Skeletal Maturity of the Hand and Wrist in Bania Girls in Punjab Assessed by the TW2 Method.

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ABSTRACT

Background: Chronological age of the child is a poor indicator of his/her maturity status especially during adolescence. Skeletal age derived from hand and wrist is well established as a method of estimating physical maturity and particularly valuable at about time of puberty when the greatest number of variations in maturation are found among children of same chronological age. **Methods**: The investigation was carried out cross- sectionally on the menstruating 200 bania girls from Punjab. Skeletal maturity was assessed by Tanner-Whitehouse-2 method (20 bone score) by taking hand wrist radiographs of left hand as advocated by Tanner. **Results**: The mean skeletal age is 11.625± .2252 at mean chronological age of 11.181± .1337 (20B) and mean skeletal age is 12.092± .8036 at mean chronological age of 12.013± .2736. Delay is seen in skeletal age than chronological age at 13 and 14 years. The differences between skeletal ages and chronological ages are statistically significant at $p < .05$ at 11 years and 13 years. Discussion: Bania girls showed advancement of skeletal age over chronological age at 11 and 12 years while Chinese girls showed advanced skeletal age at 12 and 13 years and well off Chandigarh girls showed advanced skeletal age at 12 years of age. **Conclusion**: The ages at which skeletal age preceded the chronological age occurred much earlier in bania girls than well off Chandigarh girls and Chinese girls. As all ratings were done by the first author with higher reliability and without information on age. All these factors suggest that sample is representative of bania girls from Punjab and the observations on the skeletal maturation are reliable.

Keywords: Skeletal maturity, Radiographs, Skeletal age, Chronological age, TW2 method.

1

INTRODUCTION

Skeletal maturity or bone age describes the degree of biological maturation.[1] Skeletal maturity is under genetic and environment control. It is a measure of how far the bones of an area have progressed towards maturity, not in size but in shape and their relative positions to one another, as visualized in radiograph. Each bone has a primary centre of ossification that enlarges and grows in size and ultimately fuses with epiphyses, in this way adult bone characteristic is achieved. The bones of the hand and wrist provide the measures of maturity from birth till adulthood as well as represent the skeletal development.

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Most of the scientists have preferred hand and wrist area for skeletal maturity assessment as this area is easily X- rayed without fear of any radiation being delivered to reproductive organs and requires the minute dose of the order of 4 millirems.[2]

Bone age is assessed by taking radiograph of the left hand and wrist and then compared with chronological age. Difference between two values indicates that skeleton is either advanced or retarded in its development.[3] Different areas of skeleton show good correlation in their development. Thus, any part of the skeleton can be used for maturity purposes until and unless it should include accuracy and accessibility.[4] Skeletal stages of hand and wrist can be used to indicate which period of adolescent growth an individual has attained. Further Hagg and Taranger also noticed that all stages occurred earlier in girls than in boys.[5]

There are two main clinical methods in use for skeletal bone age evaluation:
1. Greulich and Pyle method.
2. Tanner Whitehouse (TW-2) method

In Greulich and Pyle method (atlas method), radiographs are matched with a set of standard photographs in the atlas, sometimes radiographs do not match with the standards in the atlas so it is very difficult to use this method whereas TW2 method (bone specific approach) is based on matching of individual bone to a series of standard stages for each bone. Bone stages and their individual sequences are the same in all populations and are unaffected even by starvation.[6] The method of

Tanner et al 1975 popularly known as TW-2 method. Skeletal maturity was assessed from hand and wrist radiographs in Danish schoolchildren[7], Japanese children in Sapporo[8] by using TW-2 method. In TW-2 method, each bone of the hand and wrist is assigned eight or nine stages in its development. These stages are then converted in to scores, which are summed up to obtain the skeletal ages of the subject. The scores for the particular stage are obtained as advocated by Tanner.[9] The following 20 bones of the hand and wrist were [Figure 1]:
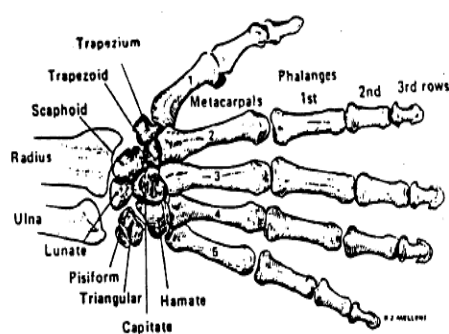
Radius, Ulna
Metacarpals (1, 3, 5),
 Proximal phalanges (1, 3, 5)
Middle phalanges (3, 5)
Distal phalanges (1, 3, 5)
Capitate, Hamate, Triquetral, Lunate, Scaphoid
 Trapezium, Trapezoid

Figure 1: Skeletal components of hand and wrist.

The TW-2 method standards are based on a large scale random sample of Scottish urban and rural children taken in 1950 s and the statement that a certain boy has a bone age of 8 years means that he had the same degree of skeletal maturity as the average 8 year old Scottish boy of the area.[2]

Tanner et al stated that in the same ethnic group, skeletal maturation varied from one person to another because each person has her/his own biological clock. In a heterogeneous society like India, which we belong, it is impractical to compare the skeletal maturity of our population to the skeletal maturity standards of other population. Therefore, standards have to be developed for each relevant population. In different ethnic groups differences have been found in the onset of the various skeletal maturation stages.[10] This report presents observations on the skeletal maturation of bania girls in Punjab, has approximately an area of 50,362 square kilometres which forms about 1.54% of the country's total geographical area with a population of 27,743,338. Out of this population, females represent 13,103,873 with girls in age group of 10-14 years form 1,137,872 as per census report of Govt. of India (2011).

Aims and Objectives

The present study was conducted in 200 middle class Punjabi bania girls with consent of girl students, parents and managements of the schools. The main objectives were:

(i) To know the radiological standard of physical maturity in Punjabi bania girls.
(ii) To compare Punjabi bania girls norms with other population.
(iii) To give the standards of skeletal age compared to chronological age.

MATERIAL AND METHODS

The subjects were 200 bania girls measured from some educational institutions of mainly Malwa region of the Punjab. The study was approved by institutional ethics committee. A written, informed consent was obtained from all the participants. Each girl was given a printed preliminary consent proforma to take home and was asked to get the consent of parents also. The sample constituted 200 healthy, unmarried school going bania girls belonging to middle class families who were about to reach menarche. Female sample were asked whether menstrual cycle had started. As soon as the girl had achieved the menarcheal status, date of menarche was noted if the answer is positive. Maximum girls were measured from Sarv Hitkari Utch Vidya Mandir, Barnala. Data was collected from various schools of the Barnala, Tapa, Dhanula, Faridkot, viz, Sarvhitkari Vidya Mandir Barnala, Amandeep Model School Barnala, N.M.S.D. School, Barnala, Y.S. Public school, Barnala Baba Farid Public School, Faridkot, Sarvhitkari Utch Vidya Mandir, Sangrur. Left hand radiographs were taken at civil hospital, Barnala by qualified radiographer adhering to the technique and precautions given by Tanner et al.[9] while protecting subjects from unnecessary radiation. The selection of subjects was based on the following criteria:

1. All subjects selected had achieved menarche within 6 six months.
2. All subjects were well nourished and free of any serious illness and belong to middle socioeconomic status.
3. There was no gross deformity of the left hand and wrist.
4. There was no history of trauma to the left hand and wrist.

Age grouping: From the date of birth and date of examination of the girls, age of each individual was calculated up to three decimal places according to the decimal age calendar given by Tanner. Based on the decimal age of the girls they were put in to one-year age groups as per the method given by Singh, Sidhu and Singh.[4] All girls for example, from the age group of 11.500 years to 12.499 years were put into the group of 12 years old and so on. In the

present study, 200 girls were examined whom age has ranged from 11.500 to 15.499 years. These girl students were put into 4 groups of yearly intervals as shown in [Table 1].

The correct positioning of the hand and wrist is of great importance since faulty posing causes some difference in bone appearance.

Left hand radiographs of 200 bania girls in sitting position with palm on the cassette was taken using X-ray machine of 500 mA Siemens company. Kodak film size 10″×12″ and 8″×10″ were exposed at 42-45 kvp for 0.8 to 0.1 seconds. The radiographs of left hand and wrist were taken with palm facing downwards, in contact with cassette and with the axis of middle finger in direct line with the axis of forearm. Upper arm and forearm should be in the same horizontal plane. Palm is placed in such a way that the fingers do not touch each other and the thumb was placed in the comfortable, natural degree of rotation with its axis making an angle of about 30 degrees with the first finger. The palm was pressed lightly downwards on the film cassette by the subject. The Tube distance from the film is 90 centimetre and is centred above the head of the third metacarpal. High definition screens should be used. Every care had been taken to protect the children from radiation. Aprons of lead material had been worn while being radio graphed. All radiographs taken in this study were exposed, developed and fixed under similar conditions to achieve uniformity in results.

According to United Nations Scientific Committee on the Effects of Atomic radiation (2000) estimates of the dose that one individual might receive from one x ray of limbs and joints is 6 (0.06) mrem (mSv).[11] The risk of hand-wrist radiographs is minimal, thus hand wrist radiographs can be used in either clinical and research settings.[12] The one part of equation is radiation, other is the susceptibility of tissue in the exposed area as some tissues are more susceptible than others (expressed as tissue weighing factor, e.g. skin 0.02, bone surface 0.05 and bone marrow 0.5). Mortality risks obtained were 5.1 x 10 (-8) for a radiogram of the hand and 1.8 x 10(-7) for an orthopantomogram. Thus, combinations of dose and area results in effective dose of a hand wrist x-ray.[13] Upper limits of effective doses for adult extremity x-ray examinations ranged from 0.17 to 2.7 μ Sv.[14]

Reliability of the TW 2 method

In the present study, radiographs of 20 females were randomly selected and assessed. All films were rated by a first author without any information on age. These films were rated on two occasions by the same observer (first author) after three months to calculate method error in assessing skeletal maturity. Very similar ratings were obtained on two occasions in 95% cases. Wenzel and Melsen advised the blind assessment as the knowledge of age is shown to influence the observer. Deviation of one score of one stage results in much greater differences in skeletal age.[15] In the present study to assess intra observer error, radiographs were randomly selected without the knowledge of age to the observer. The intra observer reliability of the first author resulted reliability coefficient of .87.

The reliability of TW 2 method has been reported by Tanner et al.[9] as ±0.5 years in 95% cases, but they stated that "reliability varies somewhat over different parts of the age span" because there are times when "a change of one in a single bone may put up the bone age by over 0.3 years. Van Venrooij-ysselmuiden and Van Ipenberg[16] reported reliabilities of ±0.22 years in 95% of cases of girls from 8-16 years**.**

RESULTS

[Table 1] shows the comparison of skeletal and chronological ages at the onset of menarche. This table represents that maximum number of menstruating girls falls in the age group of 12 years (11.5-12.5) and in this age group, mean skeletal age is advanced than mean chronological age. Similarly advancement is seen at the age of 11 years also whereas in the last two age groups of menstruating girls, mean skeletal ages are lower than corresponding chronological ages.

Table 1: Comparison o f skeletal age and chronological ages at different age groups.

	Age groups	No. of cases	Mean ± Std. Deviation	Std. Error Mean	t	Df	P value	Height
Pair 1	Skeletal Age_10.5-11.49 Chronological Age_10.5-11.49	8	11.625± .2252 11.181± .1337	.0796 .0473	4.793	14	.000	146.66
Pair 2	Skeletal Age_11.5-12.49 Chronological Age_11.5-12.49	110	12.092± .8036 12.013± .2736	.0766 .0261	.973	218	.332	149.46
Pair 3	Skeletal Age_12.5-13.49 Chronological Age_12.5-13.49	74	12.431± .7456 12.867± .2813	.0867 .0327	-4.706	146	.000	149.94
Pair 4	Skeletal Age_13.5-14.49 Chronological Age_13.5-14.49	8	13.313± .6221 13.806± .4280	.2199 .1513	-1.850	14	.086	153.19

The differences between skeletal ages and chronological ages are statistically significant at p < .05 at 11 years and 13 years. Thus, it is concluded from the above data that the maximum number (118)

of menstruating girls were showing advancement of skeletal age over chronological age. Thus, populations differ in mean skeletal maturity at a given age and in the pattern of increments from age to age.

DISCUSSION

All the measures of maturity do not proceed at the same rate of development. Though different measures of maturity are interrelated to each other at some ages, there is a lot of disagreement among them at certain other ages. Each measure of maturity reflects a specific developmental process e.g. skeletal development is a very good indicator of height. The precocious child may show accelerated sexual and skeletal development.[17]

Engstrom, Engstrom & Sagne in a statistical evaluation found a strong correlation between chronological age and skeletal age (r=0.88, p <.001).[18]

In the present study on menstruating bania girls, the mean skeletal age showed advancement over chronological age at the age of 11 and 12 years but these are not showing advancement of skeletal age at 13 and 14 years. This may be due to the lesser calories intake or other factors, which we have not been taken in to account. Japanese children in Sapporo showed advancement of skeletal age after the age of 10 years.[8] Our findings are also in close agreement with girls in the southern Chinese city of Changsha. In these girls, 20 bone score and skeletal ages are lower at 11 years, higher from 12 to 13 years again lower at 14 years.[19] whereas in our study skeletal ages are higher at 11 and 12 years again lower at 13 and 14 years.

Comparison of present study bania girls was done with Chandigarh girls from well off families. Mean, standard deviation of chronological age, 20 bone score and skeletal ages are shown in [Table 2]. When present study had been compared with well off children from Chandigarh by TW2 (20 B score) method of assessing skeletal maturity, advancement of mean skeletal age was seen at the age of 12 years and little delay in skeletal age was seen at the age of 11 years in Chandigarh population[20] whereas bania girls showed advancement of skeletal age over chronological age at 11 years and 12 years as shown in table 2.

Table 2: Comparison of Chandigarh girls from well off families with bania girls from Punjab

	Age group	N	Standard deviation with Chronological age		Standard deviation with Tw2 score (20b)		Skeletal age
Parkash and Cameron	10.5-11.49	6	10.85	0.21	817.8	96.2	10.7
	11.5-12.49	13	12.09	0.29	930.9	50.7	12.4
Present study	10.5-11.49	8	11.181	.1337	885.88	4.715	11.6
	11.5-12.49	110	12.013	.2736	906.04	4.152	12.1

All subjects in this study belong to Punjab and are from middle socioeconomic status. All ratings were done by the same observer with higher reliability and without information on age. All these factors suggest that sample is representative of bania girls from Punjab and the observations on the skeletal maturation are reliable.

CONCLUSION

This study indicates the reliability of skeletal maturation by TW2 method (20 b score) as all ratings were done by the first author without information on age. Thus sample is representative of bania girls from Punjab. The ages at which skeletal age preceded the chronological age occurred much earlier in bania girls than well off Chandigarh girls and Chinese girls.

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