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Original Research Article

Comparison of Weight for Age and Mid Upper Arm Circumference with Weight for Length to Identify Severe Acute Malnutrition in Children Under 5 Years

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Abstract:

Introduction: Nutrition is critical for child growth, especially in the first 1000 days. However, global child undernutrition remains a significant public health issue, particularly in low- and middle-income countries. Children under 5 years are susceptible to severe acute malnutrition (SAM), posing significant health risks. However, current diagnostic methods like weight for age (WFA), mid upper arm circumference (MUAC), and weight for length (WFL) have limitations in accurately identifying SAM in this age range. Our study aims to assess the effectiveness of WFA and MUAC compared to WFL in identifying SAM among children under 5 years.

Material and Methods: A retrospective observational study was conducted at a tertiary care centre in Gujarat, comparing weight for age and mid-upper arm circumference with weight for length to identify severe acute malnutrition in children under 5 years. The study spanned from March 2021 to February 2022, with a sample size of 600 children meeting the inclusion criteria of presenting in the vaccination clinic. Anthropometric measurements followed standardized procedures, with MUAC measured using WHO-recommended cutoffs for severe acute malnutrition. Demographic data were collected, and statistical analyses were performed to provide insights into effective screening methods for severe acute malnutrition in this vulnerable age group.

Results: In present study involving 600 children, the incidence of severe acute malnutrition (SAM) was 11.3%. Weight for age and mid-upper arm circumference (MUAC) correlated significantly with malnutrition severity, with the majority of SAM children underweight (88.8%) and severely underweight (71.9%). Stunting (length for age) did not differ significantly among malnourished and non-malnourished children (p=0.241), but severe stunting was prevalent among SAM children (78.5%). MUAC <11cm showed significant association with SAM (p<0.001). Majority of SAM children were exclusively breastfed (65.7%), with low birth weight being the most common risk factor (62.8%; p<0.001). Mean anthropometric measurements varied slightly, and MUAC demonstrated fair predictive ability for SAM (AUC=0.774). ROC analysis revealed high sensitivity for MUAC <11cm (86.2%). There was a significant decline in MUAC measurements with decreasing age and cutoff values (p<0.001). Overall, both MUAC <11cm and weight for age were effective in predicting SAM in children under 5 years.

Conclusion: MUAC <11cm and weight for age are valuable predictors of severe acute malnutrition in children under 5 years. Current MUAC cutoffs may not effectively identify many at-risk infants and children, advocating for revised cutoffs to better capture vulnerability.

Keywords: Severe Acute Malnutrition, Weight For Age, Mid Upper Arm Circumference, Weight For Length.

Introduction

Nutrition plays a pivotal role in fostering optimal growth and development in children, particularly during the critical first 1000 days of life and extending into later stages.[1] However, child undernutrition persists as a pressing global public health concern, exerting profound implications on child survival and well-being.[2] Insufficient nutrition not only impedes physical and cognitive development but also escalates the susceptibility to infectious diseases, heightening the risk of mortality among children.[3] Moreover, the ramifications extend beyond individual health, impacting the economic productivity of both individuals and societies at large.[4] This burden is disproportionately borne by low- and middle-income countries (LMICs), where approximately 70–80% of undernourished children worldwide reside.[5]

Children under 5 years undergo rapid physical growth and developmental changes, making them particularly susceptible to malnutrition.[6] SAM in this age group is characterized by severe deficits in weight and/or height, leading to increased susceptibility to infections, impaired cognitive development, and even death if left untreated. [7] Current diagnostic methods, including WFA, MUAC, and WFL, aim to identify children at risk of SAM for timely intervention. However, each method has its limitations and may not accurately capture the complex nutritional status of children in this critical age range.

Weight for age (WFA) compares a children's weight to the median weight of a reference population at the same age, but it may not adequately detect acute malnutrition, especially if weight loss coincides with linear growth faltering.[8] Mid upper arm circumference (MUAC) measurement assesses muscle and fat mass and is widely used in resource-limited settings due to its simplicity and reliability. [9] However, its effectiveness in identifying SAM in children under 5 years requires further evaluation. Weight for length (WFL) provides a more direct assessment of acute malnutrition by comparing a children's weight to their length, but its utility in this specific age group is not well-established. [10]

Material and Method

A retrospective observational study was carried out to compare weight for age and mid-upper arm circumference with weight for length to identify severe acute malnutrition in children under 5 years at a tertiary care centre in Gujarat over a duration of one year, from March 2021 to February 2022. The total sample size for the study was 600 children under 5 years. Inclusion criteria comprised all children under 5 years presenting in the vaccination clinic of the hospital. Among them, children meeting the predefined criteria for severe acute malnutrition (SAM) were included in the study.

Anthropometric measurements were performed using standardized methods. Mid-upper arm circumference (MUAC) was measured using a non-stretch tape measure provided by the World Health Organization (WHO), with a cutoff value of less than 115 mm utilized for severe acute malnutrition classification. Weight was measured using a calibrated digital scale, and length was assessed using an infantometer, with both measurements recorded to the nearest decimal point. Cutoff values for weight for age (WFA) and weight for length (WFL) were defined as a weight-for-age Z-score (WAZ) and weight-for-height Z-score (WHZ) below -3 standard deviations (SD), respectively. Demographic data, including gender, feeding practices, initiation of complementary feeding, maternal education status, and number of under-five children in the household, were documented for each participant.

Statistical analyses were conducted using appropriate methods such as Student's t-test for continuous variables and chi-square test for categorical variables. A receiver operating characteristic (ROC) curve analysis was also performed to determine the optimal cutoff values of MUAC for identifying SAM, with the area under the curve (AUC) calculated along with its standard error.

Data analysis was carried out using statistical software such as SPSS, with significance set at a p-value of less than 0.05. The findings of this study aim to contribute valuable insights into the effective screening methods for severe acute malnutrition in children in under 5 years, thereby informing clinical practices and public health interventions in similar settings.

Results

In the present observational study, encompassing 600 children, aimed at identifying severe acute malnutrition (SAM) using weight for age and mid-upper arm circumference (MUAC) measurements, a male preponderance (61.9%) was observed compared to females (38.1%). Most subjects fell within the 2 to 3 years age range (35.1%) and resided in urban areas (71.3%). The majority of children belonged to lower middle III (40.8%) and upper lower IV (36.7%) socioeconomic classes. Regarding vaccination status, 42.1% had complete vaccination, 43.3% had partial vaccination, and 14.5% had not received any vaccination.

The incidence of severe acute malnutrition (SAM) in the current study was determined to be 11.3%. However, upon analysis, no statistically significant difference in SAM incidence was discerned between genders, as indicated by the non-significant p-value of 0.546. Our study findings revealed a significant association between malnutrition severity and underweight status, with 88.8% of severe acute malnutrition (SAM) children and 52.1% of moderate acute malnutrition (MAM) children having a weight for age below -2 standard deviations (SD) (p=0.001). Additionally, 71.9% of SAM children were severely underweight, compared to 28.1% who were moderately underweight (p=0.021). Similarly, comparing stunting (length for age) with malnutrition severity, we found that 54.6% of severe acute malnutrition (SAM) children and 52.1% of moderate acute malnutrition (MAM) children had a length for age above -2 standard deviations (SD), with an insignificant p-value of 0.241, indicating no significant difference in stunting distribution. However, among SAM children, 78.5% were severely stunted, significantly higher than non-SAM children (p=0.021), where only 55.6% were severely stunted. In comparing wasting severity (weight for length) among children, out of the total sample, 11.3% were identified as severely malnourished, 12.2% exhibited moderate malnutrition, and the majority, comprising 76.5%, demonstrated normal nutritional status.

A significant association was found between MUAC groups and nutritional status, with a significant p-value of 0.001. Among the severe acute malnutrition (SAM) children (n=143), the majority had MUAC <8.5 (27.3%), followed by 21.6% with MUAC between 8.5-9.5, and 20.3% with MUAC between 9.5-10.5. Among the moderate acute malnutrition (MAM) children (n=73), the majority had MUAC between 10.5-11.5 (24.6%), followed by 11.5-12.5 (21.9%).

The majority of severe acute malnutrition (SAM) children received exclusive breastfeeding (65.7%), while 34.3% received mixed breastfeeding. Among moderate acute malnutrition (MAM) children, the majority were exclusively breastfed (78%), with 22% receiving mixed breastfeeding. This distribution was significant (p=0.001), indicating that the majority of children (82.2%) received exclusive breastfeeding. In the current study, the most prevalent risk factors for severe acute malnutrition (SAM) were low birthweight (62.8%; p < 0.001), followed by faulty feeding practices (35.2%; p = 0.24), and prematurity (22.8%; p = 0.006). (Table 1)

Table 1: Risk factors for severe acute malnutrition

Risk factors	With SAM		Without SAM		P value
	N	%	N	%	
Prematurity	33	22.8	60	13.2	0.006
Low birth weight	91	62.8	179	39.3	<0.001
Hospitalization history	50	34.5	120	26.4	0.059
Faulty feeding practices	51	35.2	116	25.5	0.024
Percentage calculated from SAM (n=143), without SAM (n=457)					

In our study, the average weight of the subjects was 4.365± 3.354 kg, indicating some variability within the population. Similarly, the mean length stood at 55.434± 6.226 cm. The mid-upper arm circumference (MUAC) averaged at 11.079 cm, with individual measurements varying by approximately ± 1.945 cm. Lastly, the head circumference (HC) recorded a mean value of 37.232± 3.152 cm, reflecting moderate variability among the subjects. ROC analysis demonstrated an AUC of 0.774 for MUAC in predicting SAM, indicating a significant (p < 0.001) fair test/instrument. Various MUAC cutoffs were evaluated for their predictive ability for SAM, with a sensitivity of 86.2% for MUAC 11.5cm being the highest, followed by 84.8% for MUAC cutoff of 11cm.

The distribution of mid-upper arm circumference (MUAC) measurements among children under 5 year is delineated by age groups and MUAC cutoffs. It underscores a notable decline in MUAC measurements with decreasing age and cutoff values, all exhibiting p-values of less than 0.001.

Table 2: Comparing MUAC cut offs with age groups

Age; years	MUAC; cm			
	<11.5	<11	<10.5	<10
1-2	80 (25.6)	59 (26.6)	59 (27.8)	35 (25)
2-3	141 (45)	115 (51.8)	107 (50.5)	80 (57.1)
3-4	52 (16.6)	32 (14.4)	32 (15.1)	19 (13.6)
4-5	24 (7.7)	12 (5.4)	10 (4.7)	2 (1.4)
5-6	16 (5.1)	4 (1.8)	4 (1.9)	4 (2.9)
P value	<0.001	<0.001	<0.001	<0.001

Upon comparing the diagnostic accuracy of various instruments for diagnosing severe acute malnutrition (SAM), it was found that a mid-upper arm circumference (MUAC) cutoff of <11cm demonstrated comparable sensitivity and specificity. Weight for age exhibited high sensitivity (88.81%) but lower specificity. However, MUAC <11cm showed better diagnostic accuracy (72.17%) compared to weight for age (62.83%). These findings suggest that both MUAC <11cm and weight for age are valuable tools for predicting SAM in infants under 5 years of age. (Table 3)

Upon comparing the diagnostic accuracy of various instruments for diagnosing severe acute malnutrition (SAM), it was found that a mid-upper arm circumference (MUAC) cutoff of <11cm demonstrated comparable sensitivity and specificity. Weight for age exhibited high sensitivity (88.81%) but lower specificity. However, MUAC <11cm showed better diagnostic accuracy (72.17%) compared to weight for age (62.83%). These findings suggest that both MUAC <11cm and weight for age are valuable tools for predicting SAM in under 5 years of age. (Table 3)

Table 3: Diagnostic accuracy of different instruments for diagnosing SAM

Instrument	Sensitivity	Specificity	PPV	NPV	Diagnostic accuracy
Weight for age	88.81	54.70	38.02	93.98	62.83
Head circumference	45.45	83.15	45.77	82.97	74.17
Length for age	45.45	51.42	22.65	75.08	50.00
MUAC <11.5cm	86.01	58.42	39.30	93.03	65.00
MUAC <11.0cm	69.23	73.09	44.59	88.36	72.17
MUAC <10.5cm	69.23	75.27	46.70	88.66	73.83
MUAC <10.0cm	51.75	85.56	52.86	85.0	77.50

Discussion

The WHO defines severe acute malnutrition in children who are under 5 years of age as either weight-for-length less than -3 Z-score, or the presence of bilateral pitting edema. [11] Currently, WHO guidelines recommend the use of low mid-upper-arm circumference (MUAC <115 mm), low weight-for-height (WFH < −3 z-scores of WHO standards), and/or edema as internationally recognized independent diagnostic criteria for severe acute malnutrition in children age 6–59 months [12] and at community-based programs; however, it is recommended to use only MUAC and edema as criteria to admit children with SAM to the OTP. [13]

In our study, the incidence of severe acute malnutrition (SAM) among children under 5 years old was found to be 11.3%, notably higher than the prevalence reported in Pravana et al.'s [14] study at 4.14%. While both studies identified low socioeconomic status as a significant risk factor for SAM, differences exist in the significance of other factors such as parental age, birth interval, and feeding practices. [15,16] According to an Indian survey report in 2021 of 4152 children found overall prevalence of severe acute malnutrition (SAM) to be 1.7% (95% CI 1.4 to 2.2). [17] In the current study, the ability of the two indicators (WAZ and MUAC <11.5 cm for WFH < −3) to identify SAM children was compared on 600 children to identify severe acute malnutrition in children under 5 years by weight for age and mid upper arm circumference. As an individual loses weight, the loss comes mainly from fat and muscle [18]; intuitively such a loss should affect both the upper arm and the body as a whole.

In present study, the sensitivity of MUAC 11 cm was 86.2%. The agreement based on MUAC <11.5 cm was comparable to a study conducted in Southern Ethiopia with 71% agreement between MUAC <115 mm and WHZ <−3. [19] Other studies also reported agreement in the two indicators. A study in the rural Gambia reported a 59.8% overlap between WHZ and MUAC in identifying SAM children. [20] The WHO and UNICEF report in 2009 indicated a 40% agreement in identifying SAM children using WHZ and MUAC 12, and in Niger, 39% agreement in SAM identification was reported. [21] Furthermore, a study in Nigeria also reported that none of the children classified as SAM by WHZ were classified as SAM by MUAC. [22] A part of the explanation must be related to the fact that, in contrast to WHZ, the diagnosis of acute malnutrition based on MUAC relies on a single absolute cut-off point independent of age, height and sex. As a child grows height, weight and MUAC all increase steadily albeit at different rates; children with exactly the same WHZ are more likely to fall below the absolute cut-off point for MUAC if they are shorter or younger. Thus, those diagnosed as malnourished by MUAC are likely to be substantially younger, on average, than those diagnosed as malnourished by WHZ. [23]

Our results suggest that MUAC can effectively predict SAM in under 5 years. However, in study by Abitew et al. [24], the ability of the two indicators (MUAC <11.5 cm and WHZ < −3) to identify SAM children was compared, and the findings indicated that the proportion of SAM affected children identified by the two indicators (MUAC <11.5 cm and WHZ < −3) were comparable, while a lower proportion of affected children were identified based on the admission criteria (MUAC <11.0 cm) used at the data collection time compared with the recommended criteria (MUAC <11.5 cm and WHZ <−3). [12] The finding supports the WHO and UNICEF 2009 report where the prevalence of SAM based on MUAC <11.5 cm and WHZ <−3 was very similar. [25] Similar findings were reported among Nigerian children with SAM. [22] A systematic review has also reported that MUAC performed at least as well as measures of W/H to identify SAM children. [26] A study in Southern Ethiopia indicated a nonsignificant difference in the prevalence of SAM based on MUAC and WHZ. [27] However, a study in Pakistan identified more children with SAM by MUAC compared to WHZ. [28] Moreover, two studies in Niger reported that more cases were identified using MUAC than WHZ. [21, 29] But, a study in Sudan indicated that more SAM cases were identified using WHZ than with MUAC. [23] A study in South Africa also reported the identification of more children with SAM with WHZ than using MUAC. [30]

In current study, MUAC cut-off of <11cm had comparable sensitivity and specificity for detecting SAM. Weight for age also had high sensitivity (88.81%), however specificity was low. However, diagnostic accuracy of better with MUAC <11cm (72.17%) as compared to weight for age (62.83%). These shows that MUAC <11cm and weight for age, can be valuable instruments in predicting SAM in children under 5 years of age. The WHO and UNICEF report in 2009 indicated that children with WHZ below −3 SD based on WHO standards have a high risk of death exceeding 9-fold compared with children with WHZ >−3. [31] A study in India indicated that MUAC predicted death better (sensitivity: 95.5%, specificity: 25.0%) than WHZ (sensitivity: 86.4%, specificity: 21.4%). [32] In Abitew et al. study [24], children were admitted to OTP based on MUAC <11.0 cm and/or edema, and sensitivity and specificity of MUAC <11.0 cm against WHZ <−3 in identifying children with SAM was 49% and 99%, respectively, but sensitivity is 77% and specificity is 97% if MUAC <11.5 cm was used as admission criteria.

If MUAC is used as a standalone criterion, then one-third of SAM cases of total caseload will get detected, implying that 70% SAM cases with WHZ <3SD will remain undetected at community level screening drive. However, global evidence suggests that MUAC identifies children who are at a higher risk of mortality and require immediate care. [33] Berkley et al. also suggested that MUAC is proven to be more sensitive than WHZ in identifying high-risk SAM children and predicting mortality. [34] The decision of preferring either MUAC or WHZ as a standalone criterion for any child nutrition program depends on the objective of the program as well as the feasibility.

Evidence suggests MUAC as a better predictor of mortality as compared to WHZ; however, assessing the immediate death risk should not be the only purpose of diagnosing acute malnutrition. Acute malnutrition contributes to increased morbidity and impaired physical development. [35] Both WHZ and MUAC are known to identify different sets of children and just using MUAC will underestimate the prevalence of SAM at the community level. [27] Nonetheless, MUAC tape is a preferred tool as it is feasible to use at community level screening to detect cases of acute malnutrition. Program objectives determine whether both criteria are used together or if MUAC alone is preferred, especially for managing children at higher mortality risk, reducing SAM caseload by 68%. [36]

Our study has limitations worth noting. Firstly, it did not exclude small for gestational age children and utilized purposive sampling. Additionally, the applicability of MUAC as a malnutrition indicator may be limited to children under 5 years, who experience rapid growth, possibly necessitating more specific cutoffs for those under 5 years.

Conclusion

Our study found comparable rates of severe acute malnutrition (SAM) using weight for age (WFA), MUAC <11cm, and weight for height Z-score (WHZ) <−3. Current MUAC cutoffs may not effectively identify many children under 5 years of age with SAM or moderate acute malnutrition (MAM), increasing their vulnerability. Proposing cutoffs of <11cm for SAM and <125cm for MAM may better capture risk. Additionally, MUAC <11cm and weight for age were valuable predictors of SAM in children under 5 years of age.

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