Original Articles

NUTRITIONAL STATUS OF CHILDREN: VALIDITY OF MID-UPPER ARM CIRCUMFERENCE FOR SCREENING UNDERNUTRITION

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ABSTRACT

Objectives: *To determine the nutritional status and validity of mid upper arm circumference (MAC) in diagnosing malnutrition among preschool children.* ***Design:*** *Cross-sectional household survey.* ***Setting:*** *47 villages in District Ambala, Haryana.* ***Subjects:*** *3747 children aged less than six years.* ***Methodology:*** *Trained field workers recorded age, weight, length/ height and MAC of children. Prevalence of underweight, stunting, and wasting were calculated in reference to National Centre for Health Statistics (NCHS) standards. Sensitivity and specificity of MAC for detecting underweight, wasting and stunting among children aged 1 to 4years were determined.* ***Results:*** *At the cut-off level of <-2.00 SD of Z-scores, 48.8% children were stunted, 49.6% were underweight and 9.1% were wasted whereas 47.6% children had neither wasting nor stunting. Prevalence of severe stunting, underweight, and wasting (Z-score <-3 SD) was 18.1%, 11.5% and 0.6%, respectively. Under-nutrition showed a significant rise after 12 months of age (p <0.0001). Stunting and underweight were significantly more among girls compared to boys (p <0.01) but wasting was not significantly different in them. Compared to the conventional MAC cut off levels of<13.5 cm and <12.5 cm, sensitivity and specificity in our setting were optimum at <13.5 cm for detection of wasting and <14.0 cm for diagnosis of underweight and stunting, and <13.0 cm for detection of severe wasting and <13.5 cm for diagnosis of severe underweight and severe stunting.* ***Conclusions:*** *Almost every second child was undernourished. Optimum cut off level of MAC in our setting were higher than the conventional cut off points for detection of under-nutrition among children.*

Key words: *Growth, Preschool, Anthropometry, Nutritional status, Screening.*

ANTHROPOMETRY is an accepted method for defining the nutritional status of children(l,2). However, the standard against which nutritional status of the sample population should be determined has been controversial. The current recommendation is to use the National Centre for Health Statistics (NCHS) data(3) as international reference or standard for this purpose(4-6) and to present nutritional indices in the form of Z-scores, percentiles, or percentage of median. Z-scores have distinct statistical advantages since these reflect the reference distribution and are comparable across ages and across indicators(l,2,5). There is a paucity of community based data on nutritional status of preschool children based on Z scores for the three commonly used indices (weight-for-height, height-for-age and weight-for-age).

As compared to other nutritional indices, weight-for-height is considered to be most responsive to recent and severe under-nutrition and is the most widely accepted measure of nutritional status during emergencies (1), but it requires special equipment and is difficult to measure and interpret. Another age-independent measurement which has some practical utilization in screening children for malnutrition between 1 - <5 years of age is mid upper arm circumference (MAC). The advantage of MAC is it's simplicity, particularly for screening children in emergency situations. When compared to standard anthropometry indices, MAC is a valuable form of low technology applicable at village health worker level(7). Requiring no scales, measuring devices or graph plotting, MAC costs very little and is easy to learn(8).

The present study was designed to assess the nutritional status of rural preschool children in Haryana and to test the validity of mid upper arm circumference (MAC) in diagnosing malnutrition.

Subjects and Methods

This cross-sectional study was conducted during 1987-89 in villages of Naraingarh sub-division of district Ambala, Haryana. A list of villages in a defined geographical area was prepared. From this list 47 villages were randomly selected for the study. Two field workers from the local area were trained for measuring weight, length in children below 2 years of age and height in children aged 2-5 years. Reliability of >95% was attained for taking different measurements. These field workers visited every household in the selected villages to enroll all children in the 0-5 year age group. Children who were sick or had gone away temporarily were visited again. Birth records maintained by anganwadi workers were used to determine the age. In about 10% of the cases where records were not available, caretakers were interviewed to find out the age of the child. A 'desi' calendar and local events calendar was used for facilitating age ascertainment. Age was computed in complete months. Children who were born before the middle of the month were counted in previous month while those who were born at or beyond middle of the month were counted in the next month. A pretested interview schedule was used to collect data on socio-economic factors. Weight of the children was recorded on Salter spring balance to the nearest 50 g with minimal clothing. Length in less than 2 year old children was measured by the infantometer and height in 2-5 year olds by using anthropometer to the nearest 0.1 cm. Arm circumference was measured to the nearest 0.1 cm by fiber glass tape at mid-upper arm.

Statistical Analysis

Data was analyzed using EPI-INFO computer package(9). The Z-scores for different nutritional indices, weight-for-age, height-for-age and weight-for-height were calculated in reference to NCHS standards by using EPI-NUT programme(9). There were 117 (3%) records with missing information which were not considered for further analysis. The prevalence of underweight (low weight-for-age), stunting (low height-for-age) and wasting (low weight-for-height) were calculated at cut off level of < —2 SD of Z-scores and prevalence of severe underweight, stunting and wasting at cut off level of < -3 SD of NCHS reference standards by using EPIANTH package(9). Children having stunting and wasting were cross tabulated to determine proportion of children who had stunting as well as wasting.

Sensitivity, specificity, positive and negative predictive values of MAC in detecting wasting, underweight and stunting at various MAC cut off points were calculated. Sensitivity gives the proportion of test positives to true positives while specificity gives the proportion of test negatives to true negatives as per the gold standards. Positive predictive value gives the proportion of true positives out of the total screening test positive cases and negative predictive value gives the proportion of true negatives out of the total negative cases as determined by the screening test.

Chi-square tests were used to find out the statistical significance of the difference in prevalence of malnutrition in sex and age groups for various nutritional indices.

Results

The distribution of socio-economic variables revealed that 43% respondents lived in kutcha house, 72% households had electricity, 63% had easy access to health center and 81% to nursery/balwadi. Parental literacy was 73% for fathers and 33% for mothers. Hand pump or tap water was available in 91% of the households and only 2% of the households had latrine.

Nutritional Status

Of the 3,747 children surveyed, 53% were boys and 47% were girls. The prevalence of wasting, underweight, and stunting was 9.1%, 49.6% and 48.8% respectively whereas prevalence of severe wasting, underweight and stunting was 0.6%, 11.5% and 18.1%, respectively *(Table I). A* total of 47.6% of the children had neither wasting nor stunting and 18.5% children had either severe wasting or severe stunting *(Table II).* The prevalence of malnutrition (underweight, stunting and wasting) showed a steep rise in the later half of infancy and during the second year of life ($p < 0.0001$) *(Table I).* The prevalence of stunting was

TABLE I—*Prevalence of Undernutrition Among Rural Preschool Children of Haryana*

Age group (mo)		Per cent prevalence of undernutrition					
		Stunting (Low height-for-age)		Wasting (Low weight-for-height)		Underweight (Low weight-for-age)	
	No.	< –2 SD	< –3 SD	< –2 SD	< –3 SD	< –2 SD	< –3 SD*
<6	229	13.5	3.1	0.9	0.9	8.7	1.3
6 - <12	323	32.8	9.0	3.4	0.6	29.4	7.7
12 - <24	647	53.2	20.4	11.9	1.4	54.3	14.1
24 - <36	623	51.2	18.1	10.3	0.8	60.5	17.2
36 - <48	615	56.4	22.4	10.6	0.5	55.4	13.7
48 - <60	545	52.7	21.5	8.4	0.0	48.8	9.0
60 - <72	648	52.0	18.7	10.0	0.0	54.3	8.8
Total	3630	48.8	18.1	9.1	0.6	49.6	11.5

SD = Standard Deviation
* National Centre of Health Statistics as reference standard.

significantly higher in girls (51%) as compared to boys (46.7%) (p=0.008). The prevalence of underweight was also significantly higher among girls (52%) as compared to boys (47.4%) (p=0.005); however, prevalence of wasting was similar among boys (8.3%) and girls (10%) (p=0.07). Similarly prevalence of severe stunting and underweight were significantly higher among girls but severe wasting was not significantly different among them.

TABLE II- *Distribution (%) According to Height for Age and Weight for Height*

Weight-for-height (wasting)	Height-for-age (stunting)	
	< - 2 SD	≥ - 2 SD
< - 2 SD	5.5	3.6
≥ - 2 SD	43.3	47.6
	< - 3 SD	≥ - 3 SD
< - 3 SD	0.2	0.4
≥ - 3 SD	17.9	81.5

SD= Standard deviation of Z-scores in reference to NCHS standards

Validity of MAC

Of the 2430 children aged 1 to 4 years, 252 (10.4%) had wasting, 1335 (54.9%) had underweight and 1297 (53.4%) had stunting. Severe wasting, underweight and stunting among them were 6.4%, 23.1% and 37.1%, respectively. Whereas 228 (9.3%) children had MAC of <12.5 cm, 806 (33.2%) had MAC <13.5 cm and 1648 (67.8%) had MAC <14.5 cm. Sensitivity, specificity, positive and negative predictive values of MAC for predicting different indices of under-nutrition are shown in *Tables III-V*. Sensitivity and specificity of MAC in diagnosing under-nutrition at conventional cut off levels of <13.5 cm were 81.3% and 72.4% for wasting; 52.4% and 90.3% for underweight; and 42.6% and *77.7%* for stunting. For diagnosis of severe under-nutrition at <12.5 cm, the respective values were 70.6% and 91.0% for severe wasting, 41.1% and 95.6% for severe underweight and 20.6% and 93.5% for severe stunting.

The data suggests that in our setting a level of <13.5 cm should be used for

TABLE III—*Validity of MAC for Detection of Wasting (Data in Percentages)*

MAC (cm)	Wasting				Severe Wasting			
	Sensi-tivity	Speci-ficity	Positive predictive value	Negative predictive value	Sensitivity	Specificity	Positive predictive value	Negative predictive value
<11.5	11.9	99.3	65.2	90.7	47.1	98.4	17.4	99.6
<12.0	20.6	97.9	53.1	91.4	64.7	96.4	11.2	99.7
<12.5	36.5	93.8	40.4	92.7	70.6	91.0	5.3	99.8
<13.0	62.7	85.5	33.3	95.2	100.0	81.1	3.6	100.0
<13.5	81.3	72.4	25.4	97.1	100.0	67.3	2.1	100.0
<14.0	95.2	54.2	19.4	99.0	100.0	49.4	1.4	100.0
<14.5	99.6	35.9	15.2	99.9	100.0	32.4	1.0	100.0

TABLE IV—*Validity of MAC for Detection of Underweight (Data in Percentages)*

MAC (cm)	Underweight				Severe underweight			
	Sensi- -tivity	Speci- -ficity	Positive predic tive value	Negative predic tive value	Sensi- -tivity	Speci- -ficity	Positive predic- tive value	Negative predic- tive value
<11.5	3.1	99.6	91.3	45.8	10.9	99.5	78.3	87.6
<12.0	7.0	99.6	95.9	46.8	21.8	98.8	73.5	88.9
<12.5	16.3	99.0	95.2	49.2	41.1	95.6	59.6	91.1
<13.0	32.4	96.3	91.4	53.9	68.0	88.1	47.5	94.6
<13.5	52.4	90.3	86.8	60.9	84.6	74.9	34.7	96.9
<14.0	73.4	76.4	79.2	70.2	95.8	56.1	25.6	98.8
<14.5	87.9	56.6	71.2	79.3	99.4	37.2	20.0	99.7

TABLE V—*Validity of MAC for Detection of Stunting (Data in Percentages)*

MAC (cm)	Stunting				Severe stunting			
	Sensi- -tivity	Speci- -ficity	Positive predic- tive value	Negative predic- tive value	Sensi- -tivity	Speci- -ficity	Positive predic- tive value	Negative predic- tive value
<11.5	2.8	99.1	78.3	47.1	4.4	98.8	47.8	79.9
<12.0	6.0	98.2	79.6	47.7	9.0	97.3	45.9	80.5
<12.5	13.7	95.6	78.1	49.2	20.6	93.5	45.2	82.0
<13.0	27.7	89.8	75.7	52.0	38.0	85.3	40.1	84.2
<13.5	42.6	77.7	68.6	54.2	52.6	71.9	32.6	85.4
<14.0	61.7	61.3	64.6	58.3	68.8	53.7	27.8	86.9
<14.5	76.9	42.5	60.5	61.6	80.6	35.5	24.5	87.6

detection of wasting and <14.0 cm for underweight and stunting. A cut off level of <13.0 cm should be used for detection of severe wasting and <13.5 for severe underweight and severe stunting.

Discussion

Nutritional Status

Biological, epidemiological, and statistical evidence suggests that wasting and stunting represent different processes of malnutrition. It has therefore, been recommended that attempts should be made to classify nutritional status of children for all the three basic indices namely weight-forage, weight-for-height and height-for-age(6). Low height-for-age (stunting) is a principal indicator of long-term growth impairment caused by malnutrition in the past. Low weight-for-height (wasting) indicates a deficit in tissue and fatness compared with the amount expected for a child of the same height or length and may result either from weight loss or from failure to gain weight. Thus low weight-for-height is commonly used to assess acute or recent malnutrition. Low weight-for-age (underweight) is a combined index that reflects both height for age and weight for height data. Thus use of this indicator alone does not permit a distinction to be made between wasting and stunting.

The prevalence of all the three types of malnutrition is high in our population being 49.6%, 48.8% and 9.1% for underweight, stunting and wasting, respectively *(Table* I). A high prevalence of stunting with very low prevalence of wasting has also been documented in many other populations(l0). The National Nutrition Monitoring Bureau data collected in 10 States of the country during 1974-80 showed that the prevalence of stunting is of a higher magnitude (50%) than wasting (3%)(11). According to a UNICEF Report(12), 36% of under five children in the developing world excluding China are underweight, 39% are stunted and 8% are wasted. The prevalence of underweight, stunting and wasting among preschool children in China were reported to be 24-28%, >40%, and <3%, respectively(13).

Growth in the first year of life is particularly vulnerable to environmental stresses(14). There was an increase in prevalence of underweight, stunting and wasting after the age of 6 month in our children which increased further after the age of 12 months *(Table I).* As per a UNICEF Report, malnutrition was highest during the second year of life(12). The National Nutrition Monitoring Bureau data(ll) also revealed a significantly higher percentage of stunted children (51.9%) among 2-3 years olds as compared to younger children (30.5%). The prevalence of wasting was highest in the 1-2 year age group (4.1%). Stunting was most prevalent during third year of life in Bahrain(15).

Validity of MAC

Mid-upper arm-circumference has been considered a valid and simple screening measure for protein-energy malnutrition in children between 1 to 4 years of age (16). A MAC of <12.5 cm and <13.5 cm is used to detect severe and moderate malnutrition, respectively(17). In this study, the sensitivity and specificity of MAC in diagnosing under-nutrition at conventional cut off level of <13.5 cm were 81.3% and 72.4% for wasting; 52.4% and 90.3% for underweight; and 42.6% and *77.7%* for stunting *(Tables II1-V).* For diagnosis of severe under-nutrition at <12.5 cm, the respective values were 70.6% and 91.0% for severe wasting, 41.1% and 95.6% for severe underweight and 20.6% and 93.5% for severe stunting. The predictive value of conventional MAC cut off levels is unsatisfactory since even at level of <13.5 cm, 75% normal children were over-diagnosed as wasted and about half of the children were not diagnosed as underweight. At cut off level of <12.5 cm, under-diagnosis for wasting and underweight was 64% and 84%, respectively *(Tables III-V).*

In children above 2 years of age, for detection of severe wasting (W/H <70% of the median), Gayle *et al.* have reported 8% sensitivity of MAC <12.5 cm with 98% specificity and for moderate wasting (W/H <80% of the median) sensitivity of MAC <13.5 cm was 62% with 91% specificity (18).

Compared to the conventional MAC cut off levels of <13.5 cm and <12.5 cm, in our setting, sensitivity and specificity were optimum at <13.5 cm for detection of wasting and <14.0 cm for diagnosis of under-weight and stunting, and <13.0 cm for detection of severe wasting and <13.5 cm for diagnosis of severe underweight and severe stunting. At these cut off levels, positive predictive values were 25.4% for wasting, 79.2% for underweight, 64.6% for stunting, and 3.6%, 34.7% and 32.6% for severe wasting, underweight and stunting, respectively *(Tables III-V).* Bern *et al.* have also observed that at higher cut-offs, likelihood that a child with low MAC actually has low weight-for-height declines (decreasing positive predictive value). At cutoff point of <12 cm the positive predictive value was reported to be 63% while at cutoff of <14 cm it declined to only 27%(19).

To conclude, almost every second child was undernourished in this area. Most of them had chronic under-nutrition (stunting). The optimum cut off levels of MAC in our setting were higher than the conventional cut off points for detection of under-nutrition among children aged 1-4 years. However, even at these levels, the positive predictive values were low especially for detection of severe forms of under-nutrtion.

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