

# Inadequacy of a 12.5 cm MUAC as a cutoff for malnutrition for children aged three to five years

Emmanuel Gai<sup>1</sup> and J. Clarke McIntosh<sup>2</sup>

## Author Affiliations:

1. AMREF School, Maridi, South Sudan. 2. Mary Immaculate Hospital, Mapuordit, South Sudan

## Correspondence:

J. Clarke McIntosh  
[jclarkemcintosh@gmail.com](mailto:jclarkemcintosh@gmail.com)

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## ABSTRACT

**Introduction:** MUAC (mid-upper arm circumference) is a simple and easily taught screening tool for identifying malnutrition in children. South Sudan use a MUAC of 12.5 cm for children aged between six months and five years as a cut-off for moderate acute malnutrition. Currently, in South Sudan, children from six months to five years have the same MUAC cutoff for malnutrition.

**Method:** This study evaluated the sensitivity of using a MUAC of 12.5 cm as a screening tool for children between 6 and 60 months applied to data obtained from children enrolled in urban and rural primary schools in Maridi County, South Sudan. We used the 12.5 cm cutoff which was 2 standard deviations from the median for boys at nine months and for girls at 20 months. We also used 14.0 cm as the cutoff and compared the number of children identified, and also the false positive rate, assuming -2 SD from the median to be the accepted norm for malnutrition. Finally, we considered two different standards, using 14.0 cm for children aged 3-5 years and 12.5 cm for children under three years.

**Results:** Comparing the results obtained using the two different MUAC standards (12.5 cm versus 14.0 cm) against a single MUAC standard there is a dramatic difference in outcome. Using the current standard (12.5 cm), only 7.3% of the children were found to be malnourished. Using 14.0 cm, 33.8 % were found to be malnourished (Table 4). If we accept the norm of 2 SD below the median for age as an adequate definition of malnutrition, the false positive rate using 14.0 cm is 9.6 %, an acceptable figure for a screening device, but the false negative rate for 12.5 cm is 17.4 %, a clearly unacceptable rate for a screening device. If, however, instead of using one cut-off for children from six months to five years, a period characterized normally by rapid growth and changes in body composition, we used two different standards—12.5 cm for those under three years and 14 cm for those aged 3-5 years, the number of false positives drops down to 2.7% and false negatives to 0.9 %

**Conclusion:** We suggest that the use of 12.5 cm for malnourished children is inappropriate above two years, that 14 cm would be a more appropriate screening measurement from 3-5 years of age.

**Key words:** MUAC, malnutrition, children, Maridi, South Sudan

## Introduction

MUAC (mid-upper arm circumference) is a simple and easily taught screening tool for identifying malnutrition in children. In South Sudan, we have used a MUAC (mid-upper arm circumference) of 12.5 cm for children aged between six months and five years as a cut-off for moderate acute malnutrition.<sup>[1]</sup>

The standards for MUAC, and other child growth standards<sup>[2]</sup> were developed using data collected in the WHO Multicentre Growth Reference Study<sup>[3]</sup> from children from different ethnic backgrounds and cultural settings; 12.5 cm happens to correspond to two standard deviations (SD) below the median for nine-month-old males.

That standard became entrenched in our nutritional programmes in South Sudan when the World Food Programme (WFP) initiative for infants and lactating mothers used 12.5 cm as the cutoff for all children aged five years and under. However, that standard seems to ignore the reality of childhood growth and maturity.

In general, a screening tool should be sensitive, preferably catching all the subjects. A more selective, discriminating test can then be applied. In screening for HIV, we have a sensitive test that includes some false positives and then a more selective, discriminating test to determine if a patient truly is infected. A screening test that excludes a significant percentage of the affected individuals is a poor tool.

Although there is disagreement regarding definition for malnutrition, whether we are discussing undernutrition or over nutrition (obesity), most experts regard a z score (2 SD below the median) as an acceptable value for under (mal)nutrition. The standard for obesity for years has been a BMI (body mass index) of greater than 30 [kg/(height in meters) squared], although some experts are questioning that standard. Obesity measurements have significance for medical screening, employment, and potentially for third party payments for medications. Likewise, undernutrition definitions are important for supplemental feedings and understanding risks for populations.

There is growing evidence that we need to identify malnourished children prior to entry into formal education because inadequate nutrition sets children up to do poorly in school. Nutrition and development have long been linked, but newer data are showing the critical importance of early nutrition on academic achievement. Moreover, nutrition impacts all areas of life, particularly vulnerability to infectious diseases.

Table 1. MUAC median and -2 SD for boys and girls aged 6-60 months<sup>[2]</sup>

Age months	Boys – 2 SD (cm)	Boys median (cm)	Girls – 2 SD (cm)	Girls median (cm)
3	11.6	13.5	11.1	13.0
6	12.2	14.2	11.8	13.9
9	12.4	14.5	12.0	14.1
12	12.5	14.6	12.1	14.2
15	12.7	14.8	12.2	14.4
18	12.8	14.9	12.4	14.5
21	12.9	15.0	12.6	14.7
24	13.0	15.2	12.7	15.0
27	13.2	15.4	12.9	15.2
30	13.3	15.5	13.1	15.4
33	13.4	15.7	13.2	15.5
36	13.5	15.8	13.3	15.7
39	13.6	15.9	13.4	15.9
42	13.6	16.0	13.5	16.0
45	13.7	16.1	13.6	16.1
48	13.8	16.2	13.7	16.3
51	13.8	16.3	13.8	16.4
54	13.9	16.3	13.9	16.6
57	13.9	16.4	13.9	16.7
60	14.0	16.5	14.0	16.9

South Sudan has one of the highest mortality rates in the world for children under five years<sup>[4]</sup> and malnutrition is undoubtedly a contributing factor. In this study, we evaluated the sensitivity of using a MUAC of 12.5 cm as a screening tool for children between 6 and 60 months in four primary schools in Maridi County, South Sudan.

## Method

Children in four primary schools – Michael Tawil primary school, Chanambia primary school, Haduo primary school, and Gbutala primary school – had their MUAC measured and their ages recorded as it appeared in the school registers of the rural and urban primary schools (see limitations below).

Using the MUAC standards (Table 1) from the WHO growth standard,<sup>[2]</sup> we used the 12.5 cm cutoff which was

2 standard deviations from the median for boys at nine months and for girls at 20 months.

We also used 14.0 cm as the cutoff and compared the number of children identified, and also the false positive rate, assuming -2 SD from the median to be the accepted norm for malnutrition.

Finally, we considered two different standards, using 14.0 cm for children aged 3-5 years and 12.5 cm for children under three years.

## Results

We screened 219 children in the four schools. Tables 2 and 3 show the age and sex and MUACs of the children measured.

Tables 4 and 5 show the number and percentage in each MUAC category and the number of false positives and negatives.

Comparing the results obtained using the two different MUAC standards (12.5 cm versus 14.0 cm) against a single MUAC standard there is a dramatic difference in outcome. Using the current standard (12.5 cm), only 7.3% of the children were found to be malnourished. Using 14.0 cm, 33.8 % were found to be malnourished (Table 4). If we accept the norm of 2 SD below the median for age as an adequate definition of malnutrition, the false positive rate using 14.0 cm is 9.6 %, an acceptable figure for a screening device, but the false negative rate for 12.5 cm is 17.4 %, a clearly unacceptable rate for a screening device (Table 4).

If, however, instead of using one cut-off for children from six months to five years, a period characterized normally by rapid growth and changes in body composition, we used two different standards—12.5 cm for those under three years and 14 cm for those aged 3-5 years, the number of false positives drops down to 2.7% and false negatives to 0.9 % (Table 5).

Although not statistically analysed, there appears to be no difference between the results from rural and urban schools.

## Discussion

Nutrition is universally accepted as a critical indicator of overall health, vulnerability to disease, and development. It is generally acknowledged that proper nutrition is necessary for good cognitive development and academic performance<sup>[5]</sup> and data supporting that claim are

**Table 2. Number of children measured by age and sex**

Age (in months)	Male	Female	Total
12-23	0	1	1
24-35	25	22	47
36-47	29	31	60
48-59	22	24	46
60-71	33	32	65
Total	109	110	219

**Table 3. MUAC by age group**

Age (in months)	MUAC < 12.5 cm n	MUAC 12.5-14 cm n	MUAC > 14 cm n
12-23 months	1	0	0
24-35 months	10	17	20
36-47 months	5	23	32
48-59 months	0	10	36
60-71 months	0	8	57
Total	16	58	145

**Table 4. Group data using a single MUAC standard (<12.5 cm) for all ages together**

	Rural Schools n (%)	Urban Schools n (%)	Total n (%)
Total	99 (100%)	120 (100%)	219 (100%)
MUAC < 14 cm	38 (38.4%)	36 (30.0%)	74 (33.8%)
MUAC < 12.5 cm	6 (6.1%)	10 (8.3%)	16 (7.3%)
False (+) 14 cm	9 (9.1%)	12 (10.0%)	21 (9.6%)
False (-) 12.5 cm	24 (24.2%)	14 (11.7%)	38 (17.4%)

accumulating rapidly. Indeed, there is emerging evidence from subtle nutritional differences regarding brain development and cognitive outcome in children with no evidence of insufficient (mal)nutrition. The more we understand about nutrition, the more obvious becomes its role in cognitive development. Therefore, the use of an

**Table 5. Group Data using MUAC < 14 cm for those aged 3-5 years and 12.5 cm those 2 years and under**

	Rural Schools n (%)	Urban Schools n (%)	Total n (%)
Total	99 (100%)	120 (100%)	219 (100%)
MUAC < 14 cm	38 (38.4%)	36 (30.0%)	74 (33.8%)
MUAC < 12.5 cm	6 (6.1%)	10 (8.3%)	16 (7.3%)
False (+)	3 (3.0%)	3 (2.5%)	6 (2.7%)
False (-)	1 (1.0%)	1 (0.8%)	2 (0.9%)

insensitive measure of malnutrition for screening children ready to start their formal education predisposes our most vulnerable children to poor academic performance as well as more obvious consequences of malnutrition.

UNICEF numbers from the early part of this century noted that one child in four did not live to see his/her fifth birthday. Child mortality rate of South Sudan fell gradually from 318 deaths per 1,000 live births in 1971 to 97.9 deaths per 1,000 live births in 2020, according to World Data Atlas.<sup>[4]</sup> Though these improvements are commendable and noteworthy, our childhood mortality rate is still among the worst in the world, and improving on that depressing statistic has been one of the goals of the Ministry of Health, the Government of South Sudan, and numerous non-governmental organizations (NGO) working in South Sudan. Although the causes of the horrible rate of childhood mortality remains multi-factorial, there is little argument that malnutrition is a significant contributor.

If we accept the proposition that 2 SD below the median MUAC for age defines malnutrition, then 12.5 cm is an extremely poor screening method for children three years of age and older, as others have found in different regions of the world.<sup>[6]</sup> If we use 12.5 cm for children aged under three years and 14 cm for children 3-5 years of age, we capture almost all the children with malnutrition and have an acceptably low false positive rate.

The first step in adequately addressing the scourge of childhood malnutrition is to have adequate screening tools for identifying children at risk. Perhaps the most vulnerable period, nutritionally speaking, for children in South Sudan, is after the cessation of breast feeding, which typically occurs between ages 1.5 and 2.5 years.

We agree that MUAC is probably the most cost-effective screening tool for malnutrition. Weight for age is fairly simple, but accurate scales are more expensive and those who are relatively tall, as in the Dinka and Nuer populations would have to be more severely malnourished to be identified. Height is a much more difficult measurement to make accurately, so weight-for-height would be difficult, particularly in a field office.

MUAC tapes are cheap and their use easily taught, but we suggest that MUAC tapes using 14.0 cm is the more appropriate screening tool for children 3-5 years of age. When a patient is identified, further evaluation can be done to see if he/she is truly 2 SD below the median for age using charts from WHO showing median MUAC for age from six months to five years.<sup>[2]</sup> Even if the child is considered a false positive (i.e. MUAC < 14 cm for 3-5 years, but greater than 2 SD below the median for age), he would be identified as someone to follow more closely and rechecked periodically (as we do for those identified in the HIV screening who are found to be negative with the Determine confirmatory test).

These data also show the importance of continued feeding programmes that target our most vulnerable children. Our data suggest that by using an inappropriate screening tool, one of the nutritionally most vulnerable groups, children between weaning and school age, have been overlooked. We find using a MUAC of 12.5 cm particularly inappropriate for the older children in this group. We feel that the more appropriate screening tool would be to use 14.0 cm, which is 2 SD below the median MUAC for both boys and girls at age five years.

**Limitations**

- We were unable to confirm the ages of the children screened, as there is no data bank of birth certificates in most areas of South Sudan, so were forced to use the stated age of the child given by his/her parents at registration. Also, no months were given for the ages of the children, so the calculations for each child used the MUAC at the lowest months for age (i.e. a two-year-old was screened as a 24-month-old, a four-year-old as 48 months).
- Small sample size.

**Conclusion**

Nutrition continues to be a major concern in South Sudan. As the country develops and seeks to end the perpetual cycles of poverty that have plagued the nation, education

is recognized as a critical step. For the youngest citizens to take advantage of educational opportunities that many have struggled so hard to obtain, there is need to identify those children who are at risk for failure because of malnutrition. We submit that the current screening tools are inappropriate in identifying those children.

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