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Original Article

Performance of WHO mid-upper arm circumference cut-off to diagnose severe acute malnutrition in under-fives

Fahreza Neldy Aditya, Klara Yuliarti, Murti Andriastuti

Abstract

Background Many studies indicate that the current WHO recommendation of cut-off value mid-upper arm circumference (MUAC) is not sensitive to detect severe acute malnutrition (SAM) in under-fives cases. Various new cut-off values have been proposed with better diagnostic values but have a wide interval, 12.1-14.5 cm, which may be due to different races or habitus.

Objective To evaluate the diagnostic value of MUAC in diagnosing SAM compared to the weight for height Z score (WFZ) index, to evaluate sensitivity, specificity, positive and negative predictive value of MUAC with 11.5 cm as standard cut-off, and to find an alternative cut-off value that may offer better diagnostic performance.

Methods We collected 421 subjects consecutively in January-February 2020 in Dr. Cipto Mangunkusumo Hospital (RSCM) and *Puskesmas* Cengkareng. We performed brief conversations for demographic data and did the measurement of physical examination and anthropometric measurement by trained researchers and research assistants.

Results Mid-upper arm circumference has excellent diagnostic value to assess SAM in under-fives with area under curve 0.939 (95%CI 0.903 to 0.974). Diagnostic values MUAC using cut off 11.5 cm were 21% sensitivity (Se) 21%, 99.7% spesificity (Sp) and Youden Index (YI) of 0.20. By using 13.3 cm as a new cut-off value, MUAC has Se 89%, Sp 87%, and YI of 0.76.

Conclusion We conclude that WHO MUAC cut-off using 11.5 cm has lower performance to detect SAM cases than the proposed new cut-off value of 13.3 cm. New MUAC cut-off should be considered to detect more SAM cases among under-fives. **[Paediatr Indones. 2024;64:395-402; DOI: https://doi.org/10.14238/pi64.5.2024.395-402].**

Keywords: *severe acute malnutrition; WHZ index; mid-upper arm circumference; sensitivity; specificity*

Malnutrition is still one of the world's biggest problems nowadays. *World Health Organization* stated that 45% of under-five deaths are associated with malnutrition, both directly or indirectly.[1-4] In 2016, the *United Nations of Children's Fund* (UNICEF) noted that approximately 52 million children had global malnutrition and about 17 million were severely malnourished.[5] *Riset Kesehatan Dasar 2018* (*Indonesia's 2018 Basic Health Research)* found that the prevalence of under-fives with severe acute malnutrition (SAM) was 3.5% and moderate acute malnutrition was 6.7%.[6] Severe acute malnutrition is diagnosed by having weight for height (WHZ) index < -3SD in the WHO growth chart in 2006.[7-12] In some circumstances, due to limited facility or force majeure, WHZ index is hard to perform, therefore mid-upper arm circumference (MUAC) < 11.5 cm can be used to diagnosed severe acute malnutrition in under-fives. These cut-off values were based on the similarity of mortality risk in under-

From the Department of Child Health, Faculty of Medicine, Universitas Indonesia/Dr. Cipto Mangunkusumo National General Hospital, Jakarta, Indonesia.

Corresponding author: Klara Yuliarti. Department of Child Health, Faculty of Medicine, Universitas Indonesia/Dr. Cipto Mangunkusumo Hospital. Jl. Diponegoro No 71, Jakarta, Indonesia, 10430. E-mail: klarayuliarti@yahoo.com.

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fives with WHZ < -3SD and MUAC < 11.5 cm.[13-14] Mid-upper arm circumference can be applied in patients that not have reliable body weight status such as patients with edema, mass, organomegaly or health care facilities that do not have stature meter.[7,10,15] Mid-upper arm circumference has a strong correlation with weight, easy to perform, a simple tool, and is less affected by body water status.[15-18]

Some studies stated that the 11.5 cm cut-off value is too low and not sensitive.[19-23] They recommended higher cut-off values in order to have better diagnostic performance, but the proposed values had wide intervals (12-14.1 cm).[19-23] At the beginning of this study, there was no available data regarding the MUAC cut-off value to diagnose severe acute malnutrition in Indonesia. Therefore, further data are needed to evaluate the diagnostic value of MUAC based on WHO recommendations and to find possible new cut-off values of MUAC that can give better diagnostic performance in under-fives in Indonesia.

Methods

This diagnostic study was conducted with consecutive sampling. Weight measurement was taken using *SECA 374®* and *SECA 813®*. Length and height measurements were taken using *Shorrboard™* and *SECA 216®*. Mid-upper arm circumference was taken using the non-stretchable band *SECA 202®* or the Ministry of Health of Indonesia MUAC measurement band. Measurement tools were calibrated in the Jakarta Metrology Unit. Enumerators were trained, and reliability tests were performed before the study. The nutritional status of under-fives was assessed using the WHO classification.[24-26] We performed anthropometric measurements according to the standard protocol as described in the *Food and Nutrition Technical Assistance III Project* (FANTA) that follows WHO recommendations.[25] This study was conducted in the largest primary community healthcare facility in Cengkareng, Jakarta, and has 29,110 registered under-fives in its service area. Inclusion criteria are children aged 6 to 59-month-old, and exclusion criteria applied if there were any ascites, edema, hydrocephalus, tumor or oncologic diseases, organomegaly, and uncooperative during measurement. All subjects were taken consecutively. Child growth indicator indexes such as weight for height (WFH) and weight for age (WFA) indexes were calculated using the software *WHO anthro version 3.2.2.27*. Data were analyzed using *SPSS 20*. Results were presented narratively and/or using tables and graphics. The area under the curve (AUC) was performed to evaluate MUAC diagnostic value in diagnosing severe acute malnutrition and to find the most optimum cut-off value.

Results

The reliability test showed that the enumerator has excellent reliability in anthropometric measurements with an expert as a reference. This reliability study was based on 9 subjects that also contributed to the main study. The study population included 421 subjects. The subject was recruited in Puskesmas Cengkareng in seven days. The details of the subject recruitment flow can be seen in **Figure 1**. **Table 1** represents subjects' characteristics by giving the proportion distribution of age, sex, nutritional status, and stature status of the research subjects in general.

The diagnosis validity of malnutrition (WFL < -3 SD) based on MUAC < 11.5 cm at the age of 6-59 months found that out of 421 subjects, only four subjects had proven SAM with MUAC < 11.5 cm and WFL < -3 SD. A total of 15 subjects with MUAC < 11.5 cm had a WFL < -3SD. **Figure 2** shows the receiver-operating characteristic (ROC) of MUAC in diagnosing SAM (WFH < -3SD). **Table 2** shows diagnostic test results of various MUAC cut-off points in diagnosing malnutrition compared to the WFH/WFL index.

Discussion

Early, fast, and accurate detection in diagnosing SAM is crucial to prevent mortality due to SAM at the community level.[21] Mid-upper arm circumference is a valid, simple, and affordable indicator to screen under-fives with SAM in the community.[7,8,14,19-21] Mid-upper arm circumference measurement can be easily done by the mother, village social worker, or health social worker after simple training.[23,27-31] Mid-

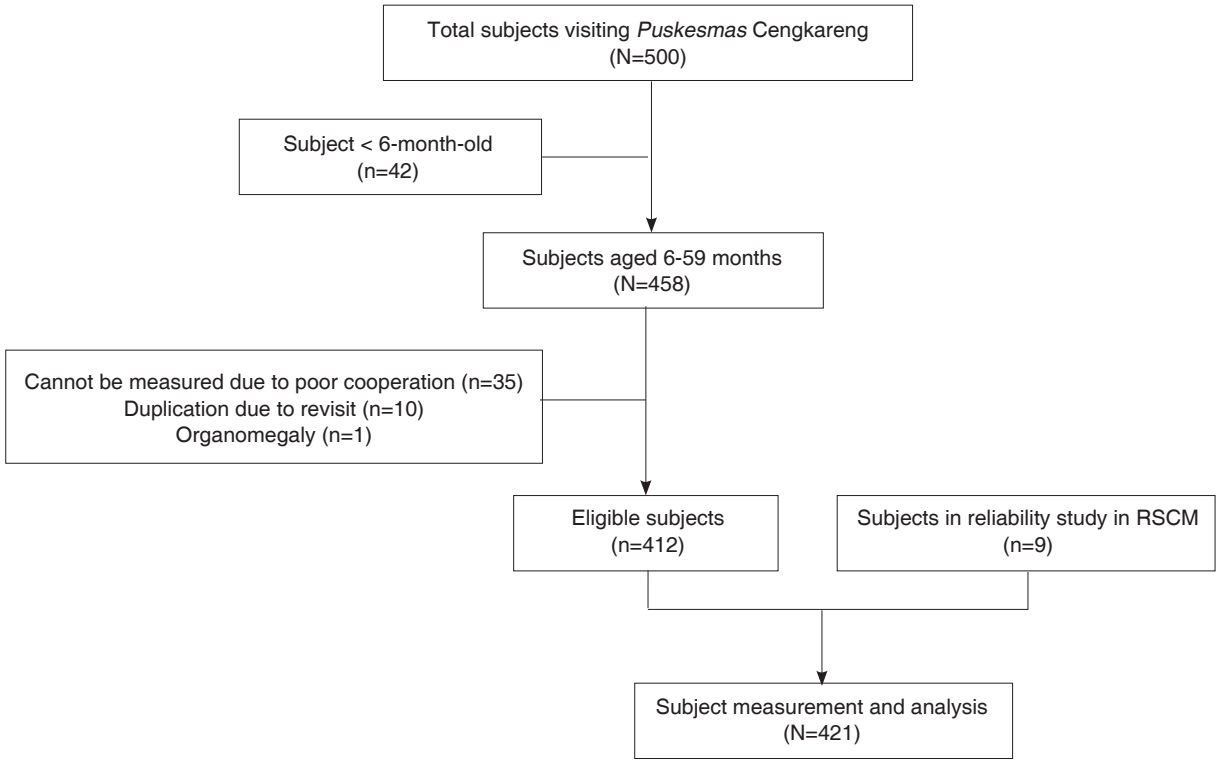

Figure 1. Subject recruitment flow

upper arm circumference can also be done to evaluate the effectiveness of therapy of SAM patients.[31-33]

Anthropometric data that are available today are usually categorized as 6 to 23-month-old and 24 to 59-month-old. As those groups have distinctive growth and development, literature defined them in different terminology: infants for 0 to 23-month-old and preschool children for 24 to 59-month-old.[29-31] This study found that there is a significant difference in median weight, height, and MUAC in these two groups. In this study, we also performed sub-group analysis.

In general, MUAC has excellent diagnostic performance in diagnosing SAM with AUC 0.939 (95%CI 0.903 to 0.974). This study reported that MUAC using WHO recommendation value has poor sensitivity (21%) and high specificity (99,7%). Other studies also support that 11.5 cm as a cut-off value has poor sensitivity and should not be used to screen SAM at the community level.[14-18] We found that MUAC 13.3 has better diagnostic performance (sensitivity 89% and specificity 87%) with YI 0.76. A study in India[15] recommends 12.8 cm as cut-off value, while a study in Cambodia[16] suggests two different cut-off values: 13.5 cm (0 to 23-month-old) and 14.1 (24 to 59-month-old), and a study in Niger[17] suggests 12 cm (6 to 24-month-old). Semarang study consisting of 843 under-fives suggests 14 cm as the most optimum cut-off value to screen SAM in community settings (sensitivity 96% and specificity 80%).[18] If we applied 14 cm as our cut-off value in

Table 1. Subject characteristics

Characteristics	N=421
Gender, n(%)	
Boy	230 (54.6)
Girl	191 (45.4)
Age, n(%)	
6-23 mo	179 (42.5)
24-59 mo	242 (57.5)
Nutrition status (WFL), n(%)	
Severe	19 (4.5)
Moderate	60 (14.3)
Well-nourished	331 (78.6)
Overweight	4 (1)
Obese	7 (1.7)
Stature (LFA/HFA), n(%)	
Normal	337 (80)
Stunted	66 (15.7)
Severely stunted	18 (4.3)

WFL=weight for length; LFA=length for age; HFA=height for age

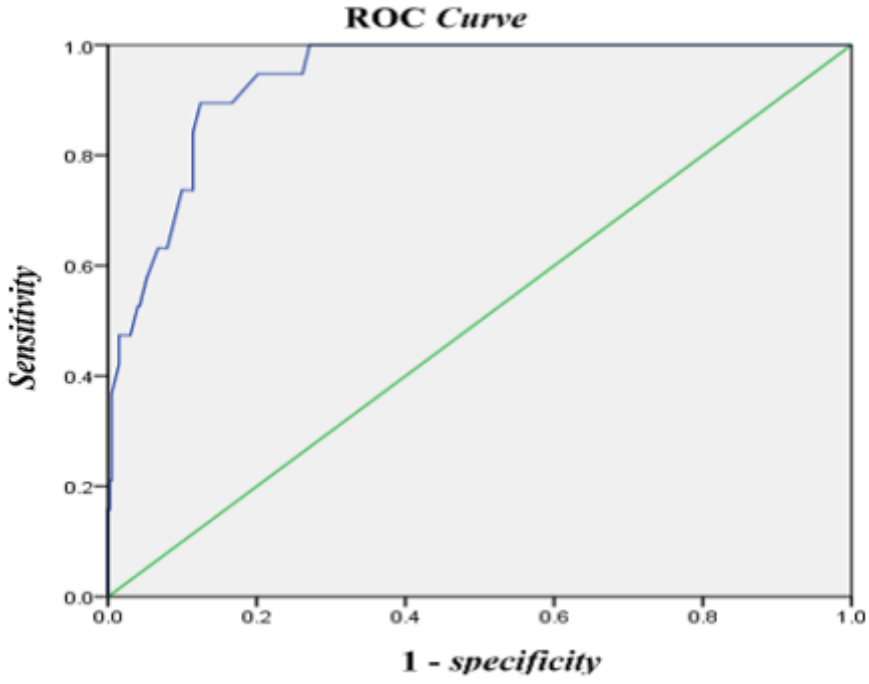

Figure 2. ROC Curve MUAC and WFL in diagnosing SAM in under-fives (6 to 59-month-old) [AUC 0.939, 95%CI 0.903 to 0.974]

Table 2. Summary of diagnostic value of MUAC in few cut-off values in diagnosing SAM (WFH/WFL < -3SD) in 6 to 23-month-old

MUAC cut-off value (cm)	Se	Sp	YI	PPV	NPV	LR+	LR-
11.5	0.31	0.99	0.3	0.8	0.95	31	0.69
12.0	0.46	0.98	0.44	0.75	0.96	23	0.55
12.5	0.69	0.97	0.66	0.45	0.97	23	0.32
12.8	0.85	0.86	0.71	0.32	0.99	6	0.17
13.3	1	0.77	0.77	0.25	1	4.35	0
13.5	1	0.69	0.69	0.20	1	3.2	0

Sn=sensitivity; Sp=specivicity; YI= Youden index; PPV=positive predictive value; NPV=negative predictive value; LR+=positive likehood ratio; LR-=negative likehood ratio

our study, the diagnostic performance of MUAC in diagnosing SAM will have 100% sensitivity and 72% specificity. A summary of available data regarding the most optimal cut-off value of MUAC is shown in **Table 3**.

The older the children, the more weight, length, and MUAC. This finding may explain the need for different cut-off values to have the most optimum diagnostic value in two different groups (6 to 23-month-old and 24 to 59-month-old). A study in Cambodia also proposed two different cut-off values to screen severe acute malnutrition, 13.5 cm for ages 6 to 23-month-old and 14.1 cm for 24 to 59-month-old. That new suggested cut value would have 73% sensitivity in each group.[14]

In this study, in the 6 to 23-month-old group, MUAC had an excellent diagnostic value with AUC 0.946. The current recommended cut-off value, 11.5 cm, has a sensitivity of 31% and can be increased by 85% using 12.8 cm as the cut-off value and 100% using 13.3 cm. The highest Youden Index was found at 13.3 cm.

In 24 to 59-month-old children, MUAC has an excellent diagnostic value with an AUC of 0.99. The current cut-off value (11.5 cm) in the 24 to 59-month-old group had 0% sensitivity. This extreme

value was also shown in a larger study in Cambodia.[15] This finding supports the policy "not to use 11.5 cm" to screen SAM in older children. The most optimum cut-off values were 13.9 cm (Se 83%, Sp 87%) and 14.1 cm (Se 100, Sp 78%).

Malnutrition should be viewed not only as a family matter but also as a national problem.[32] In addition, malnutrition has to be viewed as a syndrome of developmental disorder that may last into adulthood.[10,34-35] As we know, malnutrition is associated with motor growth retardation, cognitive impairment, decreased immunity, and function performance in school and job later on in adulthood. Furthermore, female under-fives who suffer from malnutrition tend to give birth with low birth weight.[10,34-35] National programs to prevent malnutrition and low birth weight babies are the most beneficial long-term strategy to implement in a nation.[31] Therefore, Indonesia should be able to screen SAM in under-fives and give appropriate treatment.

Limited healthcare facilities and healthcare accessibility are still problems in Indonesia. In community-based healthcare, height and weight measurements may not possible to be done. Therefore, MUAC can be a suitable diagnostic/screening tool to assess nutritional status in children under five. The use of 11.5 cm as the recommended cut-off value has a low capability to identify infants at risk or having acute malnutrition. On the other hand, 14.1 cm, if used as a cut of value, will increase referral cases exponentially to higher facilities and increase the probability of false negative cases. Cut-off values with high sensitivity and high specificity are needed in order to achieve the most likely SAM with a low false referral case rate.

We propose a two-step model for screening and treating severe acute malnutrition. Step 1 was done in community-based healthcare facilities using a new cut-off value to screen SAM. Step 2 in bigger healthcare facilities will perform height and weight measurements and verify actual nutritional status. This 2-step model has already been introduced by the Ministry of Health of Indonesia, using 12.5 cm as a cut-off value to screen moderate and severe acute malnutrition so that she/he can be treated (**Figure 3**). A study in Cambodia suggested a similar two-step model in 2017.[36]

Based on our data, 12.5 cm has only 47% sensitivity when screening SAM cases. The use of 13.3 cm as cut-off value will increase the sensitivity to 57% specificity to 94% to screen for moderate acute malnutrition (MAM). The current WHO MUAC cut-off of 11.5 cm to screen for SAM should be considered to be revised.

Conflict of interest

None declared.

Table 3. Summary of available data regarding the most optimal cut-off value of MUAC in diagnosing SAM in under-fives.

Diagnostic values	Cut off of MUAC value in diagnosing SAM (WHZ index< -3SD)											
	Cambodia[14]		India[15*]		Cambodia[16**]		Niger[17***]		Semarang[18*]		Jakarta (this study)	
Cut off value of MUAC, cm	11.5	13.3	11.5	12.8	11.5	13.5/14.1	11.5	12.0	11.5	14	11.5	13.3
Sensitivity, %	6.1	67	13.6	50%	8.6/2.8	80/81	57	88	16.7	95.8	21	89
Specificity, %	99.7	87	99.3	90.8	93/100	73/73	97	81	99.6	80.3	99.7	87
Positive predictive value, %	20	6.6	50	83.3	-	-	47	17.5	57	12.4	80	25
Negative predictive value, %	98.6	99.5	95.7	64.2	-	-	98	99.3	97.6	99.9	96.4	99

MUAC=mid-upper arm circumference; SAM=severe acute malnutrition; WHZ=weight-for-height Z-score. Study in Semarang used MUAC cut off value ≤11.5 cm and ≤ 14 cm in diagnosing SAM (*subject of study were 6 to 60-month-old; **subject of study were 0 to 23-month-old dan 24 to 59-month-old; ***subject of study were 6 to <24-month-old. A cut-off value of 11.5 cm is based on WHO recommendation and other cut-off values are the new suggested values based on each study.

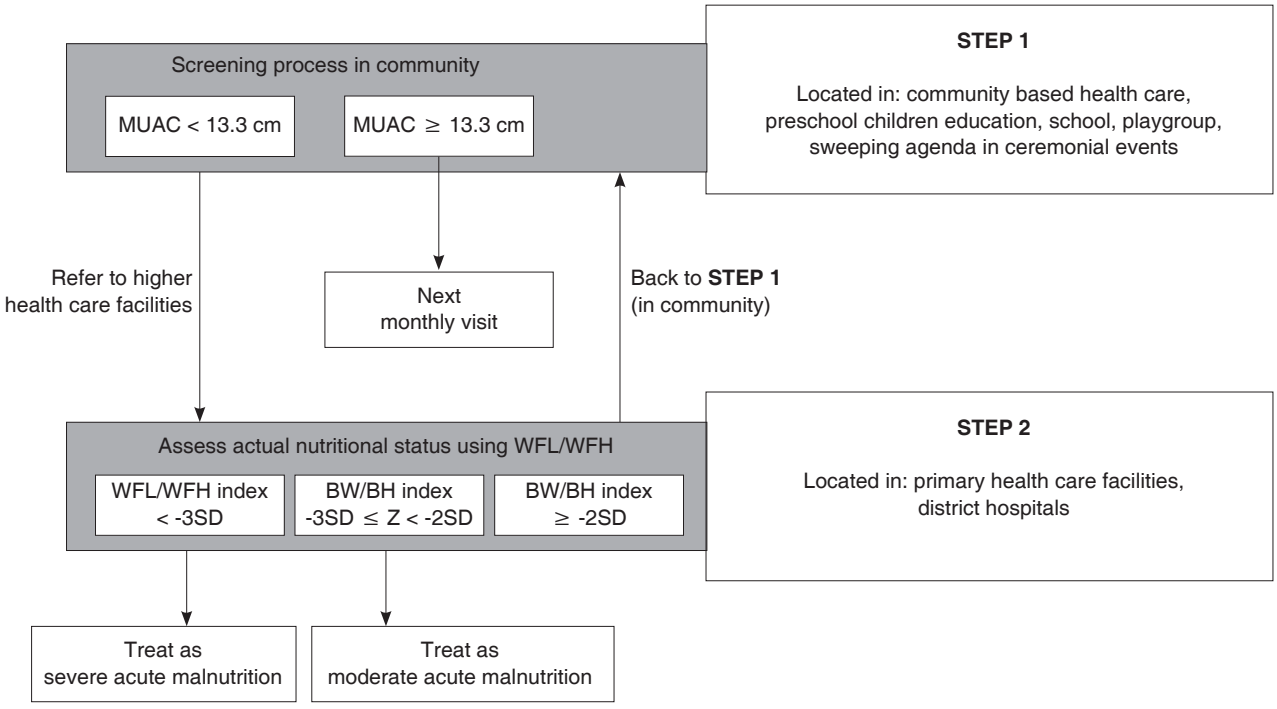

Figure 3. The proposed recommendation screening process of under-fives in a community setting with recommendation cut-off value of this study[10,19,22]

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