International Journal of Contemporary Pediatrics
*Kanani SM et al. Int J Contemp Pediatr. 2024 Jan;11(1):xxx-xxx*
http://www.ijpediatrics.com
pISSN 2349-3283 | eISSN 2349-3291

DOI: https://dx.doi.org/10.18203/2349-3291.ijcp2023????

**Original Research Article**

# A comparison of mid-upper arm circumference and weight-for-height Z score of world health organization growth standards in detecting moderate and severe acute malnutrition in children aged 6-60 months

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**Received:** 14 October 2023
**Accepted:** 12 November 2023

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## ABSTRACT

**Background:** World health organization (WHO) had defined severe acute malnutrition (SAM) and moderate acute malnutrition (MAM) by weight for height Z score (WHZ) and mid upper arm circumference (MUAC) criteria. Several studies indicate discrepancies in the prevalence of malnutrition on using either WHZ or MUAC. The prevalence of SAM was nearly same when using either criterion and only 40% children showed overlapping by using both the criteria. Present study was taken to identify the overlapping of cases by applying both the WHO criteria in children aged 6-60 months. It also identifies the optimal screening cut off values of MUAC if used as a sole criterion.
**Method:** It was a hospital based descriptive cross-sectional study done on 640 cases who were assessed for MAM /SAM by using anthropometric WHO criteria.
**Results:** From 67 SAM cases who were identified by WHZ, only17 cases had SAM on using MUAC too. The sensitivity of MUAC was 25.4% and specificity of 92.0%. From 94 MAM cases, 19 cases showed overlapping by using both the WHO criteria. At MUAC of <13.5 cm, the sensitivity ased to 86.6% for SAM and 81.6% for MAM cases at the cost of decreased specificity which was at around 36%.
**Conclusions:** The number of malnourished cases, identified by using either of WHO criteria were nearly same but both these criteria detect different subgroups of malnourished children in most cases. A MUAC of <13.5 cm may be used as a sole-criteria in the community by the health workers to detect acute malnutrition.

**Keywords:** WHO, Acute malnutrition, Optimum cut off MUAC

## INTRODUCTION

Growth and development are interrelated, simultaneous processes which follow certain principles and patterns with the rate varies from individual to individual. Various genetic, environmental and emotional factors affect these processes. To grow optimally to his genetic potential is an aim and a fundamental right of every child. Growth assessment is the single most measure that identifies the health and nutritional status of children. Growth charts are the best trackers to find out the faltering of growth. WHO growth standards (2006) have been accepted by the most countries from all over the world and are commonly used from birth to 5 years of age. These growth standards define SAM and MAM by using WHZ score or MUAC.[1] These criteria were formed based on the fact that the children with above criteria are at risk of death which is increased 3-9 folds in children with MAM/SAM than normal children.[2] Several studies indicate discrepancies between prevalence of malnutrition obtained by using either WHZ or MUAC as a sole-criteria. The prevalence of SAM was nearly similar when

using either WHZ score or MUAC but only 40% children showed overlapping by using both MUAC and WHZ criteria.[3] Present study was taken to identify the cases of MAM/SAM by applying the anthropometric WHO criteria, using them singly and combinedly. It was also taken to identify the optimal screening cut off values of MUAC against WHZ score of WHO growth standards in detecting MAM/SAM in children aged 6-60 months.

## METHODS

It was a hospital based descriptive cross-sectional study carried out on the children aged 6-60 months who fulfilled the inclusion criteria. After the approval from the ethical and scientific committee at Kashiben Gordhandas Patel (KGP) children hospital, Vadodara; 640 cases were taken between January 2021 to June 2022 to estimate 60% sensitivity with 5% precision and 99% confidence.

### *Inclusion criteria*

The cases between the age of 6-60 months were assessed for detecting MAM/SAM by using anthropometric WHO criteria and also by clinical examination for SAM. As per WHO growth standards (2006), SAM is defined as weight-for-height/ length z score (WHZ)/(WLZ)<3 standard deviation (SD) of the median of WHO growth charts or MUAC is <11.5 cm or visible severe wasting or by presence of nutritional oedema. Only those cases were included whose parents/guardian had given consent. MAM is defined as WHZ/WLZ between-2 SD to-3 SD (<2 SD and ≥3 SD) or MUAC between 11.5-12.5 cm (≥11.5 cm and ≤12.5 cm).

### *Exclusion criteria*

Edematous child, congenital skeletal birth defects, children with secondary malnutrition such as chronic lung, liver, heart, renal, endocrinal and neurological diseases, huge organomegaly, case of inborn error of metabolism, malignancies and hemoglobinopathies, inherited chromosomal defects and known or suspected HIV cases were excluded.

### *Methodology*

Demographical details and clinical profile in the form of present illness, past, family, social, birth, diet, development and immunization history were taken for all the cases after informed consent from parents/relatives. Detail feeding history was taken to find out total calories and protein intake per day, breastfeeding practices, complimentary feeds, age of starting complimentary feeds, difficulties with feeding, total intake of number of meals and type of food items offered to a child.

After evaluating for emergencies signs, child was examined for acute illnesses and for status of malnutrition in form of visible wasting and bi-pedal oedema related to SAM along with other micronutrient deficiencies. Anthropometric measurements in the form of weight, length/height and MUAC were taken as per standard procedure by using electronic weighing scale, infantometer, stadiometer and standard non stretchable tapes. WHO reference Z-scores were calculated for three anthropometric indices (length/height-for-age, weight-for-age and weight-for-length/height). WHO criteria were taken to define MAM and SAM as per inclusive criteria.

### *Statistical tests*

Frequency, percentage, proportion, mean, standard deviation, Pearson's Chi square test was applied. P value was considered significant at 5% level for all the tests. Receiver-operating characteristic (ROC)/AUC curve was plotted to determine the cut-off point of MUAC for detecting MAM/ SAM. Sensitivity, specificity, and positive and negative predictive values for MUAC was generated against WHZ score between -2 to -3SD and <-3SD WHZ score of medians of growth standards as defined by WHO growth standards**.**

## RESULTS

There were 640 cases taken for this study, whose background characteristic were shown in Table 1.

Anemia was associated in 48 (71.6%) from 67 of SAM cases and 64 (68%) from 94 of MAM cases. Acute febrile illnesses and acute gastroenteritis were two common morbidities associated with SAM and MAM cases.

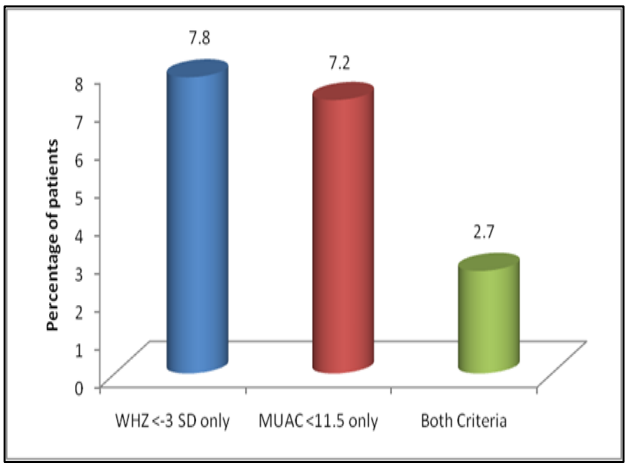


**Figure 1: Percentage of SAM patients with WHZ and MUAC cut-offs.**

Above Figure shows the percentages of SAM cases observed by using both or either criterion, MUAC or WHZ score as per WHO guidelines. Total 67 (10.5%) cases were identified as SAM by using WHZ<-3 SD criteria of which 7.8% cases were identified with WHZ<-3 SD only while it was detected in 63 (9.8%) cases by using MUAC <11.5 cm criteria with 7.2% cases by MUAC<11.5 cm only. Overlapped cases were identified by both of the above criteria in 17 (2.7%) cases. Similar

findings were found in the MAM cases with only 19 (2.96%) cases were identified as MAM by using both the criteria.

In this study, 55 children were severely stunted also. More male cases (42/42) were identified with SAM as against (21/25) females on using both MUAC and WHZ criteria. Even though the ratio of male to female looks 2:1 it was due to more male children (60%) were enrolled in this study. P value was insignificant.

**Table 1: Background characteristics of children aged 6–60 months.**

| Variables | N (%) |
|---|---|
| **Age (In years)** | |
| 6-24 months | 422 (65.9) |
| 25-60 months | 218 (34.1) |
| Mean age in years | 2.0151 |
| SD | 1.38 |
| **Gender** | |
| Male | 385 (60.2) |
| Female | 255 (39.8) |
| **Geographical area** | |
| Rural | 269 (42) |
| Urban | 371 (58) |
| **Mother's education** | |
| Illiterate | 134 (21) |
| Primary | 250 (39) |
| Secondary | 173 (27) |
| Higher secondary | 64 (10) |
| Higher (college) | 19 (3) |
| **Socioeconomic status (Kuppuswamy)** | |
| Lower | 179 (28) |
| Lower middle | 38 (6) |
| Middle | 26 (4) |
| Upper middle | 384 (60) |
| Upper | 13 (2) |
| **Feeding practices** | |
| Breastfeeding initiated | |
| Yes | 640 (100) |
| No | 0 (0) |
| Exclusive breastfed up to 6 months | |
| Yes | 502 (78.43) |
| No | 138 (21.56) |
| Complimentary feeds started at 6 months | |
| Yes | 304 (47.5) |
| No | 336 (52.5) |

**Table 2: Validity of MUAC (<11.5 cm) for SAM (WHZ<-3 SD).**

| MUAC | WHZ, n (%) | | Total, n (%) |
|---|---|---|---|
| | Positive | Negative | |
| **Positive** | 17 (25.4) | 46 (8) | 63 (9.8) |
| **Negative** | 50 (74.6) | 527 (92) | 577 (90.2) |
| **Total** | 67 (100) | 573 (100) | 640 (100) |

Sensitivity:25.4%, PPV:27%, specificity:92.0%, NPV:91.3.

Table 2 shows validity of MUAC cut off<11.5 cm and WHZ <-3 SD for identification of SAM cases. From 67 cases who were identified by WHZ <-3 SD, only 17 cases identified by using MUAC<11.5 cm criteria also and 50 (74.6%) cases had MUAC ≥11.5 cm. Similarly, out of total 63 cases who identified by MUAC <11.5 cm, 46 cases not showing SAM by using WHZ<-3 SD score. The sensitivity of MUAC <11.5 cm in identifying SAM cases was 25.4%, specificity-92%, PPV-27% and NPV-91.3%.

**Table 3: Validity of MUAC (11.5 to12.5 cm) for MAM (WHZ between-2 SD to-3 SD).**

| MUAC | WHZ, n (%) | | Total, n (%) |
|---|---|---|---|
| | Positive | Negative | |
| **Positive** | 19 (20.2) | 79 (14.5) | 98 (15.3) |
| **Negative** | 75 (79.8) | 467 (85.5) | 542 (84.7) |
| **P value** | 94 (100) | 546 (100) | 640 (100) |

Sensitivity:20.2%, specificity:85.5%, PPV:19.4%, NPV:86.2%.

Table 3 shows validity of MUAC and WHZ for identification of MAM cases. Out of total 94 cases, who were identified by WHZ between-3 SD to -2 SD, 19 cases were overlapped by MUAC (11.5 cm to 12.5 cm) too. Similarly, out of 98 cases who were identified by MUAC (11.5 to 12.5 cm) of which 79 cases were not showing MAM by using WHZ (-2 to -3 SD WHO criteria). Sensitivity of MUAC (11.5 to 12.5 cm) in identifying MAM cases 20.2% and specificity of 85.5%.

Table 4 and Figure 2 show comparison of different MUAC cut-offs for identification of SAM patients. As shown above, with increasing value of MUAC, sensitivity increases but specificity decreases. Sensitivity found to be lowest at 7.5% with highest specificity of 99.3% at MUAC of 11 cm. At 13 cm MUAC, sensitivity was 65.7% and specificity of 58.6%.

**Table 4: Different cut-outs of MUAC for the diagnosis of SAM.**

| Performance parameter | MUAC cut-off (in cm) (%) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 11.0 | 11.5 | 12.0 | 12.5 | 13.0 | 13.5 | 14.0 |
| **Sensitivity** | 7.5 | 25.4 | 34.3 | 41.8 | 65.7 | 86.6 | 95.5 |
| **Specificity** | 99.3 | 92.0 | 88.7 | 78.9 | 58.6 | 36.1 | 14.5 |
| **PPV** | 55.6 | 27.0 | 26.1 | 18.8 | 15.7 | 13.7 | 11.6 |
| **NPV** | 90.2 | 91.3 | 92.0 | 92.1 | 93.6 | 95.8 | 96.5 |
| **Youden index** | 0.07 | 0.17 | 0.23 | 0.21 | 0.24 | 0.23 | 0.10 |

**Table 5: Different cut-outs of MUAC for the diagnosis of MAM.**

| Performance parameter | MUAC Cut-Off (in cm) (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 10.5 | 11.0 | 11.5 | 12.0 | 12.5 | 13.0 | 13.5 | 14.0 |
| **Sensitivity** | 1.1 | 1.1 | 23.4 | 30.9 | 40.4 | 59.6 | 81.9 | 93.6 |
| **Specificity** | 99.5 | 99.5 | 92.5 | 89.2 | 79.7 | 58.8 | 36.4 | 14.7 |
| **PPV** | 25.0 | 25.0 | 34.9 | 33.0 | 25.5 | 19.9 | 18.2 | 15.9 |
| **NPV** | 85.4 | 85.4 | 87.5 | 88.2 | 88.6 | 89.4 | 92.1 | 93.0 |
| **Youden index** | 0.01 | 0.01 | 0.16 | 0.20 | 0.20 | 0.18 | 0.18 | 0.095 |

Table 5 shows comparison of different MUAC cut-off for identification of MAM patients.

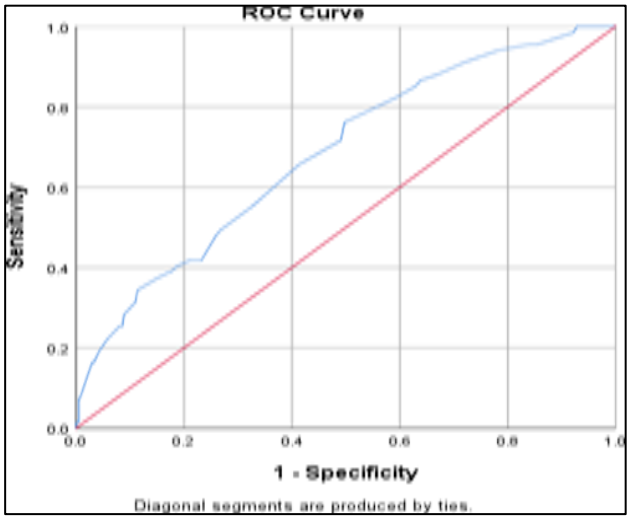


**Figure 2: Receiver-operating characteristic curve plotting the sensitivity and specificity of different mid-upper arm circumference cut-offs for SAM cases, AUC=0.683.**

The sensitivity at 12.5 cm MUAC was 40.4% which increased to 59.6% at 13 cm MUAC and 81.9% at 13.5 cm MUAC. ROC curve was showing the sensitivity and specificity of different MAUC by, AUC=0.645.

## DISCUSSION

India contributes one third of the global burden of undernutrition. Looking at India's population size, investing in actions to reduce all forms of malnutrition is especially important, not just for India itself, but also to support the attainment of global targets. The national nutritional strategy launched in 2017 provides the platform for stakeholders to converge together and drive the agenda of "mission malnutrition free India-2022" forward.

The primary objective of the present study was to identify the cases of MAM/SAM by applying the anthropometric WHO criteria, using them singly and combinedly. It was also taken to identify the optimal screening cutoff values of MUAC against WHZ score of WHO growth standards in detecting the MAM/SAM in children aged of 6-60 months.

Poverty, food insecurity, and illiteracy were the top three leading causes of malnutrition. A low level of maternal education has been associated with poor feeding practices, leading to malnutrition. Educated mothers were more likely to ensure that their children get adequate nutrition and treatment. Higher maternal schooling can reduce child's malnutrition through enhancing awareness regarding sanitation practices, healthy practices optimal resources allocation in child's favor. Furthermore, uneducated girls have been shown to have a higher probability of being undernourished. Girls who were undernourished had a higher probability of becoming an undernourished mother and therefore, were at a greater risk of giving birth to low-birth weight babies. Nearly one third family of children belonged to lower and lower middle socioeconomical class according to Kuppuswamy's classification. Higher vulnerability of food insecurity was associated with family's lower socioeconomic status because nutritious food affordability is closely associated with purchasing power. Households facing limitations in social and economic development were most probably to face issues in physical growth due to consumption of poor food, illness scenario, sanitation insufficiency, pitiable hygienic practices and inadequate safe water access. A study done by Lamsal et al on 3169 children surveyed on undernutrition, found that 21.5% and 28.6% family of children were belonged to lower and lower middle socio economical class respectively.[4] The 21.8% mothers had never attended school and majority of women (78.2%) were educated up to primary school or above. We had found similar observations related to literacy.

All mothers had initiated breastfeeding early and more than three fourth mothers (78.43%) had given exclusive breastfeeding up to 6 months. Less than half (47.5%) mothers had initiated complimentary feeds at 6 months of age. A study done by Barri et al found exclusive breast feeding in 32% cases only.[5] Improved breastfeeding rates have the potential to improve childhood nutrition, with associated impacts on infectious and non-infectious disease prevention.

In a present study, out of total 640 cases, 10.5% SAM children were detected with WHZ<-3 SD and 9.9% cases with MUAC<11.5 cm. There were 0.6% less cases detected by using MUAC <11.5 cm (Table 1). Out of these 640 cases, there were 7.8% and 7.2% SAM children identified by only WHZ <-3 SD and MUAC <11.5 respectively. Only 2.7% SAM children were diagnosed

with both WHZ<-3 SD and MUAC <11.5 cm. Similar observations were observed in MAM cases with only 2.96% MAM children were diagnosed with both WHZ between-3 to-2 SD and MUAC between 11.5 to 12.5 cm.

In a study done by Abitew et al found that **t**here were 11.0% and 11.2% SAM children identified by only WHZ <-3 SD and MUAC <11.5 cm respectively.[6] A meta-analysis study was done by Grellety et al to examine the relationship between the two commonly used WHO criteria for admission in a large number of anthropometric surveys done from the different countries.[7] From the nine surveys from our country, it was found that 22.9% SAM children were diagnosed with both WHZ<-3 SD and MUAC <11.5 cm.[7] There were 61.6% and 15.5% SAM children identified by only WHZ<-3 SD and MUAC <11.5 cm respectively.

Though both WHZ and MUAC indices are used to diagnose SAM in children aged 6-59 months, the research findings from various countries revealed that the agreement between WHZ and MUAC is poor as both anthropometric indices classify the children with wasting differently, with a small overlap, which varies greatly among countries.[3] Thus, the inconsistencies between these two anthropometric indices will have an implication in assessing the prevalence of acute malnutrition in a community, and there by taking appropriate interventions.

There was no statistically gender difference found in detecting SAM or MAM cases on using either of WHO criteria. On using MUAC criteria, 42 (10.9%) from 385 male, and 21 (8.2%) from 255 female children were diagnosed with SAM. P=0.266 which was not significant. A community study done by Wieringa et al to identify the factors for global acute malnutrition had reported that from 4381 children below 30 months of age, both MUAC and WHZ showed gender bias with MUAC was identifying more girls and WHZ was identifying more boys.[8] The difference in observations may be due to different sampling (community vs hospital).

We found that sensitivity and specificity of MUAC (<11.5 cm) for SAM children identified with WHZ <-3 SD were 25.4% and 92% respectively. A sensitivity and specificity of MUAC (11.5 to 12.5 cm) for MAM children (WHZ between -3 SD to -2 SD) were 20.2% and 85.5% respectively (Table 2 and 3). There were only 17cases (25%) who were detected, as SAM by using both WHZ and MUAC as against 50 (from 67) cases who were detected by WHO WHZ<-3 SD criteria alone and 46 (from 63) by using MUAC<11.5 cm criteria alone. One can conclude that both WHO criteria detect different class of malnourished children. This shows that if single MUAC is used as a screening tool to detect SAM by using <11.5 cm criteria, 50 (74.69%) cases could have been missed. So, it is believed that on using MUAC <11.5 cm as a sole-criteria, major population of children of SAM could have been missed. In a field situation, where taking out of WHZ score is not feasible, one should have different cut-off value of MUAC.A study done by Laillou et al found that sensitivity and specificity of MUAC (<11.5) for SAM (WHZ <-3 SD) were 6.1% and 99.7% respectively.[1] They also observed that sensitivity and specificity of MUAC (11.5 to 12.5) for MAM children (WHZ between -3 SD to -2 SD) were 13.4% and 98.1% respectively. As per a study done by Tripathy et al on 1428 cases, sensitivity was found to be 6.9% and specificity of 96.4% on using MUAC of <11.5 cm for WHZ <-3 SD score.[9] A study done by Dasgupta et al found the sensitivity and specificity of 17.5% and 96.3% respectively when using MUAC <11.5 cm which was almost similar to our study.[10] On increasing MUAC ≤13 cm, a sensitivity increased to 71.3% with specificity of 49.6%.

Kumar et al found that out of total 2127 children aged 6-59 months, 691 cases were detected as global acute malnutrition (GAM) cases of which 96% and 28.4% cases were diagnosed with WHZ and MUAC, respectively.[11] Similarly, from 123 total SAM cases, 95.1% were identified using WHZ and 30% using MUAC. The proportions of overlap between the two criteria for GAM and SAM cases were 24.5% and 25.2%, respectively which was almost similar to the present study.

In a present study, we observed that optimum cut-off for MUAC for identification of maximum number of SAM with maximum sensitivity along with acceptable specificity was 13.0 cm. In order to evaluate the performance of our analysis, the corresponding Youden index, which is the difference between the true positive rate (sensitivity) and the false positive rate, was calculated: 1 indicating a perfect test, and 0 a useless test. At 13.0 cm it had best cut-off value for detection of SAM (0.24Youden index) (Table 4). A study done by Fernandez et al found that using data from 39 surveys in 10 mostly African countries, showed that a MUAC of 13.5 cm was optimal to identify SAM (highest AUC in ROC curve), with a sensitivity of 84.5%.[12] In our study, it was found that with 13.5 cm MUAC, the sensitivity increased to 86.6%. So, in a field with a large-population surveys, where MUAC is used as a sole-criteria for screening SAM children, 13.5 cm is a good sensitive test even though it is less specific. As it is known that the death rate is high in SAM children and no child should be missed by a field worker, hence it is worth changing the cut off values for the health workers who are using them as a screening tool. Study done by Lamsal et al found that optimum cut off of MUAC for SAM was found to be 12.5 cm with a maximum Youden index of 49.9%.[4] In a study done by Shekhar et al found that on changing the MUAC cut-off from 110 mm to 115 mm, there was a large improvement in sensitivity (16.8% absolute increase, 63.6% relative increase) with a minor reduction in specificity (5.9% absolute reduction, 6.2% relative reduction), and an increase in Youden index from 0.22 to 0.33.[13] The MUAC cut-off value of 12cm resulted in an

absolute increase of 31.2% insensitivity over 115 mm cut-off, 12.2% decrease in specificity, and the highest Youden index. Their study also suggested that MUAC of 120 mm could prove to be more suitable to predict severe wasting in the Indian setting. A study done by Hai et al on 4764 Vietnamese children showed that with MUAC cut-off of 13.5 cm, the sensitivity was 65% and specificity of 72%.[14]

In our study, optimum cut-off for MUAC for identification of maximum number of MAM with high sensitivity along with acceptable specificity was 13.5cm which had the best cut-off value for detection of MAM (0.18 Youden index) (Table 5). Study done by Lamsal et al found that the best cut-off point of MUAC for optimum diagnosis of MAM was found to be 13.2cm with a Youden index of 30.5%.[4]

In our study, AUC for MUAC to detect SAM and MAM was 0.683 and 0.645 respectively suggesting that MUAC is sufficiently accurate to detect SAM and MAM in children according to classification of ROC curve (0.6-0.7=sufficient accurate test). We found that by increasing in cut off for MUAC for SAM, sensitivity increased which means that ability of MUAC test to identify those children who have the SAM. But specificity also decreased, that means the ability of MUAC test to identify them correctly who had not SAM. As per the study done by Kapil et al the diagnostic test accuracy of MUAC for detecting severe wasting was excellent (area under receiver-operating characteristic curve=0·933), with MUAC cut-offs between 110-120 mm, specificity was ranging between 99.1-99.9% but sensitivity was poor ranging from 13.4-37.2%.[15] With higher cut-offs (140-150 mm), sensitivity increased substantially (94·9-98·8 %) but at the expense of specificity (37.6-71.9%). The optimal MUAC cut-off to detect severe wasting was 135 mm.

***Limitation***

This was a hospital based study and heterogenous data were collected as per availability of indoor and outdoor patients. No comparison was done between these two subgroups.

## CONCLUSION

The number of SAM cases, identified on using either WHZ<-3 SD score or MUAC <11.5 cm criteria were almost same (67 vs 63 cases). Similar observations were obtained for MAM cases (94 vs 98 cases). Only 2.96% cases of MAM and 2.7% cases of SAM had shown overlapping by using both the above-mentioned criteria. One can conclude that both WHO criteria detect different subgroups of malnourished children in the majority of cases. A MUAC of <13.5 cm may be used as a sole-criteria in the community by the health workers to detect acute global malnutrition.

*Funding: No funding sources*
*Conflict of interest: None declared*
*Ethical approval: The study was approved by the Institutional Ethics Committee*

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**Cite this article as:** Kanani SM, Bharani SN. A comparison of mid-upper arm circumference and weight-for-height z score of world health organization growth standards in detecting moderate and severe acute malnutrition in children aged 6-60 months. Int J Contemp Pediatr 2024;11:xxx-xx.

**Provide the web link for Ref. no. 6.**