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Head Circumference Measurements Based on Nutritional Status of Hospitalized Children

Aida H Al-Sadeeq*

Department of Pediatrics, Faculty of Medicine and Health Sciences, University of Aden, Yemen

***Corresponding Author:** Aida H Al-Sadeeq, Department of Pediatrics, Faculty of Medicine and Health Sciences, University of Aden, Yemen.

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Abstract

Background: Length/height and head cercumference (HC) measurement and assessment can provide valuble information on chronic nutritional status and brain growth. Yet, in our sitting children were only assessed for acute malnutrtion.

Objective: To assess the frequency of stunting and to assess the HC size in relation to nutritional status in children 6 - 60 months suffering from severe acute malnutrition and acute diarrhea.

Methods: Hospital based prospective study, carried out among the 06-60 month old children admitted in a single unit including diarrheal diseases (DD) and therapeutic feeding center (TFC) of Al-Sadaka General Teaching Hospital (Al-SGTH)/ Aden during July 2021 - June 2022.

Results: A total of 412 children (214 boys and 198 girls) in the age group of 06 - 60 months were admitted during the study period. Severe wasting, severe stunting and acute diarrhea were found among 85.4%, 34.4% and 14.6%, respectively. Mean HC was significantly low among wasted compared to no wasted children in the age group between 6-24 months. Stunted children had significantly low mean HC in all age groups. Thirty three percent of the severely wasted children were also severely stunted. Less than -3SD HCA Z-score was found among 38.6% out of 85.4% severely wasted and 32% out of 34.4% severely stunted children.

Conclusions: The present study provides evidence that undernutrition associated with retarded linear growth, and both wasting and stunting adversely affects the developing brain as evidenced by reduced head size with increasing severity of undernutrition.

Keywords: Head circumference; Severe wasting; Stunting; Hospitalized children

Introduction

Health and nutrition are the two important and interrelated conditions for optimal human growth and development. Poor nutrition in early childhood can cause ill health, physical, cognitive, and social/emotional developmental delays. Impaired physical and intellectual development lead to suboptimal adult work capacity and increased risk of chronic diseases in adulthood. Nutritional status and growth of a child are measured by child's growth assessment [1-3].

Anthropometry is the simple, inexpensive and internationally applicable method, commonly used for assessment of growth and nutritional status in children. Most extensive anthropometric indices i.e., weight-for-length/height (WFL/H), length/height-for-age (L/HFA), and weight-for-age (WFA) have long been employed for defining nutritional status of under 5 year-old children, these indices define wasting, stunting, and underweight indicators, respectively [3, 4].

Wasting is defined as weight-for-length/height (WFL/H) Z-score of < -2 SD of the WHO Child growth standards median. It often indicates recent and severe weight loss, although it can also persist for a long time. It usually occurs when a person has not had food of adequate quality and quantity, or they have had frequent or prolonged illnesses. Wasting is potentially life-threatening. If wasting is not addressed properly particularly during the critical first 1,000 days of children's life, when development occurs faster than at any age, children will experience growth stunting, i.e., length/height-for-age (L/HFA) Z-score of < -2 SD of the WHO Child growth standards median. Stunting is an indicator of chronic malnutrition, moreover, it is not just an issue during childhood, it affects both physical and cognitive potential -impacts that can persist throughout someone's life. Underweight is defined as weight-for-age Z-score of < -2 SD of the WHO Child growth standards median. A child who is underweight may be stunted, wasted, or both [3-11].

Head cercumference (HC), also known as the frontal occipital circumference, is another simple anthropometry that can provide valuble information on brain growth and nutritional status in general. Low HC for age has been widely recognized as the most sensitive anthropometric indix of prolonged undernutrition during infancy, associated with intellectual impairment and especially verbal IQ. During the period of most rapid brain growth (from the last trimester of pregnancy to the first 9-12 months of life), undernutrition produces notable morphological changes in the brain and decreases brain size as the result of changes in structural proteins, growth factor concentrations, reduce brain DNA content, and impair myalinization, cortical dendritic growth and neurotransmitter production. Some of these changes may be permanent, even if other factors (food intake, health and other environmental influences) later improve [12, 13].

Since HC measurement is often neglected in clinical practice in our sitting, as children assessed only for acute malnutrition after interpretation of weight for height index for the purpose of management of severe acute malnutrition, there is limited data on the head size as well as the frequency of stunting among hospitalized children. The aim of this study is to assess the frequency of stunting and to assess the HC size in relation to the nutritional status in children 6 - 60 months admitted to therapeutic feeding and diarrheal center in Al-sadaka General Teaching hospital/Aden.

Materials and Methods

A prospective observational study was carried among the children admitted in a single unit including the diarrheal diseases (DD) and therapeutic feeding center (TFC) of Al-Sadaka General Teaching Hospital (Al-SGTH), Aden/Yemen during the period of July 2021 to June 2022. All children between 6 months to 60 months who were identified as primary malnutrition with medical complications, admitted for the first time [7] along with children who admitted for acute diarrhea with dehydration were included in this study. Children having edema, history of perinatal insult (birth asphyxia/trauma/intracranial hemorrhage (IVH)/kernicterus etc.), history of NICU admissions in the neonatal period, evolving central nervous system disease, gross malformation or secondary malnutrition were excluded.

On admission to the DD and TFC, all children got their weight in kilograms and length/height (length was taken for those less than two years old children or, if age is not known, less than 87 cm in recumbent position and the height for those above two year children or, if age is not known, 87 cm or more in erect position) in centimeters to the nearest of 0.1 as per standard WHO recommendations, and children were examined to exclude edema. Head circumference (HC) in centimeters was measured by non-stretchable taps to the nearest 0.1 cm, for the purpose of this study. Children who were found to have severe wasting (WFL/H Z-score of <-3 SD of the WHO child growth standards median) and had poor appetite and/or medical complications were managed as per the WHO Guideline on the Management of SAM in Infants and Children and WHO Training Modules for Participants for Inpatient Care of SAM, the Yemeni version [6, 7].

Children with diarrhea who were not severely wasted were managed according to the standard regimens of fluid therapy as per pediatric textbooks.

Data collection

The following data were recorded, at the time of admission, in a pre-structured data sheet: Age in months, gender, weight in kilogram, length/height in centimeters, and head circumference in centimeters. The (2006) WHO Child Growth Standards, age and sex specific, was used to assess every child's WFL/H and L/HFA Z scores (was assessed for the purpose of this study). Z scores < -3 SD and < -2 SD units from the median of the reference population were considered as severe and moderate wasting/stunting, respectively [14]. The (2007) WHO Child Growth Standards, age and sex specific was used to assess the SD of the measured HC for age (HCA). Z scores for HCA of < -3 SD and < -2 SD were taken as severe and moderate microcephaly [15].

A Z score of ≥ -2 SD units from the median of the reference population was taken as normal nutritional status, i.e., no wasting, stunting, or microcephaly. HC was correlated with the severity of wasting, stunting, and no wasting/stunting children.

The statistical analyses were carried with SPSS software (Statistical Package for the Social Sciences, version 24). Numerical data were described as mean ±SD. Frequency tables with percentages were used for categorical variables. A *p*-value < 0.05 is considered statistically significant.

Ethical consideration

Permission to conduct the study was obtained from the management office of Al-Sadaka General Teaching Hospital, Aden. Patient identifiers were not included; therefore, no ethical harm was inflected on the patients.

Results

A total of 412 children (214 boys and 198 girls) in the age group of 06 - 60 months were admitted during the study period, 62.4% belonged to the age group 06 - 12 months. Children between 13 - 24 months and 25 - 60 months represented 31.6%, and 6.0% respectively.

Table 1 shows mean HC among the different age group based on nutritional status. Mean HC was significantly low among wasted compared to no wasted children in the age group between 6-24 months. Mean HC among severely wasted 25-60 month old children was also low compared to moderately and no wasted children, howover, the difference was statistically not significant. Stunted children had significantly low mean HC in all age age groups.

Severely stunted children had statictically significant low mean HC when compared with severely wasted children (P value 0.000), result had not shown in the table.

Age group	*WFL/H Z-score*	*N (%)*	*Mean HC cm*	*SD*	**P Value*	*L/HFA Z-score*	*N (%)*	*Mean HC cm*	*SD*	**P value*
6-12 Mo	< - 3	221 (53.6)	41.013	2.3718	0.005	< - 3	74 (18.0)	39.054	1.5228	0.000
	< - 2	16 (03.9)	41.844	1.1792		< - 2	58 (14.1)	41.000	1.6728	
	≥ - 2	20 (04.9)	42.625	1.2341		≥ -2	125 (30.3)	42.542	1.8950	
13-24 mo	< - 3	111 (26.9)	42.405	1.8222	0.000	< - 3	61 (14.8)	41.434	1.3054	0.000
	< - 2	9 (02.2)	44.111	0.8937		< - 2	27 (06.6)	42.759	1.4960	
	≥ -2	10 (02.4)	45.750	1.0607		≥ -2	42 (10.2)	44.750	1.2843	

25-60 Mo	< - 3	20 (04.9)	45.575	1.8444	0.304	< - 3	7 (01.7)	44.214	1.3496	0.003
	< - 2	1 (0.2)	47.000	0.0000		< - 2	8 (01.9)	45.813	1.7100	
	≥ -2	4 (01.0)	47.000	1.4720		≥ -2	10 (02.4)	47.050	1.2791	

*ANOVA test.

Table 1: Mean HC ±SD based on age and nutritional status.

Table 2 shows that the severely wasted children (85.4%) were also stunted in different severity (33.0% severe and 20.1% moderate).

Children who were admitted for acute diarrhea (14.6%) were found to have moderate wasting and no wasting 6.4% and 8.2% respectively. The frequency of no stunting was 7.7% among no wasting (8.2%) children.

L/HFA	***WFL/H***							
	< -3		***< -2***		***≥ -2***		***Total***	
	No	***%***	***No***	***%***	***No***	***%***	***No***	***%***
< -3	136	33.0	6	1.6	0	0.0	142	34.5
< -2	83	20.1	8	1.9	2	0.5	93	22.5
≥ -2	133	32.3	12	2.9	32	7.7	177	43.0
Total	352	85.4	26	6.4	34	8.2	412	100.0

WFL/H = weight for length/height, L/HFA = length/height for age.

Figures in parentheses are percentages.

Chi-Square = 77.59, df =9, P= .000.

Table 2: Distribution of children based on WFL/H and L/HFA.

Table 3 presents the correlation between HCA Z-score and the severity of wasting, stunting, and no wasting/stunting children. HCA Z-score among severely wasted (85.4%) children was < -3SD in 38.6%, < -2SD in 15.5% and ≥ -2SD in 31.3%. Children who were admitted for diarrhea were 14.6% (<-2 SD + ≥ - SD, i.e., 6.4 + 8.2), 12.4% of them had HCA Z-score ≥ -2SD. There was a statistically significant correlation between low HCA Z-score and the severity of wasting.

Severe and moderate stunting was found among 34.5 % and 22.6% of admitted children, respectively. Thirty-two percent out of the severely stunted children (34.4%) had HCA Z-score < -3SD and half of the moderately stunted children had HCA Z-score < -2SD. No stunted children were 43.0% and 38.3 of them had HCA Z-score ≥ -2 SD. There was a statistically significant association between low HCA Z-score and the severity of stunting.

HCA Z-score	***WFL/H Z-Score****							
	< -3 SD		***< -2 SD***		***≥ -2 SD***		***Total***	
	No	***%***	***No***	***%***	***No***	***%***	***No***	***%***
< -3 SD	159	38.6	4	1.0	0	0.0	163	39.6
< -2 SD	64	15.5	4	1.0	1	0.2	69	16.7
≥ -2 SD	129	31.3	18	4.4	33	8.0	180	43.7
Total	352	85.4	26	6.4	34	8.2	412	100.0

HCA Z-score	L/HFA Z-score #							
	< -3		< -2		≥ -2		Total	
	No	%	No	%	No	%	No	%
< -3 SD	132	32.0	23	5.6	8	1.9	163	39.6
< -2 SD	10	2.4	48	11.7	11	2.7	69	16.7
≥ -2 SD	0	0.0	22	5.3	158	38.3	180	43.7
Total	142	34.4	93	22.6	177	43.0	412	100.0

HCA = head circumference for age, WFL/H = weight for length/height, L/HFA = length/height for age.

Figures in parentheses are percentages.

* Chi-Square = 108.9, df =9, P = .000.

Chi-Square = 593.7, df =9, P = .000.

Table 3: Distribution of children according to HCA Z-score based WFL/H and L/HFA.

Discussion

Undernourished children are not only at risk of growth retardation and increased acute morbidities and mortality but also of permanent cognitive impairment. The critical period of brain growth extends from mid gestation to the early preschool years. Thus, the fetal phase and the first two years are crucial period for brain growth and development. During the critical period, the brain has biosynthetic abilities that do not persist into later life. Head circumference, an anthropometric indicator of both head growth and nutritional back ground, has become very important anthropometric measurement for assessment and evaluation of growth and development of infancy and early childhood [2, 13, 16].

The present study revealed that the 94% of the admitted children belong to the age group 06-24 months and among this age group 80.5% were severely wasted out of the total (85.4) severely wasted children. In a hospital-based studies done in Odisha, India and Northwest Ethiopia they were found that 65.5% and 62.7% of severely wasted children belonged to the age group 06-24 months, respectively [17, 18]. This finding revealed that the majority of our children were suffering from severe wasting early in their life. In the Yemeni context, malnutrition in this age group mostly related to improper complementary feeding practice. According to SMART surveys conducted in 2021, only one in 10 children aged 6-23 months receives an adequate diet in the complementary feeding period, with only 12% receiving a minimum acceptable diet. High levels of poverty, spiraling food prices, poor access to services, and the constraints on the daily lives of women, such as movement restriction and challenges accessing financial services, all present challenges to following recommended complementary feeding practices. A lack of knowledge on age-appropriate behaviours and a lack of interaction with children during meals have also been highlighted as barriers to appropriate feeding practice [19]. Malnutrition that not addressed early in life increases children's risk to develop irreversible long term consequences, namely stunting, impaired cognitive development, reduce school performance and work capacity, maternal malnutrition and intergenerational cycle on future generation, increased risk of chronic noncommunicable disease in adulthood [20].

The mean HC in wasted 06-24 month old children is significantly decreased compared to no wasted children. Severe microcephaly (HCA Z-score < -3 SD), was found among 38.6% out of the total (85.4%) severely wasted children, this finding is higher than the finding of a hospital based study done in Udaipur, Rajasthan/India (36.3%) [13]. and much higher than the result of a hospital based study done in Midnapore, West Bengal, India (7.5) [21]. Low HC is an indicator of prolonged malnutrition, 12, 13 and this finding support the evidences that in Yemen, acute malnutrition, that is estimated to be 2.2 million, was not addressed appropriately at an early age, predisposes children to develop chronic malnutrition [22].

Our study shows that 34.4 of the admitted children were severely stunted which is higher than the result of a hospital based studies done in Egypt and Western Kenya which revealed that stunted among under 60 month old children were 23.2% and 23.0%, respective-

ly [23, 24]. More than thirty percent of severely stunted children belonged to the age group 06-24 months which is much higher than the frequency of stunting among 06-24 month old children in a study included hospitalized children in Nepal (4.7%) and a community based study done in Vellore, India (14.1%) [25, 26]. Stunting by the age of 2 years is largely irreversible, as the child cannot recover height in the same way that they can regain weight [9, 10]. Stunting is one of the long term consequences of acute malnutrition that inappropriately addressed at early age [20].

Mean HC was significantly low in stunted children of all age group children and nearly all severely stunted children had severe microcephaly (HCA Z-score < -3 SD). A study done in Southern India concluded that low HC was significantly associated with stunting [27].

Any significant reductions in HCs observed in undernourished children may have serious implications for their future cognitive performance and achievement, since it reflects the intracranial volume and brain growth attainment. Therefore, this measurement became very important for assessment and evaluation of growth and development of children aged below 5 years (WHO, 2007) [3, 16].

Nutritional status of children who admitted for diarrhea (14.6%), was 6.4% with moderate wasting and 8.2% with no wasting. The majority of no wasting children were also no stunting (7.7%) with normal HCA Z-score and nearly no moderate or severe microcephaly. These findings provide evidence that nutrition adequacy is very important for normal physical and brain growth and development [28].

Limitations of the study: The main limitation of the study is that it is a hospital-based and a single center study in Aden/Yemen. Studies should be conducted in other in patients care and in communities to have comparable results.

Conclusion and Recommendation

The present study provides evidence that undernutrition associated with retarded linear growth, and both wasting and stunting adversely affects the developing brain as evidenced by reduced head size with increasing severity of undernutrition. Therefore, the study emphasizes the importance of routine assessment of children's growth/nutritional status including HC before the severity of malnutrition increases to an extent of irreversible effects on brain growth and development. We also suggest that studies evaluating undernutrition-based on HC to be undertaken in children's care sittings. In addition, initiatives should be taken to prevent undernutrition and to improve nutritional status of all children.

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Competing interests

The author declare that they have no competing interests.

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