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**Original Research Article**

# Derivation of MUAC cut-off to identify undernourished 1-6 months old infants

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## ABSTRACT

**Background:** Under nutrition is the major public health problem in our country. There are numerous anthropometric methods, one of which is mid upper arm circumference (MUAC). MUAC cut-off classify the nutritional status of the children aged between 6-60 months. However, there is no specific cut-off for MUAC to identify the undernourished infants aged between 1-6 months. With the above background study was planned with the following objectives. Objectives of this study were to classify the nutritional status of 1-6 months aged infants using WLZ classification and to derive a cut off value for Mid upper arm circumference, to define under nutrition/wasting among 1-6 months aged infants

**Methods:** The cross-sectional study was carried out among 706 infants aged between 1-6 months. Nutritional status was assessed using WLZ. Various MUAC was tested against WLZ of <-2, in order to identify the cut-off below which, the infant will be considered undernourished.

**Results:** Mean age of the participants was 96±55 days. Mean weight, length and mid upper arm circumference was 4.75±1.02 kg, 58.51±4.47 cm and 12.15±3.01cm respectively. MUAC cut-off <13.5 cm has yielded highest youden index, accuracy and sensitivity of 0.36, 0.79,99% respectively. The total area under ROC curve is 0.707 [95% CI: 0.66, 0.74; p<0.0001], having a good diagnostic accuracy and it is statistically significant.

**Conclusions:** A MUAC cut-off value below 13.5 cm, among 1-6 months aged infants will be considered to be undernourished.

**Keywords:** Accuracy, MUAC cut-off, ROC curve, Youden's index

## INTRODUCTION

Globally a substantial progress have been made to reduce under 5 mortality during the past few decades.[1] However, among the under 5 deaths, nearly 75% of the deaths occured during the infant period.[2] According to 2016 data from the Sample registration system (SRS), infant deaths per 1000 live births in India and Tamil Nadu was 34 and 17 respectively with the major reasons for infant deaths being low birth weight, acute respiratory infections and acute diarrhoeal diseases ,and all these reasons are mainly associated or predisposed due to undernutrition.[3,4] Hence, it is of prime most importance to monitor the nutritional status of the infants. There are various anthropometric measures like weight, length. Mid upper arm circumference, skinfold thickness etc, for assessing the nutritional status.[5]

Weight for length z score (WLZ), is the preferred method of classifying the child nutritional status among 0-60 months aged children.[6] A cut off of –2 Z scores for these indices was used for classifying children as

undernourished. Children having WLZ score values between +2 to -2 were considered normal. Wasting was defined as < –2 Z-scores of WLZ. Moderate and severe malnutrition were defined as Z-scores <–2 and <–3, respectively, while >+ 2 and >+ 3 z score defines overweight and obese respectively.[7,8]

The infants under 6 months of age, are at higher risk of under nutrition and its sequale. Mid-upper arm circumference (MUAC) is an easy, quick and inexpensive, feasible field measure most commonly used for identification of severe acute under nutrition in young children (6-60 months of age) in resource-limited settings.[9]

MUAC being a simple anthropometric tool would be of great value if it could identify under nutrition at the earliest, especially for 0-6 months aged infants. This requires a cut-off value for 0-6 months aged infants, below which the infant could be classified as undernourished/wasted. Any such cut-off value should have a proper diagnostic accuracy, which is the ability of a test to discriminate between the target condition and health. This discriminative potential can be quantified by the measures of diagnostic accuracy such as sensitivity and specificity, predictive values, the area under the ROC curve, Youden's index and accuracy.[10]

Having the above background, the study was planned with the objectives to classify the nutritional status of 1-6 months aged infants using WLZ classification and to derive a cut off value for Mid upper arm circumference, to define under nutrition among 1-6 months aged infants

## METHODS

Present study was a cross sectional study carried out for a period of 12 months. Convenient sampling method was used (all the eligible participants mentioned below was included). Sample size (n) of the study was 706.

### *Inclusion criteria*

Infants aged between 1-6 months, attending Paediatric OPD for illness and/or immunization or admitted in the paediatric department of Tagore medical college and Hospital, during the study duration, whose parents have consented to participate their child will be included.

### *Exclusion criteria*

Those infants attending or admitted with oedema, ascites, pleural effusion or any significant large body masses, will be excluded.

### *Data collection*

After the approval from Institutional Ethical Committee and consent from parents or caregiver of the participants, the study was carried out among the eligible participants. Anthropometric assessment was done. WLZ and MUAC was determined to assess the nutritional status of the study participants. Sensitivity, specificity, Youden index and likelihood ratio of positive and negative tests, accuracy were calculated for MUAC cut-offs of 11.5cm, 12.5cm , 13.5 cm and 14.5 cm against the presence of wasting (WLZ <-2 ) .Receiver operating characteristic (ROC) was plotted, including the area under the curve with 95% confidence interval, using SPSS 20,to determine the optimal MUAC cut-off to define undernutrition/wasting.

### *Anthropometric assessment*

*Weight, length and WLZ assessment*

Weight was measured with infant weighing scale and was recorded to nearest 0.1 kg. Length was measured. Supine length of infants was measured with infantometer with fixed head piece. Help of the attendant was taken; infant was kept supine on infantometer and was asked to keep the vertex of the infant touching the fixed headpiece. Legs of the infants were kept fully extended by keeping the knees pressed. Feet were kept vertically at 90 degrees. Movable leg piece was opposed against the sole and the length was taken from attached scale to the nearest of 0.1 cm. the observed values for weight and length were compared with NCHS (National Centre for Health Statistics) standards for age and sex and analysed.

*Mid upper arm circumference assessment*

Place the non-stretchable graduated measuring tape around the arm (preferably left arm) at a site in the mid-point between the elbow and the shoulder (acromion and olecranon). Measure the MUAC while ensuring that the tape neither pinches the arm nor is left loose. Record the MUAC to the nearest 0.1 cm or 1 mm.[11]

### *Data analysis*

Data was entered in MS excel and analysed using SPSS 20. Frequency and proportion was used to determine the nutritional status using WLZ. The diagnostic accuracy of various MUAC cut off values against WLZ <-2, to identify the undernourished infants was determined using sensitivity, specificity, positive likelihood ratio (LR+), negative likelihood ratio (LR-), ROC, youden index and accuracy. They are calculated as follows

- Sensitivity*:* (TP/TP+FN)
- Specificity: (TN/TN+FP)
- LR+ = sensitivity/(1-specificity)
- LR- = (1-sensitivity)/specificity
- Youden index = (sensitivity + specificity) – 1
- Accuracy = (TP+TN)/(TP+FP+FN+TN)

TP, FP, TN, FN mentioned above indicates, true positive, false positive, true negative and false negative respectively.

## RESULTS

The nutritional status was assessed for 706 infants aged between 1-6 months. Mean age of the participants was 96±55 days. Nearly two-third 487 (69%) of them were males.

**Table 1: Socio-demographic profile of study participants (n = 706).**

| Parameters | Findings |
|---|---|
| Mean age±SD | 96±55 days |
| **Gender** | |
| Boys | 487 (69%) |
| Girls | 218 (31%) |
| **Socio-economic status** | |
| Class I | 402 (57%) |
| Class II | 155 (22%) |
| Class III | 85 (12%) |
| Class IV | 63 (9%) |
| **Religion** | |
| Hindu | 536 (76%) |
| Christian | 141 (20%) |
| Muslim | 29 (4%) |
| **Resident** | |
| Rural | 458 (65%) |
| Urban | 247 (35%) |

**Table 2: Distribution of anthropometric indices (n = 706).**

| Anthropometric parameters | Mean±SD |
|---|---|
| Weight | 4.75±1.02 kg |
| Length | 58.51±4.47 cm |
| Mid upper arm circumference | 12.15±3.01 cm |

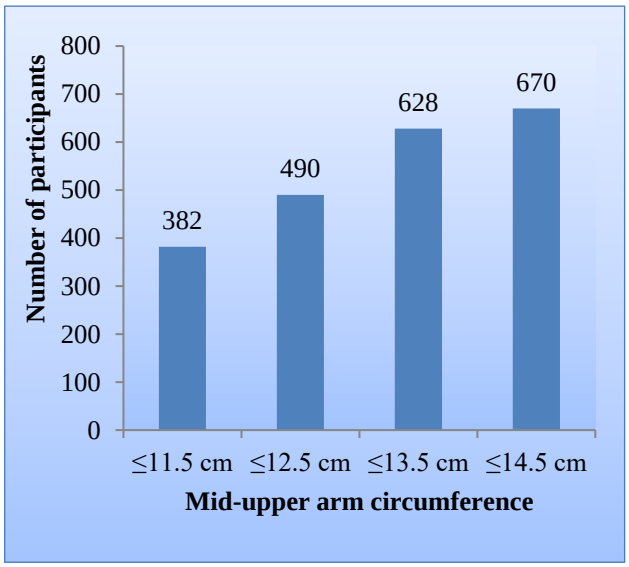


**Figure 1: Distribution of participants based on MUAC (n=706).**

**Table 3: Distribution of various MUAC against WLZ of <-2SD (N = 706).**

| Cut-off | Sensitivity | Specificity | PLR | NLR | YI | Accuracy |
|---|---|---|---|---|---|---|
| < 11.5 | 64.9 | 71.4 | 2.27 | 0.49 | 0.35 | 0.66 |
| < 12.5 | 77 | 48.6 | 1.5 | 0.47 | 0.25 | 0.68 |
| < 13.5 | 99 | 34.8 | 1.52 | 0.03 | 0.36 | 0.79 |
| < 14.5 | 95.2 | 5.7 | 1.01 | 0.84 | 0.07 | 0.68 |

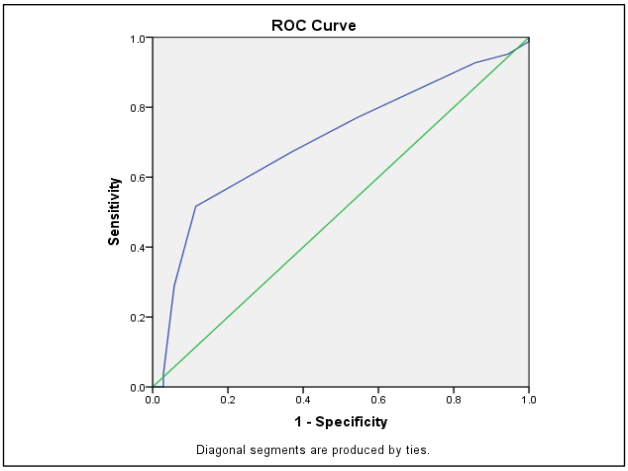


**Figure 2: ROC curve on various MUAC cut-offs (n=706).**

Most of them were Hindu 536 (76%), remaining were Christian 141 (20%) and Muslim 29 (4%) respectively. Majority of them belonged to Class I (57%) socio-economic status followed by class II (22%), class III (12%) and class IV (9%) respectively. Most of them were from rural residence 458 (65%) remaining belonged to urban setup (Table 1).

On assessing the anthropometric indices, it was found that, mean weight, length and mid upper arm circumference was 4.75±1.02 kg, 58.51±4.47 cm and 12.15±3.01 cm respectively (Table 2). Number of infants having MUAC <11.5 cm, <12.5 cm, <13.5 cm, <14.5 cm are 382 (54.1%), 490 (69.4%), 628 (88.9%), 670 (94.9%) respectively (Figure 1).

The sensitivity, specificity, Positive Likelihood ratio, Negative likelihood ratio, Youden index and accuracy for

various MUAC in detecting under nutrition/wasting is presented in the Table 3. It shows that, MUAC cut-off<13.5 cm has yielded highest youden index and accuracy of 0.36 and 0.79 respectively. The MUAC cut-off <13.5 cm also had the highest sensitivity of 99%. These values indicate that MUAC value of <13.5 have high diagnostic accuracy in detecting wasting among 1-6 months aged infants (Table 3).

Figure 2, shows the Receiver operating curve (ROC), comparing various MUAC cut-offs; the best performance was that of <13.5 cm. The total area under ROC curve is 0.707[95% CI: 0.66,0.74; p<0.0001). Since area under the curve is 0.707, it indicates that the MUAC cut-off of <13.5, has a good diagnostic accuracy and it is statistically significant. Hence any child aged between 1-6 months of age having a MUAC <13.5 are considered wasted/undernourished

## DISCUSSION

Under nutrition being a major influencing factor in determining the infant mortality, have to be detected earlier. Anthropometric variables act as sensitive indicators of health, growth and development in infants and children[13,14]

The participants of the present study was in the mean age of 96±55 days. In a study conducted at Delhi, the mean age of the infants was 99.5 (49.1) days.[15] In the present study, the, mean weight, length and midupper arm circumference was 4.75±1.02, 58.51±4.47 and 12.15±3.01 respectively, which was comparable to the study conducted by Siddhart D et al having, mean weight, length and midupper arm circumference as 4.75±1.02, 58.51±4.47 and 12.15±3.01 respectively.[15]

The prevalence of wasting in the present study using WLZ was very high (70.6%), whereas previous study showed the prevalence of wasting to be 34%. This variation could be due to the different geographic setting.[16] The present study have derived a MUAC cut-off value of 13.5 cm, below which the infants under 6 months of age are defined as undernourished /wasted. In a study conducted by Shekar S etal MUAC ≤ 12 has been suggested for diagnosing Severe acute malnutrition among 1-6 months aged children.[17]

## CONCLUSION

Infants under 6 months of age are at higher risk of under nutrition. This period with poor immune status are more viable for various communicable diseases, resulting in various life threatening complications. In spite of the fact that addressing the Severe acute malnutrition is of utmost importance to prevent malnutrition related deaths. Its also important to derive a cut-off value for such anthropometric measure, which is simple, easy, feasible to carryout and also identifies under nutrition with good diagnostic accuracy. This study has addressed this issue, by deriving a MUAC cut-off value of 13.5 cm, below which infants between 1-6 months aged will be defined as undernourished /wasted.

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