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Comparison of mid upper arm circumference (MUAC) and weight for height (WHZ) as parameters in diagnosing moderate (MAM) and severe acute malnutrition (SAM) in children between 1-5 years age

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Abstract
Aim: To compare Mid upper arm circumference (MUAC) and Weight for height (WHZ) as parameters to assess nutritional status in children between 1-5 years of age.
Materials and Methods: A total of 650 children between the ages of 1-5 years were included in our study. Length/height was measured with an "infantometer" (to the nearest 0.1 cm)A standardized, calibrated digital weighing machine was used to measure weight in kilograms. Measurement of MUAC was done by using a standard coloured non stretchable tape. All detailed anthropometric measurements were taken and compared with WHO growth charts.. The age and sex distribution of the malnourished children were analysed.
Results: Among the 650subjects, the distribution of SAM and MAM cases in our study was nearly equal, i.e; 65.2% and 65.1% respectively. WHZ criteria identified a greater number of SAM (49.8%) cases then MUAC criteria and was found to be more sensitive for detection of SAM. (35.7%). Whereas MUA Ccriteria identified more children with MAM (51.5%) when compared to WHZ (34.5%) and was more sensitive in detection of MAM cases. The sensitivity of MUAC to diagnose all cases of SAM can be increased raising the MUAC cut off for SAM diagnosis to 11.86 cms .
Conclusion: In conclusion the proportion of children identified as MAM was higher using the MUAC criteria whereas the proportion of children identified as SAM was higher using the WHZ criteria. MUAC can thus be considered as a screening tool at the community level to detect all cases of acute malnutrition (both SAM and MAM). This allows early diagnosis and referral of all MAM cases for appropriate management and prevention of progression to SAM. Following screening WHZ can be used with higher sensitivity to detect SAM cases among the acutely malnourished children and refer these children for admission and SAM based nutritional rehabilitation.

Keywords: Mid upper arm circumference, Weight for height, nutritional status, SAM,MAM

Introduction

Severe acute malnutrition (SAM) in children under five years is an important public health problem due to associated high mortality and long-term health consequences.[1]Almost 16 million under 5 children are affected by SAM and over half a million die annually. The annual childhood deaths can be prevented by in-time

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management of acute malnutrition in young children.[2] SAM is caused by either inadequate intake or improper absorption of food. Due to their weakened immune system malnourished children are more susceptible to illness, growth failure and irreversible damage to cognitive development and are nine times more likely to die than well-nourished children.[3]India has a high prevalence of SAM, representing a huge burden. According to the comprehensive National Nutrition Survey, 2016-18, 17 per cent of children under 5 years of age in India have severe acute malnutrition.[4]

Severe acute malnutrition (SAM) according to WHO is defined by a weight-for-height Z-score (WHZ)<-3, and/or mid-upper arm circumference (MUAC)115 mm and/or bilateral pitting oedema.[5] The WHO recognizes MUAC and WHZ as two independent criteria for diagnosing SAM or MAM. As the two parameters detect different sets of children to be acutely malnourished, itwould be beneficial to know how the variance between these two parameters is related to the difference in the distribution of malnourished children based on age and/or sex. The issue Is primarily important for malnourished children in the age group 12 – 60 months as there exists ambiguity in the criteria for admitting and discharging these children because of the availability of limited evidence for improving current treatment guidelines.[6] The above age group was chosen to validate the comparison between MUAC and WHZ as parameters fornutritional assessment as they independently determine the state of nutrition in children between the ages of 12-60 months and are unaffected by age of the child within this range.

It is necessary to understand the relationship between the two anthropometric measurements to help us in identifying those malnourished children who require treatment in nutritional rehabilitation program.[7] Hence, the present study was done at our tertiary care center to assessthe role of mid upper arm circumference and weight for height as anthropometric parameters in the assessment of nutritional status of children between 1-5 years age attending thepaediatric outpatient/inpatient department and to study the comparison between the twoparameters in identifying children as SAM or MAM (Moderate acute malnutrition).

Materials and Methods

Our study was a hospital based descriptive study conducted over 2 years from August 2019 to September 2021 after approval from the institutional ethical committee and informed written consent from parents. Sample size was calculated to be 600 assuming theprevalence of wasting among children under 5 years in Pune to be 16.9% and an acceptable error of 3%.

A total of 650 children between the ages of 1-5 years, who visited the Paediatric Out Patient Department as well as those who were admitted in the In Patient Department were included in the study. Children with endocrine disorders, skeletal disorders, syndromic features and congenital anomalies were excluded from the study. A detailed history of presenting complaints and other significant history was taken followed by a detailed general physical and systemic examination. Age of children was confirmed by noting the date of birth. Length/height was measured with an “infantometer” (to the nearest 0.1 cm). A standardized, calibrated digital weighing machine was used to measure weight with the child standing motionless on the weighing scale without footwear and with light clothing. Weight was measured to the nearest 0.1Kg.[8]Measurement of MUAC was done by using a standard coloured non stretchable MUAC tape implemented by UNICEF.[5] It was measured at the mid-point between the acromion of the shoulder and elbow of the left arm to the nearest 1 mm.[9]Anthropometric measurements were then transformed to Z-scores. All detailed anthropometric measurements were taken and compared with WHO growth charts. Malnutrition was categorized into SAM (WHZ score;<-3SD or MUAC;<115mm) and MAM (WHZ -2SDto -3SD or MUAC; 115mm-125mm) based on WHO criteria[5].The age and sex distribution of the malnourished children were analysed. Comparison of proportions were performed with a chi-square test. Student’s t-test was used and a p-value of less than 0.05 was considered significant. The data was analyzed by using statistical software WIN-PEPI.

Results

Among the 650 subjects studied ,the distribution of SAM and MAM cases in our study was nearly, equal 65.2% and 65.1% respectively. A total of 423 subjects were identified as MAM using WHO criteria. Among all the MAM cases, 47.1 % (199) were identified which satisfied only the MUAC criteria of 11.5cms to 12.5cms. 20.8% cases were identified which satisfied only the WHZ criteria (2SD to -3SD). 32.1% (136) MAM cases were identified satisfying both the identification criteria. The sensitivity, specificity, negative (NPV) and positive predictive value (PPV) of MUAC and WHZ in detecting MAM cases showed that MUAC (79.2%) was more sensitive than WHZ (53%) for the diagnosis of MAM. Kappa values demonstrated that the degree of agreement shown by MUAC in the diagnosis of MAM was 0.727 (good degree of agreement) which was better than WHZ whose kappa value for diagnosing MAM was 0.44 (moderate degree of agreement). Among the 650

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subjects studied a total of 424 subjects were identified as SAM. Among all the SAM cases 45.3 % (192) were identified using WHZ < -3SD alone as a criterion and 23.6 % (100) were identified using only MUAC < 11.5cms as a criterion. Around 31.1% (132) were identified using both WHZ < -3SD and MUAC < 11.5cm as the criterial. Evaluation of sensitivity, specificity, NPV and PPV of MUAC and WHZ in detecting all SAM cases demonstrated that WHZ was more sensitive (76.4%) than MUAC (54.7%) in detecting SAM cases. Similarly, the degree of agreement (kappa) shown by MUAC in the diagnosis of SAM was 0.457 (moderate agreement), which was less than WHZ which diagnosed all the SAM cases with a Kappa value of 0.693 (good degree agreement). (Table 1)

Table 1: Sensitivity, specificity, NPV and PPV to diagnose MAM and SAM.

Cases	Method	Sensitivity	Specificity	NPV	PPV
MAM	MUAC	79.2%	100%	100 %	72.1 %
	WHZ	53%	100%	100%	53.3 %
SAM	MUAC	54.7%	100%	100%	54.1%
	WHZ	76.4%	100%	76.4%	69.3%

In our study mean age of study participants was32.48±12.8 months. The cases were divided into two age groups i.e., 12-24 months and 25-60 months. 60.5% (393) were between age of 25-60 months and 39.5 % (257) were between 12-24 months.The age wise differences in the distribution of SAM and MAM cases using the two different identifications criteria were studied. Among all the SAM cases WHZ criteria identified 45.7 % children to be younger than 25 months and 54.3 % children to be 25 months or older. Using MUAC alone as the identification criteria 53.88 % belonged to the younger age group and 46.12 % belonged to the older age group. These results were found to be statistically significant with a p value of 0.000. Similarly, using WHZ as the identification criteria for MAM cases, 35.4 % children belonged to the younger age group and 74.6 % belonged to the older age group. Using MUAC as the identification criteria for MAM 37.9 % and 62.1% belonged to the younger and older age group respectively. These results were also found to be of statistical significance. (p = 0.0001)(Table 2 and 3)

Table 2:Age wise distribution of MAM and SAM based on WHZ

Age		**WHZ**			**Total**
		>-2SD	**-2SD to -3SD**	**< -3SD**	
12 months – 24 months	Count	52	57	148	257
	%	51.0%	25.4%	45.7%	39.5%
25 months – 60 months	Count	50	167	176	393
	%	49.0%	74.6%	54.3%	60.5%
Total	Count	102	224	324	650

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	%	100.0%	100.0%	100.0%	100.0%
Chi-square value- 29.30					
p value-0.001*					

Table 3:Age wise distribution of MAM and SAM based on MUAC

Age		**MUAC**			**Total**
		NORMAL >12.5cm	**MAM (11.5-12.5 cm)**	**SAM (<11.5cm)**	
12–24 months	Count	25	127	125	257
	%	30.12%	37.9%	53.88%	39.5%
25 – 60 months	Count	58	208	107	393
	%	69.88%	62.1%	46.12%	60.5%
Total	Count	83	335	232	650
	%	100.0%	100.0%	100.0%	100.0%
Chi-square value- 23.005					
p value-0.001*					

The sex wise differences in the distribution of SAM and MAM cases were studied using the two different identification criteria. Out of 650 participants, 60.3% (392) were male and 39.7% (258) were female. Among all cases of SAM, 65.4% were male and 34.6 %were female using WHZ identification criteria whereas the MUAC criteria identified 56.5 % male children and 43.5 % female children as SAM. These differences were significant with a P value of 0.000 for each. 47.8 % and 52.2 % of the MAM cases were male and female respectively using WHZ alone as the identification criteria. Using MUAC alone as the identification criteria for MAM, 58.5% were males and 41.5 % were females. These results were statistically significant with a p value of 0.0001.(Table 4 and 5)

Table 4: Sex wise distribution of SAM and MAM cases based on WHZ:

Sex		**WHZ**			**Total**
		> -2SD	**-2SD to -3SD**	**< -3SD**	
Females	Count	29	117	112	258
	%	28.4%	52.2%	34.6%	39.7%

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Males	Count	73	107	212	392
	%	71.6%	47.8%	65.4%	60.3%
Total	Count	102	224	324	650
	%	100%	100.0%	100.0%	100.0%
Chi-square value- 23.67 p value-0.00*					

Table 5: Sex wise distribution of MAM and SAM based on MUAC

Gender		**MUAC**			**Total**
		>12.5cm	**11.5-12.5 cm**	**(<11.5cm)**	
Females	Count	18	139	101	258
	%	21.7%	41.5%	43.5%	39.7%
Males	Count	65	196	131	392
	%	78.3%	58.5%	56.5%	60.3%
Total	Count	83	335	232	650
	%	100.0%	100.0%	100.0%	100.0%
Chi-square value- 20.494 p value-0.00*					

Discussion

Severe acute malnutrition in children is associated with increased risk of mortality by several folds when compared to normally nourished children. Thus early, rapid, and accurate diagnosis of SAM is necessary for preventing deaths due to SAM. In the present study out of the total 650 participants there was near equal distribution of SAM and MAM cases i.e.; 65.1 % (423) and 65.2% (424) were detected as SAM and MAM respectively when either of the two identification criteria were used for assessment. Based on MUAC criterion, MAM and SAM participants were 335 (51.5%) and 232 (35.7%)respectively and based on WHZ criterion, MAM and SAM participants were, 224 (34.5%) and 324 (49.8%) respectively. It is clear from our findings that MUAC identified more children with MAM when compared to WHZ whereas WHZ identified more children having SAM as compared to MUAC and the difference between the two identification criteria in diagnosing SAM and MAM was found to have statistical significance (p value 0.00). The results were further analysed to predict the sensitivity and specificity of MUAC and WHZ in detecting MAM and SAM cases. Our study revealed that MUAC had a higher sensitivity (79.2%) for detecting MAM cases when compared to WHZ (53%). Whereas WHZ had a higher sensitivity (76.4%) in detecting children with SAM when compared with MUAC (54.7%). The significant decrease in the sensitivity of MUAC in diagnosing SAM is a source of concern as it will lead to under diagnoses of many of the SAM cases which require urgent treatment and consequently result

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in an increase in the morbidity and mortality of malnourished children. The sensitivity of MUAC in diagnosing cases of SAM can be made comparable to that of WHZ (76.4 %) if the MUAC cut off for SAM diagnosis is increased to 11.8cm. Hussain MI et al[10] revealed that when the MUAC cut-offs in current use were applied, the sensitivities for detection of SAM and MAM were 51.2% and 63.2%, respectively which is lower to our study. A possible reason may be the different setting, different methodology and also the sample size which is larger in our study. Bari et al[11] in contrast to our study reported that sensitivity of MUAC to diagnose SAM was 80.9 % and reported it to be a better predictor of nutritional status than WHZ. WHZ criteria demonstrated a better degree of agreement (kappa 0.693) as compared to MUAC (kappa 0.457) in diagnosing children with SAM. On the other hand, MUAC demonstrated a better degree agreement (0.727) than WHZ criteria (0.444) in diagnosing children with MAM. It can be concluded that MUAC can thus be used as a screening tool at the community level to detect all cases of acute malnutrition (both SAM and MAM) which allows early diagnosis and referral of all MAM cases for appropriate management and prevention of progression to SAM. Following screening WHZ can be used with higher sensitivity to detect SAM cases among the acutely malnourished children and refer these children for admission and SAM based nutritional rehabilitation in order to prevent consequent morbidities/mortalities.

A statistically significant difference was present in the sex distribution between MAM and SAM participants based on WHZ and MUAC. Among MAM cases MUAC criteria identified more males (58.5%) than females (41.5%). WHZ criteria identified more females (52.2%) than males (47.8%) Among SAM cases both MUAC (56.5% males) and WHZ (65.4% males) identified more male children than female. P Kumar et al[12] revealed that out of 2127 children, 123 cases were diagnosed as SAM. Among all SAM cases, 36% were male and 64% were female using MUAC alone as a criterion. 54% were male and 46% were female children using only WHZ as a measure, and 51% were male and 49% were female using both criteria.

A statistical significance in the age wise distribution of MAM and SAM cases based on WHZ and MUAC was discovered. Both MUAC (37.9% < 25 months age and 62.1% > 25 months) and WHZ (35.4% < 25 months and 74.6% > 25 month) independently identified more children in the older age group than the younger age group to have MAM. Among all the SAM cases, MUAC identified more children in the younger age group (53.88%) as compared to the older age group (46.12 %.), whereas WHZ criteria identified more SAM children in the older age group (54.3 %) as compared to the younger age group (45.7%). A multi country study was conducted by Golden and Grellety et al which showed that the number of children diagnosed by one criterion or the other varied significantly across different countries. They found that excess of young children in the survey dataset would lead to the diagnosis of more SAM children using MUAC, whereas having an excess of older and taller children would diagnose more SAM children using WHZ.[13]This can be explained by the fact that diagnosing acute malnutrition based on MUAC relies on a singular absolute cut-off point independent of the age, sex and height. As a child grows, the height, weight and MUAC of the child all increase steadily albeit at different rates. Children having exactly the same WHZ are more likely to fall below the absolute MUAC cut off point if they are shorter /younger than their counterparts. Thus, those participants diagnosed as malnourished by MUAC criterion are likely to be substantially younger, on an average, than those who have been diagnosed as malnourished by WHZ. The older children are more probable to be diagnosed as SAM by WHZ than MUAC because WHZ depends on the height which is dependant on age and therefore with increasing height/age the relative weight for height for acutely malnourished children decreases. Also, since MUAC cut off is an absolute point which is not height/age adjusted, as the child gets older/increases in height, the degree of nutritional deficit with a MUAC <115mmm becomes gradually higher. A low MUAC maybe more common in the younger age group but it carries less risk of mortality for these individuals as compared to older children; because with a steady increase in the MUAC deficit with increasing age, the risk of mortality also increases dramatically.[14]

Conclusion

Our study concludes that there was a solid degree of agreement with increased sensitivity shown by MUAC in diagnosing cases of MAM whereas WHZ showed a substantial degree of agreement with increased sensitivity in diagnosing SAM cases. MUAC can thus be used as a screening tool at the community level to detect all cases of acute malnutrition (both SAM and MAM) which allows early referral of all MAM cases for appropriate management and prevention of progression to SAM. Following screening, WHZ can be used with higher sensitivity to detect SAM cases among the acutely malnourished children and refer these children for admission and SAM based nutritional rehabilitation in order to prevent consequent morbidities/mortalities.

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