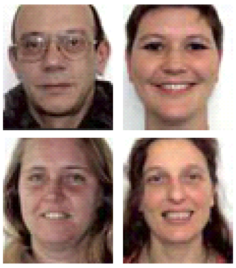
Can height-adjusted cut-offs improve MUAC's utility as an assessment tool?

By Michel Van Herp, An Verwulgen, Bérengère Leurquin, and Pascale Delchevalerie



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This field article looks at the relationship between MUAC and WH and finding that MUAC correlated most closely with W/H indices in shorter children, suggests the possibility of height specific MUAC cut-offs, distinguishing between assessment and screening.

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While quick and convenient to use, Mid Upper Arm Circumference (MUAC) measurement has limitations in the assessment of malnutrition. In certain contexts, notably the Horn of Africa, MUAC sometimes underestimates the problem on an individual and global basis compared to other anthropometric indices. Médecins Sans Frontières (MSF) first noticed this in nutritional surveys in Ethiopia (Somali region),[1] where MUAC underestimated prevalence of malnutrition compared to weight for height (W/H) indicators. In Chad, a MUAC < 125 mm was used by home visitors to refer children for W/H measurements and consideration for admission to a feeding centre. However, after an anthropometric survey,[2] calculation of the sensitivity of the 125 mm cut-off showed that 65.8 %, of all malnourished children and 42.9 % of severely malnourished were missed, as compared to W/H % of the median (WHM). With a cut-off of 135 mm, 32.9 % were still missed. These findings resulted in an adjustment of the screening strategy: the cut-off was increased to 145 mm, and W/H was calculated on the spot to exclude children who would not meet admission criteria in the feeding centre. Another example comes from Niger (2005), where rapid MUAC assessment was undertaken without other anthropometric indices being measured. The prevalence of malnutrition identified by this method was at odds with information from other sources, e.g. nutritional programmes reporting a significant increase in admissions, suggesting greater prevalence of malnutrition than that identified by MUAC assessment.

These findings raised questions about the validity of MUAC in rapid assessments (to estimate the nutritional status of populations) and as a screening tool (to select individuals requiring further assessment, e.g. W/H measurements, to determine eligibility for admission to nutritional programmes).

How were MUAC cut-offs in current use selected?

An Epicentre study of 64 nutritional surveys[3] (n=34,933) showed that the MUAC mean increases with age: 132mm at 6 months (~ -1Z of the National Centre for Health Statistics (NCHS) reference of 143 mm), 148mm at 59 months (~ -1.5Z of the NCHS ref of 174 mm). It is therefore difficult to select a single cut-off for all children under 5 years of age.

An MSF-Holland analysis of five nutritional surveys[4] (n=2,656) demonstrated a clear correlation between MUAC and W/H as expressed by Z-score (WHZ), with better correlation in populations with higher prevalence of acute malnutrition (r = 0.65 if ?10%, r = 0.57 if < 5%).

Single MUAC cut-offs of 125mm (global) and 110mm (severe) were proposed for all children under 5 years (regardless of ethnicity), and it was further suggested that these criteria could be used for quick assessment to assess the need for a survey. However, due to a significant number of false positives and negatives with MUAC, it was recommended that MUAC not be used as an entry criterion for nutritional rehabilitation programmes, but it could be used as the first stage of a two step screening process with a relatively higher cut-off (135mm). In 1994, a meeting of all MSF medical directors ratified these MUAC cut-offs for use in rapid assessments.

Finally, an Epicentre analysis of 114 nutritional surveys (December 2002; n=66,446) compared MUAC (< 125mm) to WHZ < -2 or < 80% WHM. Overall, MUAC overestimated malnutrition as compared to WHZ in 45% of the surveys, and underestimated malnutrition as compared to WHM in 8 %. In the analysis by age group, the under-estimation was greater in children ? 29 months and also in boys (13%) than girls (4%). Greater underestimation also occurred in higher prevalence contexts.

All of the above studies were based on onetime surveys. The effect of situational factors such as hunger gaps, epidemics, chronic malnutrition, etc., and the evolution of correlations between MUAC and other indices over time were not examined. Nor did these studies assess the possible effect of selection criteria age (6-59m) versus height (65-110cm) on outcomes. Our study provides a preliminary exploration of these factors.

Objectives and method

The objective of this study was to further analyse existing surveys, conducted in areas where MUAC underestimates malnutrition, with the aim of assessing the relationship between MUAC and WH indices over time. A secondary research question arose from the finding that MUAC correlated most closely with W/H indices in shorter children, thus suggesting the possibility of height specific MUAC cut-offs.

Twelve databases of nutritional surveys (n = 10,226) were used for this analysis. The surveys were conducted in Denan/Ethiopia (6) between May 2000 and September 2001, Korma and Serif Umra/Darfur (4) in 2004/2005 and Tine and Iriba/Chad (2) in 2003/2004. The standard methodology of UNHCR/WFP/MSF was followed. Only children with a length/height between 65cm and 110cm were included. Data analysis was undertaken using the computer program EPI INFO 6, version 6.04d.

The cut-off point of W/H - 2 Z-score, or 80% of median, or oedema, was used to classify global acute malnutrition. Height for Age (H/A) - 2 Z-score or 90% of the median[5] was used to determine global chronic malnutrition. MUAC was compared with global acute malnutrition expressed in W/H in % of median or oedema and Z scores.[6]

In the Chad and Korma surveys, no children with oedema were found. In the other surveys, the % of oedema was between 1.3 and 0.1, with a total of 37 oedema cases out of 10,226. These low numbers should not influence the results.

Findings

Overall, for the majority of the surveys (9/12), the under-estimation of MUAC prevalence compared to WHM prevalence was statistically significant. Malnutrition prevalence as per WHM varied from 23% to 41% for Denan, 8% to 13% for Sudan and from 12% to 18% for Chad.

The Denan curve was the most informative because it entailed the longest time series. Except for the first survey, the difference between prevalence in MUAC and W/H was statistically significant. The crude mortality rate (CMR) and under fives mortality rate (U5MR) was extremely high in the first survey, but returned to normal in the following ones (see Table 1 and Figure 1).

Influence of age or height

When the surveys were further analysed on the basis of age, it was noted that the discrepancy between MUAC and W/H occurs mainly in children above 2 years (see Figure 2). In Denan, the under five mortality was very high leading to under-representation of the 6-24 months age group in the sample (8-15 % instead than 33%), and, as a consequence, influencing underestimation of MUAC due to a greater preponderance of older children in the sample. The same phenomenon occurred to a lesser extent in the Darfur and Chad series (± 20% of 6-24 months).

As age assessment is often imprecise, children are usually selected on the basis of height, which serves as a proxy for age. Typically 65 - 110 cm represents children of 6 months to 5 years in age and 85cm represents age 24 months (this is also the cut-off point above which children are measured standing). However, in countries affected by chronic malnutrition, there will be a discrepancy between age and height. In the Denan series, with a cut-off of 85 cm, 27% of the children were declared to be above 24 months and 41% equal to 24 months (age rounding effect). With a cut-off at 80 cm, 12.5% were declared to be above 24 months and 42.5% equal to 24 months. In this context, with the second cut-off, fewer children > 24 months are included, while most children ? 24 months are captured (see Figure 3 for exact numbers).

For the groups < 85cm and < 80 cm, MUAC underestimated malnutrition compared to W/H in the majority of

the surveys (11/12) but the discrepancy was not statistically significant. In the < 80cm group, the MUAC prevalence curve lies closer to the WHM prevalence curve compared with the height group < 85cm. For the group of ? 85 cm and ? 80cm, the MUAC generally underestimated malnutrition compared to WH and in both groups, 10/12 surveys this difference was statistically significant.

These findings led us to consider whether assessment tools should be adapted to height, to achieve better sensitivity. Accordingly, malnutrition prevalence in different height groups was compared to different MUAC cut-offs to find the cut-off point that lies closest to the WHM, with results as follows:

- In areas of very high prevalence, e.g. Denan, (23.3 - 40.7 % WHM), the best cut-off was 125 or 126mm for children ? 80 or 85cm, respectively, and 133 or 136mm for children > 80 or 85cm, respectively.
- In areas of high prevalence, e.g. Tine (18.1%), the closest cut-off was 127mm for height ? 80cm and 137mm for height > 80cm.
- In areas of moderate prevalence, e.g. Iriba and Darfur (11-13%), the best cut off was 125-127mm for height ? 80cm, 125-128 mm for ? 85cm and 133-137mm for height > 80 or 133-138mm for height > 85cm.
- In areas of lower prevalence, e.g. Korma (8.3%), the best cut-off was 127mm for height ? 80cm or 128mm for height ? 85cm and 137mm for height > 80cm or 138mm for height > 85cm.

Thus there is an inverse relationship between MUAC cut-offs and prevalence of global acute malnutrition, with lower MUAC values in high prevalence areas.

However, the variation inside the same height group is small (125 to 128 mm for shorter children and 133 to 138 mm for taller ones). Therefore, in practice, we could use a single cutoff per height group.

Effect of chronic malnutrition

During the analysis of the 80 and 85 cm height groups, we explored the role of chronic malnutrition. The prevalence of chronic malnutrition (as defined by HAZ) was found to be high in all the surveys (for example, between 30 and 40% in the Denan series), with the highest overall (45.4%) in the second survey in Serif Umra.

In the Denan surveys, we examined H/A by height group and noticed that the prevalence of chronic malnutrition was higher in the group of children < 80cm (from 64.8 % to 80.2%) than in the group ? 80cm (16.6% to 28%). This is in contrast to more common findings of increased prevalence with increasing age (highest in 24-36 months group) and may be linked to the measles outbreak that occurred in 2000.

Conclusions and recommendations

It is clear that the use of a single MUAC cut-off, for all children 65 to 110 cm in height, may produce prevalence data in some contexts that correlates poorly with the prevalence of global acute malnutrition found using other anthropometric indices.

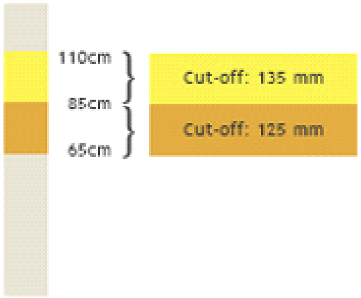

Diagram 1

Using the MUAC with different cut-offs (see Diagram 1) represents one solution. However, deeper analysis of the context for each situation is also required. Since one cut-off point is not enough for the entire age range, we propose a 'simplified quack-stick',[7] with different cut-offs for children ? 85 cm and those > 85 cm. This cutoff should be shifted to 80 cm in areas where chronic malnutrition is high. Since we are often confronted by situations of moderate/high prevalence of malnutrition, the cut-offs of 125 mm and 135 mm were chosen.

The choice of cut-off point for MUAC will be determined by the objective of the enquiry: assessment versus screening.

In some contexts, before carrying out MUAC assessment, an estimate of prevalence by W/H measurement must be obtained. If this is not available from past surveys, a preliminary survey would be worthwhile to determine population adapted cut-offs. Lot Quality Assurance Sampling (LQAS)[8] surveys with these MUAC cut-offs could ensue for further assessments or follow-up. In a case where only rapid MUAC assessment information is available, consideration should be given to basing operational decisions on the prevalence in shorter children (< 80-85cm) instead of up to 110 cm, as our studies suggest better correlation with other indices in this age group.

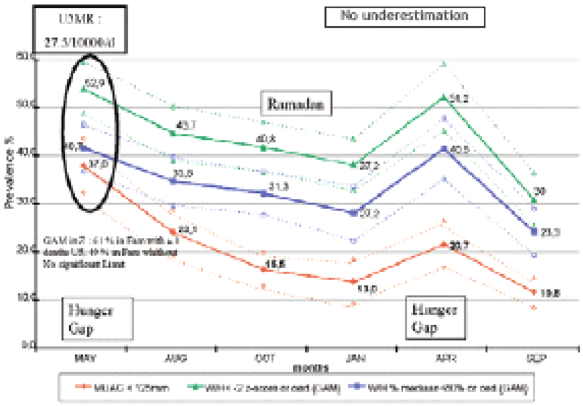

Figure 1 - Comparison of malnutrition prevalence expressed in MUAC or W/H, MSF-B nutritional surveys, Denan, Ethiopia, 2000-2001

For screening purposes, a nutritional survey should be performed first, and adapted MUAC cut-offs then chosen, for use in subsequent screening. This choice should be based on the need to have sufficient sensitivity to capture the majority of malnourished children, while minimizing false positives (children who fail W/H entry criteria for nutrition programmes). Unnecessary referrals exact a high social cost for families (travel, family disruption etc) and discredit the screening team. Where we believe that social cost may be important, implementation of W/H measurement on the spot following MUAC screening, for selected children, will differentiate between those who do and those who do not meet admission criteria, and hence reduce this social cost.

For selection criteria to a Supplementary Feeding Programme (SFP), consideration should be given to utilising both MUAC and W/H (as they detect different physiopathological situations in a child) and to adapt entry criteria to MUAC < 125mm or WHM <80%.

Considerations for future studies

In nutritional survey analysis:

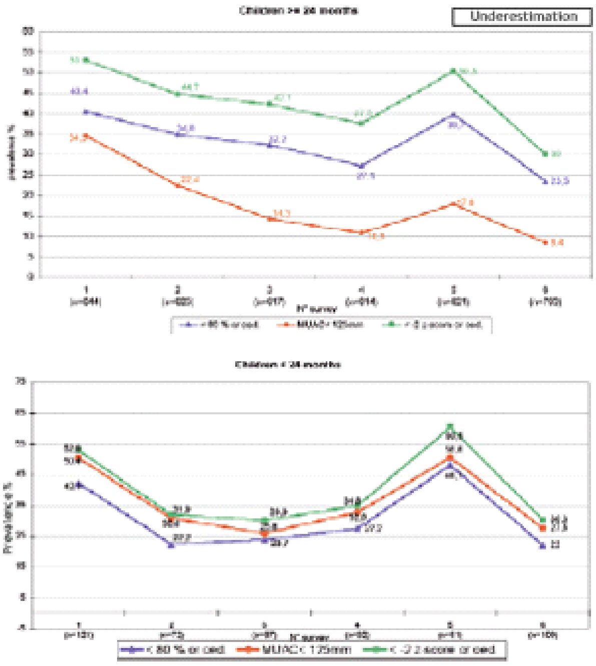

Figure 2 - Comparison of MUAC < 125 mm,
W/H < -2 Z score and W/H < 80% prevalence
by age group, MSF-B nutritional surveys, Denan,
Ethiopia, 2000-2001.

a. Consider stratifying analysis on the basis of height rather than reported age.
b. Consider presenting graph of height distribution as well as age distribution. Age rounding may bias age distribution.
c. MUAC measurements may be influenced by quality of technique. MUAC is quick and easy to measure but needs training and supervision to be precise. Presenting a graph of the MUAC ditribution may help assess the quality of measurements, influencing the validity of findings.
d. Calculate and present prevalence of chronic malnutrition (H/A).
e. Interpretation of results should consider the role of context: mortality rates, past and present epidemics, population characteristics (nomads, refugees, internally displaced persons (IDPs)), seasonal variations or practices (hunger gap, Ramadan) etc.

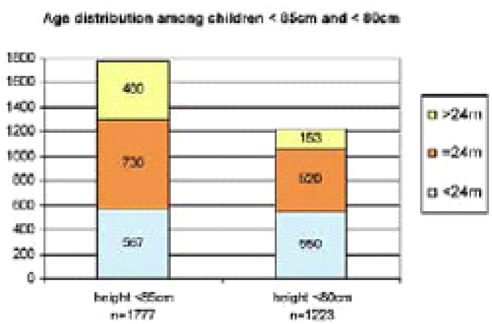

Figure 3 - Discordance between reported age
and height in MSF-B nutritional surveys, Denan,
Ethiopia, 2000-2001.

Further studies to explore these factors and their influence on malnutrition indices would be worthwhile. These investigations were done with the NCHS growth references. It would be interesting to repeat a similar analysis of the dataset with the new WHO growth standards to see if similar results are obtained. However, as the growth

standards are only presented as Z-scores, they will need to be expressed as % of the median in order to allow comparison.

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	Mortality		All children				MUAC<125 /WH<80% r_			
	CMR *	U5MR*	N°	W/H<-2 Z score or oedema	W/H < 80% or oedema	Muac <125	sens %	spec %	PPV	MUAC/ WHM
Denan			5286	42.4	32.6	19.6	46	93	0.76	0.47
05/00	27.5	8.9	765	52.9	40.7	37.0	73	87	0.79	0.58
08/00	1,2**	0,4**	897	43.7	33.8	23.1	51	91	0.75	0.49
10/00	0,27**	0,13**	914	40.8	31.3	15.5	36	94	0.72	0.43
02/01	0,25**	0,15**	906	37.2	27.2	13.0	31	94	0.64	0.29
04/01	0,25**	0,12**	902	51.2	40.5	20.7	43	94	0.84	0.41
09/01	0,27**	0,1**	902	30.0	23.3	10.8	34	96	0.74	0.55
Korma			1835	16.6	10.7	4.4	32	99	0.80	0.46
04/05	2.2	1.3	923	19.6	13.1	6.4	40	99	0.81	0.48
12/05	2.2	0.8	912	13.5	8.3	2.4	22	89	0.32	0.19
Serif Umra	1.8	0.8	1741	17.5	13.0	7.3	33	97	0.61	0.31
10/04	1.2	0.8	865	14.7	11.2	8.0	41	96	0.58	0.28
06/05	0.2	3	876	13.5	10.7	6.6	34	97	0.55	0.34
Tine	2.2	1.3	536	29.5	18.1	6.5	28	98	0.77	0.37
Iriba			828	19.6	12.2	7.7	40	97	0.63	0.38

* .. / 10.000 / day

** mortality data collected prospectively by Community Heath Workers (CHWs) during a specific period

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[1] Nutritional surveys and retrospective mortality assessment, Denan, Ogaden, Ethiopia, MSF-Belgium. May 2000 to September 2001.

[2] Jeroen Beijnsberger, Michel Van Herp, Pascale Delchevalerie. Enquête Nutritionnelle, de Mortalité Rétrospective et de Sécurité Alimentaire, camps de réfugiés Soudanais de Touloum et Iridimi, région d'Iriba, Est-Tchad, Octobre 2004.

[3] Manoncourt S, Coulombier D, Pécoul B, Desvé G, Moren A (Epicentre, MSF- France), Comparaison des informations fournies par différents indicateurs de malnutrition aiguë calculés au cours de 64 enquêtes nutritionnelles réalisées auprès de populations en situation précaire, MSF Medical News, vol 3, N°2, May 1993.

[4] Koert Ritmeijer, Arine Valstar, Austen Davis (MSF - Holland), 'Middle Upper Arm Circumference (MUAC): what are the uses and constraints at the field level; a meta analysis of MSF survey data', MSF Medical News, vol 3, N°2, May 1993.

[5] Issues in the assessment of nutritional status using anthropometry. Bulletin of the WHO 1994; 72:273-83

[6] A comparison with z scores was included in the beginning, however on further discussion and analysis, comparison was only done with % of the median that is typically used in the field.

[7] A quack stick is an instrument currently available for measuring MUAC for height.

[8] Lot quality assurance sampling (LQAS) is a methodology that originated in the manufacturing industry and has been applied to health contexts, such as immunisation coverage. Sub-populations are divided into 'lots' and the sample size is the number of units that are selected from each lot. Before sampling, a decision must be made on the number of 'defective' items, e.g. children not immunised, that will deem a 'lot' unacceptable, which in turn will influence sample size. Since the response for each sample is binary, i.e. acceptable or non-acceptable, smaller samples are required compared to other survey methods. By combining information from different 'lots', the LQAS method offers a less conventional means of stratified sampling. (WHO/V&B/0126(2001))

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