Taylor & Francis
Taylor & Francis Group

South African Journal of Clinical Nutrition

ISSN: 1607-0658 (Print) 2221-1268 (Online) Journal homepage: https://www.tandfonline.com/loi/ojcn20

Mid-upper arm circumference (MUAC) performance versus weight for height in South African children (0–59 months) with acute malnutrition

Natisha Dukhi, Benn Sartorius & Myra Taylor

To cite this article: Natisha Dukhi, Benn Sartorius & Myra Taylor (2017) Mid-upper arm circumference (MUAC) performance versus weight for height in South African children (0–59 months) with acute malnutrition, South African Journal of Clinical Nutrition, 30:2, 49-54, DOI: 10.1080/16070658.2016.1255483

To link to this article: https://doi.org/10.1080/16070658.2016.1255483

South African Journal of Clinical Nutrition 2017; 30(2):49–54
http://dx.doi.org/10.1080/16070658.2016.1255483

SAJCN
ISSN 1607-0658 EISSN 2221-1268

RESEARCH

Mid-upper arm circumference (MUAC) performance versus weight for height in South African children (0–59 months) with acute malnutrition

Natisha Dukhi[a]*, Benn Sartorius[b] and Myra Taylor[b]

[a]*Department of Human Physiology, University of KwaZulu-Natal, Durban, South Africa*
[b]*Discipline of Public Health Medicine, University of KwaZulu-Natal, Durban, South Africa*
Corresponding author, email: doctordukhi@gmail.com

Objectives: The objective of this study was to compare mid upper arm circumference (MUAC) and weight for height (W/H) as indices of acute malnutrition in children aged 0–59 months in South Africa.
Design: A cross-sectional weighted survey of households was performed.
Subjects and setting: Children aged 0–59 months and their mothers/caregivers were included in the study in iLembe district conducted between April and September 2014.
Outcome measures: W/H and MUAC were measured and z-scores were calculated using the 2006 World Health Organisation (WHO) child growth standards.
Results: Of the 572 child participants, 44 were malnourished (7.7%) using W/H measurements in comparison to 38 children (6.6%) using MUAC. There was ~54.0% agreement between the two indices when categorised in standard deviation (SD) bands and the significant Kappa statistic value of 0.27 constituted fair agreement. Similar percentages of male (1.1%) and female (1.1%) children under five years of age were detected with severe acute malnutrition (SAM) using W/H. In children aged 0–6 months W/H identified ten children as malnourished compared to only one child identified as malnourished using MUAC.
Conclusions: The study found W/H to be a more sensitive measure. At a facility level W/H is considered the anthropometric measure of choice in children aged 0–59 months as nurses are trained in obtaining this measure. At the household level MUAC is preferred as a quick and easy measuring tool. In South Africa, the Road to Health Card, given at the clinics, records the W/H of children up to five years of age to assist in the prevention of childhood malnutrition. Future studies are recommended using both indicators in community settings in children particularly during 0–6 months as it is during this critical age period that moderate acute malnutrition (MAM) and SAM can be detected for timeous treatment and management of malnutrition.

Keywords: anthropometry, children, malnutrition, MUAC, weight for weight

Introduction

Malnutrition in both children and adults is a major public health concern.[1] Approximately 45% of mortality in children under five years of age in developing countries is due to under nutrition, which increases the mortality risk resulting from compromised immune systems.[2] In assessing nutritional status, anthropometry indicators for acute malnutrition include mid upper arm circumference (MUAC) and weight for height (W/H) which measure wasting.[3] Moderate acute malnutrition (MAM) is an important focus that is often given less prominence yet it is more prevalent than severe acute malnutrition (SAM). According to Cogill,[4] the classification of malnutrition based on z-scores is as follows: +1 SD is normal; <-1 SD and ≥ -2 SD is mild malnutrition; <-2 SD and ≥ -3 SD is moderate malnutrition; and, < -3SD is severe malnutrition. However, MAM also increases the risk of morbidity and mortality.[5] Identification of SAM is critical and requires urgent medical and nutritional support.[5] Both W/H and MUAC serve as nutritional status proxies, in their use as a screening tool for SAM, but the underlying concepts differ. In wasted children MUAC has often been used as a pre-screening tool, while W/H has been used to confirm the diagnosis.[6,7]

Both anthropometric indices show an indirect reflection of fat and lean muscle catabolism that is obvious in SAM and are therefore the anthropometric measurements of choice in assessing the magnitude of malnutrition.[8] However, W/H requires the measuring of weight and height, as well as a reference table, while using MUAC requires only the use of a tape measure with a fixed cut off.[9] MUAC is regarded as a useful screening tool in community interventions and a better predictor of mortality in children.[10] However, the discrepancies regarding MUAC and W/H include age, sex, as well as body shape.[9] W/H and MUAC z-scores have been shown to identify different child populations with SAM, with only a small level of overlap.[11]

Of the approximately 45% mortality in children under the age of five due to undernutrition, a large portion of the mortality is due to diarrhoea.[12] Often diarrhoea and undernutrition manifest concurrently in children. Children with diarrhoea present with decreased weight gain, with undernourished children being more susceptible to diarrhoea.[12] Although a bidirectional relationship between diarrhoea and malnutrition exists, the impact of hydration status on malnutrition assessment in children is not well documented.[13–15] As the weight of a child can decrease due to dehydration, anthropometric measures such as W/H in children with diarrhoea can be confusing.[16]

From the data collected over the last decade and a half, measurements for MAM and SAM have been restricted to specific age groups in infants and young children.[17] However, data are lacking for the 0–6 month age group in South Africa. According to Lopriore *et al.*,[18] infants less than six months old are commonly excluded from studies, resulting in miscalculating the undernutrition prevalence in children less than five years old. Therefore, the objective of this study was to compare MUAC and W/H as indices of acute malnutrition in children aged 0–59 months in South Africa.

Method

Setting and design

The study was a randomised community-based cross-sectional household survey undertaken in iLembe district, KwaZulu-Natal (KZN). The study population included children aged 0–59 months, and their mothers/caregivers. The study was conducted over a 21 week period between April and September 2014.

Sampling

Based on the Statistics South Africa 2011 database, in a weighted cross-sectional study a randomised community survey was carried out in iLembe district, stratifying households by the four subdistricts, then by ward (n = 32) and enumerator areas (4 per ward, n = 120). A total of 1199 households in ILembe district were randomly selected using geographic positioning systems (GPS), of which 484 households were identified with children under age five, and 415 households (85.7%) consented to participate in the study. A total of 615 children under age five were enrolled in the study from these 415 households.

Measures

Basic anthropometry was performed on children aged 0–59 months measuring weight, height/length and MUAC.

Weight: The weight of the child was taken using a portable Philips® digital bathroom scale-model HF340/00, with measurements taken to the nearest 0.1 kg for accuracy. The participants were weighed with minimal clothing, without shoes and preferably with an empty bladder. Children less than 24 months of age were weighed together with the mother and the weight of the mother was subtracted to obtain the weight of the child.[19] Weight measurements were taken in duplicate for accuracy and a correct average.

Height/length: The height of the child was determined using a Scales® 2000 moveable stadiometer for ages 2–5 years or length mat for children less than two years old. Measurements were taken to the nearest 0.1 cm for accuracy. The participants were measured without shoes. Participants were required to stand with their legs straight, heels and the height measure touching at the back, arms at the sides, relaxed shoulders, with chin level to ground and looking straight ahead. With infants, participants were placed in a supine position, using the length mat to the nearest 0.1 cm to measure the infant from crown to heel.[19] Height/length measurements were taken in duplicate for accuracy and a correct average.

Mid-Upper Arm Circumference (MUAC): MUAC was measured using colour-coded non-stretch measuring tapes to the nearest 1 mm.

The tape was able to fit tightly but not so as to restrict blood flow or dent the upper arm. The left arm was bent at the elbow. The point of measurement was the distance between the bony prominence at the top of the shoulder (superiorly) and the point of the elbow being bent. To measure the MUAC, the middle of this above-mentioned distance was marked on the arm, and then the MUAC was measured at this midpoint.[19] The MUAC was also done in duplicate. If the measurements were discrepant by more than 0.5 cm then a third observation was taken and the two similar measurements were used.

Procedures

The study was approved by the University of KwaZulu-Natal (UKZN) Biomedical Research Ethics Committee (REF No BE099/14). The data were collected by five teams (1 male and 1 female per team) who underwent 2 months of training in anthropometry. During training fieldworkers completed anthropometric measurements using the same children, as well as children in the same age group. Therefore, no inter-observer significant difference between the fieldworker teams for anthropometry was found. During the pilot study this was also observed as each fieldworker in a team completed measurements to verify accuracy.

Data analysis

Data were processed and analysed using Stata 13.0 (StataCorp. 2013. Stata Statistical Software: Release 13. College Station, TX: StataCorp LP).

Anthropometric z-scores for age for MUAC, weight and height data were calculated against the 2006 World Health Organisation (WHO) growth standards for children.[20] This was performed using the "zscore06" and "zanthro" anthropometric add on modules available for Stata. Differences in mean anthropometric z-score by gender were analysed using the 2-sample independent t-test. Comparison of mean W/H versus MUAC z-score within each gender were analysed using the paired t-test.

The overall malnutrition prevalence was estimated for each index, compared using a Kappa statistic and further compared by stratifying on age and sex. The malnutrition prevalence for each metric by age group and sex are presented with 95% confidence intervals. Comparison of prevalence frequencies by age and gender as well as other categorical characteristics were assessed using a survey weighted Chi-square (χ^2) test. A p-value of < 0.05 was considered statistically significant.

Results

Demographic details of children:

There were 615 children 0–5 years participating in the study, 46.9% (n = 300) were male and 52.4% (n = 310) were female. Data regarding the sex of five children was missing. Over half of the children (63.1%) were between ages 1–4 years (Table 1). Most of the children were from the 3–4 year group (20.3%), with the 4–5 year group being the smallest (16.8%).

Table 1: Weighted Demographics of children aged 0–5 years old by sex in iLembe district (n = 615)

Age Groups (months)	Number (%), (95% CI) of Children per Age Category		
	Male	Female	Total
< 1 year	58 (20.5%, 95% CI: 15.3, 26.9)	63 (19.9%, 95% CI: 14.6, 26.4)	121 (20.1%; 95% CI: 16.1; 24.9)
1–2 years	57 (19.0%, 95% CI: 14.5, 24.4)	72 (25.4%, 95% CI: 17.9, 34.7)	129 (22.2%; 95% CI: 17.4; 27.9)
2–3 years	60 (20.3, 95% CI: 15.8, 25.7)	64 (21.1%, 95% CI: 16.1, 27.3)	124 (20.6%; 95% CI: 17.2; 24.4)
3–4 years	77 (25.0%, 95% CI: 19.8, 30.8)	53 (16.3%, 95% CI: 11.0, 23.4)	130 (20.3%; 95% CI: 16.7; 24.5)
4–5 years	48 (15.4%, 95% CI: 11.3, 20.6)	58 (17.3%, 95% CI: 12.4, 23.7)	106 (16.8%; 95% CI: 13.9; 20.1)
Total	300	310	610

Table 2: The Kappa statistic agreement between W/H z-scores and MUAC z-scores

		MAUC z-score							
	Category	**−3**	**−2**	**−1**	**0**	**1**	**2**	**3**	**Total**
	−3	0	1	0	1	1	0	0	3
	−2	0	0	2	2	0	0	0	4
	−1	1	2	7	19	0	0	0	29
WH z-score	0	1	2	20	195	30	7	1	256
	1	0	0	1	71	56	9	2	139
	2	0	1	0	16	30	18	4	69
	3	0	0	0	4	6	11	8	29
	Total	2	6	30	308	123	45	15	529

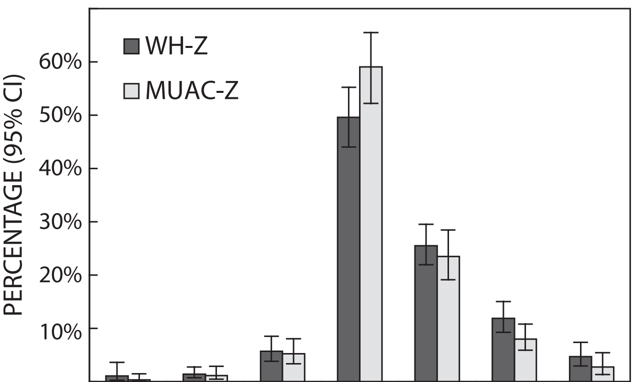
Note: Kappa statistic: 0.27 (observed agreement: 53.69%; expected agreement: 35.87%, $p < 0.001$).

Anthropometric characteristics of the children

Our study targeted children 0–59 months but when visiting households we were not able to always obtain both MUAC and W/H measurements if the child was restless. Field workers were also instructed to not insist on obtaining the anthropometric measurements if the children were restless or crying. Thus, of the 615 child participants, measurements were only obtained using both indices for 529 children. Using both the weight for height z-score ($n = 564$) and the MUAC z-score ($n = 536$) male and female children had similar low mean scores for each measure, 0.88 (SD 1.46) and 0.87 (SD 1.38) for males and females respectively for W/H z-score (p-value = 0.856) and 0.61 (SD 1.25) and 0.60 (SD 1.15) for males and females, respectively, for MUAC z-score (p-value = 0.901). Comparing mean W/H with MUAC z-scores within each gender indicated significant differences for both sexes ($p < 0.001$).

Table 2 presents the agreement between W/H and MUAC z-scores categories. There was ~54.0% agreement between the two indices when categorised in standard deviation (SD) bands and the Kappa statistic value of 0.27 constituted fair agreements for the 529 children for whom valid z-scores were estimated against the WHO 2006 standards.

Based on W/H, 44 children were identified as malnourished and were categorised as follows: 31 had mild malnutrition; eight had MAM; and five had SAM. In comparison, using MUAC, 38 children were malnourished: 30 children had mild malnutrition; six children had MAM; and two children had SAM. More male children, (2.8 % and 1.5% for W/H and MUAC, respectively) were detected as malnourished in comparison to female children (1.8% and 1.5%, respectively). Using W/H SAM was detected in 1.1% males and 1.1% females, MAM was 2.0 % in males and 1.0% in females, and mild malnutrition was detected in 6.0% males and 5.5% females. In comparison, using MUAC as a measure, SAM was detected in 0.5% males and 0.3% females, MAM in 1.5% males and 0.8% females, and mild malnutrition in 6.1% males and 4.4% females. In children aged 0–6 months using W/H, five children were identified with mild malnutrition, two were moderately malnourished and three were severely malnourished. In comparison using MUAC, only one child was identified with SAM.



	-3	-2	-1	0	1	2	3
WH-Z	0.0107	0.0145	0.0574	0.4962	0.2553	0.1188	0.047
MUAC-Z	0.0035	0.0115	0.0521	0.5903	0.2348	0.0802	0.0276

Figure 1: Percentage (95% confidence intervals) for W/H z-scores ($n = 564$) and MUAC z-scores ($n = 536$) for children aged 0–5 years old in iLembe district, based on survey weights.

Thus, Figure 1 confirms that W/H was a more sensitive measure than MUAC in identifying malnourished children in iLembe district. Figure 1 also suggests that W/H identifies more children than MUAC at risk of overweight and obesity.

In Figure 2 the correlation indicates a positive linear relationship that exists between W/H z-scores and MUAC z-scores ($r = +1$; $p < 0.001$). There are however, outlying points for children at risk of mild, moderate and severe undernutrition indicating the lack of consensus between the measures concerning the nutritional status of the children.

Figure 3 presents a comparison of W/H and MUAC mean z-scores for children by age. At <1 year, W/H appeared to be a more sensitive measure than MUAC although the 95% confidence intervals overlap, as is also shown for children from 1 to <3 years. For children 1 to 4.99 years, the mean MUAC z-score was significantly less than that for W/H. For MUAC, there was a decrease in the mean z-score with increasing age and this trend was also observed amongst children from 1 to 4.99 years for W/H.

In Table 3, the proportion of children identified with severe acute malnutrition ($n = 4$), moderate acute malnutrition ($n = 5$) and mild malnutrition ($n = 7$) by W/H measure compared to MUAC was greater in children younger than one year old.

Discussion and recommendations

While MUAC is considered an appropriate diagnostic screening tool for nutritional status,[21] minimal changes in children aged 1–5 years old have been observed.[5]

This study identified W/H (7.7%) as a more sensitive measure of child malnutrition and measured more than double for the children with SAM compared to MUAC. W/H also appeared as a

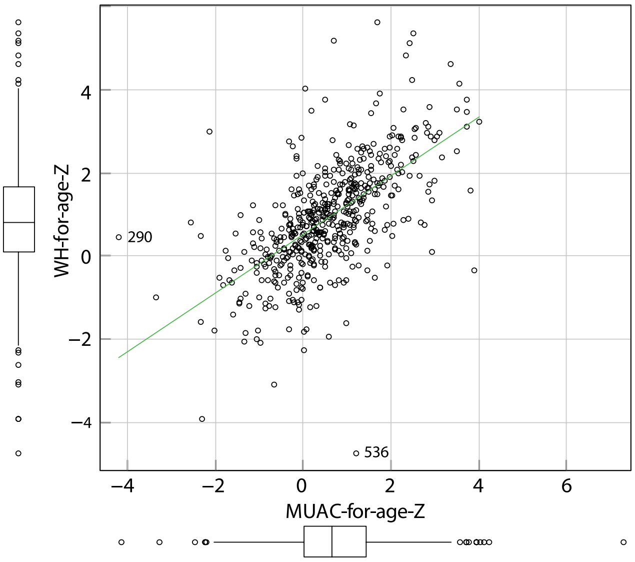


Figure 2: Correlation between W/H (*n* = 564) and MUAC (*n* = 536) z-scores for children aged 0–5 years old in iLembe district, based on survey weights.

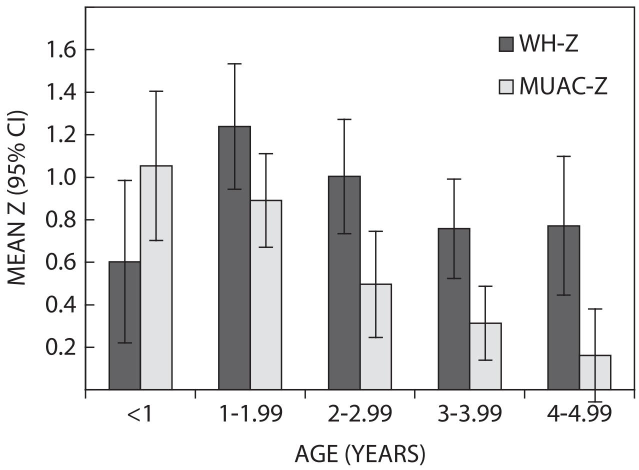


Figure 3: Mean weight for height z-scores (*n* = 564) and MUAC z-scores (*n* = 536) (95% CI's) for children aged 0–5 years old in iLembe district, based on survey weights.

more sensitive measure in children less than a year old compared to MUAC but from ages 3 to <5 years a divergence appeared whereby MUAC was a more sensitive measure than W/H as the child's age increased. There was no report of oedema in the children of this study. While SAM identification was low in our study, W/H was a sensitive measure to identify more children with MAM (3.0%). Although the level of wasting was low in our study, as per the global trend, at the primary healthcare (PHC) level there is a need for attention to malnutrition in the iLembe district. Although the debate about using W/H and MUAC is ongoing, our study confirmed wasting in children aged 0–59 months at a sub district level, requiring that children's weight be monitored throughout the district to target more interventions.

In South Africa, children face a multiple burden of disease as reported by the District Health Barometer (DHB) 2014/15. The disease burden profile indicated diarrheal disease as the leading cause of child mortality.[22] According to Modi *et al*.,[23] previous research reported that W/H measurements had variations based on the severity of a child's dehydration status, while dehydration status did not significantly affect MUAC measurements. Thus, in undernutrition W/H was considered as a poor indicator in children that also had diarrhoea. This study diagnosed more children with MAM and SAM using W/H measurements compared to MUAC.

Two previous studies in SA reported low wasting prevalence using W/H as a measure that was consistent with the current study.[24,25] The findings of both studies followed the trend that exists in SA that acute malnutrition levels were low in comparison to high chronic malnutrition levels.

To assist in addressing the current child malnutrition burden in South Africa, the Guidelines on the Integrated Management of Acute Malnutrition (IMAM) in KwaZulu-Natal was compiled in 2014. The IMAM guidelines aims to detect and treat SAM in children before any life threatening complications occur. As of 2014, nutrition advisors and dieticians have been instituted in all clinics to detect malnutrition cases as well as provide follow-up and counselling on malnutrition status at a community level.[26]

Table 3: Percentage of children by anthropometric score and age group, iLembe district

Metric	Range	Age group					Overall
		<1 yr old	1–1.99 yrs old	2–2.99 yrs old	3–3.99 yrs old	4–4.99 yrs old	
W/H z-score	−3 or less	4.30%	0.77%	0.00%	0.00%	0.00%	1.08%
	−2 to 2.99	5.04%	0.64%	1.21%	0.00%	0.00%	1.91%
	−1 to −1.99	7.47%	4.60%	6.65%	4.03%	6.10%	5.97%
	−0.99 to +0.99	50.61%	39.84%	40.41%	59.94%	62.54%	46.03%
	+1 to +1.99	17.43%	27.83%	36.74%	25.13%	17.54%	27.00%
	+2 to +2.99	10.04%	18.35%	12.40%	8.01%	9.12%	12.66%
	+3 or more	5.10%	7.98%	2.59%	2.89%	4.69%	5.35%
MUAC z-score	−3 or less	0.90%	0.00%	0.92%	0.00%	0.00%	0.45%
	−2 to 2.99	0.00%	1.86%	2.28%	0.00%	1.08%	1.50%
	−1 to −1.99	3.01%	0.54%	5.77%	6.07%	12.52%	6.14%
	−0.99 to +0.99	47.20%	52.92%	54.47%	74.63%	65.09%	58.64%
	+1 to +1.99	26.68%	29.18%	28.31%	15.70%	15.26%	23.05%
	+2 to +2.99	13.43%	11.62%	6.89%	3.60%	4.97%	7.00%
	+3 or more	8.78%	3.87%	1.37%	0.00%	1.08%	3.23%

Growth monitoring of children is important and the Road to Health Booklet is a critical tool that can monitor the progress of child growth. Nursing staff at clinics should be retrained or undergo refresher training to keep the booklet updated. Mothers should also be assisted by PHC staff and community caregivers for better understanding of the booklet. The burden of undernutrition requires urgent attention. Therefore nursing staff at PHC level should be trained on how to identify these conditions in young children. Ward-based outreach teams are also important for follow-up of identified children.

The results of this study relate closely to the previous South African studies and national surveys indicating that careful monitoring is required when using W/H and MUAC in detecting malnutrition rates. The debate about using W/H as the indicator of choice in child malnutrition is ongoing. At a global level there have been discrepancies between the uses of these two indicators, whereby acute malnutrition rates were sometimes identified as similar, or where one measure indicated a higher prevalence of malnutrition over the other.[27] National surveys in the Philippines found malnutrition prevalence to be greater using W/H in comparison to MUAC measurements.[10] A systematic review, conducted to assess acute malnutrition using W/H, reported W/H alone as a recommended anthropometric tool but its reliability in the context of a setting called for further investigated.[28] Thus, the WHO has recommended that where differences exist between W/H and MUAC, both measures should be considered.[10]

According to Young, age plays a significant role in MUAC and W/H discrepancies, as it is associated with food insecurity.[29] In young children, wasting is indicative of disease together with poor feeding practices, while wasting is indicative of food insecurity in older children. Thus, Bern suggests that during a period of food insecurity, older children are likely to experience larger acute malnutrition increases in comparison to younger children and wasting prevalence increases.[30] This further suggests that the use of MUAC alone can possibly mask malnutrition problems in children and therefore create inaccurate findings of regional and/or national food insecurity. Therefore, use of both anthropometric indices is recommended to ensure all age groups are correctly identified for malnutrition.

Limitations

Dehydration status and diarrheal disease were not included as criteria that may impact on W/H measurements and misclassify children with SAM.

Acknowledgements – The study was funded by Elma Philanthropies; N Morris, T Reddy and C Connolly (Medical Research Council) for maps and weighting; iLembe Department of Health; Research assistants and the community participants.

References

1. Zhou H, Wang XL, Ye F, et al. Relationship between child feeding practices and malnutrition in 7 remote and poor counties, PR China . Asia Pac J Clin Nutr. 2012;21(2):234–40.
2. Vakili R, Moghadam ZE, Khademi G, et al. Child mortality at different world regions: a comparison review. Int J Pediatr. 2015;3(20):809–16.
3. Walton E, Allen S. Malnutrition in developing countries. Pediatr Child Health. 2011;21(9):418–24. http://dx.doi.org/10.1016/j.paed.2011.04.004
4. Cogill B. Anthropometric Indicators measurement guide [Internet]. 2003. [cited 2016 March 20]. Available from: http://www.fantaproject.org.
5. Nikiema L, Huybregts L, Kolsteren P, et al. Treating moderate acute malnutrition in first-line health services: an effectiveness cluster-randomized trial in Burkina Faso. Am J Clin Nutr. 2014;100:241–9. http://dx.doi.org/10.3945/ajcn.113.072538
6. Laillou A, Prak S, de Groot R, et al. Optimal screening of children with acute malnutrition requires a change in current WHO guidelines as MUAC and WHZ identify different patient groups. PLoS ONE. 2014;9(7):e101159. http://dx.doi.org/10.1371/journal.pone.0101159
7. Mogendi JB, De Steur H, Gellynck X, et al. Efficacy of mid-upper arm circumference in identification, follow-up and discharge of malnourished children during nutrition rehabilitation. Nutr Res Pr. 2015;9(3):268–77. http://dx.doi.org/10.4162/nrp.2015.9.3.268
8. Dale NM, Myatt M, Prudhon C, et al. Using mid-upper arm circumference to end treatment of severe acute malnutrition leads to higher weight gains in the most malnourished children. PLoS ONE. 2013;8:e55404. http://dx.doi.org/10.1371/journal.pone.0055404
9. Goossens S, Bekele Y, Yun O, et al. Mid-upper arm circumference based nutrition programming: evidence for a new approach in regions with high burden of acute malnutrition. PLoS ONE. 2012;7(11):e49320. http://dx.doi.org/10.1371/journal.pone.0049320
10. Cichon B. MUAC versus weight-for-height debate in the Philippines. [Internet]. 2012. [cited 2016 March 20]. Available from: http://fex.ennonline.net/42/muac.
11. World Health Organization (WHO). Updates on the management of severe acute malnutrition in infants and children. Geneva: WHO; 2013.
12. Wierzba TF, El-Yazeed RA, Savarino SJ, et al. The interrelationship of malnutrition and diarrhea in a periurban area outside Alexandria, Egypt. J Pediatr Gastroenterol Nutr. 2001;32:189–96. http://dx.doi.org/10.1097/00005176-200102000-00018
13. Nel ED. Diarrhoea and malnutrition. South Afr J Clin Nutr. 2010;23: S15–8. http://dx.doi.org/10.1080/16070658.2010.11734262
14. Olimen P, Onyaye E. Nutritional assessment of children aged twelve to fifty-nine months with diarrhoea using mid-upper arm circumference (MUAC). BMJ. 2013;4:1315–26.
15. Talbert A, Thuo N, Karisa, et al. Diarrhoea complicating severe acute malnutrition in Kenyan children: a prospective descriptive study of risk factors and outcome. PLoS ONE. 2012;7:e38321. http://dx.doi.org/10.1371/journal.pone.0038321
16. Mwangome MK, Fegan G, Prentice AM, et al. Are diagnostic criteria for acute malnutrition affected by hydration status in hospitalized children? A repeated measures study Nutr J. 2011;10:243. http://dx.doi.org/10.1186/1475-2891-10-92
17. Save the Children. Emergency health and nutrition. Save the children [Internet]. 2014. [cited 2016 August 30]. Available from: http://www.savethechildren.org/site/c.8rKLIXMGIpI4E/b.6206891/k.306B/EmergencyHealthandNutrition.html
18. Lopriore C, Dop MC, Solal-Celigny A, et al. Excluding infants under 6 months of age from surveys: impact on prevalence of pre-school undernutrition. Public Health Nutr. 2007;10:79–87.
19. National Department of Health (NDoH). Training modules for growth monitoring, counseling and promotion: the road to health. Department of Health, Pretoria; 2005.
20. World Health Organization (WHO). WHO multicentre growth reference study group. WHO child growth standards: length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: methods and development [Internet]. 2006. [cited 2016 March 20]. Available from: http://www.who.int/childgrowth/standards/technical_report/en/
21. Saeed HA. Test characteristics of MUAC [dissertation]. University of Gent, The Netherlands; 2012.
22. Massyn N, Peer N, Padarath A, et al. District health barometer 2014/15 [Internet]. Durban: Health Systems Trust. 2016. [cited 2016 March 20] .Available from: http://www.hst.org.za/publications/district-health-barometer-201415-1
23. Modi P, Nasrin S, Hawes M, et al. Midupper arm circumference outperforms weight-based measures of nutritional status in children with diarrhea. J Nutr. 2015;145(7):1582–7. doi:10.3945/jn.114.209718.
24. Chopra M. Risk factors for undernutrition of young children in a rural area of South Africa. Public Health Nutr. 2003;6(7):645–52.
25. Smuts CM, Faber M, Schoeman SE, et al. Socio-demographic profiles and anthropometric status of 0- to 71-month-old children and

their caregivers in rural districts of the Eastern Cape and KwaZulu-Natal provinces of South Africa. S Afr J Clin Nutr. 2008;21(3):117–24. http://dx.doi.org/10.1080/16070658.2008.11734164
26. Department of Health (DoH). Guidelines on the integrated management of acute malnutrition (IMAM) in KwaZulu-Natal [Internet]. 2014 [cited 2016 March 20]. Available from: http://www.kznhealth.gov.za/family/MCWH/KZN-IMAM-Guidelines.pdf
27. Myatt M, Duffield I. 2007. [Internet]. A review of survey data collected between September 1992 and October 2006. [cited 2016 August 30]. Available from: http://tng.brixtonhealth.com/sites/default/files/IASC.MUAC_.WFH_.Presentation.pdf
28. Mwangome MK, Berkley JA. The reliability of weight-for-length/height Z scores in children. Matern Child Nutr. 2014;10:474–80. http://dx.doi.org/10.1111/mcn.2014.10.issue-4
29. Young H, Jaspers S. Review of nutrition and mortality indicators for the integrated food security phase classification (IPC) [Internet]. SCN Task Force on Assessment, Monitoring and Evaluation, and The Integrated Food Security Phase Classification (IPC) Global Partners; 2009. [cited 2016 August 30]. Available from: http://www.odi.org/publications/4616-nutrition-mortality-indicators-integrated-food-security-phase-classification-ipc
30. Bern C, Nathanail L. Is mid-upper-arm circumference a useful tool for screening in emergency settings? Lancet. 1995;345:631–3. http://dx.doi.org/10.1016/S0140-6736(95)90527-8

Received: 23-06-2016 Accepted: 22-10-2016