Brief Report

Evaluation of Mid-upper Arm Circumference in Pre-school Children: Comparison Between NCHS/CDC-2000 and WHO-2006 References

by Viviane G. Nascimento,1 Thais Costa Machado,1 Ciro João Bertoli,2 Luiz Carlos de Abreu,1,3 Vitor E. Valenti,3,4 and Claudio Leone1

1Departamento de Saúde Materno-Infantil, Universidade de São Paulo (USP), São Paulo, SP, Brazil
2Departamento de Medicina, Universidade de Taubaté, Taubaté, SP, Brazil
3Departamento de Morfologia e Fisiologia, Faculdade de Medicina do ABC, Santo André, SP, Brazil
4Departamento de Medicina, Universidade Federal de São Paulo (UNIFESP), São Paulo, SP, Brazil

Correspondence: Claudio Leone, Departamento de Saúde Materno-Infantil, Faculdade de Saúde Pública, Universidade de São Paulo, Avenida Dr Arnaldo 715, Cerqueira César 01246-904 São Paulo, SP, Brasil. Tel.: +55-11-30850240, E-mail: <cleto@usp.br>

Summary

We aimed to evaluate the classification of arm circumference (AC) in pre-school children by using National Center for Health Statistics (NCHS/CDC-2000) and World Health Organization (WHO-2006) references. We evaluated 205 children: weight, height and AC were assessed and the body mass index (BMI) was calculated. The BMI values were classified into Z-scores by the WHO referential. The AC was classified into Z-scores by two references, comparing the whole-sample value and among groups (tercils) of BMI Z-score. The correlation was also evaluated between differences of AC with BMI Z-score. The WHO referential classified the AC in Z-scores greater than the NCHS/CDC, which is more specific and less sensitive than the NCHS/CDC for lean children and at the same time more sensitive and less specific for children with overweight. In conclusion, a significant difference in the AC classification occurs according to the referential used.

Key words: general paediatrics, international child health, orthopaedics, nutrition, statistics.

Introduction

The arm circumference (AC), also known as brachial perimeter, has been proposed as an alternative to select children ≤5-years old in critical nutritional state, aiming to identify the risk degree, regardless of age, gender, weight and height [1, 2]. Its measurement is an important indicator of mortality prognosis [3–6], especially in cases of severe malnutrition [7].

Recently, in 2006, the World Health Organization (WHO-2006) estimated new anthropometric parameters for children aged between 0 and 60 months, proposing a reference considered as the most appropriate for growth evaluation. This reference also includes new values for brachial perimeter classification [8].

In order to assess nutritional risk in individuals and populations, researchers compare their data with measured values of growth reference [9–12]. Besides the reference of WHO-2006 for AC, there is also the National Center for Health Statistics (NCHS) USA [7], restated in 2000 by the Centers for Disease Control (CDC) and available on 5 NutStat Epi-Info software.

In a single set of individuals, the use of different benchmarks may produce different risk classifications, and therefore, create values of nutritional disorders prevalence in communities, which would derail any evaluations and comparisons over time and/or between population [13, 14]. At the moment
that we choose to use a particular anthropometry reference, it is important to know the differences in risk classification in which it will result when compared to other references. Therefore, this investigation was undertaken to evaluate the classification of AC in pre-school children by using two references: NCHS/CDC-2000 and WHO-2006.

Methods

Study population
This analysis is part of a larger cross-sectional study, which aim was to evaluate, by anthropometric analysis, growth achieved by a sample of children aged between 2 and 4 years, who attended at public nursery schools in Taubaté city, São Paulo, in 2008. The variables investigated were: weight, height, body mass index (BMI) and AC. Data collection was performed at the beginning of the school year. We excluded children who presented history of chronic diseases that could influence their growth. The consent term was sent to all parents or responsible by the daycare center, which was duly completed and signed before the start of collection data. This study was approved by the Ethical Committee in Research of our University.

In order to calculate the sample size, we used the following parameters: level of the test significance $\alpha = 5\%$; test power $(1-\beta) = 90\%$ and a minimum difference between the mean Z-scores estimated by the two benchmarks of a quarter standard deviation (0.25), which resulted in a sample size of 170 children. Taking into account the possibility of any loss of data, we added 20% to the total number of children calculated that resulted in a sample of 204 children. Children were selected from the list of daycare centers provided by the Department of Education and Culture of Taubaté in a probabilistic way, which resulted in a total of 205 children (87 girls and 118 boys).

Variables evaluation
After obtaining consent from children parents or responsible, anthropometric data were collected in the daycare center, according to Lohman et al. [15] method. The child’s weight was measured by using the Seca electronic scale with a split of 0.1 g, and height was measured by stadiometer wall (Seca) with two meters, centimeters and millimeters subdivision. The measure of AC was performed with tape fiberglass extendable using the non-dominant arm of the child, placing the tape horizontally at the mid-point between acromion and olecranon. The measurements were performed by trained professionals, according to Hauspie technique (2004) [8]. The values of BMI $[\text{BMI} = \text{weight} \ (\text{kg})/\text{height}^2 \ (\text{m})]$ in Z-scores were calculated from the reference values proposed by the WHO (2006) [8]. AC was classified in Z scores by two benchmarks: the WHO in 2006 and the reference from the National Center for Health Statistics (NCHS), USA [7] restated in 2000 by the CDC [13] and available in the NutStat Epi-Info software.

Statistical analysis
The comparison of mean AC Z-scores was made by using paired Student $t$-test, with a significance level $\alpha = 0.05\%$. In the analysis of results, we also used the Pearson correlation coefficient in order to estimate correlation between the difference between AC Z-scores (determined by the two references) and the difference between BMI Z-scores. To calculate the sample, we used the Power and Sample Calculations software (v.3.0.1) and statistical analysis was performed by Graph Pad Prism (v. 5.0.2).

Results
Mean Z-scores of AC presented a difference of 0.49 Z-scores, the one estimated by the WHO was the highest ($p < 0.0001$; Table 1).

Figure 1 shows that the classification by the reference proposed by WHO in 2006 offsets the estimated distribution curve to the right, toward higher values.

### Table 1

<table>
<thead>
<tr>
<th>Reference</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCHS/CDC – 2000</td>
<td>0.08</td>
<td>1.16</td>
<td>-2.26</td>
<td>4.22</td>
</tr>
<tr>
<td>WHO</td>
<td>0.57</td>
<td>1.12</td>
<td>-2.00</td>
<td>4.01</td>
</tr>
</tbody>
</table>

**Fig. 1.** Comparison of arm circumference Z-scores distribution for age in pre-school children according to the reference used: NCHS/CDC – 2000 and WHO – 2006. Paired Student $t$-test; $p = 0.0001$; AC, arm circumference.
of Z-scores than the observed curve of the NCHS/CDC-2000 reference, which in turn is much closer to the theoretically expected normal distribution.

The differences of mean Z-score in the first, second and third tertile of BMI were 0.478, 0.539 and 0.453, respectively, all statistically significant ($p < 0.05$; Fig. 2).

Figure 3 displays that there was an inverse correlation between the differences of Z-scores of AC and the differences of Z-scores of BMI ($r = -0.2945$; $p < 0.0001$). The regression slope was $0.0301 \pm 0.0068$ ($p < 0.0001$).

**Discussion**

The results of this study indicate that when analyzing AC in pre-school children, depending on the benchmark that is used, it may direct to different interpretations regarding the diagnostic of nutritional status. We suggest that anthropometric assessment alone is not sufficient for preparation of definitive diagnosis nutrition; it is just one tool to be considered, however, in selection situations it may influence interventions which were adopted as result of the epidemiological situation.

AC has been considered an important indicator of malnutrition, especially during population screening because it presents good correlation with BMI and it is an easy measurement to be performed. Although it was originally proposed primarily for malnutrition screening [16, 17], AC was also used as an indicator of nutritional status in general, including in Z-scores form, in order to control the influence of gender and age in its interpretation [7, 18, 19].

In order to assess whether AC could be used for screening of pre-school obese children a previous investigation [20] studied 1090 children aged between 12 and 59.9 months and proposed cut-off points for AC for age because they found no advantage in using the AC/height ratio. These authors also suggest its use as a more practical method for screening of pre-school children who are obese due to the facility and speed of its attainment in that population.

Besides its use in prevalence surveys of overweight and obesity risk and for screening populations, the arm circumference may also be useful for clinical assessment of nutritional status of critically ill children, since it has good correlation with arm muscle mass and, thus, with the base nutritional condition of the children [21]. This may be particularly interesting when it comes to children admitted to intensive care units, where it is difficult to precisely evaluate other anthropometric variables due to their critical condition, or in cases of children with large tumors or with large edema, which surely contribute to alter their real weight [21].

Currently, two references that allow the classification of arm circumference in Z-scores are available (including software to make it more accurately), the NCHS/CDC-2000 and WHO–2006, which were drawn from different population samples. The NCHS/CDC-2000 reference corresponds to the NCHS, 1977, which were developed in the first half of the 70s, from a study of children fed with formula and breast milk differently from the standard recommended by WHO. In 2000, the CDC conducted a review of anthropometric references, including a
new sample of children younger than 3-years old and modified the mathematical model used for curves generating and smoothing [13]. On the other hand, for arm circumference the EpiNut of the Epi-Info 3 software continued to be based on data from NCHS 1977.

In 2006, the WHO published the results of their multicenter study conducted between 1997 and 2003, in order to generate new growth curves for evaluation of children aged between 0 and 60 months; they collected information from approximately 8500 children from different cultures and ethnicities. The youngest children (<18-months old) were exclusively breastfed during the first 4 months of life, recommended by the WHO. Based on those findings, the WHO sought to establish what would be a normative pattern of growth and development of children up to 5-years old [8].

It is also important to be considered that the differences between the two references regarding AC are higher in absolute values of Z-score, when evaluating children which tend to thinness, a fact that recommends higher caution in the interpretation of this indicator in epidemiological situations of high prevalence of malnutrition. At the same time, this apparent disadvantage may become an advantage in epidemiological nutritional transition periods [22, 23] when a significant increase in prevalence of overweight and obesity go through, such as emerging countries.

We reported that depending on the reference (NCHS/CDC-2000 and WHO-2006), it may be directed to distinct interpretations with respect to nutritional status; both the references are used in Brazil [20, 24]. We suggest clinical professionals to consider our data before evaluate clinical status of children. Our findings are based on a population situated in the southeast of the country; it is possible that different results are found in the north of Brazil. Thus, future investigations in different areas of Brazil are necessary to verify if our data are applicable in different regions of the country.

In conclusion, when analyzing AC in pre-school children, depending on the reference (NCHS/CDC-2000 or WHO-2006) it may be directed to distinct interpretations with respect to nutritional status.

References

20. de Almeida CA, Del Ciampo LA, Rico RG, et al. Assessment of mid-upper arm circumference as a