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Original Research Article

A COMPARATIVE STUDY OF APPEARANCE OF OSSIFICATION CENTERS OF LOWER END OF RADIUS AND ULNA, CARPALS, METACARPALS & PHALANGES IN DIFFERENT GRADES OF PROTEIN ENERGY MALNUTRITION AND WITH NORMAL CHILDREN

Gnanavel A *[1], Maheswari K [2], Sreelekha D [3], Lalitha R [4].

[*1] Assistant Professor, Meenakshi Medical College Hospital & Research Instituite, Kancheepuram, Tamilnadu, India.

[2] Professor and HOD, Meenakshi Medical College Hospital & Research Instituite, Kancheepuram, Tamilnadu, India.

[3] Assistant Professor, Meenakshi Medical College Hospital & Research Instituite, Kancheepuram, Tamilnadu, India.

[4] Assistant Professor, Meenakshi Medical College Hospital & Research Instituite, Kancheepuram, Tamilnadu, India.

ABSTRACT

Background: variety of factors including geography, income, nutrition, home conditions and psychological conditions play important role in skeletal maturity. The present study shows the different grades of Protein energy malnutrition how it delays the appearance of ossification centre.

Materials and Methods: The study was conducted in the Paediatric outpatient department and Paediatric ward at Meenakshi medical College & Research institute in different grades of 125 Protein energy malnutrition children in comparison with 125 normal children. Plain X-ray left wrist with hand - AP view was taken in all controls as well as PEM children.

Results: This study showed the appearance of ossification centers were one year earlier in control group as well as grade I & II PEM children and Grade III & IV PEM the delay was less than the previous studies.

Conclusion: This study can be used for comparing the appearance of ossification centers in normal and PEM children, and it will be used as a base line data for further studies.

KEY WORDS: X-ray, ossification centers, normal children, PEM children.

Address for Correspondence: Dr. Gnanavel A, Assistant Professor, Meenakshi Medical College Hospital & Research Instituite, Kancheepuram, Tamilnadu, India. **E-Mail:** dragnanavel@gmail.com

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INTRODUCTION

The difference in skeletal maturity has been observed among children differing in a variety of ways including geography, income, nutrition, home conditions and psychological factors [1]. There is considerable evidence in western world literature that malnutrition affects the rate of skeletal maturation [2,3] and dietary intake is the key to bone acquisition throughout growth [4]. The process of bone formation is called ossifi-

cation which starts actively from certain areas called ossification centers. The centers appearing before birth are called primary and those appearing after birth are known as secondary centers. The bone formation begins in the embryo by two distinct processes called endochondral and intramembranous ossification. The primary ossification centre in the developing bone appears first in diaphysis, followed by a secondary ossification centre that appears in the epiphysis, which later fuses with the diaphysis [5]. Some bones like carpal, tarsal, lacrimal, nasal, zygomatic, inferior nasal conchae and auditory ossicles ossify from single ossification centre only [6]. Bone is a unique tissue, that constantly undergoes change and its growth is subsequently modified and refined by the process of remodeling to create a structurally and metabolically competent highly organized architectural marvel [7]. The normal development and maintenance of bone requires calcium, phosphorus, vitamin A, C & D, PTH, bile salts, calcitonin and hormones such as estrogen, thyroxine, growth hormone and testosterone which help calcium to get deposited in the bone. Our body normally maintains the ratio of calcium and phosphorus ions of 2.5:1[6,8,9]. Local factors such as Insulin like growth factors (IGF),Transforming growth factors(TGF) and Bone Morphogenic proteins(BMP) stimulates bone formation [9].

Almost one third of children in developing countries are malnourished and 150 million are underweight for that age. Another 175 million are stunted in height due to chronic illness and poor diet. And more than 60% of all children are not exclusively breastfed for the vital first 6 months. More than 6000 Indian children below five years die every day due to malnourishment or lack of basic micronutrients like vitamin A, Iron, Calcium, Phosphorus, Iodine, Zinc, Folic acid etc [10].

Globally, more than half of the under-five death is attributable to diarrheal diseases, respiratory diseases and malnutrition. Malnutrition plays a vital role in determining mortality in under-5-children [11]. The bone age was retarded in undernourished children and more delayed in severe under nutrition. A greater delay in bone age was detected in undernourished children who were born small for gestational age (SGA) [12].The incidence of malnutrition in India is 1-2% of which 80% are mild/moderate cases that frequently go unrecognized [13]. According to the National Family Health Survey (NFHS-4), children under 5 years of age who are underweight are 21.5% (29.8 - NFHS-3) and exclusive breastfed are 47.8% (34.1% - NFHS-3) [14].

The degree of skeletal maturation is closely related to sexual maturation [15].The skeletal age is more advanced in girls than in boys [6,16-18] due to advanced pubertal age [18]. According to Saxena et al there was no significant difference in ossification in both the sexes [19].

The racial differences are genetically determined. Advanced ossification is seen in Non European babies and retarded in European babies. Negroes are relatively more advanced in ossification than the Indians and Europeans [20].

Very few studies were observed in relation to bone age in PEM children in India. The present study aims to find the appearance of ossification centers of lower end of radius and ulna, carpals, metacarpals and phalanges in PEM children of different grades in comparison to normal children and with previous studies and hence, might serve as a useful tool in standardizing the bone age in normal and different grades of PEM in South Indian children.

The PEM is classified according to weight for age [15] : Normal : >80%, Grade 1 : 70-80%, Grade 2 : 60-70%, Grade 3 : 50-60%, Grade 4 : < 50%. This classification is used in the ICDS program [15].

Aim: To study the appearance of ossification centers of lower end of radius and ulna, carpals, metacarpals and phalanges in normal and children with different grades of PEM and to compare the results with the previous studies.

MATERIALS AND METHODS

The study was conducted in the Paediatric outpatient department and Paediatric ward at Meenakshi Medical College & Research institute, kancheepura, Tamilnadu in different grades of 125 Protein energy malnutrition children in comparison with 125 normal children.

Plain X-ray left wrist with hand - AP view was taken in control as well as in PEM children. The

appearance of ossification centers were taken according to the denominator of maturity (score 2).The indicators accepted in the hand and wrist are based upon those described by Greulich and Pyle [21].

Inclusion criteria: The age of children between six months to six years. Children with evidence of date of birth.

Exclusion criteria- Children with Skeletal dysplasias, Endocrine disorders, Chronic drug intake: Children on steroids and antiepileptic drugs, congenital heart diseases

RESULTS

The weights of different grades of PEM as well as control group were taken. Both Control and Protein energy malnutrition children were grouped into six as 6months - 1 year, 1.1 -2yrs, 2.1 3yrs 3.1- 4yrs 4.1 - 5years and 5.1 - 6years

X - Ray of Normal and Different grades of PEM belong to the age group of 5.1-yrs.

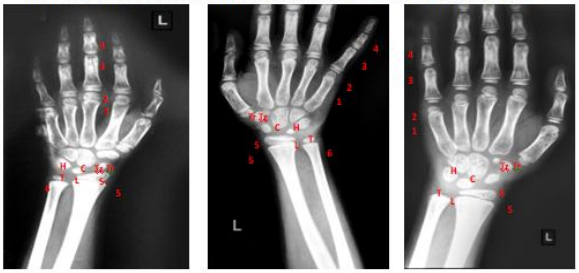

Fig . 1: Normal | Fig. 2: Grade I | Fig. 3: Grade II PEM

Fig. 4: Grade III PEM | Fig. 5: Grade IV

1. O.S for Metacarpal 2. O.S. for Proximal phalanx 3. O.S for Middle phalanx
4. O.S. for distal phalanx 5. O.S. for Lower end of radius 6. O.S.for lower end of ulna
T – Triquetral, L – Lunate, S – Scapoid, Tr – Trapezium, Tz – Trepezoid,
C – Capitate, H – Hamate

In the present study, the appearance of ossification centers were early in control as well as grade I and II PEM children when compared to previous studies and difference exists in the appearance of O.C in Grade III and IV protein energy malnutrition.

Capitate & Hamate: The O.C. of capitate and hamate were present in all children in control group, Grade I and II PEM children between 6months - 1year, whereas in grade III and grade IV PEM children, it appeared between the ages of 1.1-2years (delayed by 1 yr).

Lower end of radius: In control group, the O.C appeared, in 55% female and 40% male between 6m – 1 yr of age and becomes 100% at the age of 2.1-3yrs. In grade I PEM, the O.C appeared in 100% female and 71% male between 1.1- 2years and becomes 100% at the age of 2.1-3yrs. In grade II PEM, the O.C appeared in 100% female and 50% male between 1.1- 2years and becomes 100% at the age of 2.1-3yrs. In grade III PEM, the O.C appeared in 50% female and 50% male between 1.1- 2years and becomes 100% at the age of 3.1-4yrs. In grade IV PEM, the O.C appeared in 100% female and 100% male between 3.1- 4years. The O.C appeared in all children of control group, Grade I & II PEM at the age of 2.1-3yrs, whereas in Grade III & IV PEM children, the O.C was delayed by 1year.

Triquetral: In control group, the O.C appearedin 28% female and 36% male between 1.1 – 2 yrs of age and becomes 100% at the age of 4.1-5yrs. In grade I PEM, the O.C appeared in 25% female and 28% male between 1.1- 2years and becomes 100% at the age of 4.1-5yrs. In grade II PEM, the O.C appeared in 50% female and 50 % male between 3.1- 4years and becomes 100% at the age of 4.1-5yrs. In grade III PEM, the O.C appeared in 50% female and 66% male between 4.1- 5years and becomes 100% at the age of 5.1-6yrs. In grade IV PEM children, the O.C appeared in 100% female and 100% male between 5.1- 6 years. The O.C appeared in all children of control group, Grade I & II PEM at the age of 4.1-5yrs. whereas in Grade III PEM children, the O.C was delayed by 1year.

Lunate: In control group, the O.C appeared in 27% female and 22% male between 2.1 – 3 yrs of age and becomes 100% at the age of 5.1-6yrs. In grade I PEM, the O.C appeared in 60% female and 25% male between 3.1- 4years and becomes 100% at the age of 5.1-6yrs. In grade II PEM, the O.C appeared in 66% female and 50 % male between 4.1- 5years and becomes 100% at the age of 5.1-6yrs. In grade III PEM, the O.C appeared in 50 % female between 4.1-5years and becomes 100% in female and 50% in male at the age of 5.1-6yrs. In grade IV PEM the O.C had not appeared. The O.C appeared in all children of control group, Grade I & II PEM at

Table 1: Shows the number of cases in normal subjects and different grades of PEM.

Groups	Years	Total No. of Normal Cases - 125	No. of Normal		Total No. of PEM Cases - 125	Grade I PEM	Grade II PEM	Grade III PEM	Grade IV PEM
I	6m – 1 yr	19	F	9	19	3	3	2	1
			M	10		4	2	2	2
II	1.1 – 2 yrs	25	F	14	25	8	3	2	1
			M	11		7	2	1	1
III	2.1 – 3 yrs	20	F	11	20	5	3	2	1
			M	9		4	2	2	1
IV	3.1 – 4 yrs	18	F	10	18	5	2	2	1
			M	8		4	2	1	1
V	4.1 – 5 yrs	20	F	10	20	3	3	2	2
			M	10		4	2	3	1
VI	5.1 – 6 yrs	23	F	11	23	6	2	2	1
			M	12		7	2	2	1

Table 2: Percentage of normal children showing the presence of various ossification centers.

Bone	Sex	Percentage of normal children showing the presence of various ossification centers					
		6m-1y	1.1-2y	2.1-3y	3.1-4y	4.1-5y	5.1-6y
Capitate	F	100					
	M	100					
Hamate	F	100					
	M	100					
Lower end of radius	F	55	100	100			
	M	40	81	100			
Triquetral	F	-	28	72	90	100	
	M	-	36	66	88	100	
Lunate	F	-	-	27	40	70	100
	M	-	-	22	25	60	100
Trapezium	F	-	-	-	20	30	45
	M	-	-	-	12	20	33
Trapezoid	F	-	-	-	20	20	45
	M	-	-	-	12	20	33
Scaphoid	F	-	-	-	20	20	36
	M	-	-	-	13	10	16
Metacarpal and Proximal phalanges	F	-	43	81	90	100	
	M	-	36	66	75	100	
Middle and Distal phalanges	F	-	29	81	90	100	100
	M	-	27	77	75	100	100
Lower end of ulna	F	-	-	-	-	10	36
	M	-	-	-	-	-	16

the age of 5.1-6yrs, whereas in Grade III & IV PEM children, the O.C was delayed.

Trapezium &Trapezoid: In control group, the O.C appeared in 20% of female and 12% of male children between 3.1-4yrs and 45% of female and 33% of male children at the age of 5.1-6.yrs. In grade I PEM children, the O.C appeared in 33% female and 25% male between 4.1-5yrs and 50% female and 42% male at the age of 5.1-6yrs. In Grade II PEM children, the O.C appeared in 50% female and 50% male children at the age of 5.1-6yrs. In Grade III & grade IV PEM children, the O.C. had not appeared.

Scaphoid: In control group, the O.C appeared in 20% female and 12.5% male between 3.1 – 4 yrs and 36% female and 16% male children at the age of 5.1-6yrs respectively. In grade I PEM, the O.C appeared in 50% female and 28% male at the age of 5.1-6yrs. In grade II, III & grade IV PEM children, the O.C. had not appeared.

Metacarpals & Proximal Phalanges: In control group, the O.C appeared in 43% of female and 36% of male between 1.1-2 yrs and becomes 100% at the age of 4.1-5yrs. In Grade I PEM, the O.C appeared in 37% of female and 28% of male between 1.1-2 yrs and becomes 100% at

Table 3: Percentage of PEM children showing the presence of various ossification centers.

Bone	Grade	Percentage of PEM children showing the presence of various ossification centres					
		6m-1y	1.1-2y	2.1-3y	3.1-4y	4.1-5y	5.1-6y
Capitate and Hamate	I	F-100; M-100	-				
	II	F-100; M-100	-				
	III	-	F-100; M-100				
	IV	-	F-100; M-100				
Lower end of radius	I	F-66; M-50	F-100; M-71	F-100; M-100	-	-	-
	II	F-66; M-50	F-100; M-50	F-100; M-100	-	-	-
	III	-	-	F-50; M-50	F-100; M-100	-	-
	IV	-	-	-	F-100; M-100	-	-
Triquetral	I	-	F-25; M-28	F-60; M-50	F-80; M-75	F-100; M-100	-
	II	-	-	-	F-50; M-50	F-100;M-100	-
	III	-	-	-	-	F-50; M-66	F-100; M-100
	IV	-	-	-	-	-	F-100; M-100
Lunate	I	-	-	-	F-60; M-25	F-66; M-50	F-100; M-100
	II	-	-	-	-	F-66; M-50	F-100; M-100
	III	-	-	-	-	F-50	F-100; M-50
	IV	-	-	-	-	-	-
Trapezium and Trapezoid	I	-	-	-	-	F-33; M-25	F-50; M-42
	II	-	-	-	-	-	F-50; M-50
	III	-	-	-	-	-	-
	IV	-	-	-	-	-	-
Scaphoid	I	-	-	-	-	-	F-50; M-28
	II	-	-	-	-	-	-
	III	-	-	-	-	-	-
	IV	-	-	-	-	-	-
Metacarpals and proximal Phalanges	I	-	F-37; M-28	F-60; M-50	F-80; M-75	F-100; M-100	-
	II	-	-	F-66; M-50	F-50; M-50	F-100; M-100	-
	III	-	-	-	F-50	F-100; M- 66	F-100; M-100
	IV	-	-	-	-	F-50	F-100; M-100
Middle and distal Phalanges	I	-	F-12; M-14	F-60; M-50	F-80; M-75	F-100; M-100	-
	II	-	-	F-66; M-50	F-50; M-50	F-100; M-100	-
	III	-	-	-	F-50	F-100; M-66	F-100; M-100
	IV	-	-	-	-	F-50	F-100; M-100
Lower end of Ulna	I	-	-	-	-	-	F-16; M-14
	II	-	-	-	-	-	-
	III	-	-	-	-	-	-
	IV	-	-	-	-	-	-

Table 4: Shows the age of appearance of O.C for different bones in normal and different grades of PEM in the present study. (NA – Not Appeared).

S. No	Bone	Control	Grade I	Grade II	Grade III	Grade IV
1	Capitate& Hamate	6m - 1yr (100%)	6m - 1yr (100%)	6m - 1yr (100%)	1.1 -2yrs (100%)	1.1- 2yrs (100%)
2	Lower end of Radius	2.1 -3yrs (100%)	2.1 -3yrs (100%)	2.1 - 3yrs (100%)	3.1 - 4 yrs (100%)	3.1 - 4 yrs (100%)
3	Triquetral	4.1 -5yrs (100%)	4.1 - 5yrs (100%)	4.1 -5yrs (100%)	5.1 -6yrs (100%)	5.1 -6yrs (100%)
4	Lunate	5.1 -6yrs (100%)	5.1 -6yrs (100%)	5.1 -6yrs (100%)	5.1-6yrs (100% female &50% male)	NA
5	Trapezium	5.1 -6yrs (45% female &33% male)	5.1 -6yrs (50% female & 42% male)	5.1 -6yrs (50% female &50% male)	NA	NA
6	Trapezoid	5.1 -6yrs (45% female &33% male)	5.1 -6yrs (50% female & 42%male)	5.1 -6yrs (50% female &50% male)	NA	NA
7	Scaphoid	5.1 -6yrs (36% female &16%male)	5.1 -6yrs (50% female &28% male)	NA	NA	NA
8	Metacarpal & Proximal Phalanges	4.1 -5yrs (100%)	4.1 -5yrs (100%)	4.1 -5yrs (100%)	5.1 - 6 yrs (100%)	5.1 - 6 yrs (100%)
9	Middle & Distal Phalanges	4.1 -5yrs (100%)	4.1 -5yrs (100%)	4.1 -5yrs (100%)	5.1 -6yrs (100%)	5.1 -6yrs (100%)
10	Lower end of Ulna	5.1 -6yrs (36% in female &16% in male)	5.1 -6yrs (16% in female &14% in male)	NA	NA	NA

the age of 4.1-5yrs. In Grade II, the O.C appeared in 66% of female and 50% of male between 2.1-3 yrs and becomes 100% at the age of 4.1-5yrs. In Grade III, the O.C appeared in 50% of female between 3.1-4 yrs and becomes 100% at the age of 4.1-5yrs and for male 66% appeared between 4.1-5 yrs and becomes 100% at the age of 5.1-6yrs. In Grade IV, the O.C appeared in 50% of female between 4.1-5 yrs and becomes 100% at the age of 5.1-6 yrs and for male 100% between 5.1-6yrs. The O.C appeared in all children of control group, Grade I, II & III PEM at the age of 5.1-6yrs, whereas in Grade IV PEM children, the O.C was delayed by 1year.

Middle & Distal Phalanges: In control group, the O.C appeared in 29% of female and 27% of male between 1.1-2 yrs and becomes 100% at the age of 4.1-5yrs. In Grade I PEM, the O.C was appeared in 12% of female and 14%of male between 1.1 - 2 yrs and becomes 100% at the age of 4.1-5yrs. In Grade II, the O.C was appeared in 66% of female and 50% of male between 2.1-3 yrs and becomes 100% at the age of 4.1-5yrs. In Grade III, the O.C appeared in 50% of females between 3.1-4 yrs and becomes 100% between the age of 4.1-5yrs. Whereas O.C appeared in 66% of males between 4.1-5yrs and becomes 100% at the age of 5.1-6yrs.In Grade IV the O.C appeared in 50% of female between 4.1-5 yrs and becomes 100% between the age of 5.1-6yrs. Whereas, O.C appeared in 100% of male children between 5.1-6yrs. The O.C appeared in all children of control group, Grade I, II & III PEM at the age of 4.1-5yrs, whereas in Grade IV PEM children, the O.C was delayed by 1 year.

Lower end of Ulna: In control group, the O.C starts appearing in 10% female at the age of 4.1-5 yrs and in 36% female and 16% male between 5.1-6yrs. In Grade I PEM, the O.C appeared in 16% female and 14% male children at the age group of 5.1-6yrs. In Grade II, III & Grade IV PEM children, appearance of O.C has not appeared.

DISCUSSION

In the Normal Group: In our study, the O.C for the capitate and hamate appeared at 6months-1yr. According to the study of Ashutosh Srivastav et al [22] the O.C for the capitate and hamate appeared at 6months-1yr, whereas according to Datta Banik et al [17] and Saxena et al [19] it appeared between1-2yrs. Our findings were similar with the study by Ashutosh Srivastav et al [22]. Among the carpal bones the O.C. for Capitate and Hamate appeared first, similar to the studies of Datta Baniket al [17], Saxena et al [19] and Ashutosh Srivastav et al [22]. The O.C for the Lower end of Radius was 100% seen between 2-3ys which correlates with the study of Ashutosh Srivastavet al [22]. But it appeared 100% at 3-4yrs in the study by Datta Baniket al [17] and Saxena et al [19]. The O.C. for the Triquetral was 100% seen between 4-5yrs of age in our study and Ashutosh Srivastavet al [22], but at 5-6yrs in Datta Banik et al [17] and Saxena et al [19]. The O.C. for the Lunate was 100% seen at 5.1-6yrs of age in our study and Ashutosh Srivastav et al [22], but it was at 8yrs according to saxena et al [19]. The O.C. for the Trapezium, Trapezoid and Scaphoid starts appearing at 3-4yrs in our study, Datta Banik et al [17] and Saxena et al [19]. But the appearance of above centers was seen at 5.1-6yrs according to Ashutosh Srivastav et al [22]. The O.C. for the Lower end of Ulna starts appearing at 4.1-5yrs (only in females) in our study, which was similar to that of Datta Banik et al [17]. The O.C. of Metacarpal and proximal phalanges were 100% seen in our study between 4.1-5yrs, while there was a delay of 1 year according to Datta Baniket al [17]. The O.C. of Middle and Distal phalanges were 100% seen in our study between 4.1-5yrs in females, 5.1-6yrs in males but was delayed according to Datta Banik et al [17]. In our study, the order of appearance of ossification centers of carpals are similar to other studies by Ashwani K Sharma et al [24], Datta Banik et al [20],Ashutosh Srivastav et al [22]. For the first two carpal bones, Capitate and Hamate, there was no sex variation in their ossification and almost similar to other studies like Saxena et al [19], Datta Banik et al [17], Ashutosh Srivastav et al [22].

In control group: The centre for the Capitate and Hamate appeared in infancy, 6m earlier, lower end of radius appeared two years earlier, Triquetral appeared one year earlier, Lunate three years earlier as compared to Saxena et al [19]. The centers for the Metacarpals, Proximal,

Table 5: Comparative table shows the age of appearance of O.C for different bones in normal and different grades of PEM in present study and Saxena et al [19]

S.No	Bone	Saxena et al [19] (Control group)	Our Study (Control group)	Saxena et al [19] (Grade I,II)	Our Study (Grade I,II)	Saxena et al [19] (Grade III, IV)	Our Study (Grade III, IV)
1	Capitate & Hamate	1 – 2yrs	6m – 1 yr	2 – 3 yrs	6m – 1 yr	2 – 3 yrs	1 – 2yrs
3	Radius (Lower end)	4.1 -5yrs	2.1 – 3 yrs	3 – 4 yrs	2.1 – 3 yrs	4 – 5yrs	3.1 – 4 yrs
4	Metacarpals	6 – 8 yrs	4.1 – 5 yrs	7-8 yrs	4.1 – 5 yrs	8 – 9 yrs	5.1 – 6 yrs
5	Triquetral	5.1 – 6yrs	4.1 – 5 yrs	8 – 9 yrs	4.1 – 5 yrs	8 – 9 yrs	5.1- 6yrs
6	Lunate	5.1- 6yrs (77.50%) 8 – 9 yrs (100%)	5.1 – 6 yrs	9 – 10 yrs	5.1 – 6 yrs	9 – 10 yrs	5.1- 6 yrs GIII (100%F& 50% M)
7	Trapezium	5.1-6 yrs (62%) 8 – 9 yrs (100%)	5.1 – 6 yrs (45% F & 33% M)	9 – 10 yrs	5.1 – 6 yrs (50% F& 50%M)	9 – 10 yrs	-
8	Trapezoid	5-6 yrs (41.5%)	5.1 – 6 yrs (45% F& 16 % M)	-	5.1 – 6 yrs (50%F& 50%M)	-	-
9	Scaphoid	6-7 yrs (30%) 9 -10 yrs (100%)	5.1 – 6yrs (36% F& 16% M)	9 – 10 yrs	5.1 – 6 yrs (50% F& 28% M)	9 - 10 yrs	-
10	Ulna (Lower end)	5.1-6 yrs (14%) 9 -10 yrs (100%)	5.1 – 6 yrs (36% F& 16% M)	-	5.1 – 6 yrs (16% F& 14% M)	-	-
11	Proximal Phalanges	7 – 8 yrs	4.1 – 5 yrs	8-9 yrs	4.1 – 5 yrs	9 – 10 yrs	5.1 – 6 yrs
12	Middle Phalanges	8 – 9 yrs	5.1 – 6 yrs	9-10yrs	5.1 – 6 yrs	10 – 11 yrs	5.1 – 6 yrs
13	Distal Phalanges	7 – 8 yrs	5.1 – 6 yrs	8-9yrs	5.1 – 6 yrs	9 – 10 yrs	5.1 – 6 yrs

Middle and Distal phalanges appeared 2- 3years earlier than Saxena et al [19]. The centre for Trapezium, Trapezoid, Scaphoid and lower end of ulna appeared two years earlier.

In grade I and grade II PEM: The O.C for capitate and hamate appeared 1-2 yrs earlier, lower end of radius appeared one year earlier, Triquetral and Lunate appeared four years earlier, metacarpals, Proximal, Middle and Distal phalanges appeared 3-4 years earlier than the Saxena et al [19] study. The centers for Trapezium, Trapezoid, scaphoid and lower end of ulna appeared earlier.

In grade III and grade IV PEM: The O.C for capitate and hamate appeared one year earlier, lower end of radius appeared one year earlier, Triquetral and Lunate appeared three years earlier, Metacarpals, Proximal, Middle and Distal phalanges appeared 4 – 5 years earlier than the Saxena et al [19] study.

CONCLUSION

Economic status plays an important role to meet the adequacy of nutrition in a family, and reflects the health status of the children. Poor socioeconomic status leads to directly or indirectly delay in the appearance of ossification centers. The incidence of malnutrition in India is 1-2% of which 80% are mild/moderate cases that frequently go unrecognized. Indian children below five years die every day due to malnourishment or lack of basic micronutrients like vitamin A, Iron, Calcium, Phosphorus, Iodine, Zinc, Folic acid, etc.

In the present study, the appearance of ossification centers were one year earlier in control group as well as in grade I & II PEM children and in Grade III & IV the delay was less than the previous studies. Hence, it reflects the health status of the children in the community, when compared to the past two decades. Supplementation of macro and micronutrients through food and medicine improve the health status of the child which is needed for the proper appearance of ossification centers, process of ossification, bone deposition and resorption. The early appearance of ossification centers in our study can be explained by increased awareness and tender care of health of the child for the past 2 decades, such as: Exclusive breasts feeds for the first 6months, Proper weaning started at appropriate months, Immunization, Supplementation (Hematinics, multivitamin, calcium), The national and state government scheme for mothers like good antenatal, delivery and postnatal care, Nutritional schemes for children like Mid-

day meal program and Integrated Child Development Services (ICDS).

The study was undertaken since very few studies on appearance of ossification centers were available in Protein energy malnutrition. This study can be used as a base line data for comparing the appearance of ossification centers in normal and PEM children for South Indian population, which will help to access the improvement in the health status of Indian children.

ABBREVIATIONS

O.C. - Ossification centre
PEM - Protein Energy Malnutrition
M - Male
F - Female
m - months
yrs - years
ICDS - Integrated Child Development Services

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