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Research Article

Concordance of Moderate and Severe Acute Malnutrition Diagnosis by Mid-Upper Arm Circumference and Weight-for-Height in Children Under Five Years of Age, Mérida-Venezuela

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Abstract

Objective: To evaluate the concordance between the diagnosis of moderate acute malnutrition (MAM) and severe acute malnutrition (SAM) obtained by mid-upper arm circumference (MUAC) and weight-for-height (WFH) in children under five years of age in Mérida, Venezuela.

Methodology: An observational, analytical, cross-sectional study was conducted. Variables included age, sex, weight, height, and MUAC. MUAC was assessed using UNICEF references, and WFH was based on World Health Organization (WHO) standards. ROC curves were used to establish the ideal cutoff value (CV), and the Kappa coefficient (k) was estimated to evaluate the agreement between indicators.

Results: 1,520 patients under 5 years were studied: 614 (40.3%) infants and 906 (59.7%) preschoolers. The mean age was 28.8 months. The optimal MUAC cutoff (MUAC-Mérida) was 13.55 cm for MAM and 12.95 cm for SAM. WFH diagnosed 116 children with MAM (100%). Of these, UNICEF-MUAC identified 33 children (28.4%), while Mérida-MUAC identified 91 (78.4%). For SAM, WFH classified 71 children (100%); 32 (45%) were identified by UNICEF-MUAC and 56 (78.9%) by Mérida-MUAC. Concordance between WFH and Mérida-MUAC for MAM was weak (k = 0.223) and moderate for SAM (k = 0.474).

Conclusion: These findings allow for the establishment of optimal cutoffs based on regional characteristics, suggesting an age- and sex-adjusted MUAC. We propose a community-level cutoff and a dual-indicator assessment in health centers for inclusion in feeding programs to avoid missing at-risk children.

Keywords: *Mid-Upper Arm Circumference; Weight-for-Height; Malnutrition; Children; Concordance*

Introduction

Acute malnutrition (AM) is a global public health issue, primarily prevalent in low-income countries [1,2]. It significantly increases the risk of morbidity and mortality in children under five years of age [3,4]. Studies demonstrate that early identification and management of malnourished children are crucial in preventing fatalities [5].

The general "gold standard" for identifying AM is the weight-for-height (WFH) Z-score. Unfortunately, factors such as complex tables, patient clinical status, and lack of specialized equipment often hinder the use of this indicator in field settings [6,7]. Consequently, screening methods must be simple, particularly at the community level. Mid-upper arm circumference (MUAC) is an easy, accurate, and low-cost indicator; as subcutaneous fat and muscle mass decrease in malnourished children, MUAC measurements also drop, making it a reliable indirect indicator for AM [8-11].

According to expert consensus, a WFH Z-score < -3 SD or a MUAC < 11.5 cm can be used independently to indicate severe acute malnutrition (SAM). For moderate acute malnutrition (MAM), the criteria are a WFH between $-2 and $-3 SD or a MUAC between 11.5 and 12.5 cm [12,13].

Although both WFH and MUAC aim to measure SAM, many studies have shown that these two indices do not always identify the same children. While some reports suggest a similar diagnostic magnitude-such as Bari., *et al*. [14], who found that 73.2% of hospitalized children were identified as SAM by MUAC compared to 70% by WFH-the WHO (2009) noted that only about 40% of children identified with AM were caught by both indicators simultaneously [15]. This diagnostic discrepancy has been observed globally [16-18]. Roberfroid., *et al*. [19] examined 14,409 children across four countries and found that only 28.5% of children defined as having AM met both MUAC and WFH criteria. Similarly, Grellety., *et al*. [20], analyzing data from 1.3 million children in 47 countries, observed that only 28.2% of AM cases and 16.5% of SAM cases were diagnosed by both indicators.

Further research by Fernández., *et al*. [21] reported that 75% of children with a WFH < -3 were not identified by a MUAC < 115 mm. Bilukha., *et al*. [22] observed in surveys from 41 countries that WFH-based wasting prevalence exceeded MUAC-based prevalence in 74.1% of cases. These discrepancies can lead to differing perceptions of malnutrition severity and the required intervention. Relying on a single criterion may lead to under-detection and deny treatment to a large proportion of children at high risk of death [23,24].

Given that these two indicators appear to correlate poorly and existing data predominantly come from other regions, the objective of this study was to determine the concordance between MUAC and WFH for detecting SAM and MAM in children aged 6 to 59 months in Mérida, Venezuela.

Methodology

Study design: An observational, analytical, cross-sectional study.

Population and sample: The participants were recruited in two phases: the first phase (January 2019 to June 2022) included 871 children, and the second phase (January 2024 to June 2024) included 649 children, for a total of 1,520 participants. Subjects were recruited from the Pediatric Emergency Service, the Nutrition and Growth Clinic, and the hospitalization areas of the Instituto Autónomo Hospital Universitario de los Andes (IAHULA), as well as from the pediatric clinic of the Ambulatorio Venezuela in Mérida, both of which are public institutions.

Inclusion and exclusion criteria: Infants and preschoolers aged 6 to 59 months were included. Subjects with a history of prematurity, genetic syndromes, or chronic diseases (such as endocrinopathies, heart disease, nephropathy, and other conditions that could alter nutritional variables) were excluded.

Procedures: Mothers and caregivers were informed of the study's purpose, and participation was voluntary. Anthropometric measurements were performed by trained personnel to minimize inter-observer error. Each measurement was taken in triplicate, and the average value was used for analysis. Demographic data (birth date, age, and sex) were recorded. Weight, height, and MUAC were measured using calibrated instruments following the standards of the International Biological Programme [25].

Nutritional status was assessed using the Weight-for-Height (WFH) indicator based on the WHO 2006 Z-score model (calculated using the WHO ANTHRO software). Classification:

- SAM: < -3SD
- MAM: -3 to < -2SD
- At risk of AM: -2 to <-1 SD
- Normal: -1 to < 1 SD
- Overweight/Obesity: > 1 SD.

For MUAC, UNICEF criteria were used:

- SAM: < 11.5 cm
- MAM: 11.5 - 12.5 cm
- At risk: 12.6 - $13.5 cm (A cutoff value [CV] of $14.05 cm for "at risk" was used based on a previous study [29]).

Children with edema were automatically classified as SAM. The sample was divided into infants (6-23 months) and preschoolers (2-5 years).

Statistical analysis: Results are presented in tables and graphs. The Mann-Whitney U test was used for continuous variables with non-normal distribution. Categorical variables were analyzed using the Chi-square test. Concordance was assessed using the Kappa index (k): poor (< 0.20), weak (0.21-0.40), moderate (0.41-0.60), good (0.61-0.80), and very good (0.81-1.00). Receiver Operating Characteristic (ROC) curves were constructed to determine the optimal MUAC CV for MAM and SAM. The Area Under the Curve (AUC) and Youden's Index (J = Sensitivity + Specificity - 1) were calculated. Significance was set at $p < 0.05$. Analysis was performed using SPSS Version 23.0.

Results

A total of 1,520 children were studied: 616 (40.3%) infants and 906 (59.7%) preschoolers. The sample was 48.8% male (n = 742) and 51.2% female (n = 778). The mean age was 28.80 months. The mean MUAC was 14.70 +/- 2.4 cm. Preschoolers showed significantly higher values for age, weight, height, and MUAC ($p < 0.0001$).

Nutritional diagnosis (WFH): 61% of participants had normal nutrition. 33% were malnourished (20% at risk of AM, 8% MAM, and 5% SAM). Overnutrition (at risk of overweight, overweight, and obesity) accounted for 7% (Figure 1).

Nutritional diagnosis (UNICEF-MUAC): 70% were classified as having no malnutrition. 30% were malnourished (18% at risk, 9% MAM, and 3% SAM) (Figure 2).

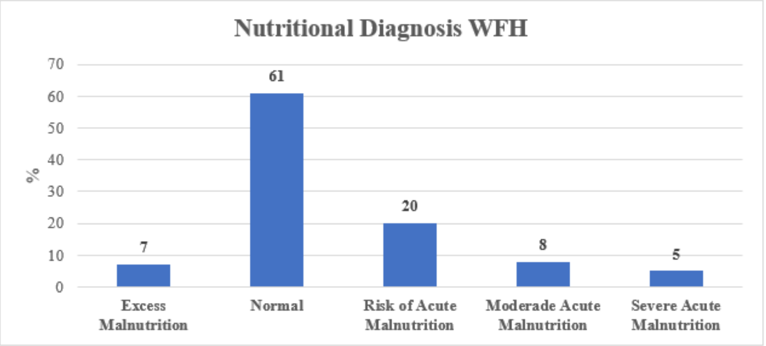

Figure 1: *Nutritional diagnosis based on Weight-for-Height (WFH) in the total sample. Percentages.*

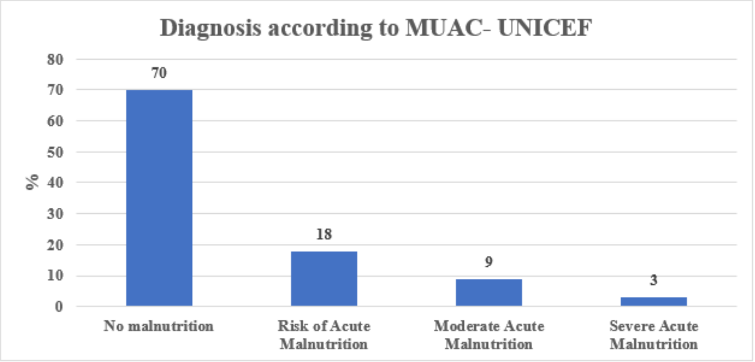

Figure 2: *Nutritional diagnosis based on Mid-Upper Arm Circumference (MUAC) by UNICEF criteria in the total sample. Percentages.*

MUAC cutoff values (ROC curve):

- **For MAM:** The Mérida-MUAC optimal CV was 13.55 cm (AUC 0.802; Sensitivity: 78.4%; Specificity: 73.9%; Youden Index: 0.524), which is considered good (Figure 3).

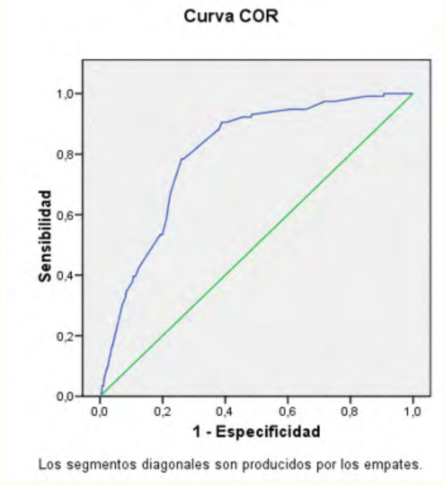

Figure 3: *ROC Curve for determining the MUAC (cm) cutoff value as a predictor of moderate acute malnutrition (MAM) in all children.*

AUC: 0.802; 95% CI: 0.767-0.838; Cutoff: 13.55 cm; Sensitivity: 78.4%; Specificity: 73.9%; Youden Index: 0.524.

- **For SAM:** The Mérida-MUAC optimal CV was 12.95 cm (AUC 0.899; Sensitivity: 78.9%; Specificity: 88%; Youden Index: 0.699), also considered good (Figure 4).

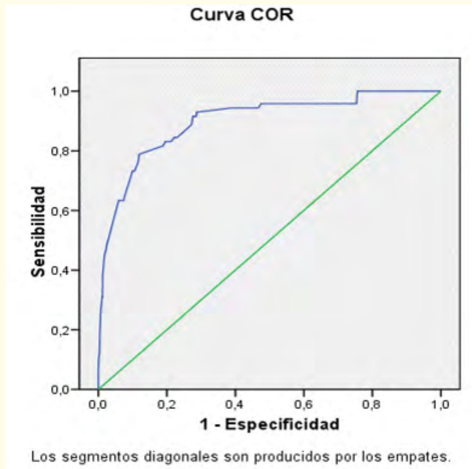

Figure 4: *ROC Curve for determining the MUAC (cm) cutoff value as a predictor of severe acute malnutrition (SAM) in all children.*

AUC: 0.899; 95% CI: 0.859-0.939; Cutoff: 12.95 cm; Sensitivity: 78.9%; Specificity: 88%; Youden Index: 0.699.

Prevalence and comparison

WFH identified 116 children with MAM (100%). UNICEF-MUAC (11.5-12.5 cm) identified only 33 of these (28.4%), while Mérida-MUAC (13.55 cm) identified 91 (78.4%). For SAM, WFH identified 71 children (100%). UNICEF-MUAC identified 32 (45.1%), whereas Mérida-MUAC identified 56 (78.9%) (Table 1).

Indicator	Malnutrition	n (%)
Moderate Acute Malnutrition	Weight-for-Height	116 (100)
	UNICEF-MUAC	33 (28.4)
	Mérida-MUAC	91 (78.4)
Severe Acute Malnutrition	Weight-for-Height	71 (100)
	UNICEF-MUAC	32 (45.1)
	Mérida-MUAC	56 (78.9)

Table 1: *Prevalence of moderate and severe acute malnutrition diagnosis by weight-for-height and cutoff values of UNICEF-MUAC and Mérida-MUAC in children aged 6 to 59 months, Mérida-Venezuela.*

Concordance

For MAM, the concordance between WFH and UNICEF-MUAC was poor ($k = 0.184$), while with Mérida-MUAC it was weak ($k = 0.223$). For SAM, the concordance between WFH and UNICEF-MUAC was weak ($k = 0.325$), but with Mérida-MUAC it was moderate ($k = 0.474$) (Table 2).

Indicator	Without Malnutrition n (%)	With Malnutrition n (%)	Kappa Value
Moderate malnutrition			
Weight-for-Height	1404 (92.4)	116 (7.6)	-
UNICEF-MUAC	1375 (90.5)	145 (9.5)	0.184 (Poor)
Mérida-MUAC	1063 (69.9)*	457 (30.1)*	0.223 (Weak)
Severe malnutrition			
Weight-for-Height	1449 (95.4)	71 (4.6)	-
UNICEF-MUAC	1462 (96.2)	58 (3.8)	0.325 (Weak)
Mérida-MUAC	1291 (84.9)**	229 (15.1)**	0.474 (Moderate)

Table 2: *Concordance in nutritional diagnosis (With and without moderate and severe malnutrition) by weight-for-height and mid-upper arm circumference (MUAC) using optimal Mérida cutoff values.*

**Weak Concordance / **Moderate Concordance.*

Discussion and Conclusion

WFH and MUAC are both used to assess children's nutritional status. Although these anthropometric indicators evaluate the same condition, relying on a single method may lead to the misdiagnosis of certain cases. Our analysis revealed a reasonable degree of agreement when children were categorized as malnourished by either WFH or MUAC criteria (33% vs. 30%), aligning with previous reports [14,15]. These findings differ from Ocheke., *et al*. [30] in Nigeria, who reported a SAM prevalence of 3.4% by WFH but only 1.5% by MUAC, suggesting that neither indicator should be used in isolation and proposing a redefinition of MUAC criteria.

Custodio., *et al*. [31] in Somalia found that among 12,170 children diagnosed with SAM by either WFH or MUAC, only 2,799 would have been identified by MUAC (<11.5 cm) alone, while 8,276 would have been identified by WFH (< -3) alone. They noted that age, sex, and stunting status affected the likelihood of diagnosis depending on the indicator used. Roberfroid., *et al*. [19] supported this by showing that MUAC detects 57.4% of AM in children under 2 years old but only 18.1% in older children, whereas WFH detection rates were more stable (75% to 65.8%). An alternative hypothesis suggests that WFH may over-diagnose AM in populations with longer legs, as argued by Briend., *et al*. [32]; however, this does not fully explain the discrepancies, which may stem from differences in body composition rather than linear growth.

Current MUAC cutoff values (CVs) may need to be increased to capture more cases of malnutrition. Laillou., *et al*. [33] in Cambodia emphasized that using only MUAC < 115 mm at the community level fails to diagnose over 90% of children with WFH < -3. They proposed a CV of 133 mm to include over 65% of children with low WFH. Fernández., *et al*. [21] suggested that a MUAC < 135 mm was optimal for identifying SAM, which is higher than the 12.95 cm identified in this study. In Bangladesh, Hossain., *et al*. [34] suggested age-specific MUAC CVs ranging from 120 mm to 140 mm. Similarly, Sougaijam., *et al*. [35] in India proposed increasing the SAM CV to 12.8 cm (close to our 12.95 cm) to ensure at-risk children are not overlooked. Other studies in Nepal [36], Ethiopia [37], and Pakistan [38] also suggest higher CVs, ranging from 12.5 cm to 13.9 cm.

Although this study focuses on Mérida, the CVs obtained are consistent with international literature. WFH and MUAC appear to identify different sets of malnourished children with minimal overlap. This suggests that each indicator measures different aspects of body composition; MUAC is strongly related to fat mass but poorly related to fat-free mass or total weight, while WFH cannot discriminate between fat and lean mass [39,40]. Since both fat and lean mass are critical for immune function and survival [41-43], these indicators should be considered independent and complementary rather than substitutes.

The diagnostic concordance for MAM between UNICEF-MUAC and WFH was poor (k = 0.184), and weak for Mérida-MUAC (k = 0.223). For SAM, concordance was weak with UNICEF-MUAC (k = 0.325) and moderate with Mérida-MUAC (k = 0.474). This suggests that standard CVs do not encompass all malnourished children, necessitating higher CVs to maximize diagnostic capacity and align with the gold standard (WFH) [43]. Low concordance, particularly in girls and older children, has been widely reported [19,21,44,46], though some studies in Ethiopia found better agreement (k = 0.729), supporting MUAC as an adequate tool for admission into outpatient feeding programs [45].

Discrepancies are often attributed to MUAC not accounting for age and sex. Age-adjusted MUAC (MUAC-for-age) might offer better concordance with WFH, but its complexity could limit community-level application [46,48]. While some studies found MUAC-for-age improved the identification of AM cases [31], others found it offered little advantage over conventional MUAC in general samples [44].

Due to its simplicity and low cost, MUAC remains essential for AM management. However, regional or national CVs adjusted for age and sex require further investigation. We propose a two-tier approach: using a community-managed CV for screening, followed by a clinical evaluation using both indicators in health centers to ensure inclusion in feeding programs without omitting at-risk children.

Ethical Responsibilities

The authors declare that no experiments on humans or animals were performed for this research.

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