

Original Research Paper

Status of Ossification at Elbow Joint, Dental Eruption and Secondary Sexual Characteristics in Schoolboys of 14-16 Years Age Group

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Abstract:

A study was conducted to make coordinated observations based on ossification of bones, dental eruption and secondary sexual characteristics. Healthy school going children (100 males) of age group 14 . 16 years were examined for ossification status at elbow joint; status of dental eruption, including space behind the second molar tooth and secondary sexual characteristics.

By the age of 14-16 years, all epiphyseal centers around the elbow joint, except for conjoint epiphyses, were still in the process of fusion. Eruption of second molar tooth, either by way of cutting or being completely erupted, was found by this age in all the cases and space behind 2nd molar tooth developed appreciably in the lower jaw. Majority of the males (66%) of this age group had their pubic hairs at stage 2 or 3.

Key Words: Age estimation; Dental status; Ossification status; Secondary sexual characteristics

Introduction:

Age group of 14 . 16 years is medicolegally important in cases related with sexual offences, juveniles in conflict with law, kidnapping and child labor. In all such cases, medical opinion regarding the age of the victim or the accused, is sought. It is not at all possible on part of a forensic practitioner to give exact age. Higher Courts of law have held that one can only estimate a range of age.¹ Study of indicators like ossification status, secondary sexual characters and dental eruption status, together, gives more reliable estimation of age, as compared to studying them individually.

In the light of these facts, it becomes an obvious necessity to have a local data for each population in the interest of proper dispensation of justice. Hence, in the present study, an attempt was made to know the status of ossification at elbow joint, dental eruption status and secondary sexual characteristics in school going boys between 14 -16 years age group of Bagalkot city in India.

Materials and Methodology:

Permission from the Institutional Ethics Committee was obtained. Informed consent was taken from the subjects after explaining the purpose and procedure of the study. A proforma was prepared to collect all relevant information from the subjects.

Inclusion Criteria:

- Healthy, normal boys between age group 14 to 16 years.
- Subjects who had documentary evidence of age.
- Subjects who were born and brought up in Bagalkot district.

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Exclusion Criteria:

- Subjects with skeletal deformity, disease, malformation or injury, chronic illness

Method of collection of data:

All the selected 100 subjects were broadly classified into two different groups:

- 14 years age group: Subjects who had completed 14 years to 14 years +364 days
- 15 years age group: Subjects who had completed 15 years to 15 years +364 days

Physical Examination:

For the height measurement, the subject was asked to stand straight without footwear, heels together, shoulder, buttocks and heel touching the scale and the subject looking straight. The weight was calculated in kilograms on the standardized weighing machine. For knowing the appearance and development of secondary sexual characteristics, the subjects were examined in a private room with cubicle curtain.

Dental examination:

Dental charting was done according to Palmer's notation. Space behind the second molar was inferred to be present in cases where the hard part of an underlying bone was appreciated and was inferred to be absent in cases where only soft tissue was felt. Staging of second molar tooth eruption was done in the following manner:²

Stage 0 - Non cutting through the gum

Stage 1 - When the tip of the crown of tooth penetrated the gum margin.

Stage 2 - When this crown has grown into oral cavity beyond gum margins, but not yet reached the occlusal plane.

Stage 3 - When the occlusal surface came in contact with its counterpart and the bite was complete.

The staging of epiphyseal union:

As the process of ossification starts, earliest appearance of epiphyses can be easily detected when it is no bigger than the size of a pin head. Its position can be recorded and its direction of spread can be watched.³ Keeping this in mind, and taking into consideration stages of ossification as given by Galstaun⁴, Sidhom and Derry⁵, McKern and Stewart⁶ and Kothari;⁷ in the present study, stages of ossification of epiphyses are noted as follows:

- **Stage 0:** When epiphyseal cartilage did not begin to decrease in thickness.

- **Stage 1:** Epiphyseal cartilage begins to decrease in thickness.

- **Stage 2:** Thickness of epiphyseal cartilage was found to be reduced appreciably.

- **Stage 3:** When epiphysis begins to fuse with the shaft and complete union was well underway.

- **Stage 4:** When epiphyseal cartilage was bony in architecture and density indistinguishable from the epiphysis and diaphysis in its surroundings, but an epiphyseal line called an epiphyseal scar could still be distinguished.

- **Stage 5:** Complete union with absence of epiphyseal scar.

Modified B. G. Prasad classification was used to determine socioeconomic status.⁸

Results:

Tables 1 to 9 show the physical, dental and the radiological status of boys of age group 14-16 years and factors affecting the same.

Table no. 1: Ossification status around elbow joint

Ossification Status	14 Years Boys		15 Years Boys		Total	
	N	%	N	%	n	%
Conjoint epiphysis						
Stage 0	00	00	02	04	02	02
Stage 1	03	06	02	04	05	05
Stage 2	00	00	00	00	00	00
Stage 3	10	20	01	02	11	11
Stage 4	05	10	00	00	05	05
Stage 5	32	64	45	90	77	77
Total	50	100	50	100	100	100
Medial epicondyle						
Stage 0	00	00	00	00	00	00
Stage 1	00	00	00	00	00	00
Stage 2	06	12	06	12	12	12
Stage 3	32	64	24	48	56	56
Stage 4	00	00	00	00	00	00
Stage 5	12	24	20	40	32	32
Total	50	100	50	100	100	100
Proximal end of Radius						
Stage 0	00	00	00	00	00	00
Stage 1	00	00	00	00	00	00
Stage 2	00	00	01	02	01	01
Stage 3	28	56	20	40	48	48
Stage 4	15	30	13	26	28	28
Stage 5	07	14	16	32	23	23
Total	50	100	50	100	100	100
Proximal end of Ulna						
Stage 0	00	00	00	00	00	00
Stage 1	04	08	01	02	05	05
Stage 2	04	08	03	06	07	07
Stage 3	24	48	18	36	42	42
Stage 4	02	04	6	12	08	08
Stage 5	16	32	22	44	38	38
Total	50	100	50	100	100	100

Table no.2: Factors affecting ossification of conjoint epiphyses

	Ossification status of conjoint epiphysis				
	Not appeared (Stage 0)	Active (Stage 1, 2)	Advanced (Stage 3,4)	Complete (Stage 5)	Total
Age (for age, n×2= %)					
14 years	0	3	15	32	50
15 years	2	2	1	45	50
Total	2	5	16	77	100
Fisher exact test, p <0.001					
Socioeconomic Status					
Upper class (I+II)	2	3	10	41	56
Lower class (III+IV+V)	0	2	6	36	44
Total	2	5	16	77	100
p =0.6867					
Exercise					
Never	2	4	13	64	83
Daily	0	1	3	13	17
Total	2	5	16	77	100
p =0.99					
Diet					
Veg.	2	2	9	28	41
Mixed	0	3	7	49	59
Total	2	5	16	77	100
p = 0.1567					

Table no. 3: Factors affecting ossification of the epiphysis of the medial epicondyle

	Ossification status of medial epicondyle				
	Not appeared (Stage 0)	Active (Stage 1, 2)	Advanced (Stage 3,4)	Complete (Stage 5)	Total
Age (for age, $n \times 2 = \%$)					
14 years	0	6	32	12	50
15 years	0	6	24	20	50
Total	0	12	56	32	100
Fisher exact test, $p = 0.2243$					
Socioeconomic Status					
Upper class	0	6	34	16	56
Lower class	0	6	22	16	44
Total	0	12	56	32	100
$p = 0.6515$					
Exercise					
Never	0	12	45	26	83
Daily	0	0	11	6	17
Total	0	12	56	32	100
$p = 0.2799$					
Diet					
Veg.	0	8	22	11	41
Mixed	0	4	34	21	59
Total	0	12	56	32	100
$p = 0.1562$					

Table no. 4: Factors affecting ossification of the epiphysis of proximal end of the radius

	Ossification status of proximal end of radius				
	Not appeared (Stage 0)	Active (Stage 1, 2)	Advanced (Stage 3,4)	Complete (Stage 5)	Total
14 years	0	0	43	7	50
15 years	0	1	33	16	50
Total	0	1	76	23	100
Fisher exact test, $p = 0.0338$					
Socioeconomic Status					
Upper class	0	1	43	12	56
Lower class	0	0	33	11	44
Total	0	1	76	23	100
$p = 0.8947$					
Exercise					
Never	0	1	63	19	83
Daily	0	0	13	4	17
Total	0	1	76	23	100
$p = 0.99$					
Diet					
Veg.	0	1	34	6	41
Mixed	0	0	42	17	59
Total	0	1	76	23	100
$p = 0.091$					

Table no .5: Factors affecting ossification of the epiphysis of proximal end of ulna

	Ossification status of proximal end of ulna				
	Not appeared (Stage 0)	Active (Stage 1, 2)	Advanced (Stage 3,4)	Complete (Stage 5)	Total
Age (for age, n×2= %)					
14 years	0	8	26	16	50
15 years	0	4	24	22	50
Total	0	12	50	38	100
Fisher exact test p= 0.3249					
Socioeconomic Status					
Upper class	0	8	29	19	56
Lower class	0	4	21	19	44
Total	0	12	50	38	100
p= 0.5811					
Exercise					
Never	0	12	39	32	83
Daily	0	0	11	6	17
Total	0	12	50	38	100
p= 0.2148					
Diet					
Veg.	0	7	22	12	41
Mixed	0	5	28	26	59
Total	0	12	50	38	100
p= 0.2394					

Table no. 6: Eruption status of the second molar tooth

Second MolarEruption	14 Years Boys		15 Years Boys		Total	
	N	%	n	%	N	%
Right Maxillary quadrant p=0.009						
Stage 0	0	0	0	0	0	0
Stage 1	4	8	0	0	4	4
Stage 2	14	28	6	12	20	20
Stage 3	32	64	44	88	76	76
Total	50	100	50	100	100	100
Left Maxillary quadrant p=0.006						
Stage 0	0	0	0	0	0	0
Stage 1	5	10	0	0	5	5
Stage 2	13	26	6	12	19	19
Stage 3	32	64	44	88	76	76
Total	50	100	50	100	100	100
Left Mandibular quadrant p=0.009						
Stage 0	0	0	0	0	0	0
Stage 1	1	02	0	0	1	1
Stage 2	17	34	6	12	23	23
Stage 3	32	64	44	88	76	76
Total	50	100	50	100	100	100
Right Mandibular quadrant p=0.009						
Stage 0	0	0	0	0	0	0
Stage 1	1	02	0	0	1	1
Stage 2	17	34	6	12	23	23
Stage 3	32	64	44	88	76	76
Total	50	100	50	100	100	100

Table no. 7: Space behind Second Molar Tooth

	14 years Boys		15 years Boys		Total	
	n	%	N	%	N	%
Right Maxillary quadrant p=0.3175						
Absent	46	92	42	84	88	88
Present	4	08	8	16	12	12
Total	50	100	50	100	100	100
LeftMaxillary quadrant p=0.2336						
Absent	46	92	41	82	87	87
Present	4	08	9	18	13	13
Total	50	100	50	100	100	100
Right Mandibular quadrant p<0.001						
Absent	34	68	13	26	47	47
Present	16	32	37	74	53	53
Total	50	100	50	100	100	100
Left Mandibular quadrant p<0.001						
Absent	30	60	9	18	39	39
Present	20	40	41	82	61	61
Total	50	100	50	100	100	100

Table no. 8: Factors affecting Pubic hair staging in Boys

	Pubic Hair Staging in Boys					
	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Total
Age						
14 years	14	30	4	2	0	50
15 years	3	8	24	14	1	50
Total	17	38	28	16	1	100
p <0.001						
Exercise						
Never	16	32	20	14	1	83
Daily	1	6	8	2	0	17
Total	17	38	28	16	1	100
p=0.329						
Diet						
Vegetarian	6	19	11	5	0	41
Mixed	11	19	17	11	1	59
Total	17	38	28	16	1	100
p= 0.582						
Socioeconomic Status						
Class I	3	8	3	5	0	19
Class II	4	16	10	6	1	37
Class III	9	9	10	1	0	29
Class IV	1	5	5	4	0	15
Class V	0	0	0	00	0	0
Total	17	38	28	16	1	100
p= 0.271						

Table no. 9: Factors affecting other secondary sexual characteristics in boys

	Axillary Hair			Mustache			Beard		
	Not appeared	Appeared	Total	Not appeared	Appeared	Total	Not appeared	Appeared	Total
Age									
14 years	20	30	50	23	27	50	47	3	50
15 years	6	44	50	12	38	50	30	20	50
Total	26	74	100	35	65	100	77	23	100
	p=0.002			p=0.035			p <0.001		
Diet									
Veg.	10	31	41	15	26	41	35	6	41
Mixed	16	43	59	20	39	59	42	17	59
Total	26	74	100	35	65	100	77	23	100
	p=0.819			p=0.833			p=0.1465		
Exercise									
Never	24	59	83	32	51	83	64	19	83
Daily	2	15	17	3	14	17	13	4	17
Total	26	74	100	35	65	100	77	23	100
	p= 0.135			p= 0.101			p=0.99		
Socioeconomic Status									
Class I	3	16	19	6	13	19	14	5	19
Class II	8	29	37	11	26	37	28	9	37
Class III	13	16	29	14	15	29	28	1	29
Class IV	2	13	15	4	11	15	7	8	15
Class V	0	0	0	0	0	0	0	0	0
Total	26	74	100	35	65	100	77	23	100
	p =0.114			p = 0.297			p = 0.639		

Table 10: Comparison of age of ossification of the epiphyses around elbow joint given by various workers in India/abroad with the results of the present study.

Authors	Age of ossification of epiphyses in years			
	Indian studies			
	Conjoint epiphyses	Medial epicondyle	Proximal end of radius	Proximal end of ulna
Lal and Nat – Lucknow ⁹	15-16	17	17	16
Pillai –Madras ¹⁰	14	17	17	16
Galstaun – Bengal ¹¹	16	16	16	17
Kothari – Marwar ⁷	15-16	17-18	16-17	16-17
Jain S – Jaipur ¹²	15-16	16-17	15-16	-
Patel D.S. – Gujrat ¹³	16-17	17-18	16-17	16-17
Bhise – Mumbai ¹⁴	14-16	16-17	15-17	16-17
Jnanesh – Davanagere ¹⁵	16-17	18-19	-	-
Foreign studies				
Davies and Parson-England ¹⁶	-	20	15-16	17
Paterson –Manchester ¹⁷	19	18-21	19	19
Sidhom and Derry –Egypt ⁵	15-16	-	16	-
Flecker –Australia ¹⁸	16	16	16	16
Patel B. – Canada ¹⁹	15.9	16.8	17.1	16.5
Present study – Bagalkot, India	15-16	Above 16	Above 16	Above 16

Discussion:

Many workers around the world have done a lot of research regarding age estimation based on ossification of bones, eruption of teeth

and pubertal changes. Most of the studies in the past have taken into consideration one of these three criteria. However, in this study all three criteria were taken together to observe the same

between the age group of 14-16 years. Our study shows that the age of union of conjoint epiphyses in Indians is about 2-3 years earlier than the Europeans (**Table No.10**).

Eruption of second molar tooth

The word eruption refers to the cutting of teeth through the gums. There is a significant time lag between the cutting of the tooth into the oral cavity and completion of eruption (i.e. Completion of bite). In the present study, as shown in **Table No. 6**, we can conclude that complete second molar eruption is more likely to occur in 15 years of age group. A similar study done by Ingle D²⁰ in Bijapur region mentions the average age of eruption of second molar as 14 years in 95% of males.

Space behind Second Molar Tooth

Modi²¹ mentions that a note should always be made as to whether there is a space behind second molar teeth if third molars are absent. In the present study, as shown in **Table No. 7**, the two age groups were found to be significantly different with respect to the space behind the second molar in the lower jaw with p value <0.001. Critical comparison of this finding was not possible as similar studies for space behind second molar are not available.

Secondary sexual characteristics in boys

As shown in **Table No. 8**, the findings in our study are consistent with the study done by Singh Z²² in Punjab, where the boys of age around 14-16 years had Stage 3 of pubic hair. In the United States of America, a study carried out by Sun,²³ observed that white boys of 14-16 years had Stage 4, which seem ahead in maturity as compared to the present study.

As shown in **Table No.9**, it was observed that in the age group of 15 years, the appearance of axillary hair, mustache and beard was seen more, as compared to the age group of 14 years and all were found to be statistically very significant. This finding is consistent with the study done by Singh Z,²² in Punjab.

Conclusion:

The following conclusions were derived from the present study about the status of ossification of the epiphyses around the elbow joint, dental eruption and secondary sexual

characteristics in schoolboys of Bagalkot city. (**Tables 4 to 9**)

Age group 14 years

- Conjoint epiphyses was found to be completely united (Stage 5) in 64% of boys.
- Medial epicondyle was found in either advanced union (Stage 3 and 4) or completely united in 88% of subjects.
- Proximal end of the radius was seen in advanced union (Stage 3 and 4) in 86% of boys
- Proximal end of the ulna was found in either in advanced union (Stage 3 and 4) or completely united in 84% of the subjects.
- The second molar tooth was in Stage 3 of eruption in all quadrants in 64% of boys.
- The space behind the second molar was more evident in the lower jaw as compared to the upper jaw.
- Pubic hair found in stage 2 of development in 60% of boys.
- Axillary hair found in 60% of boys.
- Mustache appeared in 54% of boys.
- Beard not appeared in 94% of boys.
- Deep voice developed in 86% of boys.

Age group 15 years

- Conjoint epiphyses was found to be completely united in 90% of boys.
- Medial epicondyle was found in either advanced union (Stage 3 and 4) or completely united in 88% of subjects.
- Proximal end of the radius was seen either in advanced union (stage 3 and 4) or completely united in 98% of boys
- Proximal end of the ulna was found in either in advanced union (Stage 3 and 4) or completely united in 92% of the subjects.
- Second molar tooth found in Stage 3 of eruption in all quadrants in 88% of boys.
- The space behind the second molar was more evident in the lower jaw as compared to the upper jaw.
- Pubic hair found in stage 3 of development in 48% of boys.
- Axillary hair found in 88% of boys.
- Mustache appeared in 76% of boys.
- Beard appeared in 40% of boys.
- Deep voice developed in 94% of boys.

From our study experience, we feel that instead of merely mentioning the status of ossification as

fused or not fused and dental eruption as erupted or not erupted, a better co-relation of age can be made by dividing the ossification status and dental eruption into different stages. Further studies are required on these lines.

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