that evaluates the development of children between 0 and 2 years old and corroborates the detection of nutritional deficiencies in the first years of life, it is understood that values below the Z-score indicate intrauterine growth restriction.[28] Such restriction has to do with the mother's nutritional status during pregnancy, which is strongly affected by socioeconomic conditions. The findings in this study revealed that there was an inversely proportional correlation between the cephalic perimeter and household income. As observed, children who were born in these families were not according to this parameter, which highlights the idea that the ratio of weight to the cephalic perimeter at birth, among other aspects, is associated with the mother's nutritional condition. Additionally, as noted in screening tests, there is a higher chance of a neuropsychomotor development delay in these children when they are compared with newborns from families with better income, a fact that may be associated with a smaller cephalic perimeter.[29]

Individuals whose arm circumference (anthropometric indicator that measures the muscular reserve adequacy and the excess or shortage of adiposity) is above the adequacy standard have an increased risk of developing diseases related to weight and metabolic syndromes. Such inadequacy is directly related to overweight/age, probably resultant from the excessive intake of processed and ultra-processed foods.[30-32]

In the sample, a total of 20.1% of overweight children and 6.4% of obese ones were found. It is known that one of the determining factors for an increase in weight is a low-quality nutritional diet (95%), whereas 5% of the causes are for endogenous reasons. This increase in weight is mostly seen in lower socioeconomic classes, probably because low-priced foods can be highly caloric with low nutritional value.[33]

An inadequate diet tends to trigger not only the early onset of overweight and obesity but also other associated chronic diseases that compromise the child's normal development, their productive and intellectual capacity. Parents and caretakers should then stimulate the intake of healthy foods.[34]

The findings in the current study show that children with lower education levels are more likely to develop overweight and obesity. The micronutrient deficiencies found in this study reveal inadequate eating habits, partly because of the institution where the child is placed and family routine habits. Hence, interventional programs aiming at prevention should be conducted to educate this portion of the population.

Take-home messages

- Children from lower household income families and girls from parents with lower education levels are more likely to develop overweight and obesity.
- The micronutrient deficiencies found in the study's participants reveal inadequate eating habits, partly because of the family routine habits.
- The excessive intake of micronutrients without pediatric/nutritional supervision may take serious cases of hypervitaminosis to the public health system.

Conflicts of interest

The authors declare no conflicts of interest.

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Supplementary materials

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