Anthropometric predictors of mortality in undernourished adults in southern Sudan

Summary of published research

Location: South Sudan

What we know: Acute adult undernutrition tends to occur in prolonged severe famines. There is a lack of evidence on which anthropometric measure best identifies those adults most at risk of death and which treatment protocols to use. Chronic disease presence and treatment availability will impact on adult nutritional status and response to nutrition treatment.

What this article adds: Admission and outcome data for 197 adults treated in a therapeutic programme in South Sudan were analysed. The HIV burden was low in the population. Treatment was successful (74% cure rate, 11% mortality) modelled on child protocols. Oedema on admission increased the odds of death by 15 times and accounted for over half of deaths. For every 1-cm increase in MUAC, the odds of mortality decreased by 58%. No significant interaction was found between MUAC and oedema in predicting mortality. Mean BMI on admission was 12.6 and as low as 8 but admission BMI was not significantly associated with subsequent mortality.

A group of researchers recently analysed data from the 1998 Ajiep feeding programme in southern Sudan to assess the predictive power of mid upper arm circumference (MUAC), weight, body mass index (BMI), and oedema values for adults on admission for subsequent mortality. This was a low HIV burden context. This study was conducted as part of an operational therapeutic feeding programme to inform the selection of appropriate tools to diagnose adult undernutrition in both famine and non-famine contexts.

Context

In 1998, a major famine occurred in southern Sudan. According to burial surveillance systems in major towns, crude mortality rates were frequently between 20 and 30/10,000 daily, 20-30 times the threshold used to define an emergency. Concern Worldwide implemented an adult therapeutic feeding centre in Ajiep from October 1998 to January 1999. Criteria for admission into the therapeutic feeding programme were primarily MUAC-based and the principles of the therapeutic regimen were identical to those for children (see Box 1).

Box 1: Admission criteria and treatment regimen for adults

Admission criteria

- Adults with MUAC <16.0 cm
- Adults with MUAC between 16.0 and 18.5 cm who were not able to stand or had diarrhoea.
- Adults with MUAC >18.5 cm could also be admitted if the staff judged them to be at particularly high risk of death for some other reason.

Treatment regimen

Phase 1(1–4 days):

- 8 meals/d (including 2 meals overnight) of F75 therapeutic milk, calculated as total of 60 ml/kg per day (F-
Complications such as dehydration, hypoglycaemia, dysentery, respiratory infection, malaria and helminthes infection treated.

Oral rehydration and oral antibiotics used in preference to intravenous therapy wherever possible. Patients were generally rehydrated with ReSoMal (Nutriset), a low-sodium rehydration salt, unless the patient had profuse watery diarrhoea; in this case, regular oral rehydration salts were used.

**Phase 2:**

- 6 meals of F-100 therapeutic milk (100 kcal/100 ml), in combination with SP-450, a high-energy porridge. In Phase 2, 10–12% of total calories were derived from protein and 20–30% from fat. Patients were generally fed to appetite in this phase, and local foods were added.
- Treatment of iron deficiency anaemia was commenced in Phase 2 from 7 days after admission.

Patients with dysentery were generally managed in the centre if they were able to tolerate oral antibiotics and strict precautions against cross-contamination were implemented.

In situations in which intravenous treatments could not be avoided, patients were transferred to a field hospital run by another non-governmental organisation (NGO).

Trained health workers obtained patient identification information and anthropometric measurements at admission and throughout the patient’s stay in the therapeutic unit. A physician conducted a clinical examination and initiated both routine treatment and specific treatment of any complications that had been diagnosed. There were five outcome categories in this observational study: cured (resolution of clinical symptoms and consistent weight gain), death (any death during treatment or within 2 weeks after defaulting from the treatment centre), transfer to another feeding centre, referred to a hospital for further treatment, and defaulted (absent for more than 7 days without having been medically discharged or referred).

**Analysis method**

Admission data were mainly used in the analysis, because the intention was to assess the effect of patients’ nutritional status at admission, on treatment outcomes, and the relation between the different admission anthropometric measures. This analysis showed that all three anthropometric indicators were approximately normally distributed. One-factor ANOVA, a t-test (for normally distributed variables), and a Kruskal-Wallis test (for non-normal distribution) were calculated to assess differences in admission anthropometric measures by gender and by outcome. Because the relation between MUAC, weight, and BMI may be confounded by oedema, comparisons and regression lines were calculated stratified by oedema status. Sensitivity and specificity for subsequent mortality were assessed for various threshold values of weight, BMI, and MUAC after stratification by oedema status. Receiver operating curves, AUCs, and discriminatory values were calculated and compared. Logistic regression was used to assess the effects of gender, age, MUAC, weight, BMI, or oedema on admission, on risk of mortality. The likelihood ratio test and associated P values were calculated. Adjusted and unadjusted odds ratios (ORs), 95% confidence intervals (CIs), and P values were calculated. STATA 11 (StataCorp) was used for the analysis.

**Results**

A total of 469 patients, aged 2 months to 77 years, were treated in the Ajiep therapeutic feeding centre between 9 October 1998 and 14 January 1999. Of these, completed data for 197 adults aged between 18 and 59 years were available and analysed for this study. More than two-thirds of the subjects were women (n = 138, 70%).
No statistically significant differences in mean BMI ($P = 0.55$) or mean MUAC ($P = 0.09$) were observed by gender. On average, the men ($n = 59$) were heavier and taller than the women ($n = 138$; $P < 0.001$). Neither MUAC on admission (ANOVA: $P = 0.7$) nor BMI on admission (ANOVA: $P = 0.8$) differed significantly by gender. In both men and women, mean MUAC, weight, and BMI were higher in oedematous than in non-oedematous patients ($P < 0.001$).

MUAC had better sensitivity and specificity in predicting mortality than did BMI, with weight having the lowest ($P = 0.01$). The most discriminatory threshold was determined as the anthropometric threshold with the highest value for sensitivity plus specificity; <15.6 cm for MUAC and <12.0 for BMI.

**Treatment outcomes**

Analysis of treatment outcome showed that 145 patients (74%) exited the feeding centre as cured, 22 (11%) died, 10 (5%) defaulted, and 19 (9.7%) were transferred out. Survivors had a significantly higher admission MUAC than did non-survivors ($P = 0.002$). There was only very weak evidence ($P = 0.19$) that the mean BMI was different between survivors and those who died. More than half of those who died had oedema (13/22, 59.1%; $P < 0.001$). Age and weight group on admission were not independently associated with mortality. Having oedema on admission increased the odds of death by 15 times (adjusted OR: 15.2; 95% CI: 4.24, 54.80; $P < 0.001$).

There was strong evidence that MUAC was associated with subsequent mortality ($P = 0.003$). For every 1-cm increase in MUAC, the odds of mortality decreased by 58% (adjusted OR: 0.42; 95% CI: 0.28, 0.63; $P < 0.001$). In contrast, BMI on admission was not significantly associated with subsequent mortality ($P = 0.2$). No significant interaction was found between MUAC and oedema in predicting mortality ($P = 0.34$). After adjustment for oedema and MUAC, men had a higher odds of death than did women, and this difference was nearly statistically significant (adjusted OR: 2.8; 95% CI: 1.07, 7.40; $P = 0.04$).

**Discussion**

Acute adult undernutrition tends to occur in prolonged severe famines. This study was the first to document levels of BMI as low as 8.0, previously thought to be incompatible with survival. Mean BMI on admission was 12.6, well below current accepted BMI thresholds for defining severe under-nutrition in adults. Studies conducted during the famine in Somalia of 1992 documented BMI values as low as 10.

The Ajiep study confirmed the conclusions of a small number of previous studies that suggest that relatively high rates of recovery are possible when treating even severely emaciated adults with therapeutic protocols, similar to those used and formally evaluated for malnourished children—based on low-protein, high-frequency regimens. The finding of higher odds of death in men than in women after adjustment for oedema and MUAC, despite there being no significant difference in nutritional status on admission, is also consistent with previous studies. It is likely due to the natural tendency for women to have a higher proportion of body fat that they can draw on.

Another major finding is that admission MUAC was more strongly associated with subsequent risk of death than BMI. MUAC and oedema were the only variables that were independently associated with mortality in this study. In addition, the relation between MUAC and mortality showed a dose-response or incremental pattern. The odds of death decreased by a very substantial 58% for every 1-cm increase in mean MUAC on admission. In contrast, no difference in mean BMI on admission was found between survivors and those who died. BMI was initially developed as a tool to assess overnutrition and chronic undernutrition. Although it has proven to be a useful tool in such assessments, various factors in addition to nutritional status affect the interpretation of BMI. These factors include body shape, the cormic index (sitting height to standing height ratio), oedema, age, and sex. MUAC, however, has the advantage of reflecting the status of predominantly three tissues: bone, muscle, and fat—the last two of which are particularly sensitive to weight gain and loss. Oedema or retained fluid increases
weight and changes the interpretation of BMI.

This study is also the first to document the influence of oedema on interpretation of MUAC. In addition, MUAC was significantly and independently associated with mortality. As well as being a precise and reproducible indicator, MUAC is a far more practical tool than BMI in situations of severe and prolonged famine. Severely emaciated adults may have trouble standing, which makes a height assessment both difficult and inaccurate. In addition, food security crises are more common in pastoralist communities with Nilotic ethnicity in the Horn of Africa. Such communities may have a mean Cormic index (sitting height:standing height ratio) that differs significantly from reference populations, which makes complex adjustment in BMI necessary. All these factors indicate that MUAC is likely to be a better tool for assessing acute undernutrition in adults than is BMI, especially in the resource-poor areas where the great majority of famines occur.

The data from this study were derived from a therapeutic feeding centre operating at the height of a famine under extremely insecure and difficult field conditions. Study participants were selected on the basis of being severely undernourished; as such, the findings may not be generalisable to a population of adults that includes moderately and/or mildly malnourished adults. In addition, sample sizes, particularly for men, were relatively small and resulted in wide CIs for the adjusted ORs. Importantly, the relations between the anthropometric and clinical programme indicators and mortality were measured in the presence of an active therapeutic nutritional and treatment programme, so it is not possible to know which patients would have died if this programme had not been in place or whether the relations between the anthropometric and clinical measures and mortality would have been the same in that situation. Finally, there are no accepted international thresholds for MUAC assessment of acute undernutrition in adults.

Despite the limitations of the study, the authors believe that in combination with other previous research, the current study provides sufficient evidence to recommend MUAC over BMI as the tool of choice for measurement of acute undernutrition in adults. However, further research on a population basis and from rigorously designed controlled trials within adult therapeutic feeding programmes will be required to refine admission and discharge thresholds for MUAC. Such research will need to determine whether criteria should be identical for men and women. Evidence from managing undernutrition in chronic diseases, such as HIV and tuberculosis, will also help establish thresholds.


2BMI was calculated as weight (kg)/height (m) squared.