Evaluation of the nutritional status of Indian children from Alto Xingu, Brazil

Ulysses Fagundes¹, Carlos Alberto Garcia Oliva², Ulysses Fagundes Neto³

Abstract

Objective: to evaluate the nutritional status and estimate body composition of Indian children from Xingu National Park (XNP), rain forest Amazon region, by using anthropometry and bioelectrical impedance (BI) tests.

Methods: one hundred and sixty-four Indian children (89 girls and 75 boys) of unknown age were evaluated by means of anthropometry and bioelectrical impedance. Weight and height were used to calculate z-score for weight-for-height (W/H) index. Two equations based on the resistance values obtained from the bioelectrical impedance were used to determine body composition. The values obtained were compared to standard reference.

Results: z-score median for weight-for-height index was 0.59 (boys) and 0.46 (girls) (p=0.27), respectively. Among the children studied only 1.8% showed z-score W/H <-2 standard deviations (SD), and 3% showed z-score W/H >2 SD. Mean resistance values were 625.4±79.2 Ohms (girls) and 588.8±68.9 Ohms (boys) (p<0.01). The percentage of body composition values obtained for girls were 14.2% fat mass (FM) and 85.8% fat-free mass (FFM), and 11.7% (FM) and 88.3% (FFM). The values for the boys were 14.9% (FM) and 85.1% (FFM), and 10.3% (FM) and 89.7% (FFM).

Conclusions: there were low rates of obesity and malnutrition, what leads us to believe that the nutritional status among the Indian children from XNP has been kept in good standard along the last three decades, even under some degree of the Western culture influence. The Indians’ body composition enhanced the good nutritional status among the studied population. BI played an important role in the estimation of body composition in this field study.

in the early 1970s. This series of studies demonstrates, over the last three decades, a low incidence of malnutrition in the community, as shown in Table 1.5-7 These results contrast with other studies of Native American populations in Latin America and North America, which revealed high levels of nutritional deterioration in Brazil10 and in Latin America,8 most likely due to poor health conditions in the Latin American indigenous populations, and obesity in the United States9,24 and Canada,21 probably because of the incorporation of western dietary habits of North Americans and Canadians.8-10,21,24

The assessment of body density has played an important role in identifying individuals at nutritional risk, and is therefore more than an auxiliary tool that professionals use in the management and prevention of nutritional deterioration.5,11 In this regard, there has recently been a growing interest in the study of body density and its variations, such as the method of nutritional status assessment.4,11,12 This reflects on both the increasing number of techniques developed to measure and estimate nutritional status and the recognition of its importance to the evaluation of healthy and ill individuals.3,4,11,12

Even though we recognize that some of the techniques used to determine body density such as radioisotope dilution (deuterium or potassium 40), underwater weighing, dual energy x-ray absorptiometry (DEXA) are more precise,3 they depend on sophisticated and expensive equipment. Moreover, long time periods and specialized personnel are also needed, which makes their use in field work practically impossible. For these reasons we opted for bioelectric impedance (BI), because it is a noninvasive method, quick and easy to perform, and also because it has already demonstrated consistent results for estimates of body density in adults and children, when associated with anthropometry. This technique estimates total body water (TBW) and it is based on a two-compartment model which divides the body into fat-free mass (FFM) - high conductivity, and fat mass (FM) - low conductivity.3,13,14

The present study aimed at assessing the nutritional status of indigenous children from Alto Xingu through the use of anthropometric indicators regardless of age and body density, using BI.

Patients and Methods

Patients

One hundred sixty-four randomly selected children (89 girls and 75 boys) from four villages of Alto Xingu were evaluated during a period of two weeks in December 2000. The evaluations occurred in the morning, under protection from the sun, and the children were evaluated naked in the villages where they live.

The parents of the children included in the study were informed about the procedures and were told that there was no risk to the children. Sometimes, the use of an interpreter was necessary due to language differences. The measurements were taken after verbal authorization from the parents and from the village leaders. There was no written authorization due to illiteracy of the parents.

Xingu National Park (XNP)

XNP is located in the north of the state of Mato Grosso and occupies a rectangular area of nearly 30,000 km² in the zone of transition between the cerrado of Central Brazil and the Amazon Rainforest. The park was established in 1961 by the Federal Government, with the purpose of protecting the indigenous population and culture from contact with the modern civilization.5

The difficult access to the region, due to a series of waterfalls in the course of the Xingu River and the vast Mato Grosso plain at the south of the Park, combined with the long occupation of the same area and the regularity of intertribal marriages, leads to a process of intense cultural exchange.15 Despite the language differences, this led the tribes of Alto Xingu to have the same political, social and cultural organization, known as the Culture of Alto Xingu, which still remains preserved.16

The diet of Alto Xingu is fundamentally based on cassava, in the form of beiju (grated and pressed cassava.

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**Table 1** - Percentage of eutrophy (-2 < z-score of the W/H index > 2) among children from Alto Xingu, obtained from the studies concluded in 1976, 1980 and 1992

<table>
<thead>
<tr>
<th>Authors</th>
<th>Year of study</th>
<th>Sample size</th>
<th>Percentage of eutrophy obtained in the sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fagundes-Neto et al.⁵</td>
<td>1976</td>
<td>175</td>
<td>96.0%</td>
</tr>
<tr>
<td>Morais MB et al. ⁶</td>
<td>1980</td>
<td>335</td>
<td>94.3%</td>
</tr>
<tr>
<td>Mattos A et al. ⁷</td>
<td>1992</td>
<td>172</td>
<td>93.1%</td>
</tr>
</tbody>
</table>

Sources: references 5, 6 and 7.
roots) or porridge, and fish, which is smoked or stewed. On top of that, wild fruits, eggs of yellow-spotted Amazon River turtle and honey are also a part of their diet, without any particular relevance.

Exclusive breastfeeding occurs during practically the entire first year of life and is universal, including everyone in this age group. At the end of the first year other foods are introduced, cassava porridge first, and fish and other foods later. The children continue to receive breastmilk along with other foods until approximately the third year of life.\(^5\)

**Methods**

**Anthropometry**

Weight (W) and height (H) were obtained by internationally recommended methods. Weight was obtained using a digital scale with a 0.1 kg margin of error, and height was verified by the use of a metal measuring tape coupled with an anthropometer with a 0.1 cm margin of error.

As the ages of the children studied were not known, we used only the weight for height (W/H) indicator to evaluate nutritional status. For this purpose, we used ANTHRO program version 1.02 from the Nutrition Division of the Center for Disease Control (CDC) in Atlanta, Georgia. To calculate the z-score, z-scores obtained from the curves at the National Center for Health Statistics (NCHS) were used for comparison, with 2 z-scores as cutoff values for the definition of nutritional deficiency.\(^17\)

In addition to the height and weight values, we obtained the body mass indexes (BMI) - weight divided by the squared height in meters - which was also compared to the NCHS values.\(^17\)

**Bioelectric Impedance (BI)**

BI was used to measure resistance (R) and reactance. The resistance and reactance measurements were obtained using the Body Composition Analyzer - 310 (Biodynamics Corporation, Seattle-WA), with four self adhesive electrodes, using a standard current of 800 A and a frequency of 50 kHz. Two electrodes were placed on the dorsal right foot, and two were placed on the dorsal right hand of the children studied, according to the manufacturer’s recommendations. Before the electrodes were attached, the skin of the dorsal hand and foot were appropriately cleansed with alcohol.

The consecutive measurements were done on each child, the z-value (bioelectric impedance = resistance\(^{-1/2}\) + reactance\(^{-1/2}\)) the average of the three, or the most repeated value, was used in the formulas.

To estimate FFM, the following equations were used \(^{19}\)

**Chumlea et al.**

Boys: FFM (kg) = 0.89 * H\(^2\)/R + 1.92 (R\(^2\)=0.98; SEE=1.37).

Girls: FFM (kg) = 0.90 * H\(^2\)/R + 0.69 (R\(^2\)=0.92; SEE=1.56), where H=height, R=resistance and R\(^2\)= correlation coefficient.

Fat body mass was obtained by subtracting fat-free mass from the total weight. The values obtained were compared with the density reference values established by Fomon et al.\(^{20}\) and Haschke et al.\(^{21}\)

**Statistical analysis**

For the statistical analysis, the Epi-Info 2000 (version 1.0.4) and Sigma Stat (version 2.01) programs were used. The following variables were compared: weight, height and z-score (W/H), body mass index (BMI) and the H\(^2\)/R rate, according to sex, using the Mann-Whitney test. Student’s t-test was used for the comparison of resistance and reactance values between sexes. Fisher’s exact test was used for the comparison of z-score to W/H among the genders.

The relative values of FFM and FM, obtained through the equations developed by Chumlea et al.\(^{18}\) and Lewy et al.\(^{19}\) were compared with the standard height reference found through Kruskal-Wallis analysis of variance and Dunn multiple comparison test.

The present study was approved by the local Ethics Committee.

**Results**

The weights obtained varied from 6.6 to 41.8 kg, and there were no statistically significant differences between the median values of each sex. The heights of the children studied varied between 60 and 142 cm, and again, there were no statistically significant differences between the median values obtained for boys and girls. The mass index values averaged 17.4± 3.6 kg/m² for boys and 16.6± 1.6 kg/m² for girls, (p=0.07). The median value for the z-score of the W/H index was 0.59 for boys and 0.46 for girls (p=0.27). In the studied group, only 1.8% presented a z-score of W/H < -2 standard deviation (SD), and 3.0% presented a z-score of W/H > +2 SD, without prevalence differences between sexes.

The difference in mean values obtained from bioelectric impedance was significantly greater in the female group [625.4 19.2 ohms (girls), and 588.8 68.9 ohms (boys), (p<0.01)], the same occurred for the mean reactance values [50.0 6.3 ohms (girls), and 47.2 6.5 ohms (boys), (p<0.01)]. The medians for H\(^2\)/R (boys 20.4 and girls 19.8) did not present statistical differences in terms of sex (Table 2).

There was a positive correlation only between weight and H\(^2\)/R (r=0.925; p <0.01), meanwhile the correlation between other anthropometric variables and other values determined by BI were negative. The correlation coefficient between weight and H\(^2\)/R was 0.86 (Figure 1).
Table 2 - Values obtained from anthropometry and from BI, according to sex

<table>
<thead>
<tr>
<th>Variable</th>
<th>Girls (n=89)</th>
<th>Boys (n=75)</th>
<th>Total (n=164)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (kg)*</td>
<td>19.8 (6.6 ; 35.5)</td>
<td>20.2 (7.6 ; 41.8)</td>
<td>19.9 (6.6 ; 41.8)</td>
<td>0.45</td>
</tr>
<tr>
<td>Height (cm)*</td>
<td>114.5 (60 ; 137)</td>
<td>112 (62.5 ; 142)</td>
<td>113 (60 ; 142)</td>
<td>0.81</td>
</tr>
<tr>
<td>z-score W/H†</td>
<td>0.46</td>
<td>0.59</td>
<td>0.48</td>
<td>0.27</td>
</tr>
<tr>
<td>z-score W/H &lt;= -2.00</td>
<td>2.2%</td>
<td>1.3%</td>
<td>1.8%</td>
<td>0.56</td>
</tr>
<tr>
<td>z-score W/H &gt;= 2.00</td>
<td>4.5%</td>
<td>1.3%</td>
<td>3.0%</td>
<td>0.24</td>
</tr>
<tr>
<td>BMI‡</td>
<td>16.6 ± 1.6</td>
<td>17.4 ± 3.6</td>
<td>16.9 ± 2.8</td>
<td>0.07</td>
</tr>
<tr>
<td>Resistance (W)‡</td>
<td>625.4 ± 79.2</td>
<td>588.8 ± 68.9</td>
<td>608.7 ± 76.7</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Reactance (W)‡</td>
<td>50.0 ± 6.3</td>
<td>47.2 ± 5.6</td>
<td>48.7 ± 6.1</td>
<td>0.01</td>
</tr>
<tr>
<td>H²/R (cm²/W)†</td>
<td>19.8</td>
<td>20.4</td>
<td>20.1</td>
<td>0.32</td>
</tr>
</tbody>
</table>

W/H = weight-for-height; BMI = body mass index; H²/R = squared height (cm) divided by resistance; * = Median (minimal, maximum); † = Median; ‡ = Mean ± standard deviation.

The percentage values of body density calculated by Chumlea et al. and Lewy et al. equations, respectively, were: 14.2% FM and 85.8% FFM (girls) and 14.9% FM and 85.1% FFM (boys, and 11.7% FM and 88.3% FFM (girls) and 10.3% FM and 89.7% FFM (boys).

The percentage values of body density, obtained using the two previously validated equations were compared to each other and with the reference values according to sex and height. Lewy et al. equation reveals FM values lower than those shown by Chumlea et al. equations; the same occurred when the values were compared to the reference standard. Among the girls, the values obtained for FM, using both equations, were lower than those of the standard height reference (Table 3).

Discussion

In this study, as we did not know the age of the children, the z-score of the weight for height indicator and the body mass index were used to evaluate nutritional status.17,22 Our results showed low rates of malnutrition and obesity (1.8% and 3.0%, respectively), findings that lead us to believe that the nutritional conditions of the children in XNP have maintained their quality for the last three decades. The BMI of the studied population was significantly lower than the BMI found among native North American children.23

The FM values were close to or lower than expected for the corresponding heights, and Lewy et al. equation underestimated the FM, especially when applied to girls. These results contrast with those of other studies on Native American populations, the majority of which revealed high incidences of nutritional deterioration, especially malnutrition, found in Brazil8 and in Latin America, obesity in the United States10,11 and Canada, most likely due to the poor health conditions and poverty of the Latin American indigenous populations, and the incorporation of American and Canadian (North American) western dietary habits.8-12

We believe the preservation of good nutritional status of the studied children reflects the good nutritional condition of Alto Xingu population, which, in our opinion, is related to the cultural identity of the population which allows the preservation of healthy dietary and life habits, with the conservation, at least until today, of the environment of the park area and, finally, by the control of infectious diseases in the region. The basic health conditions remains precarious in the villages. The river system surrounding the villages...
seems to be able to meet the villages’ demand, but its implementation poses a great challenge to health professionals at the Xingu National Park.

In terms of the evaluation methods used, BI, as well as traditional anthropometric methods, are widely accepted for body density studies in adults and children. BI is considered to complement well nutritional evaluation field studies. The standardization of the technique and the choice of equations, which permits adequate estimates, are two important factors to be considered in the analysis of the results.

The analysis by mean regression coefficients allows the calculation of total body water and FFM in children, with an error margin of 0.3 to 1.7 kg and 2.0 to 2.8 kg, respectively. Considering field work conditions, the equipment proves adequate to accomplish the task. After resistance and reactance were obtained, the FFM and TBW values were calculated, using the previously validated equations - Chumlea et al. and Lewy et al. It is well established that there are ethnic variations of body density, and because of this, those two equations were chosen, as one refers to a Caucasian population and the other one to an African American population.

As in other parts of the world, the XNP population is under the influence of western culture, which can lead to changes in the eating habits of that population. Most likely, these changes have already occurred in other native populations, leading to important nutritional deterioration. This justifies the importance of continually monitoring the nutritional status of the XNP population. In our opinion, this is the best way to prevent nutritional deterioration and to develop strategies to avoid the rise of health problems of western civilization among the indigenous population of XNP. Finally, in this type of field study, BI proves useful and viable for the estimation of body density.

Acknowledgments

Thanks to Dr. Gentil Jorge Alves Junior for helping with the data collection, and to Dr. Douglas Rodrigues, for logistic assistance at the Xingu National Park.

Table 3 - The percentage values of body density obtained from validated equations and expected values (references), according to sex

<table>
<thead>
<tr>
<th>Equations of body density and reference values</th>
<th>Girls (n=89)</th>
<th>Boys (n=75)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Median</td>
<td>Median</td>
</tr>
<tr>
<td></td>
<td>% Fat</td>
<td>Fat-free mass</td>
</tr>
<tr>
<td>Chumlea et al.</td>
<td>14.2</td>
<td>85.8</td>
</tr>
<tr>
<td>Lewy et al.</td>
<td>11.7</td>
<td>88.3</td>
</tr>
<tr>
<td>Referência</td>
<td>17.0</td>
<td>83.0</td>
</tr>
</tbody>
</table>

References


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