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RESEARCH

Does mid upper arm circumference identify all acute malnourished 6–59 month old children, in field and clinical settings in Nigeria?

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Objectives: To determine the utility of mid-upper arm circumference (MUAC) in identifying acutely malnourished children compared with weight-for-height (WHZ), body mass index (BMI) for age (BAZ) and MUAC z-score (MUACZ) in clinical and field practice.
Design: Cross-sectional study.
Setting: Children from immunisation and paediatric outpatient clinics of Jos University Teaching Hospital and two schools in Jos, Plateau state, Nigeria.
Subjects: Children 6–59 months with parental consent, and no chronic medical condition or pedal oedema.
Outcome measures: MUAC, height and weight were measured. The WHZ, BAZ and MUACZ were determined using the World Health Organisation (WHO) Anthro software 3.0. Prevalence of acute malnutrition was compared between these data and those given by MUAC. The World Health Organisation (WHO) z-score cut-off of < -3 and < -2 and MUAC of ≤ 11.5 cm and 11.6 –12.5 cm was used to define severe acute malnutrition (SAM) and moderate acute malnutrition (MAM), respectively. Stata 12SE was used to determine frequency distribution, means and significance.
Results: The mean age of subjects was 22.4 ± 15.5 months. The mean MUAC was 14.7 ± 1.5 cm. The MUAC differed between males and females in the age-groups of 6–11 ($p = 0.02$) and 36–47 ($p = 0.006$) months. The prevalence of SAM by WHZ was 3.4%, MUAC was 1.5%, BAZ was 4.3% and MUACZ was 1.0%. When compared, WHZ and BAZ were concordant in 77.8% ($p = 0.001$) of SAM subjects. MUAC and MUACZ indicated that none of the subjects were classified as SAM by WHZ and BAZ.
Conclusion: Neither WHZ or MUAC as a single parameter identifies all children with acute malnutrition. A re-definition of MUAC criteria for malnutrition or consistent application of both parameters is required.

Keywords: acute malnutrition, BAZ, field and clinical setting, MUAC, MUACZ, WHZ

Introduction

Childhood nutritional status remains a concern worldwide, especially under-nutrition and the rising trend of overweight/obesity.[1] In some communities and even families, both co-exist; and, it is commonly termed "double-burden malnutrition".[1,2]

Nutritional status of children is determined by several anthropometric measurements in relation to the age of the child using either single or derived indices.[3] The World Health Organisation (WHO) recommends the use of weight-for-height (WHZ) and body mass index for age z-scores (BAZ) in determination of underweight and overweight, respectively; though both parameters can measure the deviations with no statistical difference in outcome if inter-changed.[4] For any given anthropometric measure, a z-score indicates how many standard deviations below or above a reference median an individual value is found.[5]

Currently under-nutrition is defined as a z-score of < -2 using the weight-for-height index of the 2006 WHO multicentre growth reference standards, while overweight and obesity is defined as a z-score > 2 either by the weight and height index or the body mass index (BMI) for children 6–59 months in age.[6] Severe acute malnutrition is defined using either WHZ < -3 or MUAC < 11.5 cm, or presence of nutritional oedema irrespective of either criteria.[4]

The mid-upper arm circumference (MUAC), a single index, has been widely adopted in community identification of malnourished children aged 6–59 months. Severe acute malnutrition (SAM) is defined as a MUAC of < 11.5 cm. This cut-off point is utilised irrespective of age in those 6–59 months in age, but doubts about its accuracy when sexes are compared led to adoption of MUAC z-scores for males and females.[7] There is no defined MUAC cut-off point for overweight/obesity at present even though some authors postulate a MUAC of over 18 cm in children aged 5–9 years.[8] Z-scores for MUAC is usually computed and expected to follow normal distribution with a z-score < -2 indicating malnutrition but a z-score > 2 has not been used to adjudge over-nutrition, as is commonly applied when using BAZ.

How well MUAC and/or MUACZ scores correlate with states of nutrition defined by WHZ or BAZ is the subject of controversy with different authors presenting different opinions.[9–11] Weight-for-height below -3 Standard Deviation (SD) is a highly specific criterion to identify severely acutely malnourished infants and children.[10] Several authors indicate discrepancies between prevalence of malnutrition obtained using WHZ and those obtained using MUAC of < 11.5 cm for SAM and < 12.5 for moderate acute malnutrition (MAM). Although WHO reports a similar prevalence of SAM when using both parameters,[10] a higher prevalence has been reported with WHZ parameters.[11] Thus, the utility of MUAC is brought into question when identifying children with several forms of malnutrition in a clinical setting and even in the field, given its simplistic application.

The implication of sole use of any of these indices will be that severely malnourished children may be missed if one or the other parameter is used alone. Thus, there is a need to define stand-alone MUAC criteria for SAM in both clinical and field settings as in order to identify all severely malnourished children, or to ensure that children are assessed using all the parameters in both settings.

This study was designed to compare differences in WHZ and BAZ with MUAC/MUACZ; how well each identifies different states of acute malnutrition; and, applicability in clinical and field practice beyond what is currently practiced.

Methodology

This study was a cross-sectional study involving children aged 6–59 recruited from immunisation centres, pre-primary schools in Jos metropolis, and children attending the paediatrics outpatient clinic of Jos University Teaching Hospital.

Study location and site

The study was conducted in Jos metropolis, the capital of Plateau state, north-central Nigeria. The Jos University Teaching Hospital provides specialist and outpatient services to the metropolis alongside referral within and outside the zone. Two randomly selected pre-primary schools were selected and wards of consenting parents were recruited. All recruitment was done consecutively.

Data collection

Using an interviewer administered questionnaire, bio-data and past and present medical histories were taken. Children with a history of chronic illnesses that may adversely impact their nutritional states were excluded. Subjects attending the paediatric outpatient clinic were excluded, if admitted for any medical condition.

The weight of each child was measured using Seca digital weighing scale to 0.1 kg, while height was measured using Seca stadiometer to 0.1 cm. A wooden infantometer to 0.1 cm was used for children less than 24 months and who were unable to stand. All measurements were done by the researchers using age appropriate standard procedures.[12] Mid-upper arm circumference was measured using a colour-coded graduated MUAC tape.

Data analysis

The BAZ, WHZ and MUACZ were computed using WHO Anthro software version 3.0. Stata 12SE was used for further analysis. A *p*-value of < 0.05 was considered as statistically significant.

Ethical approval

Ethical clearance was obtained from the Institutional Review Board of Jos University Teaching Hospital. (JUTH/DCS/ADM/127/XIX/5856, 20/01/2014) Written informed consent was obtained from each caregiver.

Table 1: Age group and gender distribution

Age (months)	Sex		
	Female, *N* (%)	Male, *N* (%)	Total, *N* (%)
6–11	60 (28.8)	73 (35.6)	133 (32.2)
12–23	58 (27.9)	60 (29.3)	118 (28.6)
24–35	28 (13.5)	34 (16.6)	62 (15.0)
36–47	32 (15.4)	22 (10.7)	54 (13.1)
48–59	30 (14.4)	16 (7.8)	46 (11.1)
Total	208 (100.0)	205 (100.0)	413 (100.0)

Notes: $Chi^2 = 7.97$; $p = 0.0092$.

Table 2a: Mean weight by gender and age group

Age group	Mean Weight (kg)						
	Female		Male		*p*	Group Mean	
	N	Mean (SD[#])	*N*	Mean (SD)		*N*	Mean (SD)
6–11*	60	7.5 (1.6)	73	8.2 (1.3)	0.009	133	7.9 (1.5)
12–23	58	9.5 (1.6)	60	9.7 (1.6)	0.37	118	9.6 (1.6)
24–35	28	12.9 (1.7)	34	12.9 (1.5)	0.27	62	12.7 (1.6)
36–47	32	15.2 (2.1)	22	14.1 (2.1)	0.07	54	14.7 (2.2)
48–59	30	17.0 (1.7)	16	18.1 (2.3)	0.06	46	17.4 (2.0)
Group Mean	208	208 11.3 (3.9)	205	10.8 (3.4)	0.23	413	11.1 (3.6)

*Mean weight was significantly different in the age group 6–11 months with males weighing more.
[#]Standard Deviation.

Table 2b: Mean MUAC by gender and age group

Age group	Mean [@]MUAC (cm)						
	Females		Males		*p*	Mean	
	N	Mean (SD)	*N*	Mean (SD)		*N*	Mean (SD)
6–11*	60	13.6 (1.2)	73	14.2 (1.6)	0.02	133	13.9 (1.4)
12–23	58	14.6 (1.5)	60	14.4 (1.1)	0.56	118	14.5 (1.3)
24–35	28	15.6 (1.2)	34	15.2 (1.1)	0.12	62	15.4 (1.1)
36–47*	32	15.6 (1.2)	22	14.8 (0.6)	0.006	54	15.3 (1.0)
48–59	30	16.0 (1.5)	16	16.4 (1.4)	0.3	16	16.1 (1.5)
Group mean	208	14.8 (1.6)	205	14.7 (1.4)	0.38	413	14.7 (1.5)

*Mean MUAC was significantly different in the age group 6–11 months.
[@]Mid-upper arm circumference.

Table 2c: Mean MUACZ by gender and age group

Age group	Mean MUACZ						
	Female		Male		*p*	Means	
	N	Mean (SD)	*N*	Mean (SD)		*N*	Mean (SD)
6–11	60	−0.4 (1.0)	73	−0.28 (1.4)	0.64	133	−0.1 (1.3)
12–23*	58	0.1 (1.2)	60	−0.33 (1.0)	0.036	118	−0.12 (1.1)
24–35	28	0.28 (1.0)	34	−0.16 (0.9)	0.06	62	0.44 (1.0)
36–47*	32	−0.25 (1.0)	22	−0.84 (0.5)	0.008	54	0.59 (0.8)
48–59	30	−0.45 (1.1)	16	0.05 (1.1)	0.14	46	0.50 (1.1)
Group mean	208	−0.15 (1.1)	205	−0.31 (1.1)	0.14	413	−0.23 (1.1)

*Mean MUAC Z score (MUACZ) was significantly different in the age groups 12–23 and 36–47 months.

Results

Over-all, 413 subjects were recruited for the study. Among the subjects, 208 (50.4%) were females. Mean age was 22.4 ± 15.5 months. The majority of subjects were aged less than 24 months, with infants aged 6–11 months constituting 32.2% (*N* = 133) and those 12–23 months constituting 28.6% (*N* = 118), as shown in Table 1.

Table 2d: Mean WHZ by gender and age group

Age group	Mean $WHZ							
	Female		Male		p	Group Means		
	N	Mean (SD)	N	Mean (SD)		N	Mean (SD)	
6–11	60	−0.1 (1.4)	73	−0.48 (1.7)	0.06	133	−0.71 (1.6)	
12–23	58	−0.43 (1.4)	60	−0.69 (1.3)	0.3	118	−0.56 (1.4)	
24–35	28	0.41 (0.8)	34	0.35 (1.2)	0.84	62	0.37 (1.1)	
36–47*	32	0.3 (1.1)	22	−0.51 (1.8)	0.05	54	−0.03 (1.5)	
48–59	30	0.3 (1.0)	16	0.7 (1.3)	0.26	46	0.45 (1.1)	
Group mean	208	−0.26 (1.4)	205	−0.32 (1.6)	0.71	413	−0.29 (1.5)	

*Mean WH was significantly different in the age group 36–47 months.
$Weight-for-height z-score.

Table 2e: Mean BAZ by gender and age group

Age group	Mean £BAZ						
	Female		Male		p	Group Means	
	N	Mean (SD)	N	Mean (SD)		N	Mean (SD)
6–11*	60	−1.17 (1.4)	73	−0.6 (1.8)	0.045	133	−0.86 (1.6)
12–23	58	−0.45 (1.5)	60	−0.68 (1.3)	0.37	118	−0.57 (1.4)
24–35	28	0.53 (0.9)	34	0.42 (1.4)	0.72	62	0.47 (1.2)
36–47	32	0.3 (1.1)	22	−0.47 (2.0)	0.07	54	−0.01 (1.6)
48–59	30	0.31 (1.0)	16	0.74 (1.3)	0.22	46	0.46 (1.1)
Group mean	208	−0.3 (1.4)	205	−0.34 (1.7)	0.81	413	−0.32 (1.5)

*Mean BZ was significantly different in the age group 6–11 months.
£Body Mass Index for-age Z score.

Table 3: Mean MUAC in WHZ, BAZ and MUACZ (z-score < −3)

Parameter	Male		Female		Group Mean		p	Range (cm)
	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)		
*WHZ	10	13.4 (0.5)	4	12.5 (0.6)	14	13.2 (0.7)	0.01	12–14
BAZ	12	13.7 (0.8)	6	13.2 (1.1)	18	13.5 (0.9)	0.27	12–15
MUACZ	4	11.0 (0.0)	0			11.0 (0.0)	–	11

*Mean MUAC in WHZ < −3 was significantly higher in males than females.

Table 4: Prevalence of severe (SAM) and moderate acute malnutrition (MAM)

Parameters	SAM	MAM
	N (%)	N (%)
WHZ	14 (3.4)	32 (7.8)
MUACZ	4 (1.0)	14 (3.4)
MUAC	6 (1.5)	22 (5.3)
BAZ	18 (4.3)	34 (8.2)

Mean weight of male children in the age group 6–11 years (8.2 ± 1.3 kg) was higher than those of the females (7.6 ± 1.6 kg), $p = 0.009$ (Table 2a). Differences between females and males in MUAC, MUACZ, WHZ and BAZ are shown in Tables 2b –2e.

The mean MUAC in subjects with WHZ, BAZ, MUACZ < -3 is shown in Table 3.

Prevalence of Malnutrition

Using the WHO z-score cut off < -3 for SAM, and < -2 for MAM, the prevalence of SAM differed between parameters. Using WHZ, 14 (3.4%) of the subjects had SAM. Using MUAC of 11.5 cm and below, 6 (1.5%) were identified as SAM. Using BAZ, a higher prevalence of SAM was observed, 4.3%. Similarly, MAM also differed between the various measures (Table 4).

Cross tabulation of frequencies of SAM by parameters

Cross-tabulations between WHZ, MUACZ, BAZ and MUAC show that no subject classified as SAM by WHZ was classified same by MUACZ. Two (2) of the four subjects identified as SAM by MUACZ were classified as MAM and normal by WHZ (Table 5a).

Table 5a: Nutritional status by WHZ and MUACZ

WHZ	MUACZ				
	SAM	MAM	NORMAL	OVER	Total
	N (%)	N (%)	N (%)	N (%)	N (%)
SAM (z-score <−3)	0 (0.0)	0 (0.0)	14 (3.7)	0 (0.0)	14 (3.4)
MAM (z-score <−2)	2 (50.0)	6 (42.9)	24 (6.2)	0 (0.0)	32 (7.8)
OVER (z-score >+2)	0 (0.0)	0 (0.0)	14 (3.6)	6 (66.7)	20 (4.8)
NORMAL (z-score −2, +2)	2 (50.0)	8 (57.1)	334 (86.5)	3 (33.3)	347 (84.0)
Total	4 (100.0)	14 (100.0)	386 (100.0)	9 (100.0)	413 (100.0)

Notes: Pearson chi^2 (9) = 112.2; $p \leq 0.001$; Fisher's exact ≤ 0.001.

Table 5b: Nutritional status by WHZ and MUAC

WHZ	MUAC			
	SAM (%) (<11.5 cm) N (%)	MAM(%) (11.6–12.5 cm) N (%)	Normal (%) (>12.5 cm) N (%)	Total (%) N (%)
SAM	0 (0.0)	4 (18.2)	10 (2.6)	14 (3.4)
MAM	2 (33.3)	6 (27.3)	24 (6.2)	32 (7.8)
OVER	0 (0.0)	0 (0.0)	20 (5.2)	20 (4.8)
NORMAL	4 (66.7)	12 (54.6)	331 (86.0)	347 (84.0)
Total	6 (100.0)	22 (100.0)	385 (100.0)	413 (100.0)

Notes: Pearson chi^2 (6) = 36.3; $p \leq 0.001$; Fisher's exact ≤ 0.001.

Table 5c: Nutritional status by WHZ and BAZ

WHZ	BAZ				
	SAM, *N* (%)	MAM, *N* (%)	NORMAL, *N* (%)	OVER, *N* (%)	Total, *N* (%)
SAM	14 (77.8)	0 (0.0)	0 (0.0)	0 (0.0)	14 (3.4)
MAM	4 (22.2)	24 (70.6)	4 (1.2)	0 (0.0)	32 (7.8)
OVER	0 (0.0)	0 (0.0)	2 (0.6)	18(100.0)	20 (4.8)
NORMAL	0 (0.0)	10 (29.4)	337 (98.2)	0 (0.0)	347 (84.0)
Total	18 (100.0)	34 (100.0)	343 (100.0)	18 (100.0)	413 (100.0)

Notes: Pearson chi^2 (9) = 908.5; $p \leq 0.001$; Fisher's Exact ≤ 0.001.

Table 5d: Nutritional status by MUACZ and MUAC

MUACZ	MUAC			
	SAM *N* (%)	MAM *N* (%)	NORMAL *N* (%)	Total *N* (%)
SAM	4 (66.7)	0 (0.0)	0 (0.0)	4 (1.0)
MAM	2 (33.3)	6 (27.3)	6 (1.6)	14 (3.4)
OVER	0 (0.0)	0 (0.0)	9 (2.34)	9 (2.1)
NORMAL	0 (0.0)	16 (72.7)	370 (96.1)	386 (93.5)
Total	6 (100.0)	22 (100.0)	385 (100.0)	413 (100.0)

Notes: Pearson chi^2(6) = 335.6; $p = 0.000$; Fisher's exact = 0.000.

Similarly, no subject identified as SAM by WHZ was as such classified by MUAC (Table 5b). However, 14 (77.8%) of those classified as SAM by BAZ were similarly classified by WHZ (Table 5c). Among subjects classified as SAM by MUACZ, 66.7% (4) were similarly classified by MUAC (Table 5d). Thus, only WHZ and BAZ and MUACZ and MUAC showed some degrees of similarity but not WHZ and MUACZ or WHZ and MUAC.

Discussion

This study highlights significant variation in the prevalence of SAM and other forms of malnutrition when using the MUAC, MUACZ, WHZ and BAZ classification in children 6–59 months in Jos, Plateau state, Nigeria.

The MUAC was observed to increase with age in the population studied. This finding has been reported by a study in western Nigeria by Dairo *et al.*[13] although the mean MUAC in the study (15.5 ± 1.4 cm) was higher than the 14.7 ± 1.4 cm observed in our study. The use of a fixed MUAC cut-off value across the age group 6–59 months was based on the observation that it showed existence of only small age-specific and sex-specific differences.[14]

Among all the parameters used in defining levels of malnutrition, none gave similar result with the other, neither in terms of prevalence or similarity in subject identification. Higher prevalence of SAM was seen with BAZ, then WHZ, and the least was by MUACZ. There were, however, some similarities in measures that utilised same indices, i.e. between WHZ and BAZ that utilises weight and height, and between MUAC and MUACZ that utilises the MUAC measurement. This was higher between WHZ and BAZ than between MUAC and MUACZ. Some authors believe that there is no statistical difference in outcome between WHZ and BAZ if interchanged.[4] Gender differences were not determined between MUAC and MUACZ as the population of malnourished children was quite small. There are doubts about the accuracy of MUAC if gender is not taken into consideration.[7] This difference was observed between males and females who had SAM by WHZ (Table 3). Thus, from the foregoing, each anthropometric measure of WHZ, BAZ, MUACZ and MUAC identifies different subset of SAM subjects, with varying degrees, or even lack of overlap between them. Gender modifies the interpretation of any group index, particularly the WHZ.

The variation between WHZ and MUAC has also been reported by Laillou A *et al.*[11] The report showed that using the WHO MUAC cut-off of 11.5 cm for screening, over 90% of children with a weight-for-height z-score (WHZ)<-3 were missed and WHZ < -3 missed 80% of the children with a MUAC of 11.5 cm. In our study, no subject with WHZ < -3 was identified by MUAC cut-off point contrary to the WHO report of similar prevalence of SAM when both MUAC and WHZ are compared.[10,15]

Between WHZ and MUAC, as well as WHZ and MUACZ, overlap was seen mainly among those classified as normal, 86.0% and 86.5% of cases, respectively. These are lower than the near 100% seen between WHZ and BAZ among those classified as having normal nutritional status.

From the foregoing, none of these parameters can be applied alone if all malnourished children are to be identified. This view has also been reported by other authors,[16,17] though some believe MUAC alone can be used in identifying high-risk malnourished children.[18]

There is a need to develop stand-alone parameters that can identify all malnourished children whether during screening in the field or in the clinics. Some authors[11,13] have suggested a MUAC of 13.5 cm and 15.5 cm as having a good sensitivity and specificity. Among the entire subject identified as SAM either by WHZ, BAZ or MUACZ, MUAC ranged from 11–15 cm. Application of 15 cm as MUAC cut-off point for all children will overly classify many as being malnourished. A MUAC of < 12.5 will be a more modest cut-off if MUAC alone is to be applied. BMI is not constant in the paediatric age group,[19] hence there is doubt about its reliability and it is not recommended by the WHO for under-nutrition.

While we look forward to a more robust and simpler stand-alone parameter, application of all current measures of definition is expedient in both field and clinical settings to give every malnourished child a chance of treatment.

Although the study showed variation in prevalence between the anthropometric parameters, the small sample size may be a limitation to the application of its results. Also, the population studied comprised apparently healthy children or with minor illnesses and not those with frank malnutrition.

Despite the limitations noted, the observed differences in WHZ, BAZ, MUACZ and MUAC require a re-definition of MUAC criteria for classification of malnutrition in both field and clinical practice. A new MUAC cut-off as suggested has policy implications and will require resources to support the large number of children who would be identified by such. Application of a new and higher MUAC cut-off point will retain the simplicity of MUAC as a tool for definition in both field and clinical settings. Emphasis, therefore, should be placed on capturing all methods in each subject seen, either in the field or in clinical practice. By doing so, no child is inadvertently left out for intervention as may be occurring in regions where one or the other parameter is preferred or recommended as stand-alone.

Conclusion

From the foregoing, the utility of MUAC as a stand-alone criterion in identification of all acutely malnourished children in field and clinical settings is not appropriate. MUAC only identifies a subset of acutely malnourished children. Hence, a need to either develop a new set of MUAC criteria for acute malnutrition or apply WHZ, BAZ, and perhaps MUACZ, in both field and clinical settings at all times.

The application of WHZ and BAZ can be simplified by development of anthropometric applications on hand-held devices that can make the computation of anthropometric measurements simpler.

Conflict of interest – None.

Author contributions – All authors participated in data collection, analysis and review of final manuscript.

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