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Assessment of Nutritional Status in Paediatric Inpatients: A Comparative Study of MUAC and Weight-For-Height Z-Scores

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Abstract

Malnutrition affects a third of the global population, with high prevalence in Southeast Asia. Despite declining under-five deaths, it remains a major contributor to child mortality, particularly in rural India.

This study evaluates the nutritional status of children aged 6 months to 5 years in a tertiary care hospital and examines the correlation between Mid-Upper Arm Circumference (MUAC) and weight-for-height z-scores for nutritional assessment.

This observational study was conducted in a pediatric ward of a tertiary care hospital, assessing the nutritional status of children aged 6 months to 5 years admitted from January to March 2022. Excluding those with cerebral palsy or upper limb deformities, 270 children were enrolled. Anthropometric measurements, including weight, length, height, and MUAC, were taken. Nutritional status was assessed using MUAC and weight-for-height z-scores. Severe Acute Malnutrition

(SAM) and Moderate Acute Malnutrition (MAM) were defined based on z-scores and MUAC measurements, compared to weight-for-height z-scores. Data were analyzed using standard statistical software, with chi-square tests employed for statistical analyses. A P-value of <0.05 was considered statistically significant.

The study included 270 children, with a slight male predominance (55.5%). Anemia was prevalent, with moderate anemia being most common. Malnutrition assessment showed comparable results between z-score and MUAC methods, with substantial agreement. MUAC demonstrated high sensitivity and specificity for SAM and MAM detection, with 67% sensitivity for SAM and 78% for MAM, and specificity of 99% for SAM and 86% for MAM.

The study finds comparable malnutrition rates between genders, with MUAC demonstrating reliability akin to z-score methods. This indicates its potential as an effective screening tool for malnutrition in resource-limited settings. Early intervention facilitated by MUAC could mitigate adverse health outcomes associated with childhood malnutrition.

Keywords: Malnutrition, MUAC, Z-Scores, Sensitivity, specificity

Introduction

Malnutrition covers both undernutrition and over nutrition, including micronutrient deficiencies.[1] According to the WHO, malnutrition is an imbalance between nutrient supply and the body's needs for growth and function.[2] Globally, about one-third of the population is underweight, one-third is overweight, and one-third has normal weight.[2]

Malnutrition weakens children's immunity, increasing their risk of infections, which in turn can worsen malnutrition, creating a vicious cycle.[1] Approximately 45 million children under five suffer from wasting, 149 million have stunted growth, and 39 million are overweight. The prevalence of malnutrition is particularly high in South East Asia.[3]

From 1990 to 2021, under-five deaths declined from 12.6 million to 5 million, but malnourished children still face higher risks of death from common illnesses.[4] According to the National Family Health Survey 5, 19.3% of children under five years old are wasted, and 7.7% are severely wasted.[5] The WHO and UNICEF reported in 2009 that children with a weight-for-height below -3 SD based on WHO standards have a more than ninefold increased risk of death compared to children with a weight-for-height above -3 SD.[6] India accounts for 29.4% of the world's underweight children[3] and was ranked 107th out of 121 countries on the Global Hunger Index during 2019-2021, placing it in the alarming category.[7] India ranks third in child malnutrition globally, following Nepal and Bangladesh.[8] Each year, 5 million children worldwide die before the age of five, with one-third of these deaths attributable to undernutrition.[2] The infant mortality rate in India is 35.2 per 1,000 live births, with an under-five mortality rate of 41.9 per 1,000 and a neonatal mortality rate of 24.9 per 1,000.[9]

Rural children are more likely to be underweight than urban children. Although malnutrition is not a direct cause of death, it significantly increases morbidity and mortality by lowering infection resistance, contributing to 68.2% of deaths in children under five.[3][10] In Gujarat, according to NFHS 4 (2015-16) 38.5% were stunted, 39.3% were underweight, and 26.4% were wasted among children under five.[11]

The nutritional status of children is a globally recognized indicator of national development, reflecting both the

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inputs and outcomes of developmental processes. Malnutrition manifests in two extreme forms: severe undernutrition and overweight/obesity.[1]

Nutritional assessment includes seven primary components: anthropometric measurements, biochemical and laboratory parameters, clinical evaluation, dietary history, epidemiological/ecological factors, functional assessment, and growth monitoring.[12] Severe acute malnutrition is defined by a weight-for-height/length z-score less than -3 SD of the WHO median, a mid-upper arm circumference (MUAC) less than 11.5 cm, or the presence of nutritional edema.[13] Moderate acute malnutrition is characterized by a weight-for-height z-score between -3 SD and -2 SD or a MUAC of 11.5-12.5 cm without edema.[13]

MUAC and weight-for-height z-scores are commonly used anthropometric parameters for assessing nutritional status. MUAC is a quick and simple method using a colored plastic strip, while weight-for-height requires precise measurements of both weight and height to be plotted on growth charts.

This study aims to assess the nutritional status of children aged 6 months to 5 years admitted to a tertiary care hospital and to evaluate the correlation between MUAC and weight-for-height z-scores in assessing the nutritional status of these children.

Materials and Methods

This cross-sectional observational study was conducted in a pediatric ward of a tertiary care hospital from January to March 2022. It aimed to assess the nutritional status of children aged 6 months to 5 years. Inclusion criteria were the specified age range and caregiver consent; exclusion criteria were cerebral palsy and upper limb deformities. A total of 270 children met the criteria. After obtaining caregiver consent, data collection began. Each child was examined by a clinician, following standard treatment protocols. Collected data included demographics, presenting complaints, birth history, vaccination status, family history, and feeding history.

Anthropometric measurements followed standardized methods. Weight was measured with a digital scale, length for children under two with an infantometer, and height for those over two with a stadiometer. Mid-upper arm circumference (MUAC) was measured at the midpoint between the acromion and olecranon process on the left upper arm. Nutritional status was assessed using MUAC and weight-for-height z-scores. Severe acute malnutrition (SAM) was a z-score less than -3 SD, and moderate acute malnutrition (MAM) was between -2 SD and -3 SD. SAM was indicated by MUAC less than 11.5 cm, and MAM by MUAC between 11.5 cm and 12.5 cm. MUAC measurements were compared to weight-for-height z-scores, the gold standard. Measurements were taken by a single observer for consistency. Data was recorded on a standardized proforma, entered Microsoft Excel, and analyzed using statistical software.

Results

Table 1: Demographic details of study participants (N=270)

Variable		Total No. (%) N=270
Gender	Male	150 (55.5%)
	Female	120 (44.5%)
Age group	6 months — 2 years	147 (54.5%)
	2 years- 5 years	123 (45.5%)
Anemia Profile	No Anemia	78 (28.9%)
	Mild Anemia	83 (30.7%)
	Moderate Anemia	100 (37.0%)
	Severe Anemia	9 (3.3%)

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In our study involving 270 children, the gender distribution showed a slight predominance of male children, with 150 males (55.5%) compared to 120 females (44.5%). Age-wise, the children were evenly distributed between two age groups: 147 children (54.5%) were between 6 months and 2 years old, while 123 children (45.5%) were between 2 and 5 years old.

Regarding the anemia profile, the majority of the children were found to have some degree of anemia. Specifically, 83 children (30.7%) had mild anemia, 100 children (37.0%) had moderate anemia, and 9 children (3.3%) suffered from severe anemia. Meanwhile, 78 children (28.9%) were not anemic. These findings highlight that moderate anemia was the most prevalent condition among the children studied.

Table 2: Detection of Malnutrition by both Z score method and MUAC (N=270)

Malnutrition status	Z SCORE (n=270) No. (%)	MUAC (n=270) No. (%)	p value
SAM	51 (18.8%)	36 (13.3%)	0.21 (x^2=3.09, df-2)
MAM	91 (33.7%)	98 (36.4%)	
Normal	128 (47.5%)	136 (50.3%)	

The study evaluated malnutrition in 270 children using both the Z score and MUAC methods. The Z score method identified 51 children (18.8%) with Severe Acute Malnutrition (SAM), while the MUAC method identified 36 children (13.3%) with SAM, For Moderate Acute Malnutrition (MAM), the Z score method detected 91 children (33.7%), and the MUAC method identified 98 children (36.4%). Among children classified as normal, the Z score method identified 128 children (47.5%), compared to 136 children (50.3%) identified by the MUAC method. These findings indicate a high level of agreement between the two methods, with minor differences in the prevalence rates for each category but, showing no significant difference between the methods (p=0.21, χ^2=3.09, df=2).

Table 3: Gender Distribution in both Malnutrition detection method (N=270)

Gender Distribution	Z SCORE (n=270)			MUAC (n=270)		
	Malnourished child	Normal child	p value	Malnourished child	Normal child	p value
Male	74 (27.4%)	76 (28.1%)	0.23 x^2=1.44, df-1	69 (25.6%)	81 (30.0%)	0.18 x^2=1.78, df-1
Female	68 (25.2%)	52 (19.3%)		65 (24.1%)	55 (20.4%)	
Total	142 (52.6%)	128 (47.4%)		134 (49.6%)	136 (50.4%)	

The evaluation of gender distribution in our study involving 270 children revealed that 150 (55.5%) were male and 120 (44.5%) were female, indicating a predominance of male children. Among the 51 SAM (Severe Acute Malnutrition) children, 22 (43.1%) were male and 29 (56.8%) were female. Of the 91 MAM (Moderate Acute Malnutrition) children, 52 (57.1%) were male and 39 (42.9%) were female. Among the 128 well-nourished children, 76 (59.3%) were male and 52 (40.7%) were female.

According to MUAC criteria, among the 36 SAM children, 13 (36.1%) were male and 23 (63.9%) were female. Of the 98 MAM children, 56 (57.1%) were male and 42 (42.9%) were female. Among the 136 well-nourished children, 81 were male and 55 were female.

There was no significant association between malnutrition and gender (p > 0.05).

Table 4: Study of agreement between MUAC & Z Score for detection of SAM (N=270)

Nutritional Status SAM by MUAC	Nutritional Status SAM by Z score		
	YES	NO	Total
YES	35	1	36
NO	16	218	234
Total	51	219	270

Out of 51 children who were diagnosed as SAM by Z score method, 36 were also diagnosed as SAM by

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MUAC method. So, agreement between these two methods to detect SAM was found to be 93.7%. (Kappa=0.768). Value of kappa between 0.6 to 0.8 indicates substantial agreement between two methods.

Table 5: Study of agreement between MUAC & Z Score for detection of SAM (N=270)

Nutritional Status MAM by MUAC	Nutritional Status MAM by Z score		
	YES	NO	Total
YES	72	26	98
NO	19	153	172
Total	91	179	270

The agreement between the MUAC method and the Z score method for detecting MAM was found to be 83.3%, with 72 out of 91 children diagnosed as MAM by the Z score method also being diagnosed as MAM by the MUAC method (Kappa=0.634). A kappa value between 0.6 and 0.8 indicates substantial agreement between the two methods.

Table 6: Statistical analysis of MUAC method in comparison to Z SCORE in SAM patients, MAM patients, and in all Malnourished patients

Malnutrition status	Sensitivity	Specificity	Positive Predicti-ve Value	Negative Predictive Value
SAM	67%	99%	94%	92%
MAM	78%	86%	74%	88%
All malnourished patient	86%	90%	91%	85%

In this study, we calculated the sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of the MUAC method using various cut-offs, comparing them against the gold standard Weight-for-Height Z score. The sensitivity of the MUAC method for detecting SAM children was 67%, and for MAM children, it was 78%. The specificity was 99% for SAM children and 86% for MAM children.

Discussion

In this study, out of the total 270 children enrolled, 150 (55.5%) were male, indicating a predominance of male children over female children. The remaining 120 children were female. Age-wise, 147 children belonged to the 6 months to 2 years age group, while the remaining 123 (45.5%) children were in the >2 to 5 years age group, reflecting an almost equal age distribution.

Bari et al.[14] found a higher prevalence of malnutrition in male children (52.5%) compared to female children (47.5%). Similarly, a study by Praveen Kumar et al.[15] (2018) conducted in five districts of India found that out of 2127 children, 728 were in the 6 months to 2 years age group, and 1339 were in the 2 to 5 years age group, corroborating the age distribution observed in our study.

Anemia was observed in 192 out of 270 children. Among the anemic children, 9 suffered from severe anemia, 100 from moderate anemia, and 83 from mild anemia. Leidman et al.[16] reported an anemia prevalence of 47.9% in a study of 269 children, while the NFHS 5[17] (2019-2021) survey indicated that 67.1% of children aged 6 months to 5 years in India were anemic.

In this study, categorization of the 270 children using Z scores revealed that 128 (47.5%) were in the normal category, followed by those in the MAM (Moderate Acute Malnutrition) category. Among the remaining children, 51 (18.8%) were classified as SAM (Severe Acute Malnutrition). Visible wasting was observed in 77 (28.5%) children, and edema was present in 2 (3.9%) children.

Using MUAC (Mid-Upper Arm Circumference) measurements, 36 (13.3%) children were found to be

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suffering from severe acute malnutrition (MUAC <11.5 cm), 98 (36.3%) children were identified with moderate acute malnutrition (MUAC 11.5-12.5 cm), and 136 (50.3%) children were categorized as normal. Overall, 134 (49.7%) children were classified as malnourished according to MUAC criteria. Comparatively, the NFHS 5 data (2019-2021)[17] reported a prevalence of 19.3% for wasted children and 7.7% for severely wasted children. The National Family Health Survey (2015-2016) data for Gujarat indicated that 26.4% of children under five were wasted, and 9.5% were severely wasted.[11]A study by Bari et al.[14] using the MUAC method observed that 26% of children were in the MAM category and 34.2% were in the SAM category, with a total malnutrition prevalence of 60.2%, which is higher compared to our findings.

The evaluation of gender distribution in our study involving 270 children revealed that 150 (55.5%) were male and 120 (44.5%) were female, indicating a predominance of male children. Among the 51 SAM (Severe Acute Malnutrition) children, 22 (43.1%) were male and 29 (56.8%) were female. Of the 91 MAM (Moderate Acute Malnutrition) children, 52 (57.1%) were male and 39 (42.9%) were female. Among the 128 well-nourished children, 76 (59.3%) were male and 52 (40.7%) were female. There was no significant association between malnutrition and gender ($p > 0.05$). This finding aligns with the survey by Md Iqbal Hossain et al.[18], which showed no significant gender differences, with the prevalence of undernourished male children at 56.5% and female children at 43.5%.

According to MUAC criteria, among the 36 SAM children, 13 (36.1%) were male and 23 (63.9%) were female. Of the 98 MAM children, 56 (57.1%) were male and 42 (42.9%) were female. Among the 136 well-nourished children, 81 were male and 55 were female.

In this study, we calculated the sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of the MUAC method using various cut-offs, comparing them against the gold standard Weight-for-Height Z score. The sensitivity of the MUAC method for detecting SAM children was 67%, and for MAM children, it was 78%. The specificity was 99% for SAM children and 86% for MAM children. Talapalliwar MR et al.[19] found that the sensitivity for diagnosing SAM using the WHO-recommended MUAC cutoff of <11.5 cm was 13.6%, with a specificity of 99.3%. For diagnosing MAM with a MUAC cutoff of <12.5 cm, the sensitivity was 23.7%, and the specificity was 97.5%. The sensitivity of MUAC for detecting malnutrition in our study was higher compared to these findings. The specificity of MUAC in our study was high and comparable to other studies. Lambebo A et al.[20] also observed that the sensitivity of MUAC is generally lower than its specificity for detecting SAM and can vary by region. Our findings indicate that the MUAC method demonstrates high specificity and relatively higher sensitivity in detecting malnutrition in our study population, aligning with these observations.

The agreement between the MUAC method and the Z score method for detecting MAM was found to be 83.3%, with 72 out of 91 children diagnosed as MAM by the Z score method also being diagnosed as MAM by the MUAC method (Kappa=0.634). A kappa value between 0.6 and 0.8 indicates substantial agreement between the two methods. For detecting SAM, the agreement was 93.7%, with 36 out of 51 children diagnosed as SAM by the Z score method also being diagnosed as SAM by the MUAC method (Kappa=0.768). This kappa value also

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indicates substantial agreement between the two methods. These findings align with the study by Tadesse AW et al.[21], which reported an overall good agreement between the MUAC method and the Weight-for-Height Z score method. The substantial agreement observed in our study suggests that MUAC is a reliable method for diagnosing both MAM and SAM in children.

Conclusion

The study's findings reveal significant insights into malnutrition prevalence, gender distribution, and detection methods among children. Despite a slight male predominance in the study, gender did not substantially influence malnutrition prevalence, with both male and female children experiencing similar rates of malnutrition across categories of Severe Acute Malnutrition (SAM), Moderate Acute Malnutrition (MAM), and well-nourished states. Additionally, the study demonstrated substantial agreement between the Z score and Mid-Upper Arm Circumference (MUAC) methods in identifying malnutrition, highlighting the reliability of MUAC as an alternative screening tool. Notably, MUAC exhibited higher sensitivity compared to previous studies, indicating its effectiveness in detecting malnutrition, alongside a high specificity consistent with existing research. These findings underscore the importance of implementing practical and reliable malnutrition screening approaches, particularly in resource-limited settings, to facilitate early intervention and improve child health outcomes. Overall, the study contributes valuable insights into malnutrition management strategies, emphasizing the significance of timely intervention for addressing malnutrition's adverse effects on child health and development.

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