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Original Research Article

Comparison of midupper arm circumference and weight-for-height z score for assessing acute malnutrition in children aged 6-60 months: an analytical study

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ABSTRACT

Background: In clinical settings, wasting in childhood has primarily been assessed with the use of a weight-for-height z score (WHZ), and in community settings, it has been assessed via the mid upper arm circumference (MUAC) with a cutoff <115mm for severe wasting and 115-125mm for moderate wasting. Our recent experience indicates that many wasted children were not identified when these cutoffs for MUAC were used.
Methods: Authors determined the cutoffs for MUAC to detect wasting in Indian children aged 6-60 mo. A secondary analysis was carried out on data from 1446 children aged 6-59 mo. The area under the receiver operating curve was used to indicate the most appropriate choice for cutoffs that related MUAC with WHZ. The MUAC measurement of each subject was taken using standard technique. Following the World Health Organization (WHO) age and sex-specific cut-off points, nutritional status of children was determined.
Results: The mean±SD age for the entire group was 19.8±13.6 mo, MUAC was 132±13mm, and 45% of subjects were girls. Age-stratified analyses revealed that, for ages 6-24 mo, MUAC cutoffs were <120mm for a WHZ <-3 and <125mm for a WHZ <-2 with a sensitivity of 68.3% and 64.7%, respectively, and a specificity of 82.6% and 83.4%, respectively; for ages 25-60 mo, MUAC cutoffs were <135mm for a WHZ <-3 and <140mm for a WHZ <-2 with a sensitivity of 63.7% and 65.4%, respectively, and a specificity of 81.6% and 78.3%, respectively.
Conclusions: The respective cutoffs for MUAC to better capture the vulnerability and risk of severe (WHZ <-3) and moderate (WHZ <-2) wasting would be <120 and <125mm for ages 6-24 mo, <135 and <140mm for ages 37-60 mo.

Keywords: Midupper arm circumference, Wasting, Weight-for-height z score

INTRODUCTION

Malnutrition contributes to almost two-thirds of worldwide mortality, directly or indirectly caused by diarrhea, pneumonia, measles and other infections among children under 5 years of age.[1] In hospitalized Indian children, malnutrition has been shown to increase the risk of mortality up to six times in diarrhoea and acute respiratory tract infections.[2,3] To accomplish the UN Millennium Development Goal 4, which aims to further reduce under-5 mortality, it is essential to curtail child deaths occurring as a significance of malnutrition.[4] The first step in this path will be to categorize and manage the set of malnourished children at risk for imminent death.

The WHO has definite the severe acute malnutrition (SAM) in 6-60-month-old children as a weight-for-height <-3 SD (severe wasting) of the reference population.[5] The assortment of weight-for-height Z-score (WHZ) over other anthropometric criteria, namely weight-for-age Z-score (WAZ) or height-for-age Z-score (HAZ), is based on the fact that it has been exposed to be an indicator not only for nutritional status but also involves measurement of height that can be exploit to evaluate past nutritional status. Though, the use of WHZ for identification of SAM is associated with some inherent consequence, especially in the emergency setting. Difficulties arise owing to the inability to accurately weigh or measure length in sick children; the non-availability of standardize weighing scales and height boards; the need for reference charts at all times; and the complex calculations to derive and interpret WHZ. Further, WHZ is a statistically derived parameter which depends on the nutritional status of the population from which the Z-score has been derived. Recognizing these operational difficulties, in 2009 the UN endorsed mid-upper arm circumference (MUAC) <11.5cm to be an age- and sex-independent diagnostic criterion for SAM, alongside WHZ<-3.[5] However, MUAC-based and WHZ based malnutrition diagnoses have shown deprived correlation and the children acknowledged as SAM based on one criterion are often missed if diagnosed using the other.[6] Therefore, the difficulty arises of the choice of MUAC and WHZ as the criterion for selecting hospital admission among severely malnourished children in resource-poor countries.

Several studies have established the superiority of MUAC over other anthropometric indices like weight-for-age, height for- age, weight-for-height, WAZ and HAZ as a criterion to predict mortality among under-5 African children in the community as well as among hospitalized African children.[7,8] However, very few studies have directly compared MUAC<11.5cm with WHZ<-3 for predicting child mortality.[8] In India, among all GAM cases, 54.9% children were diagnosed with WHZ <-2 only, 11.7% with MUAC <125mm only, and about 33.4% children were identified with both criteria. This overlap of prevalence based on WHZ and MUAC varies between countries and also within countries.[9]

Authors conducted the present study to determine the performance of MUAC compared with WHZ for predicting deaths among hospitalized children aged 1 year to 5 years in Indian settings. Authors also aimed to determine the best cut-off value of MUAC to predict mortality in these children.

METHODS

This study included primary data analysis of anthropometric datasets from five nutrition surveys conducted in four Indian states between 2016 and 2018. Cross-sectional study was conducted in Pediatric ward, Civil Hospital, Ahmedabad. This nutrition study was conducted using standardized monitoring and assessment of relief and transitions methodology which aims to estimate the prevalence of wasting among children aged 6-60 months.

All surveys used two-stage cluster sampling where the probability of being sampled was proportional to the population size. For each survey, the sample size was calculated using emergency nutrition assessment (ENA) software which was sufficient to estimate the wasting prevalence with a precision of ±5%. Informed consent was taken from all the households that were included in the study.

Equipment of global standard was used for anthropometric assessment. For measuring height, weight, and MUAC, wooden infanto-cum-stadiometer, SECA 874 digital weighing scales and standardized MUAC tapes were used, respectively.

Data on weight, height, MUAC, gender, and age for a total of 1466 children <5 years were used in this study. The data cleaning was done by deleting the records of children <12 months, >60 months, and with missing data. At individual study level, outliers were removed as the ENA flags children who had WHZ score <-3SD or >+3SD from the survey mean. Survey mean is mean WHZ in each survey. Post dataset cleaning, 1466 children were included for the final analysis.

The WHZ <-3 SD only means those cases who were SAM by WHZ only and their MUAC were ≥115mm. The MUAC <115 mm only means those cases who were SAM by MUAC only and their WHZ were ≥-3 SD. The overlapping SAM cases were those children who were SAM based on both WHZ <-3 SD and MUAC <115mm.

The raw data were rechecked, transferred to an SPSS file (SPSS Inc.), and analyzed with the use of SPSS software (version 20; SPSS Inc.). To ensure consistency, z scores for all anthropometric data were calculated in relation to the WHO growth standard via WHO Anthro software (version 2.0.2, 2007; WHO). Children were classified as moderately wasted when the WHZ was <-2 SD and as severely wasted when the WHZ was ,<-3 SD. The data for the children with extreme anthropometric values [e.g., WHZ and height-for-age (HA) z-score values, <-6 and >.6] were excluded from the analysis. Descriptive statistics were generated for all measurements and indexes. Sensitivity, specificity, and positive and negative predictive values for MUAC were generated for the WHZ at -3 and -2 cutoffs. Receiver operative characteristic curves were generated for MUAC and WHZ.

RESULTS

The total number of children included in the study was 1466 of whom 45.2% were girls. The mean±SD age was 19.8±13.6 mo, WHZ was -1.21±1.37, weight-for-age (WA) z score was -1.87±1.39, HA z score was -

1.61±1.46, and MUAC was 132±13mm (Table 1). There was a significant correlation between MUAC and WHZ (Pearson correlation: 0.517, P<0.001). The area under the receiver operating curve (AUC) was used to identify the most appropriate choice for cutoffs that related MUAC with the WHZ by selecting the point of highest cumulative value for sensitivity and specificity. Age-stratified analyses in the 2 age groups (6-24 and 25-60 mo) revealed the following results.

Table 1: Anthropometric characteristics (N=1,466).

	Minimum	Maximum	Mean±SD
Age (mo)	6	60	19.8±13.6
Length (cm)	46.2	118.7	76.7±9.98
Weight (kg)	3.17	24.2	9.04±2.31
WHZ	-5.93	5.96	-1.21±1.37
WAZ	-6.58	5.12	1.87±1.39
HAZ	-5.98	5.87	-1.61±1.46
MUAC (mm)	71	254	132±13

HAZ, height-for-age z score; MUAC, mid upper arm circumference; WAZ, weight-for-age z score; WHZ, weight-for-height z score; WLZ, weight-for-length z score.

For children in the age group from 6-24 mo, the mean (95% CI) AUC for MUAC was 0.841 (0.817, 0.862) at a WHZ of -3 and 0.829 (0.821, 0.838) at a WHZ of -2 (P<0.001). The most appropriate MUAC cutoffs were, <120mm for a WHZ <-3 and <125mm for a WHZ <-2 with a sensitivity of 68.3% and 64.7%, respectively, and a specificity of 86.3% and 83.4%, respectively. When the MUAC cutoffs in current use were applied, the sensitivities were 49.2% and 61.6%, respectively (Table 2).

For children aged 25-60 mo, the mean (95% CI) AUC for MUAC was 0.874 (0.841, 0.898) at a WHZ of <-3 and 0.853 (0.832, 0.868) at a WHZ of <-2 (P<0.001). The most appropriate MUAC cutoffs were <135mm for a WHZ, <-3 and <140mm for a WHZ <-2 with a sensitivity of 63.7% and 65.4%, respectively, and a specificity of 81.6% and 78.3%, respectively. When the MUAC cutoffs in current use were applied, the sensitivities were 23.15% and 28.7%, respectively (Table 3).

Table 2: Evaluation of screening test of nutritional status by different cutoffs of MUAC and WHZ (to detect severe and moderate wasting status) in children aged 6-24 mo.

Ages 6–24 mo*	Sensitivity	Specificity	Positive prediction value	Negative predictive value
MUAC <115 mm for WHZ <-3 (current practice)	49.2%	91.7%	38.2	94.6
MUAC <120 mm for WHZ <-3 (proposed)	68.3%	86.3%	24.7	97.5
MUAC <125 mm for WHZ <-2 (current practice)	61.6%	82.6%	57.5	88.4
MUAC <125 mm for WHZ <-2 (proposed)	64.7%	83.4%	58.3	87.2

*Values in parentheses are exact MUAC cutoffs with the highest sensitivity and specificity at different WHZ cutoffs in different age groups. To make it easier to remember, the rounded values for MUAC cutoffs are suggested.

Table 3: Evaluation of screening test of nutritional status by different cutoffs of MUAC and WHZ (to detect severe and moderate wasting status) in children aged 25-60 mo.

Ages 25–60 mo*	Sensitivity	Specificity	Positive prediction value	Negative predictive value
MUAC <115 mm for WHZ <-3 (current practice)	23.1%	98.7%	52.1	96.9
MUAC <135 mm for WHZ <-3 (proposed)	63.7%	81.6%	14.9	98.8
MUAC <125 mm for WHZ <-2 (current practice)	28.7%	99.1%	80.2	84.4
MUAC <140 mm for WHZ <-2 (proposed)	65.4%	78.3%	43.9	92.6

*Values in parentheses are exact MUAC cutoffs with the highest sensitivity and specificity at different WHZ cutoffs in different age groups. To make it easier to remember, the rounded values for MUAC cutoffs are suggested.

DISCUSSION

Large samples of 2 groups of children to carry out a statistical comparison of the WHZ and MUAC to categorize children at risk of SAM and MAM. The samples were drawn from the hospital setting and stratified by age. The AUC for receiver operative distinctiveness was used to recognize the values that gave the best comparison between the 2 methods. With the use of the WHZ as the comparator, authors showed that current guidelines for viewing with MUAC failed to identify a considerable proportion of children at risk and that the magnitude of the mismatch increased with age. When the cutoff of <115mm recommended by the WHO was used, for children aged between 6 and 24 mo the sensitivity for the detection of SAM was 49.2%; for

children aged and for children aged 25–60 mo the sensitivity was 23.1%.

For children aged 6-24 mo, authors identified a cutoff for MUAC of <120mm to categorize SAM. Of the 835 children in this age range, 41 subjects had severe wasting on the basis of a WHZ <-3, but only 32 children would have been identified with the use of an MUAC cutoff <115mm compared with a total of 142 children who would have been identified had the cutoff been <120mm. Similar reflection would apply for recommended WHO MUAC cutoff <125mm been used for the detection of children with MAM.

For the 631 children aged 25-60 mo, 34 subjects had severe wasting on the basis of a WHZ <-3, and only 13 of these children would have been identified if an MUAC cutoff <115mm was sed. A cutoff <135mm would have detected 72 children. With the use of the recommended <125-mm cutoff for the detection of MAM, 221 children had moderate or severe wasting on the basis of a WHZ <-2 but only 23 of these children would have been identified if the MUAC cutoff <125mm was used compared with 291 children if the cutoff <140mm was used.

The findings are clear that, with the use of the currently recommended WHO cutoff for MUAC, a significant number of children would not have been identified as either severely or moderately malnourished compared with the number if the WHZ cutoff was used. MUAC has clear benefits for the screening of nutritional status in large numbers of children and in community-based programs such as growth monitoring and promotion activities that are carried out by frontline health workers.

A comparison of the data for the hospital group with those of the community group indicated a lower MUAC cutoff for WHZs <-3 and <-2 in the hospital group (<123 and <128mm, respectively) than in the community group (<131 and <135mm, respectively). For both groups, the sensitivity and specificity were similar to those in the combined analysis. The higher cutoff that was resulting from the community group was attributed to the older age of the children register in the community.[10] Because, both in the hospital and community, the programs for screening and management of children suffering from SAM have used a single age group of 6-59 mo, authors suggest the use of the results of MUAC cutoffs from the combined data for hospital and community children. For many years, MUAC has been used as an alternative indicator of nutritional status and has shown great utility in challenging situations such as during emergencies, famines, or refugee crisis. Velzeboer et al, in 1983, tested the dependability (i.e., precision) of 5 minimally trained community health volunteers in rural Guatemala for weight-for-height (WH), HA, WA, MUAC, and midupper arm circumference for age z score (MUACAZ) and reported that, under field conditions, intraobserver reliability was highest for WA followed by MUAC, MUACAZ, HA.[11] They also founded that, under field conditions, minimally trained workers made fewer and smaller errors with MUAC than with WA or WH.[11,12] An important operational improvement for the use of MUAC is that the same cutoff is used for all children. even though MUAC increases with age and height, correcting arm circumference for either of the variables MUAC-for-age or MUAC-for-height does not offer any advantage as a predictive indicator for mortality.[13,14] For this reason, community-based programs generally use a single MUAC admission threshold without adjustment for age. MUAC-based programs may also recruit younger children, but this may be beneficial because these children are also the most vulnerable to illness and at higher risk of death.[15]

It has been reported that the prevalence of SAM on the basis of a WHZ <-3 or MUAC <115mm is similar, but the comparisons were not based on measurements that were made in the same children.[14] Both MUAC and the WHZ are used as alternative for more complex changes in aspects of body composition, but they do not capture the same changes. Therefore, differences might be expected. Differences in the WHZ might be accounted for by differences in leg length that are not directly related to wasting and are not representative of important body compositional changes for a malnourished child, thus making it less reliable in the identification of children at high risk.[16,17] MUAC captures aspects of muscle mass and fat mass, and a close relation between MUAC and muscle mass has been indicated on the basis of an assessment via dual-energy X-ray absorptiometry. Evidence in support of the use of MUAC as a single indicator has come from a study in Kenya where it was shown that the use of both the WHZ and MUAC did not improve the detection of high-risk undernourished children.[18] More recently, Briend et al suggested that there is no programmatic benefit in using both MUAC <115mm or a WHZ <-3 to identify high-risk children.[8] If a higher sensitivity is required for programmatic reasons (i.e., to take into account poor food security), it seems preferable to increase the MUAC cutoff rather than to combine it with the WHZ. In the same way, if a higher specificity is required, in case of inadequate treatment capacity, lowering the MUAC cutoff should be preferable. The use of color-banded MUAC straps could also help to minimize measurement errors.[15] Experience from Burkina Faso has reported that, as an admission criterion for SAM, the use of a cutoff of 118mm for MUAC was a useful alternative to the WHZ.[19]

CONCLUSION

The analysis reported here raises concerns that the use of the currently recommended cutoffs for MUAC in identifying children aged between 6 and 60 mo who are suffering from SAM or MAM (<115 and <125mm, respectively) are unlikely to identify many of the children who would benefit from therapeutic care and, thus, remain vulnerable to the complications associated with

malnutrition and are at increased risk of death. A revised, higher value for the cutoff for MUAC in 2 age groups (6-24 and 25-60 mo) would include these vulnerable children On the basis of these observations, the present study indicates that cutoffs for MUAC (i.e.<120mm for SAM and <125mm for MAM in the 6-24 mo age group; and <125mm for SAM and <135mm for MAM in the 25-60 mo age group) would better capture vulnerability and risk. The use of these cutoffs would be a simple, reliable alternative to the WHZ in identifying children suffering from severe wasting (SAM) and moderate wasting (MAM). An obvious strength of the present study is that the data came from a adequate sample. However, it would be worth exploring the outcomes, including morbidity and mortality or subsequent growth, development, and body composition, with the use of the MUAC cutoff compared with the existing gold standard in the children aged 5 y. The findings from this analysis would provide a more secure basis for policy formulation and advice for practice.

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