Assessment of mid-upper arm circumference as a method for obesity screening in preschool children

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Abstract

Objective: To evaluate if mid-upper arm circumference (MUAC) can be used for obesity screening in preschool children.

Method: 1,090 children aged from 12 to 59.99 months were studied. Personal information, weight, height and MUAC were obtained. Sensitivity and specificity to detect obese children were calculated for MUAC to age and MUAC to height z scores. Obesity was defined as weight to height z score > 2.

Results: 6.6% of the children had a weight to height z score > 2. The best association between sensitivity (76.5%) and specificity (77.9%) to detect obese children for MUAC to age was obtained with a z score of 0.7. In terms of MUAC to height, the best association between sensitivity (79.4%) and specificity (77.6%) to detect obese children was obtained with a 0.6 score.

Conclusion: MUAC to height z score was not advantageous for obesity screening when compared to MUAC to age z score. MUAC to age z score seems to be an adequate alternative method for obesity screening in preschool children.


Introduction

The prevalence of obesity in Brazil has been increasing in all age groups. In particular, among pre-school children it has risen from 2.1% in 19891 to 4.1% in 1996.2 This increase follows the tendency to nutritional transition experienced particularly in those regions of the world that have passed through periods of socio-economic development. This being so it is highly probable that the obesity epidemic currently occurring in the United States of America, where the prevalence among children less than five years old was 10.3% in 1997,3 will also occur among Brazilian children in proportion to the extent to which the country develops.

One of the principle strategies for combating obesity lies in its prevention and early detection, making it possible to propose and implement more easily the changes to nutritional behavior that are essential to treatment. This need, however, founders on diagnostic difficulties due to a number of different factors such as the relatively high level

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of cultural acceptance that obese children receive, the lack of preparation on the part of professionals who are far better trained in the detection and treatment of malnutrition and the population evaluation methodology which is basically founded on the acquisition and analysis of two anthropometric measurements, weight and stature. Thus it would be of great use to develop strategies for universal screening based on simple, cheap and effective methodology which could be performed at locations frequented by children, such as schools and day-care centers, with the objective of making pediatricians aware of the problem when they first receive a child who has been screened and are thus able to easily diagnose and treat it. Starting from these principles a possible alternative would be to use the measurement of middle-upper arm circumference. In 1997, WHO researchers published new z score tables with values for middle-upper arm circumference, age and stature, recommending that they be used for work with malnutrition.\(^4\)\(^5\) The present study is designed to evaluate whether this indicator could also be used to assess obesity, particularly as a method of population screening, selecting those children who are at greatest risk of obesity, who would, later, be assessed by other, more complex methods.

**Material and methods**

At the start of 1999, all of the day-care centers and preschools that are officially recognized by the Education Department in the city of Ribeirão Preto were identified. Twenty-four thousand, seven hundred and six children were found to be registered in total, 12,906 with the state system and 11,800 at private institutions. After those responsible had been contacted, 30 institutions agreed to participate in the study, 23 public and seven private, giving a total of 2,063 children, of whom 1,090 were aged between 12 and 59.99 months.

After written authorization had been received from those responsible, in accordance with national standards for research involving human beings\(^6\) and approval had been given by the committee for medical ethics at the Universidade de Ribeirão Preto, personal information on weight, stature and middle-upper arm circumference was obtained from all children on a single occasion by a team of 25 medical academics. The academics were trained in anthropometrics in groups of five and were considered adequately standardized when the difference between their results was below 0.5%. The measuring technique employed complied with international recommendations.\(^7\)\(^8\) The material used was acquired specifically for this study and consisted of a metal measuring tape by Lufking\(^6\) with a 1 mm scale, electronic pediatric scales by Filizola\(^8\) with a maximum capacity of 16 kg and a 10 g scale, (used with all children who could not stand without support, portable electronic scales by Filizola\(^6\), with a 100 g scale (used for children weighing over 15 kg), an anthropometer in wood and Formica with a 102 cm metal measuring tape with a 5 mm scale (to measure the length of children less than two years old), a dismountable vertical anthropometer in wood and Formica with a 200 cm metal measuring tape with a 1 cm scale (for measuring the stature of children over two), both manufactured at a precision workshop to the authors’ specifications.

The following z scores were calculated using the EpiInfo 2000\(^9\) software package in accordance with NCHS\(^10\) and World Health Organization\(^4\)\(^5\) standards: weight for stature, middle-upper arm circumference for age and middle-upper arm circumference for stature. A “gold standard” for the detection of obesity was defined as a z score greater than 2 for the weight for stature indicator, in accordance with World Health Organization recommendations.\(^1\) Next, sensitivity and specificity were calculated for different cut-off points for obesity on the z score scales for middle-upper arm circumference for age and middle-upper arm circumference for stature, starting with the value which returns a sensitivity of 100% and continuing until a value is found which provides a specificity of 100%, using intervals of 0.1 z points. Thus, for the middle-upper arm circumference for age indicator, the assessment interval was from -0.9 to 3.2 and for the middle-upper arm circumference for stature indicator it was from -0.7 to 3.5. After the best cut-off point was obtained, EpiInfo 2000\(^9\) was used to obtain middle-upper arm circumference values corresponding to this cut-off point for boys and girls and a graph drawn for practical use in population screening for obesity in the field.

**Results**

Of the 1,090 children evaluated, 68 presented z scores for weight for stature greater than 2, resulting in an obesity prevalence of 6.6%.

Figure 1 shows the evolution of the sensitivity and specificity obesity detection values for the middle-upper arm circumference for age indicator. It will be observed that a z score of 0.7 results in the best association between sensitivity and specificity, with values of 76.5% and 77.9% respectively. At this point the method would select 278 children from the total of 1,090. Of the 68 obese children the method would have correctly screened 52 (76.5%), but, in order to achieve this it would have incorrectly included a further 226 children. Furthermore, among the 812 children who were not selected, 16 (23.5%) remained who were obese.

Figure 2 shows the evolution of the sensitivity and specificity obesity detection values for the middle-upper arm circumference for stature indicator. It will be observed that a z score of 0.6 results in the best association between sensitivity and specificity, with values of 79.4% and 77.6% respectively. At this point the method would select 283 children from the total of 1,090. Of the 68 obese children the method would have correctly screened 54 (76.5%), but, in order to achieve this it would have incorrectly included a
further 229 children. Furthermore, among the 807 children who were not selected, 14 (20.6%) remained who were obese.

Considering that the objective of the study was to obtain a population screening method for obesity, it would have been desirable to have chosen cut-offs that resulted in a high level of sensitivity. In this case, taking as an example a sensitivity of 90% of the 68 obese children, 61 (89.7%) would be detected with the middle-upper arm circumference for age indicator and 63 (92.6%) by the middle-upper arm circumference for stature indicator. However, in the first case, 462 non-obese children would also be included, and, in the second case 436. This large number of false positives would make the screening process highly inefficient, as it would result in a later re-evaluation of a large number of children. This being the case, it was decided to consider the best cut-off to be that which best associated sensitivity with specificity. As the results for the two indicators tested were very similar no advantage was seen in using middle-upper arm circumference associated with stature because of the operational difficulties involved in measuring stature compared with the ease of simply finding out age. Figure 3 shows the average values for middle-upper arm circumference measurements for both boys and girls, obtained from reference population data, which correspond to the 0.7 z score for the 12 to 59.9 month age group.

**Discussion**

The present study took as its objective to verify whether, as is the case with malnutrition in which the measurement of middle-upper arm circumference is a good indicator of nutritional status, in the case of obesity this instrument could be employed, in particular for population screening taking into account the fact that this measurement has a good level of correlation with corporal mass. The data returned shows that, for the high levels of sensitivity which are ideal for this purpose, specificity values were very low, leading to a high number of false positives, both using the middle-upper arm circumference for age indicator and for the middle-upper arm circumference for stature indicator. These results, in principle, suggest that these indicators are not appropriate for this end. The repetition of the study with populations with higher obesity prevalence could, conceivably, lead to distinct results. However, in the only other similar study found when searching research databases, Sardinha...
et al., studying adolescents, also observed an elevated number of false positives when they attempted to use middle-upper arm circumference as a screening method with this age group, demonstrating that a significant limitation to this method is the fact that, in order to obtain high values for sensitivity, the number of false positives must increase.13

Observing Figures 1 and 2, in particular at the points at which the best sensitivity and specificity are associated, very similar results will be found. This fact means that, for the ends proposed, either middle-upper arm circumference for age or for stature could have been used, but because of ease of use, logically, middle-upper arm circumference for age should be preferred.

Despite this study not having demonstrated the method to be optimally efficacious, it may be considered that in the absence of better screening methods it could be utilized, especially in day care centers and schools, both public and private, which do not have scales or anthropometers nor personnel prepared for their use and interpretation. In this case, it is of great importance that the measurement technique, apparently simple, be rigorously followed. Figure 3 shows that the differences in middle-upper arm circumference for each age are highly discrete, meaning that small measurement errors can lead to erroneous interpretations. Factors such as the correct choice of arm, the correct positioning of the tape measure at the midpoint between the acromion and the olecranon, horizontal positioning and the compressive force employed should always be taken into account when working with middle-upper arm circumferences, imposing rigorous standardization on those measuring,14 all of which should not be difficult to obtain, requiring a little objective training since this is a single, simple measurement made with an easily managed portable instrument which does not need constant recalibration. It should be remembered that, for this study, skin fold measurement was not evaluated because of the difficulty in obtaining correct measurements and the high cost of the adipometer.

Taking the limitations described above into account, this study has demonstrated that it is possible to perform population screening for obesity in pre-school children using only age and a single, easily and cheaply obtained anthropometric measurement achieving a detection rate of 76.5% of obese children, including a tolerable number of false positives who would not themselves fail to benefit from educational and preventative programs which are aimed at the population to which they pertain. The observed percentage of false negatives (23.5%) should
be considered the primary limitation of the method since it implies a relevant proportion of children would be incorrectly considered not to be obese. However, in order to correct this problem it would be necessary to choose a cut-off which resulted in greater specificity, reducing sensitivity, which would not be conducive to screening. Therefore the cut-offs presented in Figure 3 are proposed for use with populations in Brazil that attend day-care centers and schools that accept pre-school aged children, as a first step towards achieving the detection of obesity at this early age to permit the implantation of educational and therapeutic measures and the prevention of the comorbidities which are more frequent among obese adolescents and adults.

References


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