

RETROSPECTIVE RESEARCH ON REGRESSION PATTERN IN MALE SKELETAL EPIPHYSEAL FUSION

G. S. R. K. G. Ranga Rao¹, P. Phani Kiran², G. K. V. Prasad³

¹Associate Professor, Department of Forensic Medicine, Konaseema Institute of Medical Sciences, Amalapuram, East Godavari Dt., A. P.

²Assistant Professor, Department of Forensic Medicine, Rangaraya Medical College, Kakinada, A. P.

³Professor & HOD, Department of Forensic Medicine, Konaseema Institute of Medical Sciences & Research Foundation, Amalapuram, East Godavari Dt., A. P.

ABSTRACT

In developing countries like India, because of illiteracy, ignorance regarding the importance of official records like birth and death, vast majority of population fail to give information of such vital events to the concerning authorities. This causes paucity in such information when needed in a medico-legal case or for research purpose. There is a wide confusion and controversy regarding the standard method to be used for estimating age in the Indian Sub-continent. The aim of the current study is to find the correlation among the various parameters of commonly examined ossification centres, through which a regression formula with positive correlation and maximum coefficient of determination can be, derived which can be attempted to be standardised for the estimation of age.

KEYWORDS

Medico-legal age estimation, Ossification centres, Regression formula.

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INTRODUCTION: In developing countries like India, because of illiteracy, ignorance regarding the importance of official records like birth and death, vast majority of population fail to give information of such vital events to the concerning authorities. This causes paucity in such information when needed in a medico-legal case or for research purpose.

This limitation in the form of unreliable birth records is the main hindrance in conducting quality studies in our country till recent decade, but now extensive work on the determination of age of epiphyseal union has been carried out in different states of India as well as abroad. This epiphyseal union presents an almost constant feature in most individuals and therefore may be considered as an "age indicator"^[1] and from the findings of various workers, it is evident that there is not only difference in the age of epiphyseal union in India and abroad, but also in the different states of India. These differences may be on account of varying genetic and epigenetic factors like climatic, economic and dietetic conditions.^[2]

Many researchers paid attention to this subject and the different methods used for age estimation. The first persons to work on this issue were Pryor [1928]^[3] who undertook studying the time of appearance of the ossification centres of the wrist and Krogman [1939] who studied time of epiphysis union.

Data on the union of epiphyses are much more frequently used in forensic anthropology, especially for the teenage years. Standards are available for the clavicle,^[4] hand and wrist,^[5] and knee.^[6]

Mc Kern and Stewart^[7] provided data on the union of a variety of epiphyses in their study of young American males who died in the Korean conflict. General summaries of these and other works are provided by Krogman^[8] and Stewart.^[9]

All of the works cited above except Stevenson^[10] have documented a marked sex difference in the timing of epiphyseal union. Lewis and Garn^[11] noted that in the appearance of 36 ossification centres, girls were advanced over boys by about 25%. The difference was about 19% in the timing of knee ossification. Data summarized by Krogman^[8] and Stewart^[9] show that union of most epiphyses occur in females about 1 to 2 years earlier than in males.

MATERIAL AND METHODS: The present retrospective study is based on the examination of the radiographs of 300 individuals who were brought to the department of Forensic Medicine, Rangaraya Medical College, Kakinada for the purpose of Medico-legal age estimation during the academic years 2011-12, 2012-13 and 2013-14.

The ossification process is divided into the following 7 progressive stages [0-6], for which corresponding point scores were given,

Stage	Ossification process	Point score
0	Ossification centre not appeared	0
1	Ossification centre just appeared like white spots	1

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Corresponding Author:

Dr. G. S. R. K. G. Ranga Rao,
Associate Professor, Department of Forensic Medicine,
Konaseema Institute of Medical Sciences, Amalapuram,
East Godavari Dt., - 533201, A. P.

E-mail: drgsrkgrao@gmail.com

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2	Expansion of ossification centre up to half of full extent	2
3	Expansion of ossification to the full extent	3
4	Narrowing of gap between epiphysis and diaphysis	4
5	Complete union of epiphysis and diaphysis with dense white line.	5
6	Complete union of epiphysis and diaphysis without any white line.	6
Table 1: Staging and point score system of the ossification process		

Total point score is calculated by adding point scores of all the ten ossification centres in a particular case. Later the data is subjected to statistical analysis to calculate the correlation coefficient [p] for goodness of correlation between the total point score and the age of the individual. Correlation coefficient [p]: $N\Sigma XY - (\Sigma X)(\Sigma Y) / \sqrt{[N\Sigma X^2 - (\Sigma X)^2][N\Sigma Y^2 - (\Sigma Y)^2]}$,

Where,

N= number of cases.

X= total point score.

Y= age in years.

Later, a graph is plotted with age [in years] on Y-axis and total point scores on X-axis for the goodness of regression formula.

Regression equation (y) = A+ Bx.

Where, x and y are variables.

Slope (B) = $[N\Sigma XY - (\Sigma X)(\Sigma Y)] / [N\Sigma X^2 - (\Sigma X)^2]$

Intercept (A) = $[\Sigma Y - B(\Sigma X)] / N$

Where,

N= number of cases.

X= total point score.

Y= age in years.

ANALYSIS: Among the selected 300 study subjects, 64 [i.e., 21 %] are male and 236 [i.e., 79%] are female. Among males, ages of the study subjects ranged from 11 to 21 years, with maximum number of subjects at the age group of 13 to 18 years. [82.8 %]

Among males, ages of the study subjects ranged from 11 to 21 years, with maximum number of subjects at the age group of 13 years and 17-18 years. Males around 13 and 14 years are those who are under the surveillance of child labour act. In case of male convicts, the age group of 17 – 18 years indicates the dilemma: whether to consider the individual as a juvenile or as a major.

When all the available age groups are taken in to consideration for the study,

- Correlation coefficient [p]: 0.964
 - when the study is limited to the age group 13 – 18 years which has significant sample size [i.e., >75%].
- Correlation coefficient [p]: 0.989.
 - when the study is limited to the age group 14 – 18 years.
- Correlation coefficient [p]: 0.998.

A positive correlation between age and the total point score is observed.

Maximum correlation is seen in the age group 14-18 years, followed by age group 13-18 and least in age group 11 to 21 years.

Sl. No	Age group	No. of cases	Total Point Score
1.	11-12	1	27
2.	12	2	27.5
3.	12-13	1	28
4.	13	9	28.66
5.	13-14	1	30
6.	14	6	30.33
7.	14-15	4	33
8.	15	5	36.6
9.	15-16	4	41.25
10.	16	2	44.5
11.	16-17	2	48.5
12.	17	5	52
13.	17-18	10	55.9
14.	18	6	58
15.	18-19	-	-
16.	19	3	59
17.	19-20	2	59
18.	20	-	-
19.	20-21	-	-
20.	21	2	60
Table 2: Age wise distribution of male study subjects with aggregate average total point scores			

- When all the available age groups are taken in to consideration for the study,
 - Regression formula: $y = 0.205x + 6.935$

Where
y = age in years x = total point score.
 - Coefficient of determination $[R^2]$: 0.931.
- When the study is limited to the age group 13 – 18 years which has significant sample size [i.e., >75%]
 - Regression formula: $y = 0.151x + 9.163$.

Where
y = age in years x = total point score.
 - Coefficient of determination $[R^2]$: 0.978.
- When the study is limited to the age group 14 – 18 years
 - Regression formula: $y = 0.137x + 9.886$.

Where
y = age in years x = total point score.
 - Coefficient of determination $[R^2]$: 0.996.

Among the regression formulae derived, the formula that was obtained for the age group 14-18 years has the maximum coefficient of determination.

Age group [in years]	Correlation Coefficient [p]	Coefficient of determination [R ²]	Regression formula
11 to 21	0.964	0.931	$Y=0.205x + 6.935$
13 to 18	0.989	0.989	$Y=0.151x + 9.163$
14 to 18	0.998	0.996	$Y=0.137x + 9.886$

Table 3: Correlation coefficients, coefficients of determination and regression formulae for various age groups in males

- This implies that the age calculated by the regression formula derived for the age group 14-18 years is the nearest possible value to the age calculated by the standard method.
- Hence only the ages between 14 and 18 years can only be estimated precisely using the above derived regression formula.

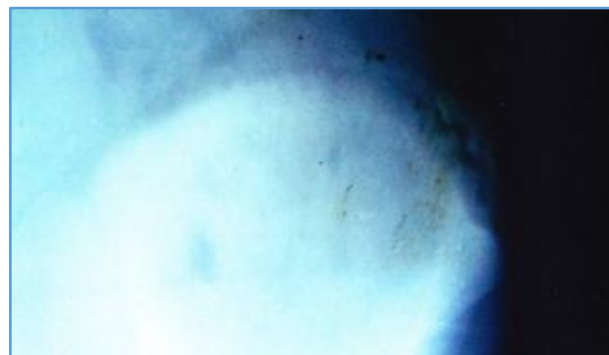
CONCLUSION: This is a humble effort to experiment a point score system in age estimation. The study is about the correlation between the age estimated as per the standard method and the total point score, obtained through a series of calculations done after grading the stages of appearance and fusion of ossification centres. This study depicted a linear positive correlation among the above considered parameters. In males, maximum correlation was observed in the age group between 14 and 18 years. An attempt was made to derive a regression formula that can be used to estimate age. Because of the limited scope of this study involving only limited number of ossification centres which are significant to a particular age group, the regression formulae thus derived cannot be applied to estimate the age beyond the age group 14 to 18 years in males. It is our hope that this attempt, may stimulate further work in the area leading to further enlightenment.



RADIOGRAPH 1: ILIAC CREST - STAGE 0



RADIOGRAPH 2: ILIAC CREST - STAGE 1



RADIOGRAPH 3: ILIAC CREST - STAGE 2



RADIOGRAPH 4: ILIAC CREST - STAGE 3



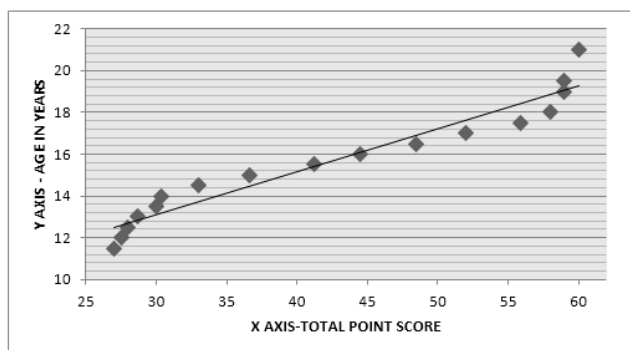
RADIOGRAPH 5: ILIAC CREST - STAGE 4



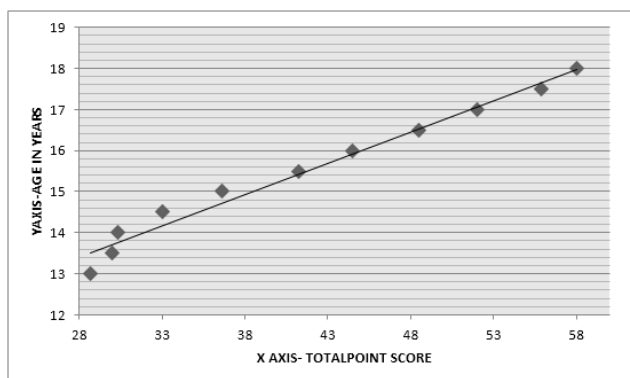
RADIOGRAPH 6: ILIAC CREST - STAGE 5



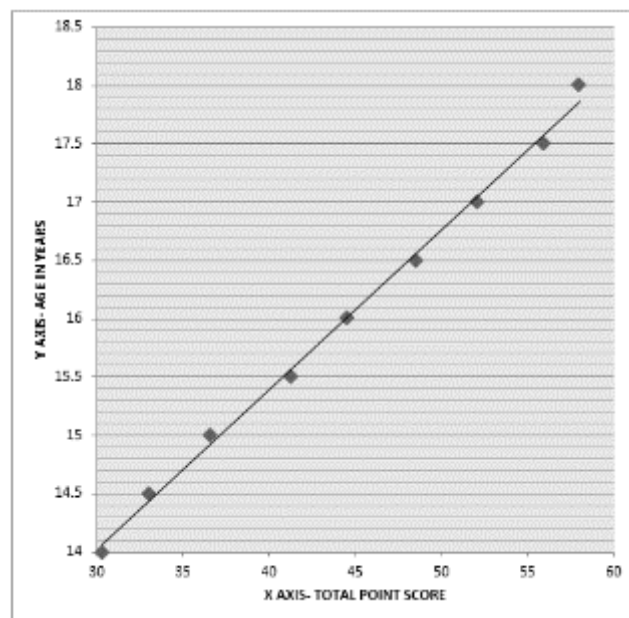
RADIOGRAPH 7: ILIAC CREST - STAGE 6



Graph 1: Regression graph for age group 11 to 21 years in males



Graph 2: Regression graph for age group 13 to 18 years in males



Graph 3: Regression graph for age group 14 to 18 years in males

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