Original Article

Body mass composition: a predictor of admission outcomes among hospitalized Nigerian under 5 children

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BACKGROUND: Malnutrition remains a public health problem and a significant contributor to morbidity and mortality among children less than 5 years, in spite of global efforts at improving nutrition. OBJECTIVE: To examine the impact of nutritional status, by measured anthropometric indices and derived body composition, on disease outcomes in under-5 children hospitalised in an emergency unit. METHODS: All (n=164) consecutive children aged 12–59 months admitted into the Children Emergency Ward of the University College Hospital, Ibadan over a 3 month period (May to July, 2007) had weight, length/height, mid upper arm circumference (MUAC) and skin fold thicknesses recorded. The BMI, Rohrer index, z-scores for weight-for-height and weight-for-age were calculated. Malnutrition was defined as z scores < –2. Other derived parameters included Arm-Fat-Area (AFA), Arm-Muscle-Area (AMA), Upper-Arm-Muscle-Estimate (UME), and Total-Upper-Arm-Area (TUA). Relative risk was calculated and logistic regression was used to determine which variables independently predict death. RESULTS: There were 153 survivors and 11 deaths giving an overall death rate of 6.7%. The mean age of survivors (26.7 ± 12.5 months) compared with those who died (23.1 ± 12.1 months) were similar (p>0.05). The risk of death was significantly higher among the malnourished compared with the well nourished. The TUA, AMA and UME of those who died were significantly lower than survivors' (p<0.05). MUAC remained an independent predictor of death among other measured and derived anthropometric indices. CONCLUSIONS: MUAC remains a useful anthropometric measurement for nutritional assessment and an independent predictor of survival among hospitalised under-5 children in Nigeria.

Key Words: anthropometry, body mass, malnutrition, death, children

INTRODUCTION

Malnutrition remains a significant contributor to morbidity and mortality among children worldwide in spite of global efforts at achieving adequate nutrition. The World Health Organisation estimated that malnutrition was associated with over 50% of all childhood deaths in developing countries.[1,2] The high under-5 mortality rate in Nigeria of 191/1000,[3] may also have underlying malnutrition as one of the important factors influencing the outcomes of diseases. The 2008 National Demographic Health Survey revealed that, the percentage of children in Nigeria who were stunted, wasted and underweight were 41%, 14%, and 23%, respectively.[4]

Studies have shown that nutritional status may be a strong determinant of hospital admission outcomes among children in developing countries.[5,6] The assessment of nutritional status and body composition by using non-invasive methods such as height, weight, mid upper arm circumference (MUAC)[7] and skin fold thickness has made early identification of malnutrition and evaluation of body reserves relatively easy to compute. Anthropometry of the upper limb is a useful indicator of nutritional status of children. Skin fold thickness which predict body fatness and energy reserve,[8] as well as weight-for-age, height-for-age, weight-for-height and MUAC define the adequacy of nutrition and the severity of malnutrition.[5,9,10] Using the MUAC and the triceps skin fold thickness (TSF), arm muscle area (AMA), which reflects protein reserves and arm fat area (AFA), energy reserves can be estimated.[11-13] These estimates of body composition assume that the upper arm which comprises of the skin, subcutaneous fat, muscles and bone is cylindrical and using various formulae, these areas can be computed from the arm circumference.[14,15] Therefore arm area measurements are better indicators of fat and protein reserves than triceps skin fold thickness and MUAC.[16] In addition, estimates of body composition as a measure of nutritional

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Manuscript received 21 February 2009. Initial review completed 23 January 2010. Revision accepted 14 May 2010.

reserves may define the relationship between malnutrition and mortality.[10,17]

While MUAC has been shown to be a consistent predictor of under-5 malnutrition and mortality in some developing countries,[9,10,17] weight-for-age,[18] weight-for-height,[5] and skin fold thickness[19] have also been adjudged as important anthropometric measures of malnutrition and/or mortality among children in others. There is a dearth of information on body composition as determinants of mortality or survival among hospitalised children in Nigeria. Though Akinyinka *et al*[14] evaluated body mass composition in Nigerian neonates and Owa and Adejuyigbe studied older children in the community,[20] these studies did not evaluate the relationship of malnutrition with mortality. Defining nutritional status or body composition is important for early identification of at risk children of mortality and therefore planning of appropriate dietary intervention. Therefore this study was carried out to evaluate the usefulness of measured and derived anthropometric indices as outcome measurements of admission of under-5 children into the emergency ward in a Nigerian tertiary institution.

MATERIALS AND METHODS

All (n=164) children aged 12–59 months admitted into the Children Emergency Ward of the University College Hospital, Ibadan Nigeria over a 3 month period (May to July, 2007) had weight, length/height, MUAC and skin fold thicknesses recorded three times within 24 to 36 hours, after resuscitation such as correction of fluid deficits. Although anthropometry was part of data being collected for routine care in the emergency ward, written informed consent was obtained from parents or caregivers of all the children enrolled into the study. This study was conducted in accordance with the internationally agreed ethical principles for the conduct of medical research. Each patient was followed up till discharge or death. The major diagnoses were severe malaria (36.0%), pneumonia (19.5%), acute diarrhoeal diseases (14.6%), acute airway obstruction (6.7%), septicaemia, (5.5%), sickle cell diseases (5.5%), meningitis (3.7%) and others (8.4%). The diagnoses among patients that died were severe malaria (45.5%), acute diarrhoeal diseases (27.3%), tumours (18.2%) and meningitis (9.1%). Social class stratification of the patients was done using parents level of education and occupation.[21]

Within 24 hours of admission, each patient had the following measurements taken; skinfold thicknesses (mm) measured over the triceps, abdominal, thigh and subscapular areas as well as length /height (cm), weight (kg) and mid-upper arm circumference (cm). All measurements were taken by a trained research assistant using standardised instruments. MUAC was measured to the nearest millimetre using a non-stretchable tape (Butterfly, China) with the left arm hanging and relaxed in sitting or in lying positions, midway between the tip of the acromion and the olecranon process. Length/height was measured to the nearest centimetre using a modified board for children less than 36 months of age and a modified graded stadiometer for those who were 36 months and older. Weight was measured with only the underpants to the nearest 0.1 kg using a calibrated baby scale (Seca, Model 834, Japan). Zero error of this weighing scale was checked against a standard tare daily.

Body mass index (BMI) was calculated as the weight (kg)/ height squared (m^2) and Rohrer index as weight (kg)/ height cubed (m^3). The skinfold thicknesses were measured on the right side of the body thrice at four sites; triceps, subscapular, abdominal and thigh using the Lange Skinfold Caliper (1985 Beta Technology Inc. USA). The mean of the two closest measurements at each site was recorded. Triceps skinfold thickness was measured vertically over the triceps muscle midway between the acromion and olecranon process.[15] Arm muscle area (AMA) and arm fat area (AFA) were derived from measures of arm circumference (AC) and triceps skinfold (TSF) using the formula below.[15,22]

$$AMA = (AC - \pi TSF)^2 / 4\pi$$

Arm Fat Area (AFA) was derived thus:

$$AFA = (AC^2 / 4\pi) - AMA$$

The formulae utilised assume that the upper arm is cylindrical and the estimation of muscle area does not take into account the humeral diameter and variable skin fold compressibility.[15,22] The patients' body fat proportion was calculated from the formula of Deurenberg *et. al;*[23] Child Body Fat % = (1.51×BMI) – (0.70×Age in years) – (3.6× gender) + 1.4 (where male gender = 1, female = 0). Lean body mass was estimated by subtracting the estimated body fat from the body weight (kg).

Data analysis

Z-scores for weight-for-height (WHZ), weight-for-age (WAZ), height-for-age (HAZ), MUAC and BMI were computed using the WHO Anthro 2005 software.[24] Data was analysed using SPSS 11.0 for Windows (SPSS Inc., Chicago, USA). Patients were divided into groups based on gender and outcome of admission (Died vs. Survived). Descriptive statistics were done for all variables and the predictive power of variables was tested by logistic regression for any significant association with the outcomes. The level of statistical significance was set $p < 0.05$.

RESULTS

There were 164 patients aged 12 to 59 months during the period of study comprising of 86 boys and 78 girls. There were 11 deaths (6.7%), with more deaths in the female group, though this was not statistically different (OR= 0.05, 95% CI = 0.16, 1.89. p=0.359). The overall mean age ± SD of all subjects was 26.5 ± 12.1 months, 27.3 ± 11.9 months for males and 25.4± 12.3 months for females (p=0.326). The mean age ± SD of the survivors (26.7 ± 12.5 months) and those who died (23.1 ±12.1 months) were also not statistically different (p=0.356). Majority (73.5%) of the children involved in this study were from low socioeconomic background whose parental income ranged from US$1.0 to US$3.0 per day.

On admission, except for the subscapular skinfold thickness which was thicker in girls (p=0.013), all measured anthropometric values of the male were not different from those of the girl group (Table I). The measured anthropometric values were compared by outcome of disease as shown in Table 2. Only the abdominal skinfold

Table 1. Anthropometric measurements on hospitalized children by sex

Anthropometrics	Boys (n = 86)		Girls (n = 78)		*p-value*
	Mean	SD	Mean	SD	
Weight (kg)	12.3	2.7	11.9	2.7	0.345
Height (cm)	86.9	10.4	83.9	10.9	0.073
BMI (kg/m^2)	16.1	3.1	16.5	3.2	0.417
Rohrer's index (kg/m^3)	19.3	4.9	20.9	5.9	0.059
Mid-upper arm circumference, MUAC (cm)	14.4	1.5	14.1	1.9	0.261
Skinfold thickness					
Subscapular, SSF (mm)	4.3	0.7	4.6	1.1	0.013
Triceps area, TSF (mm)	6.5	1.1	6.8	1.8	0.119
Abdominal area, ASF (mm)	3.7	0.6	3.8	1.2	0.949
Thigh area, THF (mm)	10.7	2.2	11.5	2.6	0.053

thickness (p=0.045) and MUAC (p=0.002) were significantly lower in those children that died than in those who survived.

Table 3 shows the mean derived anthropometric indices in those who died and the survivors. Calculated indicators of nutritional status showed that the mean TUA was significantly lower in patients that died (13.1±3.6 mm^2) than in the survivors (16.7±3.9 mm^2); p=0.004. Also the mean AMA of 0.7±0.2 mm^2 in patients that died was significantly lower than 0.8±0.2 mm^2 in the survivors (p=0.036). The estimated fat areas and proportions as well as the lean body mass were not significantly different in the survivor and those who died.

The prevalence of malnutrition and admission outcomes was as shown in Table 4. The overall prevalence of stunting was 18.9%, wasting 13.4% and underweight 24.4%. Proportionately more of the patients who died (54.5%) had measurements below –2.0 z-score for MUAC-for-age compared with only 24.8% in the survivors (RR=3.62; 95% CI= 1.05, 12.57). Similarly, 72.7% of those who died had measurements below –2.0 z-score for MUAC-for-height compared with 28.1% in the survivors (RR=6.82; 95% CI= 1.73, 26.92). Nearly half (45.5%) of the deceased group had a BMI z-score of below –2.0 compared with 10.5% in the survivors (RR=3.89; 95% CI= 1.20, 12.63). However, the proportions of those who had z-scores < –2.0 for weight-for-age, height-for-age and weight-for-height z-scores were not significantly different in both groups. All potential risk factors for deaths were subjected to multivariable logistic regression as shown in Table 5. Only MUAC remained an independent predictor of survival after controlling for other factors.

Table 2. Comparison of anthropometrics by outcome

	Age (years)	Weight (kg)	Height (cm)	BMI (kg/m^2)	Rohrer's index (kg/m^3)	Skinfold thickness: Triceps (mm)	Thigh (mm)	Subscapular (mm)	Abdominal (mm)	MUAC (cm)
Died (n=11)										
Mean±SD	23.2±12.5	12.4±2.3	83.0±12.1	16.7±3.4	22.8±5.8	6.5±1.9	11.4± 2.9	4.6±1.4	3.2±1.2	12.7±1.9
Range	12.0-56.0	7.5-20.1	71.0-115	10.7-18.3	11.7-30.9	3.0-10.0	2.1-6.2	2.5-8.0	2.1-6.2	10.0-15.0
Survived (n=153)										
Mean±SD	26.7±12.1	12.1±2.7	85.9±10.1	16.2±2.7	19.8±5.3	6.7±1.5	11.0±2.4	4.4±0.8	3.8±0.9	14.4±1.6
Range	12.0-54.0	7.5-20.1	68.0-113	8.9-31.0	11.9-37.2	2.5-13.2	4.0-18.0	2.5-13.2	1.5-9.0	10.2-21.5
p-value	0.351	0.697	0.387	0.694	0.067	0.753	0.621	0.609	0.045	0.002

Table 3. Mean estimated body mass composition by outcome

	Total upper arm area (mm^2)	Upper arm fat estimate	Upper arm muscle area	Upper arm fat area	Upper arm muscle estimate	% Arm fat	Body fat mass (kg)	% Body fat	Lean Body mass (kg)
Died (n=11)									
Mean	13.1	4.2	0.7	12.4	8.9	31.9	4.4	37.8	8.0
SD	3.6	1.6	0.2	3.6	2.6	8.9	2.2	5.8	4.0
Range	7.9-17.9	1.5-7.5	0.2-0.9	7.2-17.3	4.7-12.9	18.9-51.4	1.1-6.8	5.3-61.9	3.5-18.5
Survived (n=153)									
Mean	16.7	4.8	0.8	15.9	11.9	29.2	3.4	30.7	8.6
SD	3.9	1.3	0.2	3.9	3.2	6.5	2.0	4.5	3.7
Range	8.3-30.7	1.4-9.9	0.9-1.4	7.8-35.4	4.9-29.7	12.6-55.5	0.7-8.2	4.3-72.4	2.2-19.2
p-value	0.004	0.165	0.036	0.587	0.005	0.193	0.124	0.226	0.587

Table 4. Prevalence of malnutrition and admission outcomes

Nutritional Status	All subjects (n=164) n (%)	Died (n=11) n (%)	Survived (n=153) n (%)	RR†	95% CI‡	*p*-value
Stunting (HAZ< –2.0)	31 (18.9)	4 (36.4)	27 (17.6)	2.66	0.73, 9.75	0.222
Wasting (WHZ< –2.0)	22 (13.4)	2 (18.2)	20 (13.1)	1.48	0.30, 7.33	0.644
Underweight (WAZ< –2.0)	40 (24.4)	2 (18.2)	38 (24.8)	0.69	0.16, 3.06	0.620
MUAC-for-age, z< –2.0	44 (26.8)	6 (54.5)	38 (24.8)	3.62	1.05, 12.6	0.032
MUAC-for-height, z< –2.0	51 (31.1)	8 (72.7)	43 (28.1)	6.82	1.73, 26.9	0.002
Body Mass Index for age, z< –2.0	21 (12.8)	5 (45.5)	16 (10.5)	3.89	1.20, 12.6	0.045

†relative risk; ‡ confidence interval.

Table 5. Logistic regression analysis for potential predictors of survival

	B	S.E.	OR†	95% CI‡	*p*-value
MUAC (cm)	0.701	0.236	2.02	1.27, 3.20	0.003
Abdominal skinfold (mm)	0.63	0.44	1.89	0.793, 4.52	0.150
Upper arm muscle estimate	1.85	2.70	6.39	0.032, 13.0	0.493
MUAC for height z-score	2.03	3.65	7.62	0.006, 99.5	0.579
Total upper arm area	-9.79	18.7	0.00	0.000, 42.7	0.600
MUAC for weight z-score	-2.32	4.51	0.098	0.000, 68.6	0.607
Upper arm fat area	7.98	15.9	2.93	0.000, 10.9	0.617
Weight-for-age z-score	-0.17	0.75	0.842	0.191, 3.71	0.820
Weight-for-height z-score	-0.12	1.00	0.886	0.124, 6.31	0.904

†odds ratio; ‡ confidence interval.

DISCUSSION

Despite the known association between malnutrition and diseases, the contributions of malnutrition, to morbidity and mortality is not frequently reported in health statistics of many developing countries and Nigeria in particular. This may probably be due to the difficulty of estimating the contribution of malnutrition to outcome of illnesses. Adequate nutrition is a major factor in maintaining good health, and malnutrition appears to generate increased susceptibility to a variety of diseases and poor outcomes. In developing countries macro- and micronutrient deficiencies are common and have significant impact on anthropometry, immune competence as well as disease burden and outcomes of illness.[25,26]

The overall prevalence of underweight in this hospital based study were 23% and 14.0%, respectively. In a similar Indonesian study,[27] prevalence of malnutrition in hospitalised under-5 children of 12% was comparable to the general population. The present data suggests that malnutrition continues to be a persistent problem in hospitalised patients and in the community. The relatively high degree of underlying malnutrition may be associated with a high degree of poverty in Nigeria, which consequently may lead to chronic undernutrition and also influence health seeking behaviour.

The clinical relevance of estimating body composition by anthropometry, using simple and readily available tools specifically the tape measure is well known but the use of skinfold thickness is often overlooked in paediatric practice in Nigeria. The present study showed that survivors, on admissions, had significantly higher MUAC, abdominal skinfold thickness as well as a proportionately bigger upper arm cross-sectional area compared with those patients who died. These findings suggest that adiposity which provides energy and muscle mass which provides amino acids may play a vital role in the survival of hospitalised under-5 children. The relatively inadequate body storage of fat and protein in the patients who died compared with those who survived, a situation made worse by the associated anorexia and increased catabolism that occur during illnesses may explain this poor outcome.

This study demonstrated that only MUAC, after controlling for other measured and derived parameters, could independently predict survival among the patients. A one unit increase in MUAC increases the chance of survival as high as 200%. It implies that fatter children had a better chance of survival. This is in agreement with findings from several countries that MUAC was as predictive of mortality as WHZ among hospitalised children[5] or was the strongest predictor of subsequent mortality.[28-30]

Though there were no significant differences in wasting, stunting and underweight rates in the deceased- and survivor groups, there was significantly less adiposity as measured by AFA, muscle mass defined by AMA and MUAC in the patients that died compared with the survivors. This probably may be due to less energy stores and amino acids available to the patients at the outset of admission to tide the patients over the associated anorexia and increased catabolism, a situation more acute in the more malnourished group.

Though vitamins and minerals status of the patients studied were not evaluated, which may also influence outcomes, the results of this study suggest that notwithstanding the cause or nature of illness, simple anthropometric indices of the upper limb are useful indicators of nutritional status of children and are predictive of impending mortality in hospitalised under-5 children in Nigeria and probably other developing countries. The overall implication of these findings is that prompt nutritional status evaluation using MUAC would allow paediatricians to identify children at higher risk of death and the need for nutritional intervention in the treatment of hospitalised under-5 children.

ACKNOWLEDGEMENTS

We appreciate the willingness and cooperation of the caregivers, nursing officers and physicians who took part in the study.

AUTHOR DISCLOSURES

The authors declare that they have no competing interests.

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Original Article

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身體質量組成為奈及利亞 5 歲以下住院孩童預後的預測因子

背景：儘管全球致力於改善營養，營養不良仍是一個公共衛生課題，並且是 5 歲以下孩童罹病率及致死率的重要影響因子。目的：藉由測量體位指標及其衍申的體組成，來檢測營養狀態對於醫院急診病房 5 歲以下孩童疾病預後的影響。方法：在三個月期間(2007 年 5 月-7 月)，共有 164 位 12-59 月齡的孩童進入伊巴丹市大學醫院的兒童急診病房，紀錄每位的體重、身長或身高、上臂中圍及皮脂厚度。然後計算其身體質量指數、羅勒指數、重高指數和年齡標準體重的 Z 分數。營養不良定義為 Z 分數小於-2。由測量數據衍申的其它指標，包括臂脂肪面積、臂肌肉面積、上臂肌肉估計值、總上臂面積。最後計算其相對危險性，並且利用邏輯迴歸來確定何種變項是死亡的獨立預測因子。結果：共計有 153 個存活個案及 11 個死亡個案，整體死亡率為 6.7%。存活個案(26.7±12.5 月齡)與死亡個案(23.1±12.1 月齡)的平均年齡並無差異($p>0.05$)。營養不良孩童死亡的相對危險性高於營養狀況佳的孩童。死亡個案的總上臂面積、臂脂肪面積、上臂肌肉估計指標顯著地低於存活個案($p<0.05$)。在所有體位測量及衍申的指標中，上臂中圍是死亡的獨力預測因子。結論：對於營養評估，上臂中圍仍然是一項有用的體位測量，並且對於奈及利亞 5 歲以下住院治療的孩童，是一個存活與否的獨立預測因子。

關鍵字：體位測量、身體質量、營養不良、死亡、孩童