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Determination of Bone Width in Malnourished Children under 5, and its Inter Relationship with Mid Arm Muscle Thickness, Subcutaneous Fat Thickness and the Mid Upper Arm Girth

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The mid upper arm of 516 malnourished children (one to five years) were studied radiographically for changes in bone width, muscle mass and subcutaneous fat, of malnutrition at different ages. The data was studied by statistical analysis, determining the correlation coefficients of each of the factors. The findings indicate that previous assumptions about the components and the changes of the mid upper arm girth (MUG) in chronic severe malnutrition, were perhaps too simplistic.[1]

Key Words: *Malnutrition; Mid upper arm; Radiological changes.*

Most criteria of measurement of malnutrition available today relate to anthropometric parameters which are age dependent. However, in underdeveloped countries where malnutrition is rampant, illiteracy is also rife and parents cannot be relied upon to recall the ages of their children accurately. The need therefore arises for the development of age independent criteria of malnutrition.

Among the various age independent criteria that have been studied and have come to be accepted as reliable is the measurement of mid upper arm girth (MUG), which remains constant between the ages of one and five years and which alters in a grade wise manner in malnutrition. However, there is a dearth of objective studies on the effects of chronic undernutrition on the various components of the MUG, namely bone circumference, muscle bulk and the thickness of skin and subcutaneous fat. Previous studies had assumed that bone thickness remains constant[2] and that the fat of the early years reduced gradually with a corresponding increase in muscle mass as age increased up to five years.[3] With malnutrition, fat, the most labile tissue, is presumed to be utilised first - and should malnutrition be chronic, reduction in muscle mass follows. This combined reduction of muscle and fat is said to cause the reduction of the mid upper arm girth which helps it as an indicator of malnutrition. All along, bone width is assumed to remain static.

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Thus, the present study was aimed to evaluate the effect of malnutrition on bone width and the inter-relationship of MUG, subcutaneous fat and muscle circumference seen as soft tissue shadows on X-ray film of left upper arm.

MATERIAL AND METHODS

Five hundred and sixteen children of various grades of malnutrition presenting themselves in the out-patient department of Medical College Hospital, Jabalpur, between May 1979 and August 1980 comprised the material for this study. Nutritional status was graded according to the nutrition sub-committee of the Indian Academy of Paediatrics.[4] These children were divided into four age groups: Group I - 1 to 2 years; Group II - 2.1 to 3 years; Group III - 3.1 to 4 years; Group IV - 4.1 to 5 years.

In each age group, the child was further classed according to his grade of malnutrition. Mid upper arm measurements of the children were taken by the standard crossed

TABLE 1. Correlation Coefficients of Different Age Groups for Bone Thickness in Different Nutrition Grades

Age groups (years)	Age groups I 1-2 years	II 2.1-3 years	III 3.1-4 years	IV 4.1-5 years
Grade I PEM				
1 - 2	1.00	-0.1805	-0.2773	-0.0338
2.1 - 3		1.00	-0.1952	0.0313
3.1 - 4			1.00	0.00
4.1 - 5				1.00
Grade II PEM				
1 - 2	1.00	0.6801*	-0.0672	0.9118*
2.1 - 3		1.0	0.740	0.6808*
3.1 - 4			1.00	0.0618
4.1 - 5				1.00
Grade III PEM				
1 - 2	1.00	0.1408	0.0454	-0.1279
2.1 - 3		1.00	0.00	0.1165
3.1 - 4			1.0	0.00
4.1 - 5				1.00
Grade IV PEM				
1 - 2	1.00	0.4207*	0.3329*	-0.4018*
2.1 - 3		1.00	-0.0850	-0.3962*
3.1 - 4			1.00	-0.1689
4.1 - 5				1.00

* Significant at 5% level.

tape technique at the mid point of the left arm, measured between the tip of the acromian process and the olecranon process.

For radiographic measurements, the radiographic technique of Stuart and coworkers[5] was adopted. X-ray film was taken (using 40 to 46 KV at 1/20 of a second) of the left upper arm with the child lying flat with left arm abducted at 45°. To avoid magnification, the tube plate distance was kept constant at 36". The mid arm width, the width of the humerus, muscle shadow thickness and thickness of the shadow of skin and subcutaneous tissue on each side of the humerus was measured.

The data was analysed statistically using simple and multiple correlation technique on a DCM micro-computer to find various correlation co-efficients. Each value was tested for significance at 5% level.

RESULTS

Correlation co-efficients of different age groups for bone thickness in different grades of malnutrition are given in Table 1. It reveals that in grade I, malnutrition bone thickness remained constant after the first birthday up to five years of age. In grade II malnutrition bone thickness had increased during the second and third year (0.6801). In grade IV severe malnutrition bone thickness tends to increase from two to four years (0.4207, 0.3329) and thereafter in the fifth year it has shown a negative correlation (0.4018).

Table 2 shows the correlation co-efficients of MUG with bone thickness of different grades of malnutrition with different age groups and indicates that there is no systemic tendency of relationship of bone thickness with MUG.

Table 3 shows the correlation co-efficients of subcutaneous fat thickness (radiological) in the different age groups and in different grades of malnutrition. In grade II malnutrition, this tendency is observed in the three to four years of age group (-0.5218). In grade III malnutrition also, a negative correlation (-0.6762) was seen between ages three to four years.

No relationship between MUG and subcutaneous fat, measured radiologically could be established in different age groups in different groups of malnutrition.

Table 4 shows the correlation co-efficients of muscle thickness (radiological

TABLE 2. Correlation Coefficients of MUG with Bone Thickness in Different Grades with Different Age Groups

Age groups (years)	Grades of malnutrition			
	Grade I	Grade II	Grade III	Grade IV
1 - 2	0.0165	0.4408*	0.5119*	0.1955
2.1 - 3	0.4174*	0.5351*	0.0217	0.1250
3.1 - 4	0.7276*	0.2755	0.5012*	-0.0456
4.1 - 5	0.5053*	-0.1713	0.1285	-0.0616

* Significant at 5% level.

TABLE 3. Correlation Coefficients of Subcutaneous Fat Thickness (Radiological) and MUG in Different Age Groups and in Different Grades of Malnutrition

	Age groups			
Age groups (years)	I 1-2 years	II 2-3 years	III 3.1-4 years	IV 4.1-5 years
Grade I PEM				
1 - 2	1.00	-0.1649	-0.0119	0.0517
2.1 - 3		1.00	0.0067	-0.825
3.1 - 4			1.00	-0.7376*
4.1 - 5				1.00
Grade II PEM				
1 - 2	1.00	-0.0130	-0.5218*	0.3949*
2.1 - 3		1.00	-0.0317	-0.1786
3.1 - 4			1.00	-0.1448
4.1 - 5				1.00
Grade III PEM				
1 - 2	1.00	-0.1795	-0.6762*	0.0785
2.1 - 3		1.00	0.1356	0.3014
3.1 - 4			1.00	-0.1512
4.1 - 5				1.00
Grade IV PEM				
1 - 2	1.00	0.0375	-0.1095	-0.1491
2.1 - 3		1.00	0.0032	0.2210
3.1 - 4			1.00	0.4291
4.1 - 5				1.00

* Significant at 5% level.

method) in different grades of malnutrition in different age groups. It shows an increase in size between one and three years of age in grade I malnutrition (0.9155, 0.9785). In grade II malnutrition there was no significant correlation observed in the early years but, it was significantly positive from third to fifth years (0.6178, 0.3821). On the other hand, the significant positive relationship was observed only in the one to two years age in grade III malnutrition (0.6092). In severe malnutrition no systematic tendency was seen.

DISCUSSION

Observations of this study indicate that in the comparatively well nourished (grade I malnutrition), bone width remains constant inspite of increasing age. In moderate malnutrition, bone width increased with age up to four years of age. This apparent paradox may be explained on the strength of Hammond's theory[6] of "heterogenic velocity of growth" which suggested that each tissue has a definite period of "height of natural intensity of growth" and that for bone it

Table 4. Correlation Coefficients of Muscle Circumference by Radiological Method in Different Grades of Malnutrition with Different Age Groups

Age groups (years)	Grades of malnutrition			
	Grade I	Grade II	Grade III	Grade IV
1 - 2	0.9155*	0.2755	0.6092*	0.5698*
2.1 - 3	0.9785*	0.3098	-0.1737	-0.0974
3.1 - 4	0.2087	0.6178*	0.2182	0.3061
4.1 - 5	0.2207	0.3821*	0.2490	0.3826*

* Significant at 5% level.

came very soon after birth. In normal children, it should therefore be inferred that this growth was completed in the first year of life and subsequently remains fairly constant up to the fifth year of life. However, the same is not true for the malnourished. In moderately malnourished children, it is perhaps true that optimal growth could not occur during the first year of life and subsequent efforts to catch up have to be made during the next three years. In severe malnutrition, it was found that bone width increased significantly up to the fourth year of life and then it decreased between the fourth and fifth year of life. John Mcfie has suggested that bone growth may be retarded in the presence of malnutrition.[7] The apparent "decrease" observed in this study is perhaps due to the cross sectional nature of this study and it can at least be interpreted as a retardation of bone width in malnutrition. Studies on larger sample, and perhaps of a longitudinal nature, would, however, be required to confirm these findings.

No constant relationship of bone thickness and MUG was observed. This would be expected, given the above described peculiarity of the relationship of bone width with age in malnutrition and as MUG reduced constantly with increasing severity of malnutrition.

The reduction of subcutaneous fat observed in this study is in accordance with the observation of Jelliffe.[8] The study indicated that in moderate malnutrition, the reduction occurs at an earlier age (three to four years) compared to grade I malnutrition (four to five years). In grade IV malnutrition, no significant reduction of subcutaneous fat was observed with increasing age. This may be due to pre-existing depleted subcutaneous fat. The study thus suggested that the previous more simplistic assumption that skin fold thickness reduces constantly with increasing age to be replaced by muscle, holds strictly true only for normal children and for children with very mild malnutrition.

Increase in muscle width occurred earlier than the age at which subcutaneous fat began to reduce in the better nourished (grade I). This suggested that the concept of muscle replacing fat to maintain consistency of MUG cannot be accepted in its entirety.

The mid upper arm girth was primarily devised as a simple method of detecting

early malnutrition by field workers, who do not have access to weighing balances and normograms, in communities where parents are so illiterate that they cannot be relied upon to report the ages of their children accurately. This has proved itself to be both, a versatile and reliable index of malnutrition and has stood the test of time.

The findings from this study suggested that bone width, muscle and subcutaneous fat are variably affected by malnutrition and its severity. These findings need to be documented through a longitudinal study, and their implications on the interpretation of mid arm girth as a marker of malnutrition needs careful assessment.

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FAMILY WELFARE IN INDIA

The Minister of Health and Family Welfare, Shri M.L. Fotedar gave the radical call for 'Hum Do Hamara Ek' instead of the existing norm 'Hum Do Hamare Do'. He suggested that from a stipulated date, the eligibility of elected offices right from the panchayat to parliament level should be confined to those who adhered to the small family norm. He advocated similar conditions for appointment in government services in future, and stressed that people holding high offices should set an example for others, and called for a national debate on these points to focus attention on the gravity of the population situation.

Underlining the importance to be given to the family as a unit to promote small family norm, the Minister made it aclear that it should be the quality of life of the children that should be cared for, rather than the number. The quality of the life could be improved only by consciously planning the size of the family.

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