BONE MINERAL CONTENT IN NORMAL AND MALNOURISHED CHILDREN

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ABSTRACT

Bone mineral content (BMC) was determined at the distal radius in 70 children aged 2-14 years; Group I comprising 34 normal healthy children and Group II 36 malnourished children by the method of single photon absorptiometry. The mean value of BMC in Group I was 0.3 ± 0.04 g/cm in 2-5 year, 0.52 ± 0.08 g/cm in 6-10 year and 0.77 ± 0.88 g/cm in 11-14 year age groups. No significant difference in the BMC was seen between boys and girls. An increase of BMC corresponded to growth spurts in 2-5 year and 11-14 year age groups. There was a significant reduction of BMC in Group II and in grade III malnutrition in 2-5 year and 11-14 year age groups as compared to Group I children. The study provides normal BMC data for Indian children and suggests that this can help to detect undermineralization of bones in malnourished children during the growth periods.

Key words: *Bone mineral content, Growth spurt, Pubertal growth.*

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The minerals are chiefly stored in bones and remain in a constant state of flux, being deposited or resorbed continuously. The bone mineral content (BMC) is affected by many factors including nutritional, hormonal, genetic, systemic disease and administration of drugs. Establishing normal standards of BMC is necessary for the detection of bone mineral deficiency and monitoring changes during treatment(1). Photon absorptiometry is reliable, reproducible, non-invasive and frequently used for the determination of BMC in biomedical research and clinical practice(2-5).

Malnutrition is common in children in developing countries and the availability, absorption, utilization and excretion of minerals may play an important role in determining the bone mineral status. The present study was undertaken in order to determine the normative BMC data, so far not available for the Indian children, and to ascertain whether malnutrition causes any significant change in the bone mineral status.

Materal and Methods

The study was carried out in the Department of Pediatrics and Biochemistry, JLN Medical College, Ajmer. Seventy children between the age of 2 and 14 years were included in the study and divided in two groups. Group I comprised of 34 normal healthy children (15 boys and 19 girls) selected after ensuring that none of the children had recent fractures, signs and symptoms of metabolic bone disease, malnutrition, or other conditions likely to influence BMC or growth. Group II comprised of 36 malnourished and sick children (22 boys and 14 girls) from amongst the hospital patients. The subjects were sub-divided according to the grade of malnutrition(6), and into age-groups 2-5, 6-10 and 11-14 years. Grade I malnutrition (body weight 70-80% of the 50th percentile of ICMR standard(7) taken as normal) was present in 2 cases. Grade II malnutrition (body wt 60-70% of the normal) was found in 17 patients; of these 4 patients had acute diarrhea, 2 each had ancylostomiasis and ascariasis, and one each had amebiasis, cervical adenitis, giardiasis, Indian childhood cirrhosis, malaria, mitral stenosis, nephrotic syndrome, pertussis and pulmonary tuberculosis. Grade III malnutrition (body weight 50-60% of the normal) was seen in 17 cases including 6 cases with acute diarrhea, 5 with enteric fever, 3 with measles, 2 with malaria and one patient with pulmonary tuberculosis.

The measurements of BMC were carried out on a 1100 A bone density scanner (BDS 1100 Molsgaard Medical, Denmark), using the technique of single photon absorptiometry on the subject's forearm. An Americium-241 and a scintillation detector moved simultaneously across the forearm. The forearm was enclosed in a water filled latex cushion which was flattened between two parallel plastic slabs. Part of the radiation emitted from the radioactive source passed through the forearm, and was detected by a scintillation detector on the opposite side. The signal emitted by the detector is proportional to the energy of photons. This signal was amplified and processed in the scalar/analyzer, by conventional amplifier and dual analyzer technique. The collected counts are transmitted to the external computer through the built-in RS-232 interface. The parameters BMC-I, BMC-II were computed for each pass of the scan. The value of BMC available from the printout data expressed in g/cm describes the weight of hydroxyapatite in 1 cm thick slice of bone. Each measurement took about 5 minutes and the radiation dose was less than 5 mRad. For comparison of BMC values, the 't' test of significance was employed and two-tailed probability obtained.

Results

The mean and range of BMC g/cm in normal and malnourished children are shown in *Table I.* The BMC showed a significant increase ($p<0.001$) with advancement of age in males and females of both groups. Spurts of increase in BMC were seen in 2-5 year and 11-14 year age groups. The boys had higher BMC than girls, but lower in 2-5 year age group; the sex difference was not significant ($p>0.05$). The fall in BMC was significant in age group 2-5 year ($p<0.001$) and 11-14 year ($p<0.01$) in Group II as compared to Group I; the difference was not significant in age group 6-10 year ($p>0.05$). The BMC achieved by girls at age 2-5 year was 39% of the peak value at age 11-14 year in Group I and 31% in Group II.

The value of BMC in grade I, II, III malnutrition in boys and girls in various age groups are shown in *Table II.* There was a reduction of BMC in all grades of malnutrition, which was significant in age group 2-5 year and 11-14 year ($p<0.001$), as compared to normal, but not significant ($p>0.05$) in age group 6-10 year.

The BMC growth curve for boys and girls in Groups I and II are shown in the *Figure.* The progressive increase of BMC with age was rectilinear. The girls had higher BMC than boys till age 4 years. The BMC in girls of Group I increased by 34% from 0.60 g/cm at age 9-10 year to a level of 0.79 g/cm at age 12-13 year; the increase was 20% in Group II from 0.54 g/cm to 0.65 g/cm. Peak BMC level was not reached in boys at 14 year.

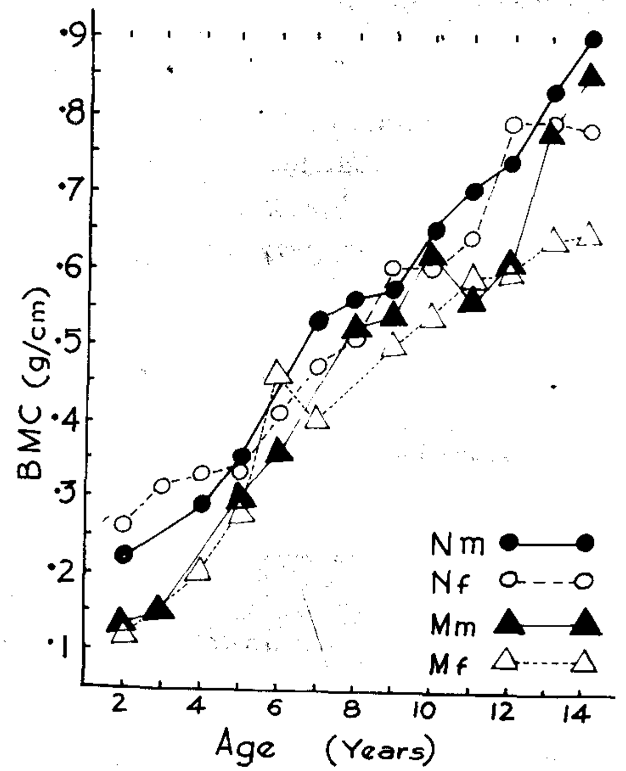

Fig. Bone mineral content (BMC) in relation to age in normally nourished boys (Nm), girls (Nf), malnourished boys (Mm), and girls (Mf).

Discussion

The growth period of infancy and childhood showed a progressive rectilinear increase of BMC with age (*Fig.*), as previously observed by Specker *et al.*(8). Thin bones of the newborn contain about 30 g of calcium, which increase to over 1 kg by late adolescence(9); the increase is due not only to a larger size of the skeleton but also due to an increasing BMC per volume of bone(8,10). It is not certain at what age the sex difference begins to appear(11). The girls, in this study and as reported earlier(8), had higher BMC than boys upto the age 4 years. The BMC was higher in boys thereafter, but during the pubertal spurt in girls, the values were similar in boys and girls. Statistically significant sex difference has been reported in the BMC at 5 year age(12), but this was not so in this study.

There is a positive correlation of BMC with age, height and weight(4), and the total bone body mineral(5,13). Spurts of

TABLE I–*Bone Mineral Content in Normal and Malnourished Children*

Category	Age groups (yrs) [mean ±SD (g/cm)]		
	2-5	6-10	11-14
Normal (Group I) (n=34)	0.30±0.04 (0.22–0.35)	0.52±0.08 (0.39–0.65)	0.77±0.08 (0.64–0.91)
Normal boys (n=15)	0.29±0.07 (0.22–0.35)	0.55±0.07 (0.46–0.65)	0.79±0.09 (0.70–0.91)
Normal girls (n=19)	0.31±0.03 (0.26–0.34)	0.51±0.08 (0.39–0.60)	0.75±0.06 (0.64–0.79)
Malnourished (Group II) (n=36)	0.19±0.07 (0.10–0.30)	0.49±0.10 (0.32–0.66)	0.67±0.10 (0.56–0.86)
Malnourished boys (n=22)	0.18±0.07 (0.10–0.30)	0.52±0.12 (0.32–0.66)	0.70±0.12 (0.56–0.86)
Malnourished girls (n=14)	0.20±0.07 (0.12–0.28)	0.46±0.07 (0.35–0.54)	0.63±0.03 (0.59–0.65)

Range given in parentheses.

TABLE II–*Bone Mineral Content in Grades I, II, III Malnutrition (MN)*

Category	Age groups (yrs) [mean ± SD (g/cm)]		
	2-5	6-10	11-14
Grade–I MN	–	–	0.74 ± 0.09 (0.65–0.84)
Boys (n = 1)	–	–	0.84
Girls (n = 1)	–	–	0.65
Grade –II MN	0.25 ± 0.06 (0.16–0.30)	0.54 ± 0.11 (0.40–0.64)	0.69 ± 0.10 (0.58–0.86)
Boys (n = 11)	0.24 ± 0.07 (0.16–0.30)	0.56 ± 0.10 (0.40–0.66)	0.74 ± 0.12 (0.58–0.86)
Girls (n = 6)	0.28	0.50 ± 0.04 (0.46–0.54)	0.62 ± 0.04 (0.59–0.65)
Grade–III MN	0.15 ± 0.05 (0.10–0.24)	0.45 ± 0.10 (0.32–0.58)	0.61 ± 0.04 (0.56–0.64)
Boys (n = 10)	0.13 ± 0.04 (0.10–0.17)	0.48 ± 0.14 (0.32–0.58)	0.60 ± 0.04 (0.56–0.64)
Girls (n = 7)	0.18 ± 0.06 (0.12–0.24)	0.43 ± 0.58 (0.34–0.50)	0.64

Range given in parentheses.

increase in BMC in 2-5 year and 11-14 year age groups corresponded to the periods of growth, high metabolic activity and biological variation of puberty. The pubertal increase in BMC may be 35% in boys(14), calcium accumulation may triple during this period(15) and about 50% increase may occur between Tanner Stage 1 and 5 in both sexes(4). The bone mineral density of lumbar spine peaks by age 12 year(16) or late puberty in girls(17-19), and the end of puberty in boys(14), or even as late as 35 year of age according to various studies(20).

Determination of BMC at the distal radius assumes importance due to significant reduction ($p < 0.001$) observed in age group 2-5 year and 11-14 year in Group II and in grade III malnutrition, as compared to Group I. It would appear that the periods of growth spurt are more sensitive to mineral needs. The BMC level may reach about 1/3 of the normal adult value by age 6 year(21). In the present study, the BMC level in normal girls at age 6 year was over 50% of the peak value attained by age 12 year (*Fig.*).

This study provides the normative

BMC data for Indian children which can be used to assess the bone mineral deficiency, particularly in cases of malnutrition affecting the growth periods, and monitor changes during the treatment. Since, there is a correlation of BMC with pubertal maturation, the period of mid-adolescence may be the crucial time for maximising bone mineral density(18). Dietary calcium is related to the level of BMC(3) and higher intake may help correct the imbalance and prevent some of the problems of brittle bones later in life(1). Further studies on a larger number of Indian children are needed to supplement the data.

REFERENCES

1. Kreipe RE. Bones of today, bones of tomorrow. Am J Dis Child 1992, 146: 22-25.
2. Griffiths HJ, Zimmerman RE. An overview of clinical applications of photon absorptiometry. Third International Conference on Bone Mineral Measurement. Am J Roentgenol 1976, 126: 1301-1302.
3. Chan GM. Dietary calcium and bone mineral status of children and adolescents. Am J Dis Child 1991, 145: 631-634.
4. Ross JL, Long LM, Marin G, Rose S, Cutler Jr JB. Bone mineral content of the wrist and spine in normal girls and boys. Pediatr Res 1991, 29: 493.
5. Chesney RW, Shore RM. The noninvasive determination of bone mineral content by photon absorptiometry. Am J Dis Child 1982, 136: 578-580.
6. Shah PM. Nutrition subcommittee of the Indian Academy of Pediatrics. Report of Convener. Indian Pediatr 1972, 9: 360.
7. Growth and Development of Indian Children. Technical Report Series No. 18, New Delhi, Indian Council of Medical Research, 1972.
8. Specker BL, Brazerol W, Levin R, Searcy J, Tsang RC. Linear increase in bone mineral content in children 1-7 years of age with lower content in females after 4 years. Pediatr Res 1985, 19: 209 A.
9. Robson AM. Calcium. *In:* Nelson Textbook of Pediatrics, 14th edn. Eds Behrman RE, Vaughan VC. Philadelphia, WB Saunders Co, 1992, p 184.
10. Landin L, Nilsson BE. Forearm bone mineral content in children: normative data. Acta Pediatr Scand 1981, 70: 919-923.
11. Specker BL, Tsang RC. Bone mineralization. Ann Nestlé 1987, 45: 18-25.
12. Specker BL, Brazerol W, Rsang RC, Levin R, Searcy J, Steichen J. Bone mineral content in children 1-6 years of age. Detectable sex differences after 4 years of age. Am J Dis Child 1987, 141: 343-344.
13. Krabbe S, Gotfredsen A, Christiansen C. Relationship between local and total bone mineral in normal pubertal boys. Eur J Pediatr 1984, 143: 149-151.
14. Krabbe S, Christiansen C, Rodbro P, Transbol I. Effect of puberty on rates of bone growth and mineralization. With observations in male delayed puberty. Arch Dis Child 1979, 54: 950-953.
15. Matkovic V. Calcium metabolism and calcium requirements during skeletal modelling and consolidation of bone mass. Am J Clin Nutr 1991, 54 (Suppl): 245-260.
16. Glastre C, Braillon P, David L, Cochat P, Meunier PJ, Delmas PD. Measurement of bone mineral content of the lumber spine by dual energy *X*-ray absorptiometry in normal children: correlations with growth parameters. J Clin Endocrinol Metab 1990, 70: 1330-1333.
17. Bonjour JP, Theintz G, Buchs B, Slosman D, Rizzoli R. Critical years and stage of puberty for spinal and femoral bone mass accumulation during adolescence. J Clin Endocrinol Metab 1991, 73: 555-563.
18. White CM, Hergendroeder AC, Klish WJ. Bone mineral density in 15 to 21 year old

eumenorrheic and amenorrheic subjects. Am J Dis Child 1992, 146: 31-35.

19. Bachrach LK, Guido D, Katzman D, Litt IF, Marcus R. Decreased bone density in adolescent girls with anorexia nervosa. Pediatrics 1990, 86: 440-447.

20. Ott SM. Attainment of peak bone mass. J Clin Endocrinol Metab 1990, 71: 1082A-1082C.

21. Klemm T, Benzer DH, Schneider U. Bone mineral content of the growing skeleton. Third International Conference on Bone Mineral Measurement. Am J Roentgenol 1976, 126: 1283.

NOTES AND NEWS

PEDIATRICS & NEONATAL EMERGENCIES

The book provides clear guidelines for the diagnosis and management of various problems that constitute emergencies. Prompt recognition of emergencies along with their appropriate and adequate initial management is essential to save lives and prevent complications. In a number of situations the doctors cannot do very much and must send the patient to the casualty services of a hospital. One needs to be aware of such conditions. What not to do is also important. Emergencies in the newborn present very different and often unique problems that require special skills and proficiency for their recognition and management. A group of outstanding contributors have presented the various topics in an informative and lucid manner. The book has 58 chapters spread over 500 pages.

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