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Relevance of Mid Arm Circumference with Mid Thigh Circumference in Identifying Protein Energy Malnutrition in Children 1 To 5 Years of Age

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Abstract

Protein-energy malnutrition (PEM) remains one of the leading causes of morbidity and mortality among children under five years of age, particularly in low- and middle-income countries. This condition results from inadequate intake of protein and energy, compounded by recurrent infections and socio-economic disparities. Early identification and timely intervention are crucial for improving health outcomes and reducing long-term developmental impairments associated with PEM.

This study investigates the diagnostic relevance of Mid Arm Circumference (MAC) and Mid-Thigh Circumference (MTC) in identifying PEM among children aged 1 to 5 years. Conducted at the Kempegowda Institute of Medical Sciences, Bengaluru, the research involved 60 children. Anthropometric measurements including MAC, MTC, weight, height, and head circumference were assessed following WHO guidelines. Statistical analyses such as chi-square tests and Receiver Operating Characteristic (ROC) curve evaluations were employed to determine the sensitivity, specificity, and overall diagnostic accuracy of these tools.

The findings revealed a high prevalence of PEM (66.7%) in the study population. MTC emerged as a highly reliable diagnostic measure, demonstrating a sensitivity of 95% and specificity of 100%, significantly outperforming MAC, which showed a sensitivity of 67.5%. Correlations between PEM grades and other anthropometric indices such as weight-for-height and height-for-age were statistically significant ($p < 0.001$).

The study highlights MTC's potential as an accurate, accessible, and cost-effective screening tool for PEM in resource-limited settings. Its integration into community health programs could enhance early detection, enabling timely interventions and reducing the burden of

malnutrition. While MAC remains a valuable metric, incorporating MTC into standard pediatric assessments is recommended. Further large-scale studies are essential to validate these findings and optimize PEM screening protocols.

Keywords: Protein-energy malnutrition, mid-arm circumference, mid-thigh circumference, anthropometry, child nutrition

Introduction

Malnutrition is a pervasive global health concern, particularly in developing regions, where it continues to claim millions of lives annually. Among children under five years of age, malnutrition is one of the leading causes of morbidity and mortality, often compounded by infections and socio-economic disadvantages. Protein-energy malnutrition (PEM), a critical form of malnutrition, is a condition arising from insufficient intake of protein and energy. This condition is preventable, yet it remains alarmingly prevalent, particularly in low-income regions such as South Asia, Sub-Saharan Africa, and parts of Latin America. Addressing PEM requires an integrated approach involving prevention, early detection, and effective treatment. Early identification is especially crucial for timely intervention to mitigate the long-term impacts of malnutrition.

The Burden of PEM: A Global and Regional Perspective

Globally, approximately 45 million children under five suffer from wasting, with an additional 149 million experiencing stunted growth, according to the World Health Organization (WHO). These statistics underline the massive scope of PEM and the need for targeted interventions. The prevalence of PEM is particularly high in South Asia, where one-third of the global burden is concentrated, followed by Sub-Saharan Africa. Factors such as inadequate breastfeeding practices, poor complementary feeding, maternal malnutrition, and recurrent childhood infections drive these high rates.

In India, for example, malnutrition remains a pressing issue despite decades of government programs. According to the National Family Health Survey (NFHS-5), nearly one in three children under five are stunted, and one in five are wasted. These figures illustrate the persistent gaps in nutritional interventions and the urgent need for effective diagnostic and preventive strategies.

Challenges in Detecting PEM

Timely and accurate detection of PEM is essential for early intervention and improved health outcomes. However, the diagnostic landscape for PEM presents significant challenges. Traditionally, anthropometric indices such as weight-for-height, weight-for-age, and height-for-age have been used to assess nutritional status. Each of these measures has limitations:

- Weight-for-height is sensitive to acute malnutrition but does not capture long-term deficits.
- Height-for-age is a marker of chronic malnutrition but cannot diagnose immediate nutritional risks.
- Weight-for-age combines both parameters but may miss specific nutritional deficiencies.

Additionally, these indices require precise measurements and age or height data, which are not always readily available in resource-limited settings.

Mid Upper Arm Circumference (MUAC) has emerged as a simple and effective screening tool for PEM. It is particularly useful in community and emergency settings due to its ease of use and minimal resource requirements. However, MUAC also has limitations, such as reduced sensitivity in detecting moderate

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malnutrition and challenges in monitoring nutritional recovery. These gaps necessitate the exploration of supplementary or alternative tools to enhance PEM diagnosis.

The Case for Mid-Thigh Circumference (MTC)

Recent research highlights the potential of Mid-Thigh Circumference (MTC) as a reliable anthropometric measure for PEM detection. MTC reflects skeletal muscle and fat reserves, providing a direct indicator of nutritional status. Muscle wasting is a hallmark of PEM, particularly in marasmus, making MTC a valuable tool for identifying malnutrition. Unlike MUAC, which remains relatively stable between the ages of one and five, MTC is dynamic and better captures variations in body composition.

MTC also has advantages in terms of accessibility and feasibility. Like MUAC, it can be measured using simple, portable tools, making it suitable for large-scale screenings in resource-constrained environments. The diagnostic accuracy of MTC, especially when used alongside MUAC, holds promise for improving early detection and intervention strategies.

Study Context and Relevance

The critical developmental period of 1 to 5 years of age represents a window of opportunity for nutritional interventions. During this stage, children are particularly vulnerable to the effects of malnutrition, yet they also have the greatest potential for recovery if timely interventions are implemented.

This study focuses on evaluating the relevance of MTC and MUAC in detecting PEM among children aged 1 to 5 years in Bengaluru, Karnataka. By comparing these measures' sensitivity, specificity, and diagnostic accuracy, the research aims to provide evidence for their combined use in routine pediatric assessments.

Anthropometry as a Diagnostic Tool

Anthropometry, the measurement of the human body, is the cornerstone of nutritional assessment. Its non-invasive, inexpensive nature makes it indispensable in public health. Anthropometric measures like MUAC and MTC enable the identification of malnutrition, monitoring of recovery, and planning of nutritional interventions.

MUAC is widely accepted for its simplicity and effectiveness in community settings. It correlates strongly with weight-for-height and serves as a reliable predictor of mortality risk in malnourished children. However, its inability to capture nuanced changes in muscle and fat composition limits its utility in certain contexts.

MTC, on the other hand, provides a more comprehensive picture of body composition by assessing muscle mass and subcutaneous fat. This study contributes to the growing body of evidence supporting MTC as a complementary tool to MUAC, particularly in resource-limited settings.

Significance of the Study

The findings of this study have significant implications for public health, particularly in regions with high PEM prevalence. By demonstrating the diagnostic potential of MTC, the research aims to inform guidelines for early PEM detection and management. Integrating MTC into community health programs could enhance the accuracy of malnutrition screenings, ensuring timely and targeted interventions.

Moreover, the study highlights the importance of anthropometric innovation in addressing malnutrition. While MUAC remains a valuable metric, the addition of MTC could bridge existing gaps in PEM diagnosis, improving outcomes for millions of children worldwide.

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Materials and Method

Study Design This was a descriptive study conducted in the both outpatient and In- patient Department (IPD) of tertiary hospital over a period of 18 months, from November 2022 to June 2024.

Study Setting: The study was carried out at the Kempegowda Institute of Medical Sciences, Bangalore.

Study Population The study focused on children aged between 1 year to 5 years

Inclusion Criteria

- Both out patients and IN patients of age group in between 1 to 5 years attending to KIMS hospital

Exclusion Criteria

- Children who are critically ill
- Children with any syndromic features

Methods of Collection of Data

Consent and Participant Selection

- **Informed Consent**: Written informed consent was obtained from the parents or guardians of each child after the study's nature, objectives, and procedures were explained in detail.
- **Inclusion and Exclusion Criteria**: Children aged 1-5 years who met the study's inclusion criteria were enrolled. Children with chronic illnesses or conditions affecting growth were excluded from the study.

Data Collection

- **Personal and Family Information**
- **Anthropometric Measurements**

The study followed standardized techniques recommended by Jelliffe for anthropometric assessments.

1. **Mid-Arm Circumference (MAC)**:

- MAC was measured on the left arm, at the midpoint between the acromion process of the shoulder and the olecranon process of the elbow. The arm was uncovered, and a measuring tape was gently placed around the arm, ensuring it wasn't pressing into the soft tissues.

2. **Mid-Thigh Circumference (MTC)**

- The procedure for measuring MTC begins by first determining the midpoint of the thigh. The upper leg length is measured, and a mark is made at the midpoint between the inguinal crease (just below the anterior superior iliac spine) and the middle of the patella.
- The child was instructed to stand with weight on the left leg, with the right leg forward and knee slightly bent. The measuring tape was placed around the marked midpoint of the thigh, ensuring that it was perpendicular to the long axis of the leg, and the measurement was recorded to the nearest 0.1 cm. The tape was rested firmly on the skin but not compressed.

Statistical Analysis

- The data were analyzed using SPSS 20.0 software for statistical analysis.
- Categorical variables (e.g., gender, PEM grade) were presented as frequencies and percentages.
- Continuous variables (e.g., age, anthropometric measurements) were presented as mean ± standard deviation (SD).
- The association between categorical variables was analyzed using the Chi-square test to determine any significant differences.
- To determine the diagnostic cutoff for MTC, Receiver Operating Characteristic (ROC) analysis was performed.

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- A p-value of less than 0.05 was considered statistically significant for all tests, indicating that observed differences were unlikely to be due to chance

Results

Prevalence of Protein-Energy Malnutrition (PEM)

The study included 60 children aged 1-5 years, and 66.7% of the children were diagnosed with Protein-Energy Malnutrition (PEM). This high prevalence indicates the ongoing nutritional challenges faced by children in the target age group. Among these children, varying degrees of PEM were observed, including both acute and chronic forms, as well as mixed malnutrition (marasmic-kwashiorkor).

Diagnostic Accuracy of Mid-Thigh Circumference (MTC) and Mid-Arm Circumference (MAC)

- Mid-Thigh Circumference (MTC) showed exceptional diagnostic value with:
  - AUC (Area Under the ROC Curve) = 0.992, which represents an almost perfect ability to distinguish between children with and without PEM.
  - Sensitivity of 95% and Specificity of 100%, meaning that MTC was able to correctly identify nearly all children with PEM, and no false positives were recorded.
- Mid-Arm Circumference (MAC), while useful, showed:
  - 67.5% Sensitivity and 100% Specificity, indicating that MAC was less sensitive in detecting PEM but had perfect specificity.

These findings highlight MTC as a highly reliable tool for screening PEM, especially in environments with limited resources.

Table 1:Mid-Arm Circumference (MAC) and PEM

Mid arm circumference	GRADE OF PEM					Total	Chi sqaure	p value
	Normal	Grade I	Grade II	Grade III	Grade IV			
Moderateacute malnutrition	0	9	5	6	1	21	28.105	p<0.001
	0.0%	42.9%	23.8%	28.6%	4.8%	100.0%		
Normal	20	6	3	4	0	33		
	60.6%	18.2%	9.1%	12.1%	0.0%	100.0%		
Severe acute malnutrition	0	2	3	1	0	6		
	0.0%	33.3%	50.0%	16.7%	0.0%	100.0%		
Total	20	17	11	11	1	60		
	33.3%	28.3%	18.3%	18.3%	1.7%	100.0%		

This table shows the diagnostic performance of MAC in identifying different grades of PEM. It was found that MAC is particularly useful for detecting severe malnutrition but less so for detecting moderate malnutrition.

Test Variables for MTC

This table presents the test variables used for MTC, including sensitivity, specificity, and positive predictive values, which demonstrated MTC's high diagnostic performance

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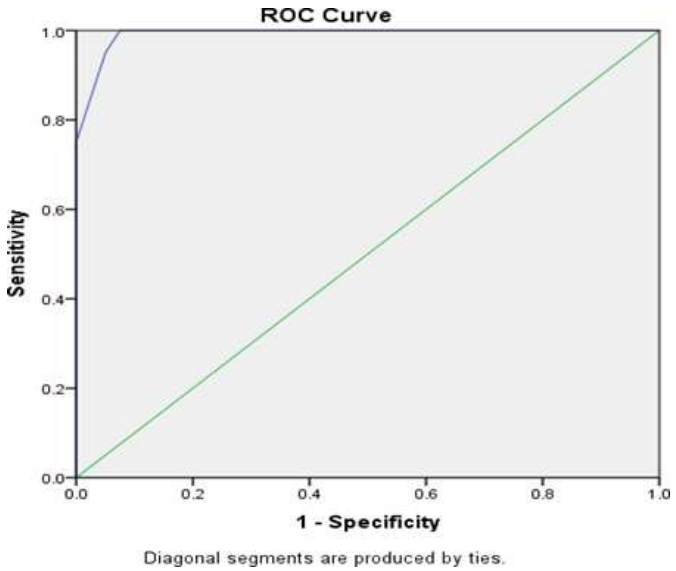

ROC Curve for MTC

The ROC curve for MTC highlights its diagnostic accuracy. The curve confirms that MTC is a highly sensitive and specific method for identifying PEM, with an AUC close to 1, which is considered ideal.

Table 2:

Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval		Cut off
			Lower Bound	Upper Bound	
.992	.007	.000	.977	1.000	25.5

Statistical Analysis and Correlations

- **Chi-Square Test**: Significant associations were found between family size, parental education, and occupation, and the severity of PEM.
- **ROC Curve Analysis**: The ROC analysis provided clear evidence that MTC is a superior diagnostic tool for PEM compared to MAC, with both showing high specificity but MTC outperforming MAC in sensitivity.

Our study revealed that 66.7% of children in the study population diagnosed with PEM, Of the children diagnosed with PEM, 28.3% were classified as Grade I, 18.3% as Grade II, 18.3% as Grade III, and 1.7% as Grade IV. This high prevalence underscores the nutritional crisis faced by children in this age group and highlights the urgent need for efficient screening methods. The high rates of malnutrition observed in our study are consistent with previous research conducted in similar regions, including a study by Pravana et al. in Nepal, where high levels of underweight and stunting were reported among children under five years old. living in a low-resource setting—may have contributed to the observed disparity.

Age and Gender Distribution in PEM Prevalence

The study showed that the majority of affected children were in the 12-24 months age group (55%), followed by the 25-36 months group (20%). This finding is consistent with other studies that show the highest prevalence of malnutrition in children between 12 and 24 months. This age group is particularly vulnerable to malnutrition due to rapid growth, increasing energy needs, and often inadequate or improper complementary feeding practices.

In terms of gender distribution, the study found that 55% of participants were male, and 45% were female. However, notable differences were observed in the distribution of PEM grades across genders. A larger percentage of females (29.6%) were classified as having Grade III PEM compared to males (9.1%). This gender disparity warrants further investigation, as it could indicate a need for gender-specific nutritional interventions. Chowdhury et al. reported similar findings in Bangladesh, where girls were found to be more likely to suffer from stunting and undernutrition than boys, highlighting the importance of considering gender in nutritional assessments and interventions.

Relevance of Mid-Arm Circumference (MAC) in Identifying PEM

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Our study demonstrated that Mid-Arm Circumference **(MAC)** is a valuable tool for identifying PEM in children aged 1-5 years. With a sensitivity of 67.5% and specificity of 100%**,** MAC was particularly effective in correctly identifying children who did not have PEM, but it had moderate sensitivity in detecting all malnourished children. The high specificity indicates that MAC is a reliable tool for ruling out PEM but may not detect all cases, particularly those of moderate malnutrition**.**

This performance is consistent with findings from Bilukha et al.**,** who reported similar sensitivity and specificity for MAC in detecting acute malnutrition in children aged 6-59 months. Our lower sensitivity compared to some studies may be attributed to differences in the study population, geographical location, or specific cutoff values for MAC. Interestingly, MAC performed better in detecting severe acute malnutrition (SAM)**,** with a sensitivity of 61.76%**,** as compared to moderate acute malnutrition (MAM)**,** which had a sensitivity of just 31.58%**.** This suggests that MAC is more effective in identifying children with severe forms of PEM, a finding that aligns with other studies, such as Tadesse et al. (2014), where MAC showed better sensitivity for SAM than for MAM.

Relevance of Mid-Thigh Circumference (MTC) in Identifying PEM

One of the most significant findings of this study was the diagnostic performance of Mid-Thigh Circumference (MTC)**.** With an Area Under the Curve (AUC) of 0.992**,** MTC demonstrated excellent diagnostic accuracy. It showed a sensitivity and specificity of 95%**,** which suggests that MTC is highly effective in both detecting malnutrition and confirming its absence. The positive predictive value (PPV) of **97%** and negative predictive value (NPV) of **90%** further demonstrate its robustness in screening for PEM.

This high diagnostic accuracy of MTC aligns with findings from other studies, such as Jain et al.**,** who reported that MTC is strongly correlated with other anthropometric measures, and Ahmed et al.**,** who found it to be a reliable alternative to traditional measures like weight-for-height. The optimal cutoff for MTC in our study was determined to be 25.5 cm, which provided the best balance of sensitivity and specificity for identifying PEM. This cutoff can serve as a reference point for future research and community-based screening programs, though further validation in diverse populations is recommended.

Comparison between MAC and MTC

When comparing MAC and MTC, both measures showed high specificity (100% for MAC, 95% for MTC), but MTC demonstrated superior sensitivity (95%) compared to MAC (67.5%). This suggests that MTC is more effective in identifying a broader range of malnutrition cases, including those of mild-to-moderate severity that MAC might miss. The findings support the idea that MTC could complement MAC in improving overall diagnostic accuracy. While MAC remains a useful tool, combining MTC with MAC may provide a more comprehensive nutritional assessment, capturing both protein and energy deficits more effectively.

These results are consistent with studies by Sultana et al.**,** which found that MTC showed stronger correlations with weight-for-height Z-scores than MAC. However, the relative effectiveness of MAC and MTC may vary depending on population characteristics and the specific setting, suggesting the importance of validating these tools in different regions.

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Strengths and Limitations of the Study

The study's strengths include its comprehensive anthropometric assessments, the use of ROC curve analysis, and the inclusion of socioeconomic factors. However, limitations include a small sample size, the study being single-center, and the lack of biochemical markers to assess micronutrient deficiencies. Additionally, the cross-sectional design limits the ability to establish causal relationships, and the absence of detailed dietary patterns means that specific nutritional deficiencies could not be directly assessed.

Future research should focus on multi-center studies with larger sample sizes to validate these findings across diverse populations. Longitudinal studies are also needed to examine the predictive value of MAC and MTC for long-term health outcomes. Furthermore, combining anthropometric measures with dietary and biochemical markers could provide a more holistic approach to evaluating and addressing PEM in young children

Conclusion

Our study provides valuable insights into the relevance of MAC and MTC in identifying PEM among children aged 1 to 5 years. The findings suggest that both measures, particularly MTC, have strong diagnostic accuracy and could serve as effective screening tools in resource-limited settings. The high prevalence of PEM observed in our study population underscores the urgent need for effective nutrition interventions and highlights the potential utility of these anthropometric measures in identifying at-risk children.

Summary

Protein-Energy Malnutrition (PEM) is a major public health issue globally, particularly in developing countries. The World Health Organization (WHO) estimates that around 181.9 million children worldwide were malnourished as of 2000, with malnutrition contributing to about 60% of deaths in children, mainly due to infectious diseases. Despite ongoing global efforts, including initiatives like the Millennium Development Goals, malnutrition remains widespread, particularly in South Asia, where the rates of underweight and stunting among preschool children are still alarmingly high.

This study aimed to evaluate the effectiveness of two simple and cost-effective anthropometric measures—mid-arm circumference (MAC) and mid-thigh circumference (MTC)—as screening tools for identifying PEM in children aged 1 to 5 years. The study was conducted over 18 months at the Kempegowda Institute of Medical Sciences in Bangalore, and involved 60 children suspected of having PEM. The children were selected based on common indicators of malnutrition, and measurements such as height, weight, mid-upper arm circumference (MUAC), and mid-thigh circumference were taken. These measurements were then analyzed using z-scores to classify PEM based on weight-for-height z-scores (WHZ), MUAC, and MTC.

The study found a high prevalence of PEM in the sample population, with 66.7% of children diagnosed with some form of malnutrition. Among these, 28.3% were classified as Grade I PEM, 18.3% as Grade II, 18.3% as Grade III, and 1.7% as Grade IV. These findings align with previous studies, underscoring the persistent issue of malnutrition in vulnerable populations. The study also highlighted important socio-economic factors, noting that most of the parents in the study had a school-level education (86.7% of fathers and 81.7% of mothers), but despite this relatively high educational level, the prevalence of PEM remained significant. The

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occupational distribution showed that 58.4% of fathers were employed, while 90% of mothers were homemakers, which may influence the nutritional practices and household food security.

Regarding the diagnostic utility of MAC and MTC:

- MAC showed a sensitivity of 67.5% and a specificity of 100%. This suggests that while MAC is effective at confirming the absence of malnutrition (high specificity), it has moderate sensitivity and may miss cases of moderate malnutrition (MAM). MAC was more effective in detecting severe forms of malnutrition (SAM), with a sensitivity of 61.76% for SAM compared to 31.58% for MAM.
- MTC demonstrated excellent diagnostic accuracy with an Area Under the Curve (AUC) of 0.992, a sensitivity of 95%, and a specificity of 95%, making it a highly reliable tool for detecting PEM. Furthermore, it had a positive predictive value (PPV) of 97% and a negative predictive value (NPV) of 90%, indicating that MTC is effective in both identifying PEM and confirming the absence of malnutrition.

The study emphasizes the importance of MTC as a superior diagnostic tool compared to MAC, particularly due to its high sensitivity and specificity. The findings suggest that MTC is particularly useful for identifying a broader range of mild-to-severe cases of malnutrition, while MAC can serve as a valuable complementary tool, especially for confirming the absence of malnutrition. The combination of both measures could enhance the accuracy of nutritional assessments, making them more reliable for early detection and intervention in resource-limited settings.

In conclusion, the study supports the incorporation of MAC and MTC into routine screening programs for identifying protein-energy malnutrition in children. These measures are not only cost-effective and easy to use, but they also provide a reliable way to assess malnutrition in settings where more advanced diagnostic tools may be unavailable. MTC, in particular, emerged as a highly accurate and reliable indicator of malnutrition, and its use, along with MAC, could significantly improve early detection and management of malnutrition in vulnerable populations. The study's findings align with global research on the utility of these anthropometric measurements, reinforcing the potential of these simple tools to reduce the burden of PEM in children under five years of age.

References

1. Park K editor. Textbook of preventive and social medicine, 20th ed, Jabalpur Banarsidos bhanot 2009; 526-578.
2. Szajewska H, Warsaw. Malnutrition in developing countries- A changing face.Annals Nestle 2009; 67(2): 73-80.
3. Harishankar, Dwiwedi S, Dabral SB, Walia DK. Nutritional status of children under 6 years of age. Indian J Prev Soc Med 2004; 35(3&4): 156-162.
4. Grangnolati M, Shekhar M, Gupta MD, Brendenkamp C, Lee YK. India's undernourished children: A call for reform & action: What are the dimensions of under nutrition problem in India? The world bank; 2005; 1: 6.
5. Trowbridge, Frederick L, Staehling N. "Sensitivity and specificity of arm circumference indicator in identifying malnourished children" Am J Clin Nutr 1980; 33: 687-696.
6. Mathur JS, Mehrotra SK, Maheshwari BB. Nutritional disorder among children below Five years in a rural community. Indian J Pediatr 1974;

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41: 184.

7. UNICEF statistics, found at www.unicefi.org/ infobycountry/india_statistics.html
8. International Institute for Population Sciences (IIPS) and ICF. 2021. National Family Health Survey (NFHS-5), 2019-21: India. Mumbai: IIPS.
9. Jelliffe. "Arm circumference as a public health index of protein calorie malnutrition of early childhood". J Tropical Pediat 1989; 15: 179-189.
10. Sharma JN, Bora P. "Mid-Arm circumference as an index of protein energy malnutrition between 6-12 months of age". Ind Paed 1995; 35: 1005-1008.
11. Trowbridge, Frederick L, Staehling N. "Sensitivity and specificity of arm circumference indicator in identifying malnourished children" Am J Clin Nutr 1980; 33: 687-696.
12. Pravana NK, Piryani S, Chaurasiya SP, Kawan R, Thapa RK, Shrestha S. Determinants of severe acute malnutrition among children under 5 years of age in Nepal: a community-based case-control study. BMJ Open. 2017 Aug 28;7(8):e017084.
13. Bilukha O, Leidman E. Concordance between the estimates of wasting measured by weight-for-height and by mid-upper arm circumference for classification of severity of nutrition crisis: analysis of population-representative surveys from humanitarian settings. BMC Nutrition. 2018 May 24;4:24.
14. Tadesse AW, Tadesse E, Berhane Y, Ekström EC. Comparison of mid-upper arm circumference and weight-for-height to diagnose severe acute malnutrition: A study in Southern Ethiopia. Nutrients. 2017 Mar 1;9(3):267.
15. Jain V, Fernandes S, Jain S, Saxena A. Mid upper arm circumference as a screening tool for identifying children with low birth weight and at risk of childhood malnutrition: A community-based study from India. J Family Med Prim Care. 2020 Jun 30;9(6):2914-2918.
16. Siddiqa M, Shah GH, Mayo-Gamble TL, Zubair A. Determinants of Child Stunting, Wasting, and Underweight: Evidence from 2017 to 2018 Pakistan Demographic and Health Survey. Kamath R, editor. Journal of Nutrition and Metabolism. 2023 Mar 4;2023:1–12.Soumyajit Maiti, Kazi Monjur Ali, Ghosh D, Paul S. Assessment of Head Circumference among Pre-school Children of Midnapore Town, West Bengal using WHO (2007) Recommended Cut-off Points. DOAJ (DOAJ: Directory of Open Access Journals). 2012 Oct 1;

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