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Review Article

Anthropometric diagnosis of 6-59 months Children with Severe Acute Malnutrition: Weight for Height-Z scores Versus Mid Upper Arm Circumference

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Abstract: An unhealthy dietary habit leads to excess calorie consumption (overnutrition) or inadequate supply of one or more essential micronutrients (undernutrition).This nutritional imbalance is assessed by Anthropometric measurements, Biochemical estimations, Clinical examination and assessment of Dietary intakes. Anthropometry is an inexpensive, rapid and non-invasive method that provides details on different components of body structure and is highly sensitive to the broad spectrum of nutritional status. Hence, it has always been an important tool for screening and early diagnosis of malnutrition. Undernutrition in below 5 year children is life-threatening epidemic contributing to about 45% of under 5 child deaths. Children with Severe Acute Malnutrition (SAM) are nine times more likely to die, compared to their healthy counterparts. Therefore, early and accurate diagnosis of children with SAM is crucial for its management and prevention of morbidity and mortality from the same. SAM is defined as weight-for-height Z scores (WHZ) below -3SD of the median or a mid upper arm circumference (MUAC) of <115mm in children of 6-59 months age. The cut-offs for MUAC and WHZ are scientifically approximated to each other and both are used to diagnose children with SAM (Severe Wasting). However, the research findings from various countries revealed that the agreement between WHZ and MUAC is poor as both indices classify the children with SAM differently, with a small overlap, which varies greatly among countries. These discrepancies have an implication when using either one alone for measuring the prevalence of acute malnutrition. Therefore, it is pertinent to adopt both WHZ and MUAC indices to assess the burden of severe acute malnutrition (SAM) in the community.

Keywords: Severe Acute Malnutrition, SAM, MUAC, WHZ, under 5 children and Anthropometric Indices

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1. Introduction

Over the last century, world has transitioned from a rural agriculture based economy to that of modern, industrialised, capitalistic economy and populations have experienced a steady shift in dynamics associated with socio-economic development. With newer farming techniques, high yielding seeds and green revolution, hunger and undernutrition have showed decreased trends since mid 20th century. Along with these, there has been a reduction of poverty, improved literacy levels, and advances in health care that reduced preventable child mortality [1] which attributed to the decline in the proportion of people with hunger globally i.e. chronic undernutrition, which decreased from 18.6% in 1990-2002 to about 11% in 2014-16[2]. Thus the demographic transition combined with the changed dietary pattern and food preferences which deviated from traditional staples has impacted on the nutritional status of individuals in particular and populations in general.

On account of the advancement in the standard of living and dietary intakes, there is a steady growth in the body composition and decline in age at menarche [3-5]. This steady phenomenon is known as the 'secular trend'. These positive secular trends in weight, height and body mass index (BMI) were observed in almost all the populations around the world and have been well documented [6,7].As reported by the NCD Risk Factor Collaboration, about 18.6 million participants from 200 countries, born between 1896 and 1996 and found that there was steady increase in body stature over a period of time[8].These population trends are believed to be due to improvements in environmental conditions, including better living standards, nutrition, sanitation and health care, while inadequacy of all these environmental parameters during childhood can result in decreased final adult height[3,6,9-13].Thus, changes in anthropometric dimensions are attributed to optimal health and nutrition standards than that of traditional economic parameters [14]and convey the comprehensive development of a society[15].

Human body needs a balanced nutrition for optimal growth and development and to maintain basic body physiology. An unhealthy or inappropriate dietary habit leads to excess calorie consumption (overnutrition) or inadequate supply of one or more essential micronutrients (undernutrition).This nutritional imbalance could be estimated by various methods of nutritional assessment. They include anthropometric measurements, biochemical estimations, clinical examination for detection of nutritional deficiency signs and assessment of dietary intakes.

2. Methods

2.1. Biochemical Estimations

Advances in knowledge of metabolic activities of vitamins and minerals paved the way for assessment of nutritional status using more precise biochemical estimation of concentration of various nutrients in body fluids, e.g., estimation of blood haemoglobin, serum albumin, serum retinol, serum iron, serum creatinine, blood urea and urinary iodine and creatinine. All the above mentioned biochemical estimations are laborious, invasive, and expensive and give results with low sensitivity and/or specificity [16].Therefore, their application is difficult in assessing the nutritional status of population in large community based studies, hence these tests are performed in a sub-sample.

2.2. Clinical Examination

Clinical examination to detect the objective clinical signs of deficiencies of various nutrients is an essential feature of all nutritional surveys. It is the simplest, non-invasive, inexpensive and practically quick method of assessment of nutritional status of individuals or the community. This method is highly specific and sensitive to detect the objective clinical signs like severe pallor in lower palpebral conjunctiva, surface of the tongue and nail beds, Bitot's spots on the bulbar conjunctiva and enlargement of thyroid gland i.e. Goitre which are diagnostic of iron, vitamin A and iodine deficiencies, respectively.

2.3. Diet Surveys

The standard of assessment of nutritional status is reinforced when there is a component of assessment of dietary intakes of individual or community is included. It involves direct assessment of intakes of various foods among individuals or households using different Diet survey methods such as weighment of raw foods, weighment of cooked foods and food frequency questionnaire (FFQ) method.

2.4. Anthropometry

Anthropometry is an inexpensive, simple, safe, rapid and non-invasive method of measure of the human body composition with regard to the proportions of bone, muscle, and body fat [17] and is an essential tool for assessment of nutritional status of children and adults [18]. The anthropometric measurements include height/length, weight, skin fold thickness, mid-upper arm circumference (MUAC), waist circumference, etc which will reflect the pattern of growth and development of individual as well as any morphological variation occurring because of a significant functional physiological change. The periodic growth monitoring of children under 5 through anthropometric measurements will provide the growth pattern. Two most important health indicators of child are his growth pattern and his weight for height relationship. Defects in linear growth or weight gain are associated with several confounding factors such as nutritional, medical, psychological, socio-economic problems, etc.[19]. Sub-optimal weight gain is an objective sign of undernutrition, abnormal infant and young child feeding (IYCF) practices or manifestation of underlying health disorder. Early diagnosis of undernutrition is crucial as it impairs child's growth and development as well as immunity levels, and also adversely impacts the cognition and socio-affective competence [2].

Therefore, anthropometry has always been a major tool for screening, early diagnosis and treatment of children with acute malnutrition in both community and hospital settings and also to plan an appropriate intervention for prevention and control of morbidity and mortality.

3. Guidelines for anthropometric measurement in children[21]

3.1. Weight

Tared weighing is generally practiced when child is below 2 years of age and unable to stand on weighing scale on his own. The mother is asked to take out her ornaments, shoes, socks and stand on weighing scale to be weighed alone first. Once the mother's weight is appeared on weighing scale, re-set the reading to zero while mother is still standing on weighing scale. Give the child to her/his mother and ask her to hold the child. The child's weight will appear on the scale. Likewise, weigh the children alone if they are 2 years or older and able to stand still on weighing scale without support. Before weighing the child, instruct the mother to remove child's shoes and external clothing. Then the child is asked to stand in the middle of the weighing scale keeping feet slightly apart and to remain immobile till the weight appears on the display. Weight of the child is recorded close to 0.1 kg (100gr).

3.2. Length or height

Recumbent length of a child is measured while child is in lying down position while the standing height of the child is measured in upright position. Generally, the standing height is about 0.7 cm lower than the recumbent length and the WHO growth standards were developed keeping in view this difference. Measure the standing height of the child if he is 2 years or older and capable of standing alone without support. Likewise, measure the recumbent length of child if he is less than 2 years old. If the child's ages is below 2 years and unable to lie down for measurement of length, measure standing height and add 0.7 cm to convert the same to length. Similarly, for a child aged 2 years or older and cannot stand alone, measure recumbent length and subtract 0.7 cm to convert it to height. Child's length/height is recorded in centimeters close to 0.1 cm (1 mm).

Anthropometric instrument required for measurement of child's length is called length board or an infantometer which is kept horizontally on a smooth surface. Child should be on minimal clothing and mother is asked to remove child's shoes, socks, and hair ornaments if any before taking measurements of length or height. Height board or stadiometer is set up at a right angle between a level floor and against a straight vertical wall or pillar. The child is asked to stand straight with arms loose at the sides by keeping heels together and look forward horizontally (Frankfurt plane) so that the stadiometer should touch the heels, buttocks, shoulder blades and head (occiput) of the child.

3.3. Mid-upper arm circumference (MUAC)

MUAC is one of the anthropometric measurements for quick assessment of nutritional status of children 6 months 59 months. It is the circumference of the left upper arm, measured with a tape at a marking made with pen at the mid-point between the tip of the acromian process of Scapula of the shoulder and the tip of the olecranon process of Ulna at elbow. If the MUAC of children between 6 months to 5 years of age is below 11.5 cm is considered as severe acute malnutrition (SAM), while the MUAC of 11.5 to 12.5 cms is considered as moderate acute malnutrition (MAM) and if child's MUAC is ≥12.5 cms, it indicates that the child's nutritional status is normal [22].

3.4. Determinants of Child's Growth

In general, children will grow at similar rate during foetal life irrespective of geographical areas, [23-25] if they born to well nourished mothers and rose in favorable environments. The paramount environmental predictors of child's growth throughout the first 2 years of child's life include maternal nutritional status, infant and young child feeding (IYCF) practices, personal hygiene and environmental sanitation, frequency of episodes of diarrheal and other infectious diseases, and access to healthcare [26].

3.5. Indicators of Child growth

In terms of anthropometry, the term undernutrition includes underweight, stunting and wasting [27] and it adversely affects children's growth and development i.e. physical and mental development. Undernutrition also increases the vulnerability of children to spectrum of infectious diseases [28] and accounts for about 45% of all child deaths among children of below 5 years.

The World Health Organization endorses use of Standard Deviation (SD) classification [29] to classify the nutritional status of children into distinct grades. The grading of nutritional status of children below 5 years as per the anthropometric indices such as weight-for-age (underweight), height-for-age (stunting) and weight-for-height (wasting) were computed using WHO Standards [30] as given below:

SD Classification	Weight-for- age	Height-for-age	Weight-for-height
≥ Median – 2SD	Normal	Normal	Normal
<Median – 2SD to ≥ Median – 3SD	Moderate underweight	Moderate stunting	Moderate wasting
< Median–3 SD	Severe underweight	Severe stunting	Severe wasting

These anthropometric indices can be interpreted as follows:

Weight-for-age: A low weight-for-age is also called as underweight and calculated by comparing the weight-for-age of a child with the WHO international growth reference values. Weight-for-age reflects body mass corresponding to chronological age. It is determined by both the height of the child (height-for-age) and his or her weight (weight-for-height). It indicates child's nutritional status i.e. normal, underweight or severely underweight, and does not indicate whether the child is overweight or obese.

Height-for-age: A low height-for-age is also called as stunting. Children are defined stunted when height-for-age ≤-2 SD of the WHO Child growth standards median. Stunted growth considers when a child failed to reach linear growth potential consequent to suboptimal health and/or nutritional factors.

Weight-for-height: A low weight-for-height is also called as wasting (Thinness).It is an acute malnutrition develops consequent to current rapid weight loss or a failure to gain weight connected with acute starvation and/or illness. Wasting is defined when weight-for-height ≤-2 SD of the WHO child growth standards median.

Body Mass Index (BMI): The Centers for Disease Control (CDC) and the American Academy of Pediatrics (AAP) endorse BMI for assessment of nutritional status of children aged≥2 years. The BMI is calculated as weight in kilograms, divided by the height in meters square. BMI is age- and gender-specific and is generally mentioned as "BMI-for-Age. The calculation of BMI is similar method used for adults, but is expressed, not as an absolute value, but as a percentile which can be derived from either a graph or a percentile calculator [31, 32].

- Underweight: below the 5th percentile
- Healthy Weight: 5th percentile to the 85th percentile
- Overweight: 85th percentile to the 95th percentile
- Obese: 95th percentile or higher

Consequent to variations in weight and height with age and their relation to body fatness, the BMI in children and teens are expressed corresponding to standard children of the same sex and age. These percentiles are derived from the CDC growth charts, which were based on national survey data collected from 1963-65 to 1988-94 [33].

3.6. Severe Acute Malnutrition (SAM)

Severe acute malnutrition (SAM) is the state that is determined when the measurement of Mid-Upper Arm Circumference (MUAC) is below 115 mm or Weight- for -Height (wasting) less than median minus 3SD Z-score in 6 to 59 months children [34]. Undernutrition among children below 5 years is a serious public health concern in developing and underdeveloped countries and is correlated with infectious diseases [35], poverty [36] as well as poor dietary diversity, environmental sanitation and personal hygiene [37].

Nevertheless the possibility of death among children with SAM is significantly correlated with the severity of undernutrition; they are at increased risk of dying because of decreased immune response to infections [34, 38] and it contributes to more than one million under-five deaths per year. Likewise, they are at increased risk of developing stunting and various health disorders, poor scholastic performance, and decreased productive life [39].

Severe acute malnutrition affected approximately 19 million children under the age of five. The risk of death among the children under 5 with a weight-for-height below -3 SD of the median based on the WHO standards was more than 9 times higher in contrast to that of children with a weight-for-height above -1 SD [40] and likewise, the risk of death rise among the children with the MUAC is below 115 mm [41].

Nevertheless many anthropometric indices such as weight for age, height for age, waist hip ratio, body mass index etc. are applied to assess the nutritional status of the children, the most accepted indices adopted to assess the extent of acute malnutrition among children 6-59 months are weight for height /length (wasting) and mid-upper arm circumference (MUAC). The WHO guidelines define severe acute malnutrition (SAM) as weight-for-height Z-score (WHZ) of less than-3SD of the median or mid-upper arm circumference (MUAC) below 11.5cms and moderate acute malnutrition (MAM) as WHZ between -3SD to -2SD of the median and MUAC between 11.5 to 12.5cms and Global Acute Malnutrition (GAM) [42]. These two indicators are used independently to define the sum of moderate acute malnutrition (MAM) and severe acute malnutrition (SAM) in children aged 6-59 months is referred to as global acute malnutrition (GAM). Indian Academy of Paediatrics (43) and many other national & international bodies adopted WHO definition of SAM and MAM.

The MUAC is strongly correlated to fat mass in children; still it is not indicative of fat free mass or overall weight. Hence, weight for height index can't distinguish between fat and lean body mass. The indices of weight-for-length-Z score or weight-for-height- Z score (WHZ) are adopted in clinical settings to determine severe wasting or severe acute malnutrition (SAM) and moderate wasting or moderate acute malnutrition (MAM) [44]. The alternate use of the simpler measurement of mid upper arm circumference (MUAC) has a long history [45].

4.Discussion

Though both indices are used to diagnose severe acute malnutrition (severe wasting)in children aged 6–59 months, the research findings from various countries revealed that the agreement between WHZ and MUAC is poor as both anthropometric indices classify the children with wasting differently, with a small overlap, which varies greatly among countries [46]. Similarly, the WHO and United Nations Children's Fund (UNICEF) combined declaration reported that only about 40% children with SAM were classified by both criteria [34].Thus, the inconsistencies between these two anthropometric indices will have an implication in assessment of prevalence of acute malnutrition and it's magnitude in a community, and guiding an appropriate intervention. Grellety and Golden have also reported that only 33.4% children in India were identified with both criteria for GAM and it has been observed that there was a great variation among number of children diagnosed by one criterion or the other, across countries [47].In India, among total global acute malnutrition (GAM) cases, 96% and 28.4% cases were classified with WHZ and MUAC, respectively. Similarly, of total severe acute malnutrition (SAM) cases, 95.1% were identified using WHZ and 30% using MUAC [48].

The Cambodian study analysed the secondary data of 11,000 datasets from 2010 and 2012, and reported the prevalence of wasting as 3.3% using MUAC as against to 10.6% using WHZ [49].Contradictory to this, Tadesse et al., observed that "MUAC classified more children as wasted (10.5 %) as compared to WHZ (5.4%)[50].The discrepancy was discussed in Integrated Phase Classification for Acute Malnutrition (IPC for AMN) workshops in Mozambique, where the prevalence of Global Acute Malnutrition (GAM) assessed using MUAC was reported to be higher than GAM assessed using WHZ. Thus, several studies reported poor correlations between MUAC and WHZ-scores [51].

Measurement of MUAC of children in community level is considered as quick, easy to use and cost-effective screening tool in contrast to WHZ. Similarly, using MUAC measurement as the discharge criteria to get rid of the effect of shorter treatment in most severely malnourished children compared to least severely malnourished, as is observed with percent weight gain [52]. WHO's revised guideline on the management of SAM in infants and children also suggested MUAC for identification of children with acute malnutrition by grassroots integrated child services (ICDS) and health workers at community setting [42].

Velzeboer et al., and Collins et al., are also advocate the use of MUAC at community setting, keeping in view the competency of grassroots health workers and minimal errors with MUAC than with Weight for Height/Length [53, 54]. Briend et al., opined that children with MUAC <115 mm and/or WHZ<–3 SD are at increased risk of mortality [54]. However, Global evidence corroborate that MUAC demonstrated to be more sensitive than WHZ in classifying high-risk children with SAM at greater risk of mortality and required immediate care [55,56].However, National Family Health Survey (NFHS), in its periodic surveys has been using Weight for Height Z-score, as a basis to identify acute malnutrition among children under 5 years [57].

Keeping in view the discrepancy in classification of severe acute malnutrition between WHZ and MUAC, applying any one of the two anthropometric indices alone for assessing the magnitude of SAM among the children would under estimates the real number of children in need of community or facility based management of children with SAM and adversely impacts the planning nutrition interventions[48].

5.Conclusions

Therefore, it is pertinent to adopt both WHZ and MUAC indices to assess the burden of severe acute malnutrition in the community. It is also suggested that there should be a revision in the existing WHO guidelines for optimal screening and identification of children with SAM as MUAC and WHZ are identifying them as different groups. This will help to determine globally most accurate and acceptable anthropometric index for screening and early identification of children with severe acute malnutrition so as to initiate appropriate nutrition intervention measures for prevention of morbidity and mortality among under 5 children.

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