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Physical growth in the first year of life of Terena Indigenous children living in an urban zone: longitudinal study

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Abstract *The present study aimed to assess the anthropometric nutrition status and physical growth of Terena Indigenous children living in an urban zone of the city of Campo Grande, Mato Grosso do Sul, Brazil, in their first year of life. Children who were born between June 2017 and July 2018 (n = 42) participated in the study. In total, 4.8% of the children presented a low height for age (H/A) in the 12th month of life. According to body mass index (BMI) for age, overweight affected 15.0% of the individuals belonging to the female sex at the age of 12 months, and obesity was observed in 4.8% of the children belonging to both sexes at this same age. Terena Indigenous children's length curve failed to reach the median value recorded for the reference population. Weight and body mass index curves for age, mainly among individuals belonging to the female sex, were often above the reference median value. The Terena growth curves recorded an average linear growth of lower than expected and a weight gain of higher than the reference median. This profile is compatible with the persistence of unfavorable conditions for children's growth and nutrition, as well as with an accelerated process of food and nutritional transition, where the racial dimension of health inequities cannot be disregarded.*

Key words *Indigenous peoples, Anthropometry, Child*

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Introduction

Studies with Indigenous people around the world have indicated a high prevalence of malnutrition[1-3]. In Latin America in particular, they have very high frequencies of low height for age (H/A), in addition to other nutritional issues[1,3]. In Brazil, Indigenous children are also affected by the high prevalence of anthropometric deficits, in addition to high rates of infant mortality, anemia, and infectious-parasitic diseases[4-7].

Low H/A affected 25.7% of all Indigenous children under 5 years of age in Brazil in 2009, a value much higher than that recorded among non-Indigenous children[4,8]. Regional, age, and ethnic variations may reach even higher frequencies[9-13], pointing to persistent health inequities between Indigenous and non-Indigenous people in Brazil[8]. In countries such as Australia, China, Colombia, India, and Pakistan higher frequencies of child malnutrition are also observed among native people[1]. Conversely, excess weight is still rarely observed among Indigenous children in Brazil. However, it has already been reported in the literature among specific ethnic groups[14,15] and is frequent among the Indigenous adults[16-19]. The double burden of malnutrition, in which overweight and low H/A and weight-for-age (W/A) coexist within a population[20], is increasingly documented among Indigenous people in other parts of the world[21-23].

Physical growth in childhood is strongly influenced by the living conditions to which children are subjected. Environmental factors, such as unfavorable socioeconomic and health conditions, recurrent infectious diseases, food insecurity, and nutritional deficiencies, among others, are among the main causes of childhood low H/A and W/A[4,24]. Likewise, some of these factors can also result in excessive weight gain[23,25]. Furthermore, a given group may have a low frequency of weight and height deficits, but they cumulatively present growth failures, with negative impacts at the end of childhood or even in adulthood, such as an increased risk of developing chronic Noncommunicable Diseases (NCDs)[26,27].

Despite the recognized severity of the nutritional situation of Indigenous children in Brazil, the available data are still insufficient to identify trends, except in a few case studies[28]. Even scarcer are studies focused on the Indigenous population living in urban areas, which constituted 40.0% of the Indigenous population in Brazil, according to the 2010 demographic census[29]. Thus, this study was designed to evaluate the anthropometric nutritional status and physical growth of Terena Indigenous children living in an urban area of Campo Grande, Mato Grosso do Sul, Brazil in their first year of life.

Methods

Study design and population

This prospective cohort study monitored Terena Indigenous children during the first year of life. The study included Terena Indigenous women who lived in four villages (Água Bonita, Darcy Ribeiro, Marçal de Souza, and Tarsila do Amaral) located in an urban area of Campo Grande, Brazil, and who had children born alive between June 1, 2017, and July 31, 2018. These villages are the only ones in urban areas that are recognized by the state[30]. Children born from twin pregnancies (n = 2) and preterm births (gestational age < 37 weeks, n = 1) were excluded.

The Terena belong to the Arawak linguistic family and their first contact with non-Indigenous people occurred in the 16th century[31]. Mato Grosso do Sul has at least 13 Indigenous Lands (IL) where the Terena live. They also live in one IL in Mato Grosso and two in São Paulo. The Terena are considered the fifth largest ethnic group in Brazil with the largest number of people living outside the IL (9,626 people)[29]. The city of Campo Grande is among the ten Brazilian municipalities with the largest Indigenous population living in urban areas (5,657 people) and the Terena represent two-thirds of this population[29,32].

The Terena began migrating to Campo Grande in the 1910s, with this flow intensifying from the 1970s onwards. Thus, the Indigenous people settled in a dispersed manner on the city outskirts and in groups[33]. From these groups, on the outskirts of the city, in the 1990s, the construction of housing complexes began, with popular houses, specifically for the Indigenous population, which came to be known as urban villages[33]. There are no official records on the number of Indigenous people in these villages. However, estimates indicate that Água Bonita, Darcy Ribeiro, Marçal de Souza, and Tarsila do Amaral have, respectively, around 200, 115, 170 and 80 resident families[34].

Data collection and study variables

Data were collected through home visits in three waves: at the 1st, 6th, and 12th months of the

child's life. Regarding the representativeness of the data, the study included all children born in the four Terena urban communities in the municipality of Campo Grande, which corresponds to half of the Indigenous births in the municipality during the period[35].

The interviews were conducted with the children's mothers, and there was no need for a translator. Mothers who did not agree to participate in the research either chose not to participate or moved to another municipality during the data collection period and were considered losses.

The child's weight and length were measured at the 6th- and 12th-month visits. An interviewer trained in anthropometry was responsible for taking all anthropometric measurements of the children. The protocol described by Lohman et al. was followed for taking the measurements[36]. A portable, detachable anthropometer was used to measure the child's length, with an accuracy of 0.1 cm. A portable electronic platform scale with a capacity of 200 kg and an accuracy of 50 g was used to measure the child's weight. The child's weight was determined using the "mother/baby" function (the child was weighed with as little clothing as possible, on the mother's arms; later, only the mother was weighed to check the child's weight (child's weight = mother's and child's weight – mother's weight).

Birth weight and length were collected from the Child Health Booklet, as were follow-up weight and length measurements during the months of the first year of life.

Data analysis

Data were tabulated with the double entry in the EpiData 3.1 program (EpiData Assoc., Odense, Denmark), and statistical analyses were performed in Stata 16.0 (Stata Corp., College Station, USA). Z-scores were calculated for birth weight for gestational age, birth length for gestational age, and weight (kg)/length (m) for gestational age ratio, according to Intergrowth–21st parameters[37]. For the anthropometric measurements of the 6th and 12th months, the Z-scores were calculated for the length-for-age (L/A), weight-for-age (W/A), and body mass index (BMI)-for-age (BMI/A) indexes, according to the parameters of the World Health Organization (WHO)[38]. The differences between the mean z-score values for the three indexes over time (at birth, 6 months, and 12 months) were analyzed using the ANOVA test, with Tukey's post-test, considering p-values < 0.05 as statistically significant.

Z-score values were used to classify the children's nutritional status. For the L/A index, low L/A values were considered to be Z-scores < -2. For the W/A index, low W/A was considered to be Z-score values < -2, while high W/A was considered to be Z-score values > 2. For the BMI/A index, low weight was considered to be Z-score values < -2, overweight to be Z-score values > 2 and ≤ 3, and obesity to be Z-score values > 3[39]. The combination of the categories overweight and obesity was considered excess weight.

For the average Z-scores of the anthropometric indices and the prevalence of nutritional status at 6 and 12 months, only the anthropometric data measured in the research were used, since it was an assessment of the nutritional status at a specific age of the children. The set of anthropometric measurements taken and those collected directly from the Child Health Booklet were used to construct the growth curves. The L/A, W/A, and BMI/A were then formulated.

The number of anthropometric measurements of the same individual varied over time, and not all of the measurements were equidistant in time, as they were considered unbalanced and unstructured data. Thus, the Generalized Additive Mixed Models (GAMM) were used to construct the growth curves, considering the relationship between inter-individual and intra-individual measurements over time[40]. The spline adjustment function was used to construct the curves. The procedure was performed separately for each sex, including all measurements for each individual, both those measured and those collected from the Children's Health Handbooks, following the methodology proposed by Ferreira *et al.*[11]

The adjusted curves were compared to the WHO reference curves[39,41] based on sex and age. The Anthro 3.2.2 software (WHO Anthro, Switzerland) was used to calculate Z-scores for anthropometric indices. The statistical software R 3.6.8 (R Development Core Team, 2004) and the gamm4[42] and lme4[43] libraries were used to develop the curves.

Ethical aspects

This study was approved by the Human Research Ethics Committee of the Federal University of Mato Grosso do Sul and by the National Research Ethics Commission (CAAE No. 64555517.6.0000.0021). The investigated community leaders approved the study, and the interviewed mothers, as well as their guardians, when

the mother was under 18 years of age, provided the free and informed consent to participate in the study.

Results

Among 49 children eligible for the study, 42 participated (85.7%). There were three refusals (6.1%), two withdrawals (4.1%), and two mothers who moved to another municipality during the study (4.1%). Among the children who participated in the study, in one case it was not possible to obtain anthropometric data at 6 months due to a temporary move to a different municipality. For the growth curves, 207 weight measurements and 207 length measurements were used.

The mean L/A index Z-scores, in both sexes, decreased throughout the first year of life. The difference was statistically significant when comparing the averages at birth to the averages at 6 months and 12 months in males (-0.01 versus -0.47; $p < 0.05$ and -0.01 versus -0.67; $p < 0.05$; respectively) and in females (0.18 versus -0.36; $p < 0.05$ and 0.18 versus -0.53; $p < 0.05$; respectively). There was no difference in the W/A index over time in either sex. The mean BMI/A Z-score was higher at 6 months when compared to the Z-score at birth for males (0.15 versus 0.78; $p < 0.05$) (Table 1).

In males, the prevalence of low L/A at the end of the first year of life was 4.5%. In females, there was one case of low L/A at 12 months. No cases of low weight were recorded among the evaluated children, according to the W/A and BMI/A indices, respectively. According to the W/A index, 4.5% of boys and 10.0% of girls had high weight for their age at the end of the first year of life. According to BMI/A, excess weight was recorded in 4.5% of boys and 20.0% of girls at 12 months (Table 2).

The L/A curves, for both boys and girls, do not reach the median of the reference population at any time, except at the moment of birth, when they start close to the Z-score = 0. For girls, the distance from the median seems more pronounced than for boys, with a slight closeness at around 6 months until approximately 10 months, when they diverge again (Figure 1).

Regarding the W/I index, the curve for males remains close to the median with some fluctuations over time. For girls, the curve starts slightly above the median, overlapping it at approximately 30 days of age and remaining above it from 4 months onwards (Figure 2).

The BMI/A curve for males started its trajectory close to the median and then remained below the median until around 3 months when it exceeded it. For girls, the BMI/A curve was always above the reference median (Figure 3).

Discussion

In summary, the data recorded in this study for Terena Indigenous children indicate an average linear growth that is lower than expected, based on the criteria used internationally to assess the physical growth and nutritional status of children. At the same time, they record excess weight in the first year of life, as well as a weight gain of greater than the reference median.

The Terena Indigenous children evaluated in this study present a more favorable profile than that observed in some cross-sectional studies that were carried out in past decades in non-urban Terena communities, which revealed, at the time, a high prevalence of low H/A[44-46], which reached 26.1% among children aged one to five years[45]. In comparison with Indigenous children under one year of age, assessed in the first and only National Survey of Health and Nutrition of Indigenous Peoples, carried out in rural areas, the prevalence of low L/A at the end of the first year of life of Terena children was also lower (4.8% versus 14.9%)[4].

The low prevalence of height deficits observed among Terena children could indicate optimal linear growth, as well as the existence of socioenvironmental conditions favorable to child growth. However, this does not appear to be the case. The L/A curves remained below the reference medians throughout the first year of life. Furthermore, a previously published study of this same population[47] shows that variables, such as mother's education, sanitation conditions, housing, and per capita income, present systematically worse indicators than those recorded for the Brazilian and Mato Grosso do Sul populations[48-50]. Almost half the Terena women (46.5%) had up to eight years of education, 74.4% lived in households not connected to the sewage collection system, and a third lived in houses with seven to nine residents[47,51]. Per capita income reached a maximum value of R$800.00, and in 65.5% of households, this value did not exceed R$265.00.[47] Anemia data from these same children reveal that at least half of them were anemic at six (53.6%) and twelve months of age (61.9%)[51]. Diarrhea was recorded for 19.5% of children in the week before the six-month-old interview and

Table 1. Mean and standard deviation of Z-score of anthropometric indices of the Terena birth cohort. at birth. 6 months. and 12 months. according to sex. Campo Grande. Mato Grosso do Sul. 2017-2018.

Age	Length/age		Weight/age		Body mass index/age	
	Male n = 22	Female n = 19	Male n = 22	Female n = 19	Male n = 22	Female n = 19
	Average (SD)	Average (SD)	Average (SD)	Average (SD)	Average (SD)	Average (SD)
At birth*	-0.01 (0.90) [a]	0.18 (0.85) [a]	0.09 (1.06) [a]	0.69 (0.91) [a]	0.15 (1.17) [a]	0.80 (1.09) [a]
6 months	-0.47 (1.09) [b]	-0.36 (0.68) [b]	0.31 (1.26) [a]	0.67 (0.93) [a]	0.78 (1.05) [b]	1.16 (1.03) [a]
12 months	-0.67 (0.95) [b]	-0.53 (0.74) [b]	0.12 (0.95) [a]	0.61 (1.16) [a]	0.70 (0.78) [ab]	1.25 (1.17) [a]

* For data at birth: length/gestational age, weight/gestational age, and weight-length/gestational age ratio, according to Intergrowth–21st37. Z-scores at 6 and 12 months, according to the World Health Organization38. Different letters in the columns indicate significant statistical differences by Tukey's test ($p < 0.05$). SD: standard deviation.

Source: Authors.

Table 2. Low length for age, overweight, and obesity prevalence of the Terena birth cohort, at birth, 6 months, and 12 months, according to sex. Campo Grande, Mato Grosso do Sul, 2017-2018 (n = 41).

Nutritional status	Boys			Girls		
	At birth n = 22	6 months n = 22	12 months n = 22	At birth n = 20	6 months n = 19	12 months n = 20
Length for age						
Low length for age (%)	4.5	9.1	4.5	-	-	5.0
Weight for age						
High weight for age (%)	4.5	4.5	4.5	10.0	5.3	10.0
BMI for age						
Overweight (%)	4.5	-	-	5.0	15.8	15.0
Obesity (%)	4.5	4.5	4.5	5.0	-	5.0

Z-scores at birth: Intergrowth–21st37. Z-scores at 6 and 12 months: World Health Organization38. BMI: body mass index.

Source: Authors.

exclusive breastfeeding had a median duration of 2.5 months[51]. This set of variables, therefore, outlines a largely unfavorable scenario for children's health and nutrition, which will possibly have a cumulative effect during childhood.

Literature has shown that human growth up to the age of five is subject to little genetic influence[52,53]. The proposal for the universal applicability of anthropometric parameters for assessing child growth, recommended by the WHO, is based on this evidence, which indicates a lower influence of genetic variability when compared to the impact of environmental conditions on children's physical growth. The Terena growth curves are compatible with the precarious environmental and health conditions to which these children are subjected since birth, and it is plausible to see in them the negative impact of this scenario. In other words, as a whole and in interactions, these factors have a recognized impact on children's nutritional conditions and physical growth and partly explain the behavior of the growth curves of the Terena children evaluated here.

Equivalent contexts have been highlighted in the analysis of the nutritional situation of Indigenous children throughout the country, and point to precarious socioeconomic and sanitary conditions, in addition to nutritional profiles where height deficits predominate in prevalence rates that are usually high, higher than those recorded among non-indigenous children in the same regions[4,10-13]. Evidence in the literature suggests that inadequate basic sanitation conditions have a negative effect on child growth and development, due to greater exposure to pathogens. Social and economic mechanisms are also linked to these conditions[54]. A study that analyzed the presence of basic sanitation services in urban households with children up to five years of age, based on data from the 2010 census, revealed that Indigenous

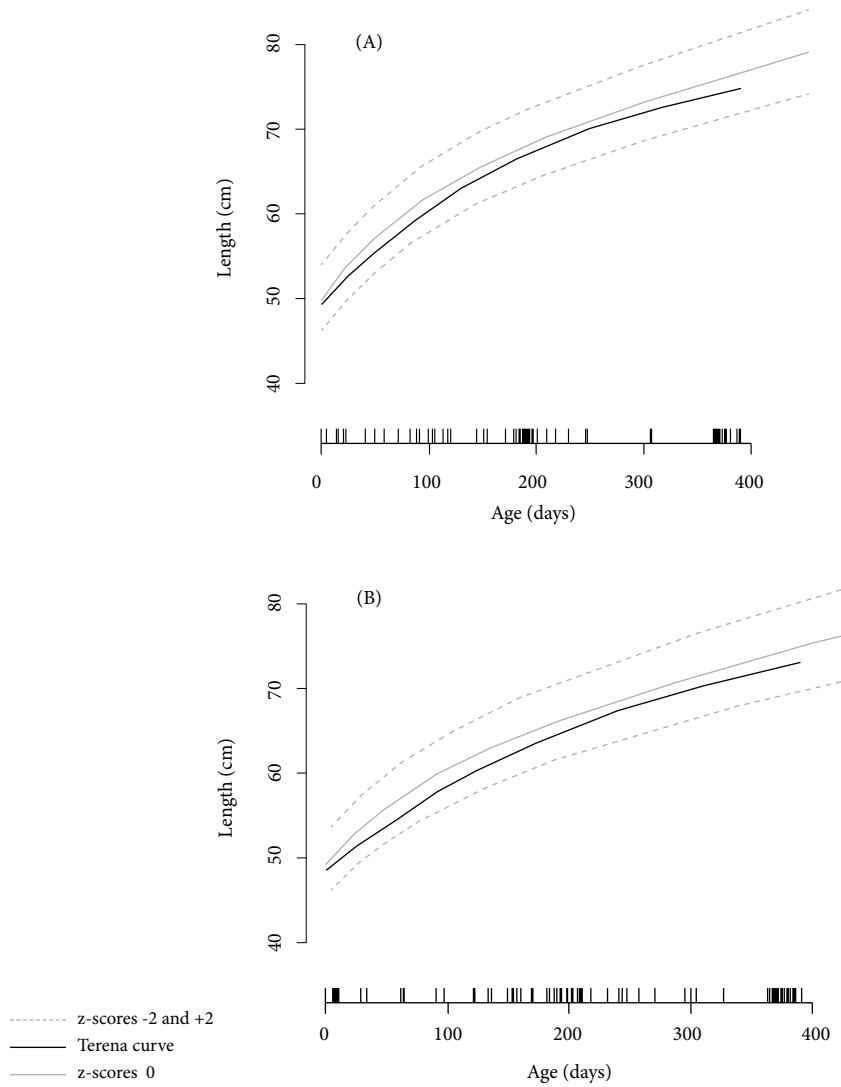

Figure 1. Length curves (cm) of Terena boys (A) and girls (B) up to 12 months of age compared with the Z-scores of the World Health Organization reference population. Campo Grande, Mato Grosso do Sul, 2017-2018.

Source: Authors.

households generally had the lowest frequency of adequate sanitation services[55]. Higher mothers' maternal education is associated with a series of behaviors that can be positive for the child's health and nutrition, such as longer breastfeeding duration, use of health services, and appropriate infant feeding, in addition to normally meaning better economic conditions for the family, which together can influence linear growth[56].

Although the assessment of excess weight using the BMI/A index in children under five years of age requires additional assessments for diagnosis, prevalence rates at the end of the first year of life were recorded in Terena children similar to those found among non-Indigenous children under one year of age in the country (12.3% versus 9.1%)[9]. Few studies have assessed excess weight among Indigenous children in Brazil, especially

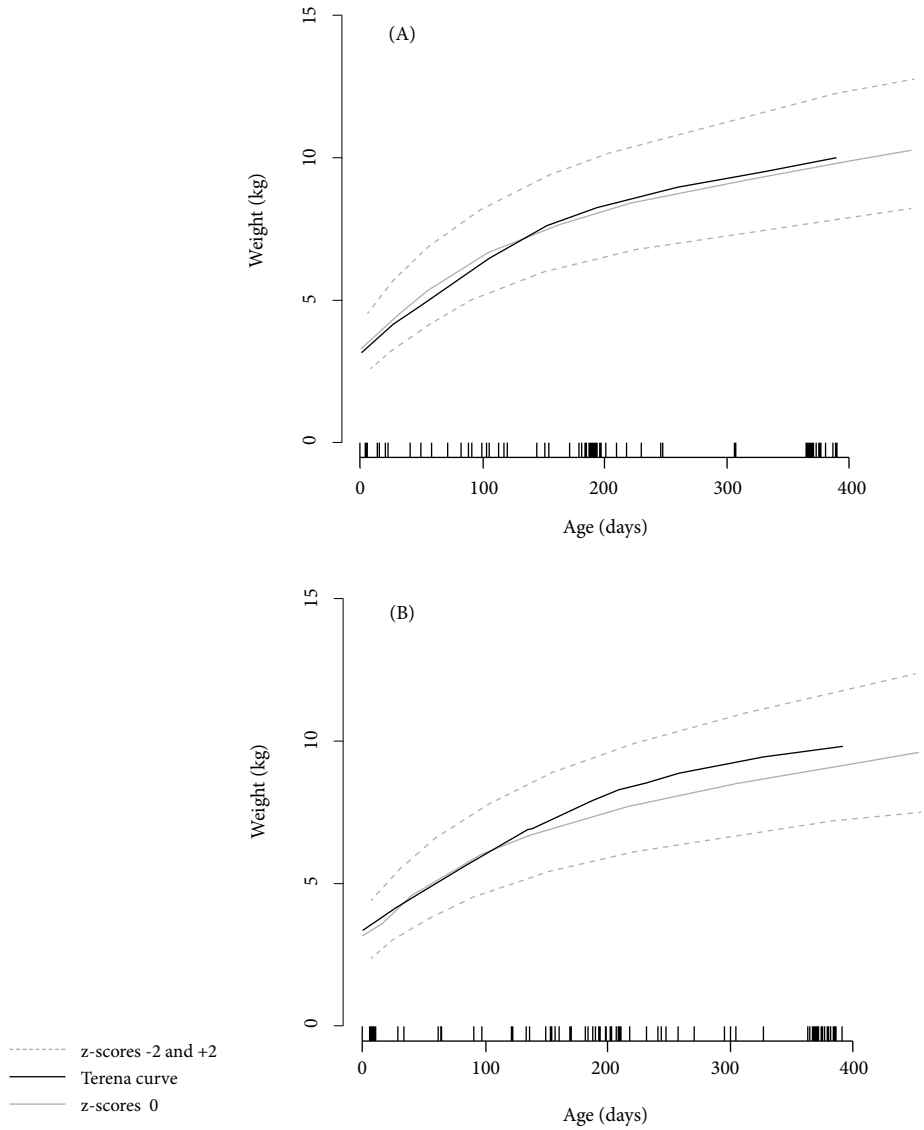

Figure 2. Weight curves (kg) of Terena boys (A) and girls (B) up to 12 months of age compared with the Z-scores of the World Health Organization reference population. Campo Grande, Mato Grosso do Sul, 2017-2018.

Source: Authors.

in this age group, and using the BMI/A index, which is recommended for classifying childhood overweight and obesity and comparing it with the WHO reference population[57,58]. Among Xukuru do Ororubá children under two years of age, in Pernambuco, according to BMI/A, the prevalence of excess weight was 6.9%[14]. Among Pataxó children under five years of age in Minas Gerais, the prevalence of overweight, also according to BMI/A, was 2.9%[15]. In both studies[14,15] the authors point out that the prevalence of excess weight recorded reflects, to a large extent, the transformations in subsistence strategies, combined with changes in eating patterns and physical activity among native populations.

When interpreting excess weight among children, it is important to consider the parents' weight; a child with one obese parent has a 40.0% greater probability of being overweight; when both parents are obese, the probability increas-

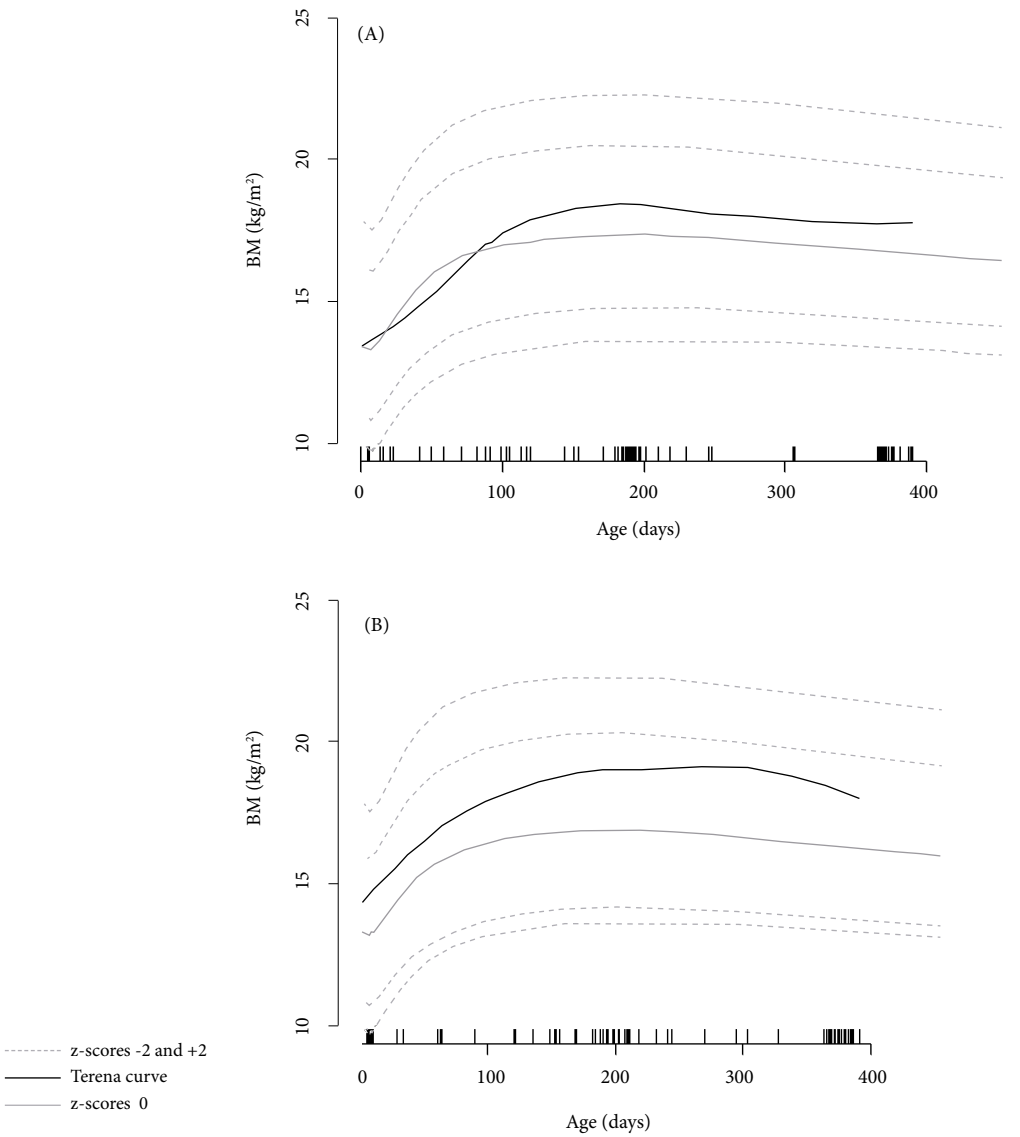

Figure 3. Body mass index (BMI) curves (kg/m²) of Terena boys (A) and girls (B) up to 12 months of age compared with the Z-scores of the World Health Organization reference population. Campo Grande, Mato Grosso do Sul, 2017-2018.

Source: Authors.

es to 70.0%[57]. Obesity, like other NCDs, has been frequently mentioned in studies with Indigenous adults in the country[12,18,19,59-62]. Furthermore, the results of a study with the same population evaluated in the present study indicated that 61.0% of Terena women were overweight before pregnancy, and maternal pre-gestational obesity was associated with higher birth weight in Terena children[47]. Excess weight during childhood increases the risk of excess weight in adolescence and adulthood, and is associated with the emergence of NCDs[63-65].

When the data are examined longitudinally, it can be observed that the L/A curve of Terena children did not reach the median of the reference population at any time during the first year of life, with fluctuations being recorded over time: this presents a greater distance from the median up to 6 months, with a subsequent approximation until 10 months, when it diverges

again. Added to this picture, the average Z-scores of the L/A index decreased throughout the first year of life. Conversely, the W/A curve, especially among girls, starts slightly above the median, overlapping around the first month of life. From the fourth month onwards, it follows a trajectory above Z-scores 0. The BMI/A curves follow the same trend, and it is also in females that the Terena curve remains systematically above the reference median.

The only published study that longitudinally assessed the physical growth of Indigenous children in Brazil was a study among Xavante children under 10 years of age, conducted in Mato Grosso[11]. The study showed that the H/A curves of Xavante children, for both sexes, start close to the median of the reference population, starting to move away from it around six to eight months of age, but, unlike what was observed among the Terena, they reach Z-scores of -2 around 12 months. Similarly, the W/A curve starts close to the median, but, at around six to eight months, it moves negatively away, although it does not reach Z-scores of -2 at any point in its trajectory[11]. By contrast, among the Terena, the W/A curve, especially among girls, exceeds the median of the reference population. Studies with native peoples from other parts of the world that have carried out longitudinal analyses on the physical growth of children are rare, and methodological differences complicate and limit any attempt at comparison[65,66].

Studies indicate that failures in linear growth during the first two years of life generate greater risks of morbidity and mortality and can lead to unfavorable outcomes over the long term, such as shorter height in adulthood, reduced economic productivity, and, for women, lower offspring birth weight[67]. There is a higher risk of developing NCDs in adulthood, especially when they experience rapid weight gain after the first two years of life[67-69].

Growth patterns that simultaneously present height deficits and excess weight have been described in the literature[28,57,70]. A systematic review of research from low- and middle-income countries found that although child malnutrition is decreasing, there are still populations with high frequencies of linear growth deficits and at the same time with increasing records of overweight, producing a double burden of disease at the population and individual levels[71].

The situation recorded among Terena children reveals L/A curves systematically below the reference median, indicating growth failures and excess weight appears in the first year of life. Although the universe of children evaluated is small, and we do not have information on the food consumption of this population, this situation is compatible with food and nutritional transition processes that have been reported among Indigenous adults of different ethnicities in the country for at least two decades[60-62,72]. These records describe a high prevalence of overweight and obesity and the emergence of other NCDs, such as systemic arterial hypertension and diabetes mellitus. At a national level, this situation is highlighted in the National Survey among women of childbearing age[17].

Urbanization, experienced by the Terena population evaluated here, may be a critical point in understanding the growth profile found among their children. Although Indigenous peoples in the country have undergone major changes in their subsistence modes throughout history, migration to urban centers can further accelerate the transformations, involving the adoption of high-calorie diets, rich in fats and simple carbohydrates, high in salt, and low in dietary fiber. The changes also extend to physical activity patterns, which can be negatively affected by this process[2,73].

Finally, we highlight that monitoring the physical growth of Indigenous children over longer periods may be important to understand this complex process, which is still scarcely described in the literature. Limitations of the study include follow-up during only the first year of life and the number of children evaluated, although all children born during the period were included in the study and monitored throughout the period. Other limitations lie in the number of anthropometric assessments and the variable interval between them.

Conclusion

Although moving to an urban environment could potentially represent an improvement in environmental conditions and access to goods and services, including healthcare services, in the families monitored here, it does not translate into a guarantee of truly favorable conditions for child growth and nutrition. Their insertion into the urban environment occurred in the outskirts of Campo Grande and in the lower socioeconomic strata, where they experience precarious sanitation and housing conditions and, in broader terms, less access to goods and services,

including health services when compared to other social segments. Their socioeconomic and sanitation indicators are systematically worse than both regional and national averages, which points to the racial dimension of the significant socioeconomic inequalities and health inequities that affect Indigenous peoples in the country.

The data also suggest that the urban Terena population is going through a rapid process of nutritional transition, with excess weight present in the first year of life, which represents, in the medium and long term, an undeniable challenge for the health services that serve this and other Indigenous peoplethat currently live in urban environments. Health policies and programs aimed at Indigenous peoples in the country must urgently consider these particularities and be able to contemplate the growing Indigenous population contingent living in urban areas currently not assisted by the National Policy for Health Care for Indigenous Peoples, which is only intended for Indigenous people living in IL.

Collaborations

All authors participated in the conception and design of the study, data interpretation, write-up, and review of the manuscript, as well as its final approval.

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