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Mid-upper arm circumference (MUAC) for identification of nutritional status in pediatric clinical practice: a literature review

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Abstract

Childhood obesity and malnutrition are global public health concerns. In 2020, over 39 million children under 5 were overweight or obese. This narrative review explores the clinical utility of Mid-Upper Arm Circumference (MUAC) in pediatric nutritional assessment. A structured literature search was conducted in PubMed, Scopus, and Web of Science, covering studies from 1999 to 2025. Articles were selected based on relevance and methodological rigor. The review synthesizes historical evolution, validation studies, and clinical comparisons of MUAC with other anthropometric methods.

Keywords: Obesity. Childhood. Malnutrition. Mid-Upper Arm Circumference. Anthropometric methods

Introduction

Nutritional assessment is defined as the interpretation of information obtained from dietary, biochemical, anthropometric and clinical studies, allowing the determination of health status based on the intake and use of nutrients by individuals or population groups. It consists of dietary, anthropometric, laboratory and clinical assessments, and can be used alone or in combination. Childhood obesity and malnutrition are increasingly prevalent worldwide, affecting millions of children and adolescents **[1,2]**.

According to global estimates, over 39 million children under the age of 5 were overweight or obese in 2020, while undernutrition remains a major issue in low- and middle-income countries. Nutritional assessment is essential for identifying these conditions early and guiding appropriate interventions. MUAC has emerged as a valuable tool due to its simplicity, cost-effectiveness, and applicability in diverse clinical settings **[1]**.

This review addresses the gap in literature regarding MUAC diagnostic potential across the full spectrum of nutritional disorders, aiming to validate its use in pediatric clinical practice.

Methods

This narrative review was conducted through a structured literature search and critical appraisal of relevant studies published up to 2025. The databases searched included PubMed, Scopus, Lilacs and Web of Science, using keywords such as 'Mid-Upper Arm Circumference', 'MUAC', 'nutritional assessment', 'malnutrition', 'obesity', and 'children'. Boolean operators (AND, OR, NOT) were applied to refine the search. Articles were included based on relevance, methodological transparency, and peerreviewed status. Two reviewers independently selected articles, resolving discrepancies by consensus.

Historical Survey

A comprehensive historical analysis was conducted to trace the evolution of Mid-Upper Arm Circumference

(MUAC) as a nutritional assessment tool. This included its initial applications and the development of contemporary reference curves.

Validation Studies

A targeted review of validation studies was performed, focusing on research that supports the use of MUAC in diagnosing malnutrition, overweight, and obesity in pediatric populations. Studies were selected based on their methodological rigor and relevance to clinical practice.

Clinical Contextualization

MUAC was contextualized within the broader framework of nutritional assessment methods. Comparative analysis was conducted to highlight its clinical advantages, particularly in resource-limited settings and scenarios requiring rapid, noninvasive evaluation. This approach allowed for a comprehensive synthesis of existing evidence, providing both historical and clinical perspectives on the utility of MUAC in pediatric nutrition assessment.

Results and Discussion

The dietary assessment identifies food intake and evaluates it in relation to nutritional recommendations, recognizing deficient or excessive intake of energy, macro and micronutrients, and eating habits. Thus, it achieves the goal of diagnosing the dietary problem in order to provide appropriate treatment or counseling to alleviate the problem. There are several methods of food survey. However, in general, all of them have advantages (ease, low cost and speed for some methods) and limitations (reporting what is considered the right and not the real consumption, difficulty remembering, little attention, limited vocabulary and when it requires an interviewer, he must be trained and in this case it has a long duration). They are: 24-Hour Recall, Food Frequency Questionnaire – FFQ, Dietary History, Food Record, Heavy Food Record, Food Record by Image.

Considering the importance of dietary assessment in diagnosing the nutritional status of children, the food pyramid proposed by the Brazilian Society of Pediatrics (Tables 1A and 1B) is a didactic and practical tool. The application in clinical practice allows an approach to promote healthy eating habits and the identification of nutritional imbalances, allowing the rapid identification of inadequacies, such as low vegetable intake or excessive consumption of foods of low nutritional quality. Based on these data, it is possible to guide intervention strategies by advising on healthy substitutions and the importance of variety, obviously considering individualization for the child and the family context. Tables 1A and 1B present the expected distribution in portions and the meaning of 1 portion in household measurements.

Table 1A. Expected distribution in portions and the meaning of 1 portion in household measurements.

Pyramid level	Food group	6 to 11 months	1 to 2 years	Preschool and school	Adolescents
1	Cerals, breads, tubers and roots	3	5	5	5 to 9
2	Greens and vegetables Fruits	3 3	3 4	3 3	4 to 5 4 to 5
3	Milk, cheeses and yoghurts Meats and eggs Beans	Breast milk 2 1	3 2 1	3 3 1	3 1 to 2 1
4	Oils and fats Sugar and sweets	2 0	2 1	1 1	1 to 2 1 to 2

Table 1B. Expected distribution in portions and the meaning of 1 portion in household measurements.

Food group	1 Portion in homemade measure
Cereal	2 tbsp rice 2 tablespoons of pasta 1 small potato
Vegetables	1 tablespoon cooked vegetables 1-2 tablespoons raw vegetable
Fruits	1/2 banana 1/2 small papaya unit 1/2 small guava 1 unit of orange
Dairy	1 cup cow's milk 2 thin slices cheese plate 1 1/2 slice Minas cheese
Meats and eggs	1 small steak 2 tbsp cooked beef 1 hard-boiled egg 1 small fish steak 1 small chicken fillet
Legumes	1 tablespoon (beans, peas, lentils, chickpeas)
Oil and fats	1 dessert spoon filled butter 1tbsp level vegetable oil
Sugars	1 tbsp sugar 2 dessert spoons of jam

Source: Tables 1A and 1B are cited here to support dietary assessment. Adapted from: Philippi et al., 1999 **[2]**; and Brazilian Society of Pediatrics – SBP **[3]**.

Anthropometric assessment consists of taking measurements of physical dimensions and body composition at different ages, aiming to determine nutritional status **[4]**. This evaluation has the advantages of being simple, safe, non-invasive, inexpensive, being precise and accurate as long as standardized techniques are used; identifying changes in nutritional status. On the other hand, it is not very sensitive when it does not detect acute changes in nutritional status and does not identify specific nutritional deficiency **[4]**.

The most commonly used methods are body weight, height (height or length), head circumference, and measurements of body segments during physical limitation for growth assessment **[5]**. For body composition assessment, skinfolds, arm circumference, arm muscle circumference and arm muscle area, bioimpedance testing and dual X-ray beam emission (DXA) **[6]**.

It is noteworthy that the weight-for-age (W/A), height-for-age (H/A), weightfor-height (W/H), and head circumference for age indices require, after the measurements, growth reference tables to establish nutritional status **[4]**. In body composition assessments, in turn, the measurements have to be calculated by equations and the result compared with the reference used. Methods of assessing body composition are not often calculated in routine clinical practice **[7]**. DXA is expensive and usually limited to small-scale studies.

Biochemical evaluation

Laboratory tests can aid in the diagnosis of primary malnutrition, resulting from inadequate intake, and are invaluable in guiding therapeutic decisions in secondary malnutrition, resulting from conditions of increased need or substrate losses **[8]**. In other words, biochemical evaluation allows the identification of specific nutritional alterations, detecting states of subclinical deficiency by comparing the results with basic laboratory indicators. They are a valuable tool that can and should be used in addition to other methods of nutritional assessment **[9]**.

Clinical evaluation

Clinical evaluation comprises medical history and physical examination. The first can be obtained through a questionnaire. The physical examination used for nutritional assessment has several limitations **[9]**. For instance:

- Non-specific physical signs: they can be produced by the deficiency of more
- than one nutrient;
- Multiple physical signs: produced by concomitant nutrient deficiency;
- Bidirectional physical signs: may occur during disability and/or recovery;
- Variations in the pattern of physical signs: There is no universal set of signs and symptoms for all ages and all countries. The pattern of physical changes associated with specific nutrient deficiency varies according to genetic factors, activity level, environment, dietary pattern, age and degree, duration, and speed of onset of deficiency **[10]**.

Despite the limitations of nutritional assessment methods, they are still useful for determining the nutritional intervention and education necessary for healthy growth and development.

Historical aspects of the MUAC

Although the nutritional assessment, classically, since Gomez's studies **[11]** and Waterlow **[12]**. To be made using weight and height, in some circumstances, it may be important that the diagnosis be made easier and faster, selecting patients at higher risk to be reassessed in detail **[13]**. This can occur in population studies, public health strategies, and even in outpatient care, where the focus is directed to other conditions, but the recognition of nutritional status can help in taking action **[14]**. In emergency services, where children with respiratory and gastrointestinal infections, among others, are treated, nutritional diagnosis can guide therapy, knowing its influence, for example, on asthmatic conditions, immunity, and the presence of dysbiosis and subclinical inflammation **[15]**.

The history of the use of the MUAC begins in 1958, when Derrick Jelliffe used this measure in Haiti for large- scale nutritional assessment **[16]**. However, in 1969, the MUAC definitively entered the set of anthropometric measures in nutritional assessment when, in the midst of the Nigerian civil war (1967-70), the International Committee of the Red Cross (ICRC) carried out extensive research based on the MUAC,

demonstrating its relevant capacity to diagnose malnutrition and direct therapy **[17]**.

Later, Shakir idealized, in works begun in 1974 **[18-21]**, the use of a tape, even regardless of the individual's age (between 1 and 5 years), in which he associated certain values of the arm circumference to three colors, taking advantage of its well-known correlation with those universally standardized for traffic lights (Figure 1). Thus, when surrounding the middle portion of the left arm, if green color is obtained, the child does not present nutritional alteration; yellow represents moderate malnutrition; red indicates malnutrition serious. The correspondence between the colors and the measurements were based on a percentage of the reference values obtained in Wolanski's studies **[22]**.

In Brazil, this tape has already been recommended as a nutritional assessment method **[23]**.

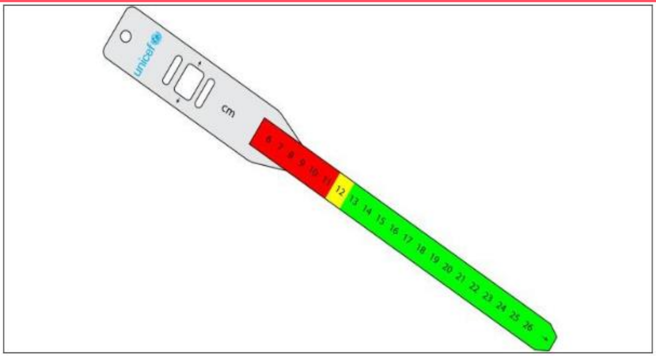

Figure 1 – Shakir's Tape. Source: Unicef Website.

The World Health Organization created and disseminated MUAC reference curves, developed for children under five years of age **[24]**. In 2017, Abdel-Rahman et al. published MUAC reference curves based on z-scores for children aged 2 months to 18 years and proposed a tape based on this study, in which the measurements and their interpretation are arranged (Figures 2 and 3) **[25]**. This strand was validated in later studies **[26-29]**. Historically, MUAC has been used almost always to detect malnutrition, however, from the end of the last century and the beginning of the present, the first studies seeking to evaluate the feasibility of its use for the diagnosis of obesity have emerged **[30-32]**. Subsequently, other researchers also evaluated this possibility using different methodologies **[33-57]**.

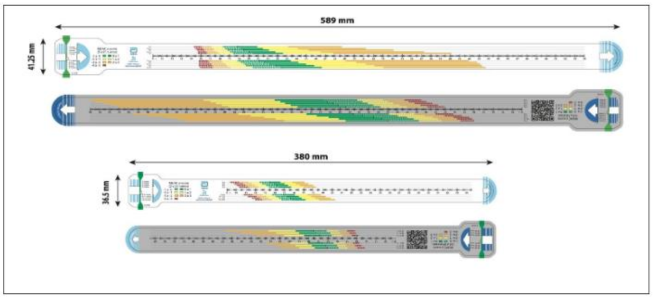

Figure 2. MUAC Tape. Source: Abbott Website.

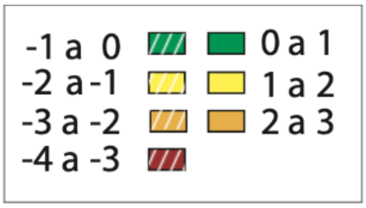

Figure 3. MUAC tape legend (z-scores). Source: Abbott Website.

Currently, MUAC is recognized as a method of assessing nutritional status capable of diagnosing the full spectrum of malnutrition possibilities and, additionally, it is no longer considered a method aimed only at screening and has started to be used effectively as a diagnostic strategy. The use associated with weight and height may bring even more information and make the nutritional diagnosis more complete.

How to Use z-Score-Based MUAC Tape

The non-dominant arm is the one typically used. The technique consists of placing the horizontal tape, around the arm, at the midpoint of the distance between the acromion on the shoulder and the olecranon on the elbow, obtaining the circumference value in centimeters. Figure 4 illustrates the measurement technique. This value obtained can be plotted on a specific graph, taking into account age and gender, so that the corresponding z- score can be verified. An alternative is to use specially made tapes for immediate evaluation and interpretation of the MUAC. In this case, the measurement obtained can already be verified and interpreted directly on the tape, which presents the corresponding z-score values, which, for ease, are color-coded (Figures 2 and 3) **[58]**. Therefore, it is simple, fast, easy to handle, directly provides the classification of nutritional status, dispensing with the use of tables and equations.

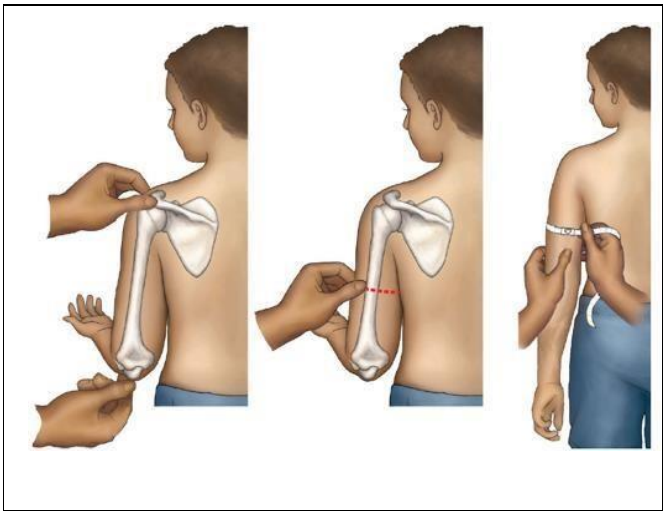

Figure 4. MUAC measurement technique. Source: Abbott Website.

MUAC for the assessment of malnutrition

Based on the Gauss Curve, negative values are considered for the diagnosis of malnutrition. The color coding of the z-scores present on the tape are as follows

- (Figure 2):
- Green: Normal, -1 to 0
- Yellow: mild malnutrition, from -2 to -1
- Orange: moderate malnutrition from -2 to -3.
- Red: severe malnutrition < -3

Research endorses the use of the MUAC as a practical and efficient anthropometric measure. An interesting example may be the clinical case report carried out at Texas Pediatric Hospital, Houston, TX, USA, with a 3- year-old male child admitted to the ICU with acute respiratory syndrome, fever, decreased food and fluid intake for about 5 days. Due to his clinical condition, it was not possible to obtain adequate weight and height measurements. The MUAC measure was then used, which showed a z-score between -2 and -3, i.e., moderate acute malnutrition. After 10 days of hospitalization and treatment, the same measure showed a z-score between -1 and -2, indicative of mild acute malnutrition. Therefore, the monitoring of the nutritional evolution of this child was only possible through the use of the MUAC **[58]**.

Evidence has suggested that MUAC may have value beyond its traditional application in assessing malnutrition. It should be noted that accurate measurement of body weight is often impossible in places with few resources. And this is important because it substantially increases the risk of inappropriate medication dosing (when this is body weight dependent). Thus, MUAC, when combined with other anthropometric measurements, can be a useful and accurate technique for estimating body weight in children **[59]**.

Mean arm circumference, MUAC, which estimates nutritional status, and body mass index, BMI, which indicates relative weight, were evaluated as biological indicators of life changes between 1966 and 2012 in Polish children from different socioeconomic status (SES). The total sample involved 64,393 children, aged between 7 and 18 years, investigated in 4 studies (1966, 1978, 1988, 2012). The results showed that both the year of the survey, gender, the SES category, and the interactions between them had a greater impact on MUAC than on BMI. The authors concluded that long-term socioeconomic changes affect MUAC more noticeably, making this measure a more accurate screening tool **[60]**.

A study showed that for the z-score of 0.7 of the MUAC ratio for age, a better association was obtained between sensitivity (76.5%) and specificity (77.9%). For a zscore of 0.6 in the MUAC ratio for height, there was a better association between sensitivity (79.4%) and specificity (77.6%). As no advantage was observed in the use of the MUAC related to height, when compared to its relationship with age, cut-off points are proposed, using only the MUAC measure for age, which, due to the ease and speed of obtaining it in populations, is a viable alternative method for preschool children **[30]**.

MUAC for obesity assessment

Considering the high and growing prevalence of obesity in all age groups and worldwide **[61]**. Diagnostic measures should always be included in the clinic so that treatment can be implemented. Considering absolutely technical criteria, the diagnosis should be based on excess body adiposity, through of tests such as dual-energy X-ray absorptiometry (DXA) or bioimpedance testing **[62]**. However, especially in childhood, most of the time, excess weight is due to excess fat, so the body mass index (BMI), which relates weight to height, is the most used method **[63]**. In fact, from the point of view of epidemiological studies, or even for a first individual screening, BMI has been shown to be a relevant indicator, despite requiring two measurements and mathematical calculation **[64]**.

In many cases, despite its relative simplicity, BMI can become difficult to obtain and interpret. This occurs more frequently in population studies, with many individuals to be evaluated. But obtaining this index can also be a problem when the focus of the consultation is not the nutritional issue; in cases of need for quick consultations; when it is impossible to obtain accurate averages of weight and height; in urgent/emergency environments; in intensive care units; and so on. In some cases, even in emergency situations, knowing that the patient is obese can direct the conduct **[15]**. Therefore, it is often important that the diagnosis is made quickly **[65]**.

MUAC is not a new method for diagnosing obesity, since studies in this regard date back more than 30 years **[31,32,66]**. Several researchers have sought to validate this measure for this purpose **[33-48, 50-52, 54, 56, 67-70]**. The ability of the MUAC measure to classify overweight and obesity, defined by the *WHO BMI-for-age reference*, was reported in a study carried out with 978 children and adolescents with excess fat, divided into specific sex (male and female) and specific age (5-9, 10-14 years) groups. The area under the curve (AUC) is a measure of accuracy, indexed from 0 to 1, where 1 indicates perfect test. In this study, the AUC showed 0.97 and 0.98 for girls and boys aged 10-14 years, respectively. In general, sensitivities were relatively high for the cutoffs chosen for all sex and age groups. The percentage of individuals correctly classified ranged from 72% to 94%, showing that the MUAC correctly classifies excess weight. The following cut-off points were proposed, considered potentially optimal, respectively for girls and boys; For age 5-9 years: 18.3cm/18.4cm and 18.4cm/18.6cm. For age 10-14 years: 22.5cm/22.8cm and 22.2cm/23.2cm **[34]**.

Study evaluated MUAC in addition to waist circumference (WC) to describe obesity defined by BMI. While the use of BMI to measure excess fat in children has well-known problems (fat reserve may differ between individuals, with no indication of fat distribution), WC has been recognized as a useful measure, reflecting both excess fat and disease risk **[71]**.

MUAC and CC, which are used to determine adiposity, show a good level of correlation with body mass. However, in circumstances where WC is not feasible (skeletal deformities, intra- abdominal disorders, abdominal changes related to respiratory movements), MUAC may be a reliable alternative. However, WC and MUAC monitoring is not a commonly used procedure in pediatric studies in many countries, and internationally accepted cut-off values have not yet been established. After analyzing the data obtained from 5,358 children and adolescents (2,737 females), between 6 and 17 years of age, the authors conclude that WC and MUAC can be replaced by each other, as an additional evaluation tool, with a good correlation with BMI in the detection of overweight and obesity in children and adolescents and that these two measurements have the characteristic of indirectly defining the composition of the body (fat mass and lean mass), more than providing information on total body mass **[33]**.

In 2024, Nogueira-de-Almeida et al. **[72]** carried out a systematic review with meta-analysis that allowed the creation of the MOSTA-Tape (Figure 5), which is a simplified MUAC tape aimed at screening for obesity in adolescents. Using the proposed methodology, simplified MUAC cut-off points (cm) were obtained for screening adolescents at risk of obesity: 23 for girls and 23.5 for boys (10-14 years); 28.14 for girls and 27.14 for boys (15-20 years old).

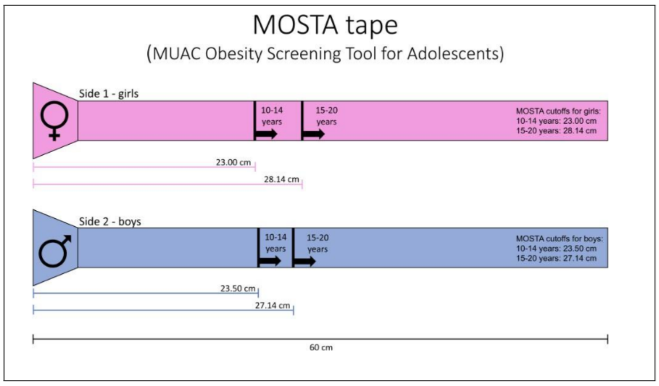

Figure 5. MOSTA-Tape. Source: Nogueira-de-Almeida et al **[72]**.

The tapes proposed by Susan Abdel-Rahman et al. **[25]** have the great advantage of allowing immediate interpretation of the measurement obtained, using z-scores and allowing the diagnosis of overweight (z-scores between +1 and +2) and obesity (z-scores above +2) in a wide age range, ranging from 2 months to 18 years of age.

Limitations

This review is limited by its narrative nature, which may introduce selection bias. The absence of meta-analytic synthesis restricts quantitative comparison across studies. Additionally, the reliance on published literature may overlook unpublished data or regional practices not indexed in major databases.

Conclusion

It was concluded that measurements of height (height or length), weight, head circumference and skinfolds are not always possible to obtain or be accurate due to clinical conditions (wheelchair users, bedridden patients, ICU, fluid changes). In addition, they need a stadiometer, scale, adipometer and several tables or equations to reach the nutritional diagnosis through the measures taken. MUAC, in turn, depends on a single device, simple, non-invasive, accurate, not influenced by edema, inexpensive, suitable from 2 months to 18 years of age, and can be cleaned after each measurement, and is therefore useful in population screening, office, and hospital bed. The present review demonstrates that MUAC should be considered an adequate and scientifically based strategy for assessing nutritional status. Its use, according to current knowledge, should not be limited only to population screening, as was previously understood. In fact, it can be used as a definitive diagnostic criterion, especially when traditional measurements, especially weight and height, are not available. Among the various tape proposals, there is no doubt that it is possible to measure with any tape measure, provided that, through appropriate technique, the values in centimeters are obtained accurately. In this case, the result obtained should be evaluated through curves or reference tables, preferably described through z- scores. Figures 3 and 4 show the curves recommended in the present review.

CRediT

Author contributions: **Conceptualization**; **Data curation**; **Formal Analysis**; **Investigation**; **Methodology**; **Project administration**; **Supervision**; **Writing - original draft**; **Writing-review & editing-** Carlos Alberto Nogueira-de-Almeida, Patrícia Ruffo, and Olga Maria Silvério Amâncio.

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Informed Consent

It was applicable.

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Conflict of Interest

The authors declare no conflict of interest.

Similarity Check

It was applied by Ithenticate@.

Application of Artificial Intelligence (AI)

Not applicable.

Peer Review Process

It was performed.

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