

## A new way to measure mid-upper-arm circumference in African villages

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### Abstract

In 2011 we published a study on how to detect the threshold for malnutrition in children, simply using their own hands and without any technical tool. The fight against malnutrition can only be reached when its measurements involve every single child, almost continuously, in the affected villages. In this paper we try to show that, thanks to our method, it is possible to use mid-upper-arm-circumference as a measurement for malnutrition in children, discriminating between severe and moderate malnutrition and providing the basis for the decision on whether to admit a child to a nutritional rehabilitation unit or not. We trained 63 participants in four groups (Group 1: doctors and clinical officers; Group 2: nurses and students; as Group 3 we defined the 20 best participants and Group 4 consisted of 10 more intensely trained participants) to measure the circumference of 9 different artificial arms (between 9 and 13 cm) using their own fingers and hands. The training was short and consisted of an introduction of 5 min, a first training phase of 10-15 min, a test, the critical discussion of the results, a second training phase of 5 min and a final test. We found that 95.3% of participants in the general group and 97.9% in the intensely trained group have identified the severely malnourished child; 87.3% in the general group and 91.9% in the intensely trained group have additionally identified the moderately malnourished child. Both groups haven't admitted the well nourished child to a therapeutic feeding program retaining their resources. The third group reached without any additional training the results in the above categories. A subsequent discussion with the participants on the influence of procurement, maintenance and pricing of our tool, found our method much less vulnerable than others. We conclude that this method should be considered as a future training in the villages to detect the trend towards malnutrition early enough.

### Introduction

Malnutrition still is one of the most important risk factors of childhood mortality in developing countries.<sup>1</sup> This is recognized through the Millennium Development Goals (MDG), which aim at reducing underweight in children (in MDG 1)<sup>2</sup> and childhood mortality (in MDG 4).<sup>3</sup>

Prevalence of malnutrition can be estimated by several indices involving height, weight or mid-upper-arm-circumference (MUAC). Such anthropometric measurements in rural communities of developing countries are important to reach the most vulnerable groups with health interventions.<sup>4</sup>

To reach these goals it is not enough to measure MUAC when children come to the health centers (because families often do not combine illnesses with malnutrition). For a sustainable impact on children in the villages it is necessary to measure the children's nutritional status directly in the villages almost continuously (e.g. weekly), which only can be done by the mothers. This measurement needs to be as *low-tech* as possible.

Mogeni *et al.*<sup>5</sup> showed that pure eyesight is not enough to determine whether a child is malnourished or not. For correct measurements of height measuring boards are needed, for weight scales and for MUAC tapes. Any technical measurement carries the danger that it falls prey to damage, procurement or maintenance. We searched for a way to eliminate these challenges.

In 2011 we published three articles showing that a variety of professionals and laymen can decide through a *threshold decision* whether a child is malnourished or not by applying a semi-quantitative measurement of MUAC with their own fingers.<sup>6-8</sup>

Today we try to show that it is possible to discriminate almost exactly the circumference with your own fingers. This is necessary to answer different questions in malnutrition. Several parameters are important: the definition of severe and moderate acute malnutrition, admission and discharge in different nutritional rehabilitation programs,<sup>5,9,10</sup> the change of guidelines,<sup>3,11</sup> and the incorporation of younger or older children in these programs.<sup>12-14</sup>

### Objective

To provide first evidence that it is possible to measure MUAC for children between 6 and 60 months with their own fingers accurately enough to provide the basis for the decision to admit a child to a nutritional rehabilitation unit.

### Materials and Methods

In order not to disturb sick children with

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repeated measurements, we designed artificial mid upper arms from metal and plastic in nine different sizes. The smallest with a circumference of 9 cm, the largest with 13 cm (incremental steps of 5 mm and a triplication of the 11 cm size, Figure 1).

The 63 participants, randomly taken from health care providers of our hospital, were taught in groups of 1-4. The participants were divided into two subgroups. The *clinicians* (group 1), as they are called in Malawi (doctors and clinical officers) and the *non-clinicians* (group 2: nurses, students *etc.*). As group 3 we defined the 20 best participants.

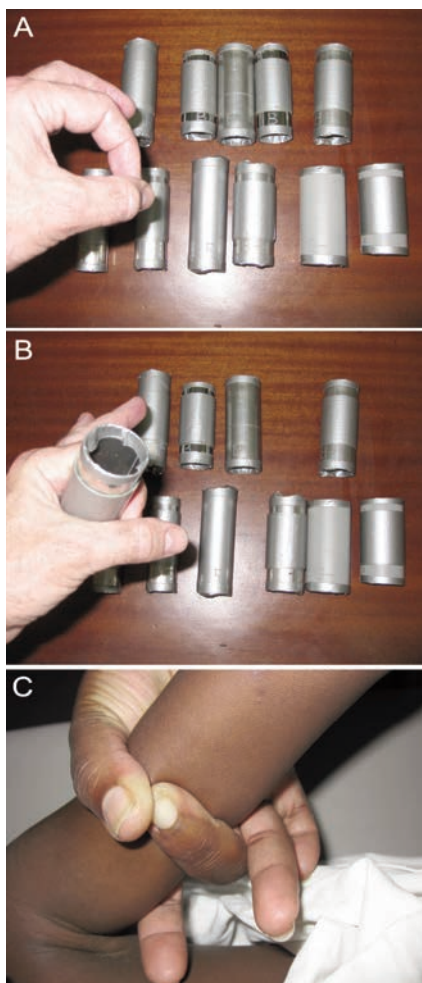
All received a 5 min introductory talk, where we suggested ways on how to use the crests of the fingers, the fingernails or other landmarks to remember different sizes of the artificial arms. The participants then were allowed for 10-15 min to train with the artificial arms to find their own, personal way to identify the nine different circumferences. After this the first test followed. In this tests all nine sizes and additional two size eleven arms were shown at random to the participant. The results were than discussed with the groups, questions answered and feedback or hints given on how to avoid misjudgment. This was followed by a further free training for 5 more min. Then the second and final test took place in the same way with unmarked artificial arms.

We defined severe malnutrition and the admission to a therapeutic feeding program with a MUAC of  $\leq 11.5$  cm,<sup>11</sup> moderate malnutrition and the admission to a supplementary feeding program with  $>11.5$ , but  $\leq 12.5$  cm,<sup>3,10</sup> and a well-nourished child with 13 cm

MUAC.<sup>3,10</sup> The results were judged whether they are *adequate* and only secondarily whether they are absolute correct by numbers. *Adequate* meant that a result would have provided a child with the necessary therapeutic procedure (e.g. the therapeutic feeding program) even when it would not have been absolutely correct (e.g. when a child with a MUAC of 11.5 would have been rated as 11. It would still be admitted to the right program.

After the tests a second group of ten was chosen randomly from the participants for an intensified training (group 4). This group was trained individually until 90 min or until participants showed no dedication to proceed. Depending on the individual participant they had 1-7 additional tests done.

In non structured discussions with our participants we discussed whether our method might be vulnerable to influences like loss, maintenance, procurement, corruption, bureaucracy and misappropriation.



**Figure 1.** The artificial arms (A) and the method of measurement (B). C) The same method of measurement with a child.

## Results

### Severe malnutrition and the admission to a therapeutic feeding program

Nine-hundred and sixty-six of 1007 applicable decisions (95.3%) in the general group (Groups 1 and 2) were adequate (as defined before) and would have identified the severely malnourished child.

Overall (tests 1 and 2) the four groups reached 95.9% (G1), 95.8% (G2), 97.8% (G3) and 97.9% (G4). A deterioration was seen in the second test (after training) from 96% to 95.8% (-0.2%). The group of clinicians, comprising 39 participants, (group 1) deteriorated from 96.3% adequate decisions (not missing the severely malnourished child) to 95.5% (-0.9%). The group of non-clinicians (group 2) with 24 participants improved from 95.3% to 95.8% adequate decisions (+1.04%). The group of the best 20 participants enhanced their performance from 96.8% adequate decisions to 98.75% (+1.92%). The group of intensively trained participants reached 97.9% adequate decisions. For the most severely malnourished group of children with an MUAC  $\leq 11$  cm the results for the identified children were: (G1: 98.8%, G2: 99.3%, G3: 100%, G4: 100%). For a MUAC of  $\leq 10.5$  cm: (G1: 100%, G2: 99.6%, G3: 100%, G4: 100%).

### Moderate malnutrition and the admission to a supplementary feeding program

Two-hundred and seventeen of 249 applicable decisions (87.3%) in the general group would have identified (additionally to the severely malnourished child) the moderately malnourished child. Overall (test 1 and 2) the four groups reached 84.3% (G1), 91.6% (G2), 91.98% (G3) and 93.6% (G4) and an improvement was seen in the second test (after training) from 84.9% to 89.7% (+5.68%).

The group of clinicians (group 1) improved from 75.6 (%) adequate decisions (not missing

the moderately malnourished child) to 88% (+12.4%). The group of non-clinicians (group 2) had 91.7% adequate decisions in both tests ( $\pm 0\%$ ). The group of the best 20 (group 3) enhanced their performance from 90% adequate decisions 97.4% (+7.4%). The group of intensively trained participants (group 4) reached 91.9%.

## Resources

All 1331 applicable decisions in the normal groups and in the intensively trained group (100%) would not have admitted the well-nourished child to a therapeutic feeding program. In 40 of 335 applicable decisions in the general groups and in the intensively trained group (11.9%) a well-nourished child would have been admitted to a supplementary feeding program despite being well nourished.

## General measurements and experiences

Overall 54.5% of the 1372 applicable decisions in the general group were taken exactly (Test 1: 51.1%, Test 2: 58.1%; improvement: 7%). The 20 best showed 79% exact measurements overall. The intensively trained group displayed 74.5% exact measurements.

In 89 % of the wrong decisions the deviation was  $\pm 0.5$  cm. In the intensely trained group this were 99.8% and in the group of the best 20 candidates 98.4%.

Over all groups 68.4% of all wrong decisions were deviations to the lower side, 31.6% to the higher side.

The measurement was most often correct (all groups) for the extreme data (9 and 13 cm). Of 1835 collected single data in all groups 24 were lacking (1.3%). From test one to test two 32 of 63 participants improved (clinicians: 22, non clinicians 10), 15 deteriorated (clinicians: 10, non clinicians 5) and 16 got the same result (clinicians: 7, non-clinicians 9). In the group of the 20 best participants we saw improvement in 12 cases deterioration in 3 and a standstill in 5 cases (Table 1).

**Table 1.** Investigators experience with the two devices.

Influence	Finger method	MUAC tape
Loss	-	+
Maintenance	-	(+)
Procurement	-	+
Corruption	-	+ (?)
Bureaucracy	-	+
Misappropriation	-	+
Price	-	+

MUAC, mid-upper-arm circumference.

## Discussion

The quickest and probably most appealing method to get information on acute malnutrition- guessing- is not good enough.<sup>5</sup> All other methods need equipment. This is relatively expensive like scales or measurement tables. Even the well established red-yellow-green tape for the MUAC measurement is in reality, often lost, locked away, destroyed or simply unavailable.<sup>7</sup>

In previous studies,<sup>6,8</sup> we showed that it is possible for health care providers and even for laymen to identify the threshold of malnutrition with a third type of measurement, involving their own fingers. With the current work we believe to have demonstrated that with the static concept (to find a threshold) we did not exhausted the possibilities of our method. Even a real measurement, which is correctly enough to provide the children with the adequate treatment, is possible.

Our participants discriminated 9 different sizes of artificial arms with their fingers. This is much more than what might be needed in reality (admission and discharge to therapeutic or supplemental feeding programs - adding up to three values). Nevertheless it can be seen how dynamic and flexible the concept is and that it can incorporate future challenges as changing WHO guidelines,<sup>3,11</sup> the demand of regional organizations or different values,<sup>9</sup> when the measurement will be used for younger or older children than the ones from 6 to 60 months.

The most important measurement is the circumference which decides on the admission into a therapeutic feeding program. Much more important than the absolutely correct measurement is, that the measurement does not withhold therapy from a child in need even when the measurement deviates from the true value. Our study showed that this is the case with our method (95.3 and more than 98% in group 3 and 4). To our knowledge this was not described before. 89% of the incorrect decisions in the general group and more than 98% in the best 20 group and the intensively trained were deviating only 0.5 cm from the true value. Interestingly the deviating decision was in more than two thirds to the lower side of the 0.5 cm. Moreover we could demonstrate, that this effect is even more pronounced in the high risk group of extremely malnourished children with a MUAC of <105 cm. We could show, that all results improve dramatically, when we either use only the best 20 candidates (around 30 % of the participants, as done by Ayele *et al.*<sup>4</sup> in Ethiopia or just train more intensive for up to 1.5 hours.

The well nourished child would have never (100%) been admitted to a therapeutic feeding program and in only 11.9% of the cases to a

supplementary feeding program.

The second short training we gave in the general group improved the results, but was not really convincing with some detrimental results in subgroups. This was probably due to too much stress in finding landmarks for nine circumferences in this short time. Intensive training improved the results greatly and they were comparable with the results of the best 20 participants. The results for clinicians and non-clinicians did not show a consistent difference.

The results for the less important measurement for the admission to supportive feeding programs and for the discharge from such a feeding program are, as much as the correct measurement not as impressive.

We see enormous space for improvement, when we compare our training with other methods. Our method is easy to learn even for alphabets. We trained much shorter than other authors trained established methods for MUAC, weighing or height measuring in Ethiopia, United States or Bolivia.<sup>4,15,16</sup> There is no interpersonal anthropometric difference as with some other nutritional parameters,<sup>17</sup> when the measurement is used as a trend for the villages. Only very few of our participants were trained in their mother-tongue. English was a foreign language for almost everybody and our training method was admittedly boring. A training in Chichewa, the most common language in Malawi, combined with a more intensive training and the selection of the 30% most promising candidates will improve the results significantly and will facilitate the further training for the Health Surveillance Assistant (a health worker with 6 weeks of training). Moreover by this method mothers and guardians as members of the villages and rural communities can be trained through pre-defined protocols which will enhance the outcome further.<sup>18</sup> But the most powerful booster for our method will be the dedication of the mothers to measure their own child over time (achieving year long experiences) and to be able to take the consequence to seek help in the health center when the weekly measured MUAC – trend is deteriorating.

Finally the financial costs of our *device* are obviously not existing. Additionally it can't be lost, sold, destroyed or locked away and it is always available exactly in the numbers you need it. This provides advantages over all other available measurements.

## Conclusions

With a short and cheap training it is possible to discriminate with your own fingers various thresholds of the MUAC, which might decide whether a child should be admitted to a nutri-

tional rehabilitation unit or not. This free measurement should be trained finally to the mothers in the villages in order to enhance the proportion of children who come to the health care facilities in time before they deteriorate too much.

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