

## Determination of Age of Epiphyseal Union of Bones Around Knee Joint by Radiological Approach in the Varanasi Region

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### ABSTRACT

**Background:** Age is an important parameter for medico-legal cases. Age of epiphyseal union is an important objective method of age determination. But these ages vary with racial, geographic and various other factors. These variations have suggested need of separate standards of ossification for separate regions. **Methods:** After approval from institutional ethical committee, present work was undertaken to work out ages of epiphyseal union around knee joint for Kolhapur region. Study was carried out in total 200 healthy subjects aging from 13 to 21 years. **Results:** The chronological age was determined & A-P view of right knee joint was taken in each case. These radiographs were studied to determine the age of union of epiphyses of lower end of femur, upper end of tibia & upper end of fibula.

**Conclusions:** These ages were compared with those reported from various states of India & abroad.

**Key words:** Epiphyses, Ossification, Femur, Tibia, Fibula

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### INTRODUCTION


Determination of age of an individual is a matter of great medico-legal importance and of academic interest. Medical professionals are often required to evaluate the age of a person which may be for diagnostic or medico-legal purpose, for juvenile court procedures or for entry to government services. Accurate age determination is also important in taking consent, in case of rape, kidnapping, in determining competency as a witness, attainment of majority, marriage, fixation of criminal responsibility, for driving license, eligibility for election voting, etc.. So it becomes necessary to use some objective method to find exact age of a person. Among various methods of age

determination, ages of appearance & union of epiphyses with diaphyses as observed radiologically, are considered to be a reliable guide.<sup>[1]</sup> Though these ages are fairly constant for a particular bone, there are great variations with racial, geographic, climatic & various other factors.<sup>[2]</sup> Appreciable variations have been recorded not only by workers from different countries but even by the workers from various provinces of India. Due to this, need for separate standards of age of ossification for separate regions have been suggested. Such standard have been investigated in many states of India, but no such standards have been investigated for Kolhapur region. So the present work was undertaken to investigate the same in Kolhapur.

### METHODS

This was a cross sectional, non-interventional descriptive study.

The present study was carried out in the Department of

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Anatomy, Heritage institute of medical sciences, Varanasi. Study was performed in total 100 subjects (52 boys & 48 girls) having ages between 13 and 21 years. Freedom from musculoskeletal, 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 noted for. Accurate age was determined in each case based on the statements of the subjects, supported by their school leaving certificates. The subjects were divided into eight groups as 13-14, 14-15, 15-16, 16-17, 17-18, 18-19, 19-20, 20-21 years according to their ages. All these subjects were examined clinically and radiologically. Antero-posterior views of right knee joint were taken in each case. Radiological findings regarding epiphyseal union were classified as follow;

- A - Stage of non-union (N)
- B - Stage of partial union (P)
- C - Stage of complete Union (C)

Stage of non-union is the stage where epiphyseal growth plate was clearly visible on the X-ray film throughout the width of the bone. (Fig.1)

Stage of partial union is the stage where growth plate was partially replaced by bony tissue at one or more places and epiphyseal line on X-rays was partially visible.(Fig.2)

Complete union is the stage where growth plate was replaced by solid bone and therefore was not visible on X- ray film. (Fig.3) In fixing the range of union for general purposes by assuming the age at which 100% cases showing complete union was the upper age limit. The age at which 75% cases showing complete union was considered as average age. The age at which a minimum of 50% cases showing complete union was considered as lower limit.



Fig. 1: A-P view of right knee joint showing unfused epiphyses around knee joint



Fig. 2 : A-P view of right knee joint showing partial union of epiphyses around knee joint



Fig. 3 : A-P view of right knee joint showing complete union of epiphyses around knee joint

## RESULTS

There were two groups of subjects, males and females in our study. Average age of complete epiphyseal union in the males was 17-18 years for femur, 18-19 years for tibia and 19-20 years for fibula. While in the females it was 16-17 years for femur, 17-18 years for tibia and 17-18 years for fibula. (Table1) The study revealed that epiphyseal union occurs 1 to 2 years earlier in females than males. Percentage (%) of year-wise changes in the pattern of skeletal maturity / status of epiphyseal union in the bones of the knee joint that is femur, tibia and fibula are given in figure 4, 5 & 6 respectively.

Table 1: Summary of observations of epiphyseal union of bones of Knee

Name of Epiphysis	Age group (Years) showing Union in						Exact age beyond which all cases found united	
	50 % of cases		75 % of cases		100% of cases			
	M	F	M	F	M	F	M	F
Lower end of Femur	16-17	15-16	17-18	16-17	19-20	17-18	19	17
Upper end of Tibia	16-17	15-16	18-19	17-18	19-20	18-19	19	18
Upper end of Fibula	17-18	16-17	19-20	17-18	20-21	18-19	20	18

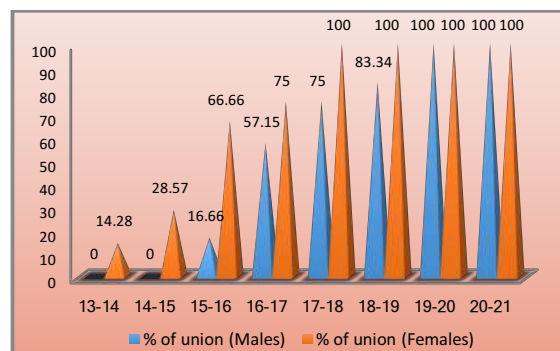


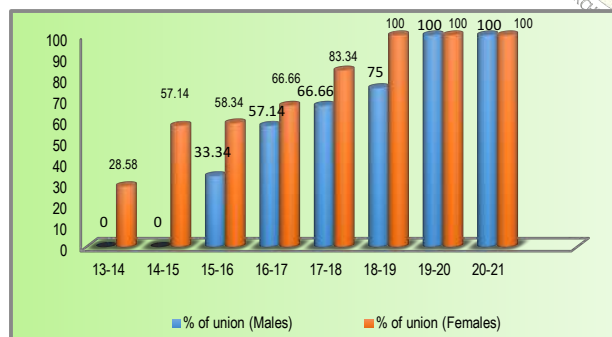
Fig. 4: Percentage of epiphyseal union of lower end of Femur

**Table 2: Comparison of ages of union of epiphyses around knee joint given by Various workers in India with findings of present study**

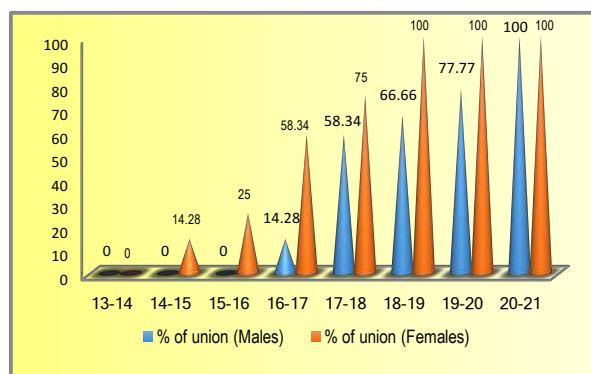
Authors	Lower end of femur		Upper end of tibia		Upper end of fibula	
	Male	Female	Male	Female	Male	Female
Hepworth (1929) (Punjab) <sup>7</sup>	16 ½ -17 ½ yrs	16 ½ -17 ½ yrs	16 ½ -17 ½ yrs	16 ½ -17 ½ yrs	16 ½ -17 ½ yrs	16 ½ -17 ½ yrs
M.J.S. Pillai (1936) (South India) <sup>3</sup>	17yrs	17yrs	17yrs	17yrs	17yrs	17yrs
Galstaun (1937) (Bengal) <sup>5</sup>	17 - 18 yrs	14 - 17yrs	16 - 17 yrs	14 - 15 yrs	14 - 16 yrs	14 - 16 yrs
Misra B.D. (1966) (Gujarat) <sup>4</sup>	18yrs	17yrs	19 ½ yrs	18 yrs	20 yrs	19 ½ yrs
Saksena and Vyas (1969) (M.P.) <sup>6</sup>	18 - 19yrs	16 -17yrs	18 - 19 yrs	16 -17yrs	18 - 19 yrs	16 -17yrs
Gupta et al (1974) (U.P.) <sup>8</sup>	18 - 19yrs	17 - 18yrs	18 - 19yrs	17 -18yrs	20 -21 yrs	20 -21 yrs
Present Study (2017) (Varanasi)	17-18yrs	16-17yrs	18-19yrs	17-18yrs	19-20yrs	17-18yrs

**Table 3: Comparison of ages of epiphyseal union around Knee joint given by various workers from other countries with findings of present study**

Authors	Lower end of femur		Upper end of tibia		Upper end of fibula	
	Male	Female	Male	Female	Male	Female
Davies and parsons (1927) (English) <sup>13</sup>	19 yrs	19 yrs	19-20 yrs	19-20 yrs	Above 20 yrs	Above 20 yrs
Paterson (1929) (English) <sup>10</sup>	18 yrs	16 yrs	18-19 yrs	16-17 yrs	18yrs	16 yrs
Flecker (1942) (Australian) <sup>14</sup>	19 yrs	17 yrs	18 yrs	15 yrs	19 yrs	17 yrs
Cunningham (1953) (European) <sup>11</sup>	18 yrs	16-17 yrs	19-20 yrs	17-18 yrs	20 yrs	18-19 yrs
Frazer (1958) (European) <sup>9</sup>	17-18 yrs	16-17 yrs	19-20 yrs	17-18 yrs	19-20 yrs	17-19 yrs
Gray (1995) (European) <sup>12</sup>	18 yrs	16 yrs	18 yrs	17 yrs	19 yrs	17 yrs
Present Study (2017)(Varanasi)	17-18yrs	16-17yrs	18-19yrs	17-18yrs	19-20yrs	17-18yrs



**Fig. 5: Percentage of epiphyseal union of upper end of Tibia**



**Fig. 6: Percentage of epiphyseal union of upper end of Fibula**

## DISCUSSION

It has been observed by various workers that age of union of epiphyses of bones is affected by climatic, dietic, hereditary, nutritional, sociological, racial, environmental and other factors.<sup>[2]</sup> Since most of these factors affecting the people vary from place to place in India, no uniform standard for determination of the age of union of epiphysis for the whole of India can be made. It is therefore always advisable to use figures of a particular region in India when determination of age is required for an individual who is a bonafide resident of that region. Ages of epiphyseal union around knee joint has been worked out in present study. These are 17-18 years for males & 16-17 years for females in case of lower end of femur; 18-19 years for males & 17-18 years for females in case of upper end of tibia; 19-20 years for males & 17-18 years in case upper end of fibula.

From Table 2, It can be seen that the age of union of lower end of femur corresponds with M.J.S. Pillai<sup>[3]</sup>, Misra B.D<sup>[4]</sup> and Galstaun<sup>[5]</sup> in case of boys, whereas Saksena & Vyas<sup>[6]</sup> and Hepworth<sup>[7]</sup> show similarity in case of girls. The age of union of upper end of tibia corresponds with Gupta et al.<sup>[8]</sup> in case of both sexes, with Saksena & Vyas<sup>[6]</sup> in case of boys & with Misra B.D<sup>[4]</sup> in case of girls. The age of union of upper end of fibula corresponds with that reported by Misra B. D<sup>[4]</sup> but differs in case of all other authors. Table no. 3,

shows age of union of lower end of femur corresponds with Frazer<sup>[9]</sup> in both sexes. The age given by Paterson<sup>[10]</sup>, Cunningham<sup>[11]</sup> & Gray<sup>[12]</sup> matches with the upper limit of age for boys found in present study, whereas except the age given by Davies & Parson<sup>[13]</sup> rest all authors findings match with the age found for girls in present study. Age of union of upper end of tibia for boys found in present study corresponds with Paterson<sup>[10]</sup>, Flecker<sup>[14]</sup> & Gray<sup>[12]</sup>; that for girls corresponds with Cunningham<sup>[11]</sup>, Frazer<sup>[9]</sup> & Gray<sup>[12]</sup>. Age of union of upper end of fibula found in present study matches with Flecker<sup>[14]</sup>, Cunningham<sup>[11]</sup>, Frazer<sup>[9]</sup>, Gray<sup>[12]</sup>, but differs in other cases.

## CONCLUSION

Thus, ages of union of epiphyses around Knee joint have been observed in present study. For lower end of femur, it is found to be 17-18 years for boys & 16-17 years for girls, for lower end of tibia, it is found to be 18-19 years for boys & 17-18 girls & 19-20 years & 17-18 years in case of upper end of fibula.

On comparison with other authors, these ages are found to vary greatly not only all over the world but also in different states of India which may be due to the geographical variations. So, this suggests need for separate standard of ossification for separate regions.

From comparison with authors from western countries, it may be concluded that greater height of white races than Eastern is not due to the time lag in the epiphyseal union but it may be due greater growth per year which may be contributed by genetic factors.

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