Original Article

Validity of "Mid-Upper Arm Circumference" as a Parameter to Identify Undernourished Children in Rural Gujarat

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Abstract

Introduction: Mid-upper arm circumference (MUAC) measures the arm muscle and fat area. The use of MUAC as a screening measure for assessing undernutrition has the following advantages; it makes use of a simple equipment, is easy to carry at the field sites, and requires minimal training. In India, "mid-upper arm circumference" is widely used and accepted in many nutritional programs. **Objectives:** This study was conducted with the primary objective to compare different anthropometric parameters of children and to validate the usefulness and limitations of MUAC to screen out undernourished children. **Subject and Methods:** Anthropometric measurements were recorded for all the anganwadi centers of the selected sub-center that comes under the field practice area of our department. The measurements like weight, height, MUAC were done according to the standard guidelines as per WHO, and further, calculations were done with the help of "Anthro software 3.2.2." Comparisons were done between categorization of **MUAC tape** and **Weight-for-Height Z-scores (WHZ)**, and hence, the sensitivity and specificity of the MUAC tape to screen the malnourished child were found out. **Results:** Sensitivity of MUAC to categorize a child in red/yellow was only 9.03%, negative predictive value (NPV) was 40.75%, specificity came 95.10%, and positive predictive value was 73.68% on taking WHZ as the gold standard. **Conclusion:** MUAC has a limited role in screening out an undernourished child (red/yellow category), whereas it has a good role in screening healthy children (green category).

Keywords: MUAC, undernutrition, WHZ

Introduction

Mid-upper arm circumference (MUAC) was introduced to monitor food intake and repeated infectious diseases among the communities. Malnutrition encompasses being underweight for one's age, too short for one's age (stunted), dangerously thin for one's height (wasted), and deficient in vitamins and minerals (micronutrient malnutrition).[1]

MUAC measures the arm muscle and fat area. Employing MUAC as a screening tool for assessing undernutrition presents numerous advantages, such as its dependence on simple equipment, ease of transportation to field sites, and minimal training requirements. In India, MUAC is extensively adopted and employed in various nutritional initiatives, primarily serving as the basis for screening, admission, monitoring, and discharge criteria within these programs. In the past, MUAC cutoff values were revised several times. Currently, MUAC cutoff for the red category is set as 11.5 cm and it is one of the criteria used to diagnose a case of severe acute malnutrition (SAM). This MUAC cutoff is based on mortality data compared to other anthropometry measurements like weight/height and weight/age which are based on their z-scores. MUAC is used widely in field-based practice to screen out children because it is said to be an easy and convenient method.

Since 1969, there have been persistent criticisms regarding the accuracy of mid-upper arm circumference (MUAC) measurements.[2,3] Chomtho and their team conducted a study in London, which involved sick children from the Great Ormond Street Hospital and healthy children recruited as part of a body composition reference study. Their findings revealed a robust correlation between MUAC and fat mass in children.

Access this article online

Quick Response Code:

Website: www.ijcm.org.in

DOI: 10.4103/ijcm.ijcm_789_22

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How to cite this article: Chawada BL, Devaliya JJ, Kurian S. Validity of "Mid-upper Arm Circumference" as a parameter to identify undernourished children in rural Gujarat. Indian J Community Med 2024;49:475-9.

Received: 20-09-22, **Accepted:** 13-02-24, **Published:** 24-05-24

However, the relationship between MUAC and fat-free mass or overall weight was notably weaker.[4,5] Documented by Glasman. J. in his research paper the more MUAC has been criticized for inaccuracy, the more it has come to be used. This is because supporters of MUAC, rather than defending its accuracy, have paid more importance to its materialization and industrialization. Despite its inherent imprecision, MUAC has evolved into an affordable and rapid screening method for identifying undernutrition.[6] Accurate and early identification of acutely malnourished children has the potential to reduce related child morbidity and mortality.

The current guidelines from the World Health Organization (WHO) distinguish non-edematous acute malnutrition in children under five by employing either MUAC or WHZ. However, an ongoing debate persists regarding the suitability of the current MUAC cutoff points.[7] This study would investigate the diagnostic performance of MUAC to identify children aged 6–60 months as undernourished. So far, the WHZ indicator has become the accepted "gold standard" anthropometric indicator for acute malnutrition, which is an index of weight and height based on the WHO 2006 Child Growth Standards.[8] Yet, to obtain the WHZ, a measurement of height and weight by trained personnel using a board and scale is required.[7]

Objectives

The primary objective of this study was the assessment of "mid-upper arm circumference (MUAC)" as a parameter to diagnose undernutrition and comparison of different anthropometric parameters to list out limitations of MUAC.

Subjects and Methods

The cross-sectional study was conducted as a part of the State nutritional drive program in December 2016.

The study was aimed to cover a sub-center under the field practice area of the department. Under the field practice area of our department, the sub-center having the maximum number of malnourished children was selected for our study. This sub-centers covered six anganwadi centers which were our study units.

The sample size was determined based on a single proportion population formula using $z^2 \times p \times q/d^2$ considering the following assumptions: 95% confidence level, estimated proportion (p) underweight (39.3%) taken from Gujarat's NFHS 2 data and margin of error (d) of 6.18; accordingly, the calculated sample size obtained was 250 (n = 250). Our study included 257 children from the six anganwadi centers that were screened for undernutrition.

The study sample included all the registered children in the anganwadi centers functioning under this sub-center. All the registered children were in the age group of 6–60 months.

However, children with congenital anomalies or developmental delays were excluded from our research. All the registered children coming to the anganwadi centers were selected as the sample of our study.

The data was collected by a team comprising of two interns and a faculty member. Data collection was done at the anganwadi centers in the presence of field staff, where anthropometric measurements like weight, height, and MUAC of the registered children were recorded along with their socio-demographic details. Standardization of measuring equipment like weighing machines, stadiometer was done on a daily basis before starting data collection. Demonstrative training was given to the interns regarding the anthropometric measurement which was followed by a daily briefing by the principal investigator. Anthropometric calculations were computed with the help of WHO Anthro software version 3.2.2.

Weights were recorded in grams by using standardized age-appropriate weighing machines, which included Salter's scale and adult weighing scale. Height was recorded in centimeters by using infantometer and stadiometer. All the values were recorded separately in two sets by two interns and matched by the principal investigator for the final recording. In case of any discrepancy, the measurements were done second time and this continued till all the values matched. These measurements were entered in WHO Anthro software to obtain weight/height values along with their weight for height Z (WHZ) scores, according to which all the children were categorized in green, yellow, and red categories.

The study is susceptible to selection bias due to the exclusive selection of a single sub-center as our sample.

Red category was allotted for children with WHZ scores below or equal to -3SD. Those children with WHZ scores below or equal to -2SD; categorization as yellow was done for them. Lastly, the kids with WHZ scores above -2SD were put in the green category. Children were also categorized by the MUAC cutoff levels, as per the current national nutritional guidelines.[9]

If MUAC measurement was below 11.5 cm, then the child was identified in the red category; similarly, if MUAC was in the range of 11.5 cm to 12.5 cm (with 11.5 cm to be inclusive), the child was put in the yellow category. All the MUAC measurements above and equal to 12.5 cm were classified in the green category. Finally, an assessment of the "MUAC tool" was done by comparing it with other age-independent parameters like weight/height, which was calculated by the WHO Anthro software version 3.2.2. We found out the sensitivity and specificity of the MUAC tape as a screening tool for undernutrition using WHZ score as the gold standard screening criteria for undernutrition.[8] Comparison and analysis were carried out using Microsoft Excel 2007 and ethical clearance was obtained by the "Institutional Ethics Committee for Biomedical and Health Research" on 09-11-2020.

At the end, an interactive session with the mothers of all the children examined was organized. Counseling for their

children's respective nutritional categories and appropriate referrals were done for the children in need.

Results

This study assessed the anthropometric parameters of children registered at various anganwadi centers in the field area under the Community Medicine department of our college. The data were collected from the sample consisting of 257 children between the age group of 6–60 months. The distribution of children in different nutritional categories according to measurements of MUAC tape and weight/height (i.e., the gold standard) is described as follows: according to the gold standard (WHZ) measurement, only 39.7% of children were screened as green, while 37.7% and 22% as yellow and red, respectively. However, MUAC tape screened out 92.6% in the green category, 7% as yellow category, and 0.4% as red category. According to the kappa statistical test, the agreement levels between MUAC tape and the gold standard findings (WHZ) showed poor kappa value of 0.003. According to Table 1, about 39.69% (102) of observations showed agreements under Kappa statistics.

Figure 1 shows the further sub-categorization of all children. Out of the 58 children, who were diagnosed by the gold standard as red, MUAC tape could not screen out any child (0%) as red category, while 13.79% of children were screened out as yellow and 86.21% as green by MUAC criteria. Among 97 children categorized by the gold standard as yellow, MUAC tape has categorized 93.81%, 5.16%, and 1.03% as green, yellow, and red, respectively. Finally, within those 102 children, categorized as green by WHZ, MUAC identified 95.1% of them as green, 4.9% as yellow, and 0% as red category. The power of MUAC tape as a screening tool using WHZ scores as the gold standard test was also calculated. The sensitivity of MUAC was 9.03%, negative predictive value (NPV) was 40.75%, specificity came 95.10% and positive predictive value was 73.68%. (See Table 1)

Moreover, the accuracy, positive likelihood ratio, and negative likelihood ratio of MUAC as a screening parameter were 0.09516, 1.053, and 1.003, respectively.

Discussion

The study compares MUAC categorization with the WHO gold standard categories (WHZ scores). The objective was to assess the power of MUAC as tool to screen the undernourished children.

From the WHZ red categorized SAM children (22.5% of the total), a large proportion from it, i.e. 86.21%, were misdiagnosed as green category by MUAC criteria; 13.79% children were screened out as yellow, and none of these children were labeled in the red category by MUAC criteria [Refer Figure 1]. In other words, MUAC tape could not identify red category children correctly. Similar results were obtained in a study conducted in Niger.[7] In fact, the study suggested that a higher MUAC cutoff (<12.0 cm) could improve accurate case identification of SAM when undertaking community screening among children under five. This finding suggests the need of reviewing and modifying the standards of screening guidelines in the program. Another study conducted in the United States supports the idea of adjusting the MUAC cutoff value, suggesting a change from <110 mm to <115 mm. This 5 mm increase is anticipated to lead to a significant enhancement in sensitivity, improving it from 16% to 25%, while causing only a minimal reduction in specificity. This adjustment enhances the likelihood of accurately diagnosing severe wasting and reduces the occurrence of false-negative results by 12%.[10] Among children categorized by the gold standard as yellow, MUAC criteria have surprisingly put >93% of these children in the green category, while only a few, that are approximately 5% were labeled correctly as yellow and MUAC tape has even misdiagnosed around 1% of these children as red category. Lastly, within the WHZ green categorized children (39.7%), approximately 95% of them were screened as green, while 4.9% of these were incorrectly labeled as yellow and none of these were categorized as red by MUAC tool. In our study, there was poor agreement between the gold standard and MUAC criteria by using Kappa statistical test. Agreement level was found less than half (i.e. 39.69%). This agreement level is considered as weak in reference to the textbook "Principles and Practice of Biostatistics by J V Dixit."[11] With poor sensitivity (9.03%) and NPV (40.75%), the power of MUAC tape as a screening tool should be considered highly weak. Keeping the above values regarding the power of MUAC tool in consideration, we can also conclude that WHZ needs to be retained as an independent criterion for the diagnosis of SAM in the community.[10] Moreover, using MUAC alone as a means to identify child undernutrition within a community is not recommended. While it is a convenient and straightforward tool, its effectiveness as a screening measure for undernutrition has been a subject of scrutiny by numerous researchers.[7,12,13] Our research revealed that the existing MUAC cutoff values, as defined by the WHO, exhibit limited

Table 1: Power of MUAC tape as a screening tool (*n*=257)

		Weight-for-Height Z-Scores (WHZ)		
		Undernutrition Present (Yellow+Red)	Undernutrition Absent (Green)	Total
MUAC Tape	Undernutrition Present (Yellow+Red)	14 (5.44%)	5 (1.95%)	19 (7.39%)
	Undernutrition Absent (Green)	141 (54.86%)	97 (37.74%)	238 (92.6%)
	Total	155 (60.3%)	102 (39.69%)	257

Number of observed agreements: 102 Kappa: 0.003 Sensitivity=9.03% Specificity=95.10% NPV=40.75% PPV=73.68% Accuracy=0.09516 Positive likelihood ratio=1.053 Negative likelihood ratio=1.003

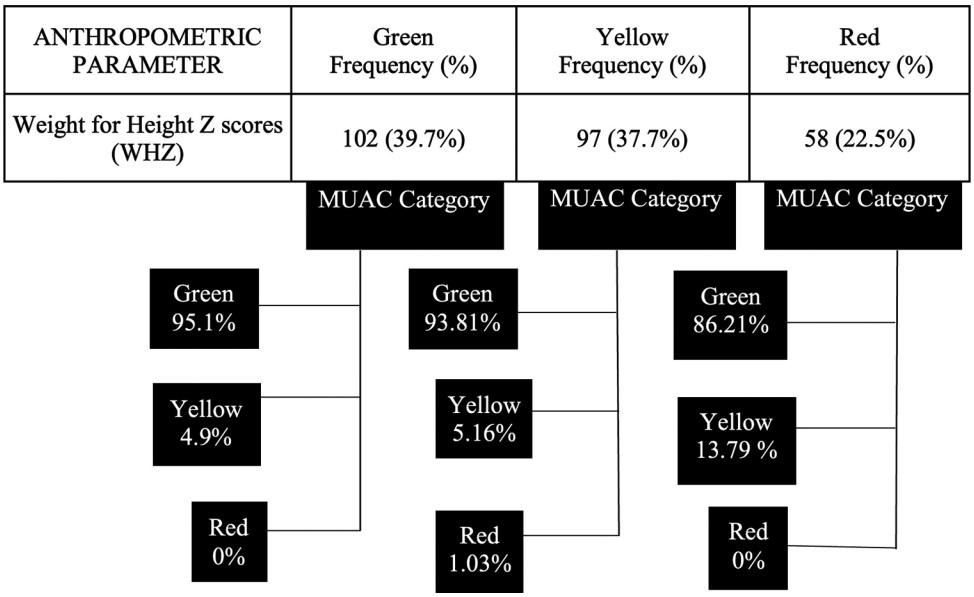

Figure 1: Distribution of nutritional categories of children (n = 257)

effectiveness in identifying acute malnutrition, particularly when conducting community screenings for children under the age of five. This observation is consistent with the findings of numerous other studies conducted worldwide, all of which have reported subpar performance of the MUAC tape as a screening tool.[12-15] According to a study conducted in Somalia, the MUAC-for-age (MUAC-Z) indicator has been identified as a more effective alternative for screening purposes, as opposed to using the MUAC tape.[16] Neither WHZ nor MUAC as a single parameter identifies all children with acute malnutrition. A re-definition of MUAC criteria for malnutrition or consistent application of both parameters is required as concluded by research in Nigeria.[17] The question of whether anthropometry (especially WHZ and MUAC) is an "early" or "late" indicator in nutrition emergencies and thus can or cannot provide useful information for early warning has not been convincingly resolved to date.[18-20]

Conclusion

This study concluded that MUAC tape had not added any extra advantage over other parameters for identifying children with undernutrition. In our study, we observed that MUAC categorization placed children into a higher category (green) compared to their actual lower category (either red or yellow) based on their WHZ. Therefore, MUAC had poor sensitivity for identifying an undernourished child. MUAC findings show poor agreements with the gold standard observations (WHZ). To conclude, this study contributes to the poor performance of current MUAC cutoffs to identify acute malnutrition as defined by WHZ. Indicators, such as MUAC, needed to be used with caution since they are not sensitive enough to detect all the cases of malnutrition.

Limitation

Study unit being one sub-center population, findings cannot be extrapolated and cannot be generalized. Absent children in anganwadi centers could not be included even after repeat visits. Being a cross-sectional study, we could not comment on the confounder and effect modifier parameters, which may have different roles to play in the outcome.

Acknowledgment

We would like to thank Dr Neha A Shah for her constant support for this study.

We extend our sincere gratitude to Dr. Vikas Desai madam, for her constant support and guidance in this research project.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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