

## Assessment of Age of Epiphyseal Union Around Pelvis in Maharashtra

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### Abstract

Age of union of epiphysis is an important objective method of age determination which is a difficult task for medico-legal person. However, this age varies with racial, geographic, climatic and various other factors. Because of this, many authors suggested need of separate standards of ossification for separate region. As no such standards were available for Maharashtra, present study aimed to study ages of epiphyseal union around pelvis, a rarely studied region. Present study was a cross sectional study. It was performed in total 400 healthy subjects having ages from 13 to 23 years and length of residence in Maharashtra more than 10 years. Chronological age upto the day of examination was determined and A-P view of pelvis was taken in each case. Age of union of epiphyses of iliac crest, ischial tuberosity, head of femur and greater trochanter was determined using criteria of union and compared with the other authors from other states of India and also with other countries and found to vary appreciably.

**Keywords:** Epiphysis; Hip Joint; Femur; Iliac Crest; Greater Trochanter.

### Introduction

Age determination is considered important for various reasons e.g. medicolegal purposes, juvenile court procedures, entry to the government service or to enable a candidate to sit for university examination.

As registration of birth is still extremely incomplete in India and many times real age is concealed with various intentions, doctors are called to opine about the age. Many times mutilated skeletal remains are found and again age determination becomes important. In such cases, it becomes necessary to use some objective method to find out exact age of an individual.

Among various methods of age determination, ages of appearance and union of epiphyses with

diaphyses, as observed radiologically is considered to be a reliable guide and in many cases it is the only guide for anatomists and medico-legal experts for the estimation of age of the individual. These ages of appearance and union of epiphyses vary with racial, geographic, climatic and various other factors. Appreciable variations in the time of fusion of epiphysis with diaphysis have been recorded not only by the workers belonging to different countries [3, 9,10,16,19,20] but even by the workers from the various provinces of the Indian subcontinent [1,5,12,15,18,22].

Because of the existence of such racial, geographic and climatic variations, need for separate standards of ossification for separate regions have been suggested [8,14,17].

Most of the time, epiphyses around wrist joint, elbow joint are studied. However, data for epiphyses around pelvis is sparse. Also, use of pelvis radiographs help to estimate the ages beyond 20-21 years, as epiphyseal fusion around pelvis is later than the limb bones.

Thus, the present work is undertaken to investigate the ages of epiphyseal union around pelvis radiologically in boys and girls in Maharashtra.

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## Material and Method

Present study was cross-sectional study carried out over a period of three years from 2005-2008. Study was performed in total 400 subjects having ages from 13 to 23 years. The length of residence of each subject in Maharashtra was ascertained and those having less than 10 years stay in Maharashtra were excluded from the present investigation. All the subjects belonged to middle socio-economic status. Freedom from musculo-skeletal, nutritional and endocrine disorders and also from any debilitating ailments in childhood was taken into account. Height, weight and general physical development were recorded in all cases and the menstrual history of girls was also accounted for. Dietetic history was also taken for all subjects.

Out of total 400 students examined, there were 180 boys and 220 girls. Accurate age, as far as possible, was determined in each case based on the statements of the subjects, supported by their school leaving certificates. The subjects were divided into ten groups as 13-14, 14-15, 15-16, 16-17, 17-18, 18-19, 19-20, 20-21, 21-22, 22-23 years according to their ages. The distribution of boys and girls in each age group is shown in Table 1.

All these subjects were examined clinically and radiologically. Antero-posterior view of pelvis was taken in each case. Study was approved by ethical committee, Government medical College, Nagpur, Maharashtra. Written consent was taken in each case for participation in study and in case of minors consent was obtained from parents or gaurdians.

Epiphyses of Iliac crest, Ischial tuberosity, Greater trochanter and Head of femur were studied in present study and to determine age of union criteria for union was used as stated below –

## Criteria for Union

The union was considered as complete when space between diaphysis (shaft) and epiphysis was fully obliterated and bony in architecture and density, indistinguishable from the epiphysis and diaphysis in its neighbourhood. Periosteum between the epiphysis and diaphysis should be in continuity without any notching at the periphery of epiphyseal line. Cases of recent union, where a white transverse line was still seen in place of the epiphyseal cartilage, was also taken as complete union and the so called epiphyseal scar was disregarded. The youngest age group showing complete union in 100% subjects was taken as criteria for generalization.

## Observations and Results

Earliest age at which complete union of iliac crest with rest of the ilium is found in 100% cases was 22 to 23 years in case of males and 21 to 22 years in case of females (Table 2).

Youngest age group showing complete union of ischial tuberosity in 100% subjects was 22 to 23 years in case of males and 21 to 22 years in case of females (Table 3).

Complete union of head of femur was first seen in 100% subjects at 18 to 19 years among boys and at 14 to 15 years among girls (Table 4).

Youngest age group showing complete union of greater trochanter of femur in 100% subjects was 18 to 19 years in case of males and 16 to 17 years in case of females (Table 5).

Table 1 shows distribution of no. of subjects and their percentage according to age and sex and there



Fig. 1: Antero-posterior view of pelvis showing un-united epiphyses of head of femur and greater trochanter of femur



Fig. 2: Antero-posterior view of pelvis showing un-united epiphysis of iliac crest



Fig. 3: Antero-posterior view of Pelvis showing completely united epiphysis

is no significant difference in distribution of number of subjects in different age groups.

Table 2 showing age of union of the iliac crest with rest of the ilium.

Table 3 showing age of union of the ischial tuberosity with ischium.

Table 4 showing age of union of the head of femur with the shaft.

Table 5 showing age of union of greater trochanter of femur with the shaft.

Table 1: Showing Distribution of no. of subjects and their percentage according to age and sex

Age (in years)	No. of cases		Total	%	$\chi^2$ -value
	Boys	Girls			
13-14	0	15	15	3.75	8.5 Non Significant
14-15	0	15	15	3.75	
15-16	25	25	50	12.5	
16-17	20	25	45	11.25	
17-18	25	20	45	11.25	
18-19	25	30	55	13.75	
19-20	25	20	45	11.25	
20-21	20	25	45	11.25	
21-22	20	25	45	11.25	
22-23	20	20	40	10	
Total	180	220	400	100%	

Table 2: Showing age of union of the iliac crest with rest of the ilium

Age group (Years)	Number of cases examined		Number of cases showing complete union		%	
	Boys	Girls	Boys	Girls	Boys	Girls
13-14	0	15	-	0	-	0
14-15	0	15	-	0	-	0
15-16	20	20	0	0	0	0
16-17	20	25	0	5	0	20
17-18	25	20	5	5	20	25
18-19	25	30	10	5	40	16.66
19-20	25	20	10	10	40	50
20-21	20	25	10	15	50	60
21-22	20	25	10	25	50	100
22-23	20	20	20	20	100	100

**Table 3:** Showing age of union of the ischial tuberosity with ischium

Age group (Years)	Number of cases examined		Number of cases showing complete union		%	
	Boys	Girls	Boys	Girls	Boys	Girls
13-14	0	15	-	0	-	0
14-15	0	15	-	0	-	0
15-16	25	25	0	0	0	0
16-17	20	25	0	0	0	0
17-18	25	20	0	0	0	0
18-19	25	30	5	5	20	16.66
19-20	25	20	10	10	40	50
20-21	20	25	10	20	50	80
21-22	20	25	15	25	75	100
22-23	20	20	20	20	100	100

**Table 4:** Showing age of union of the head of femur with the shaft

Age group (Years)	Number of cases examined		Number of cases showing complete union		%	
	Boys	Girls	Boys	Girls	Boys	Girls
13-14	0	15	-	5	-	33.33
14-15	0	15	-	15	-	100
15-16	25	25	5	25	20	100
16-17	20	25	5	25	25	100
17-18	25	20	20	20	80	100
18-19	25	30	25	30	100	100
19-20	25	20	25	20	100	100
20-21	20	25	20	25	100	100
21-22	20	25	20	25	100	100
22-23	20	20	20	20	100	100

**Table 5:** Showing age of union of greater trochanter of femur with the shaft

Age group (Years)	Number of cases examined		Number of cases showing complete union		%	
	Boys	Girls	Boys	Girls	Boys	Girls
13-14	0	15	-	0	-	0
14-15	0	15	-	10	-	66.66
15-16	25	25	5	15	20	60
16-17	20	25	10	25	50	100
17-18	25	20	20	20	80	100
18-19	25	30	25	30	100	100
19-20	25	20	25	20	100	100
20-21	20	25	20	25	100	100
21-22	20	25	20	25	100	100
22-23	20	20	20	20	100	100

## Discussion

A. Comparison of ages of epiphyseal union around pelvis found in present study with those reported by workers from other regions of India. (Table 6).

In present study, age of union of iliac crest and ischial tuberosity is found to be 22-23 years for boys and 21-22 years for girls. From Table 4 this age is later than the age reported by all other authors for other states in India in case of both sex except the age of union of ischial tuberosity reported by Sharma

et al (2013) [21] matches with the present study. Iliac crest epiphyses is widely studied but data available for ischial tuberosity is very sparse. In present study, both the epiphyses are studied using large sample size and exact age of union is found out for Maharashtra which is different from other states in India. This may be contributed to different environmental conditions in different states. [1,12,18,22].

Present study gives age of union of head of femur as 18-19 years for boys and 14-15 years for girls. This is also rarely studied epiphyses. Among males, age is given by Galstaun (1937) [12] for bengalees

**Table 6:** Showing comparison of ages (years) of union of epiphyses around Pelvis given by various workers in India with findings of present study

Authors	Sex	Cases Examined		Age group (years)	Iliac crest		Ischiel tuberosity		Head of femur		Greater trochanter	
		Number	Total		Male	Female	Male	Female	Male	Female	Male	Female
Agrawal and pathak (1957) (Punjab) <sup>1</sup>	Female	99 but for pelvis x-ray 177		12 - 17 $\frac{1}{2}$ 12 - 20 $\frac{1}{2}$	-	17 - 17 $\frac{1}{2}$ yrs	-	-	-	13 $\frac{1}{2}$ - 14 yrs	-	-
Jit and Singh (1971) (Punjab) <sup>12</sup>	Male Female	572 406	978	11 - 25	17 - 22 (21) yrs	17 - 22 (21) yrs	17 $\frac{1}{2}$ - 22 (21) yrs	17 $\frac{1}{2}$ - 22 (22) yrs	14 - 18 $\frac{3}{4}$ (18) yrs	12 - 17 $\frac{1}{4}$ (17) yrs	-	-
Galstaun (1937) (Bengal) <sup>11</sup>	Male Female	472 235	707	0 - 19	-	-	-	-	18 yrs	15 yrs	18yrs	15yrs
	Male Female	347 136	573	11 - 20	19 - 20 yrs	17 - 19 yrs	-	-	-	-	-	-
	Male Female	238 109	447	13 - 22	-	-	Around 20 yrs	Around 20 yrs	-	-	-	-
Basu and Basu (1938) (Bengal) <sup>4</sup>	Female	116		7 - 19	-	-	-	-	-	13-14 yrs	-	-
Gupta, et al (1974) (Uttar Pradesh) <sup>10</sup>	Male Female	44 31	75	16 - 23	21 - 22 yrs	19 - 20 yrs	21-22 yrs	Inconclusive	-	-	18-19 yrs	17-18 yrs
Bajaj et al (1967) (Delhi) <sup>7</sup>	Male Female	120 120	240	0 - 21	20 $\pm$ 1.3 yrs	19 $\pm$ 1.0 yrs	-	-	-	-	-	-
Saksena and Vyas (1969) (M.P) <sup>23</sup>	Male Female	50 25	75	16 - 21	20 - 21 yrs	18 - 19 yrs	-	-	-	-	-	-
Sharma et al (2013) Rajstan Present study (2015) (Maharashtra)	Male Female Male Female	50 50 180 220	100 400	18-23 13-23	21-22 22-23 yrs	20-21 21-22 yrs	21-22 22-23 yrs	21-22 21-22 yrs	18-19 18-19 yrs	18-19 14-15 yrs	18-19 18-19 yrs	18-19 16-17 Yrs

which corresponds to the lower limit of age in present study and Jit and Singh (1971) [13] for punjabees, higher limit of which matches with the lower limit of age in Present study. Agrawal and Pathak (1957) [1] and Jit and Singh (1971) [13] studied the epiphyses in Punjabi girls. The result of Agrawal and Pathak (1957) [1] is earlier than Present study. Age range given by Jit and Singh (1971) [13] is very wide and cannot be compared. Age found by Galstaun (1937) [12] for bengalee girls corresponds to the higher limit of age in Present study whereas in case of Basu and Basu (1938) [5] the same age corresponds to lower limit of age in Present study.

According to present study, age of union of greater trochanter of femur is 18-19 years for boys and 16-17 years for girls. On comparison, this age matches with the age given by Galstaun (1937) [12] for bengalees in case of boys but later in case of girls. It also matches with age given by Gupta et al (1974)

[11] for Uttar Pradesh in case of boys but earlier in case of girls. Age of union of these two epiphyses given by Sharma et al (2013) [22] for Rajasthan could not be compared as he did not study age below 18 years.

Thus this comparison shows that ages of union of different epiphyses vary greatly even in the same country and medicolegal person cannot apply standards from one part to the other as stated by all previous authors.

B. Comparison of ages of epiphyseal union around pelvis found in present study with those reported by workers from other countries (Table 7).

For iliac crest, ischial tuberosity and greater trochanter, data is available only for European and it is given by Frazer (1958) [6] and Gray (2008) [2].

Frazer (1958) [6] gave age of union of iliac crest and ischial tuberosity for Europeans as after 20 years and according to Gray (2008) [2] union of iliac crest

unites between 15-25 years among Europeans which is a very wide range. Comparison cannot be done due to lack of exact figures. According to Gray (2008) [2], epiphyses of greater trochanter fuses after puberty. Exact age is not given by him. Age of union of this epiphyses given by Frazer (1958) [6] matches with the present study in case of girls but earlier in case of boys.

For English people age of union of head of femur is given by Davis and Parson (1927) [9] as 19-20 years which is later than present study. The same age given by Paterson (1929) [19] for English people is also later than that found in present study. The age commented by Flecker (1942) [10] for Australians is earlier in case of boys but matches with the lower limit of age for girls as found in present study. This age given by Frazer (1958) [6] for European is earlier

for boys and later for girls than the present study and the same given by Gray (2008) [2] is earlier in case of boys but matches with the lower limit of age for girls found in present study.

This comparison indicates that greater height of white races than eastern is not due to the late epiphyseal union but it may be due greater growth per year which may be due to genetic factors.

### Conclusions

The age of union of epiphyses found in present study is given in Table 8 for both the sex. Comparison of ages of epiphyseal union from different states of India and also from different

**Table 7:** Showing comparison of ages (years) of union of epiphyses around Pelvis given by workers from other countries with findings of present study

Authors	Cases Examined			Age group (year)	Iliac crest			Ischial tuberosity		Head of Femur			Greater trochanter		
	Sex	Number	Total		M	F	Mixed	M	F	M	F	Mixed	M	F	Mixed
Davies and parsons (1927) <sup>p</sup> (English)	Not Men tion	Examined over 5000 X-rays	-	0-23	-	-	-	-	-	-	-	19-20 yrs	-	-	-
Paterson (1929) (English) <sup>18</sup>	M F	100 100	200	0-22	-	-	-	-	-	18 yrs	17 yrs	-	-	-	-
Flecker (1942) (Australian) <sup>9</sup>	M F	98 106	204	15-20	-	-	-	-	-	17 yrs	14 yrs	-	-	-	-
Frazer (1958) (European) <sup>6</sup>	-	-	-	-	After 20 yrs	After 20 yrs	-	After 20yrs	After 20 yrs	17-18 yrs	16-17 yrs	-	17-18 yrs	16-17 yrs	-
Gray (2008) (European) <sup>28</sup>	-	-	-	-	-	-	15-25 yrs	-	-	17 yrs	14 yrs	-	-	-	After Puberty
Present study (Maharashtra India) (2015)	M F	180 220	400	13-23	22-23 yrs	21-22 yrs	-	22-23 yrs	21-22 yrs	18-19 yrs	14-15 yrs	-	18-19 yrs	16-17 yrs	-

Note:- M - Male, F - Female, Mixed - sex not mentioned by author

**Table 8:** Showing age of union of epiphyses

Name of epiphyses	Age of union for male	Age of union for female
Iliac crest	22-23 yrs	21-22 yrs
Ischial tuberosity	22-23 yrs	21-22 yrs
Head of femur	18-19 yrs	14-15 yrs
Greater Trochanter	18-19 yrs	16-17 yrs

countries it is concluded that the ages of epiphyseal union varies greatly not only all over the world but also within the same country. So, authors suggested need of separate standards of ossification for separate regions for medicolegal reporting of age based on epiphyseal union.

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