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CORRELATION OF SEXUAL MATURATION WITH SKELETAL AGE OF SOUTHERN CHINESE GIRLS

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The correlation of skeletal maturation with the chronological ages of the onset of four secondary sexual characteristics (menarche, appearance of pubic hair and axillary hair, and breast development) was studied in a group of 117 Southern Chinese girls aged between 11 years, 9 months and 12 years, 3 months, who were born and brought up in Hong Kong. The skeletal maturation was assessed from left hand and wrist radiographs by the Greulich and Pyle Atlas Method (1959). The early maturers in sexual maturation were significantly more advanced in skeletal maturity with $p<0.001$.

Keywords: Sexual characteristics, Skeletal age

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Introduction

Because human growth shows considerable variation in the chronological age, physiological maturity is preferred to chronological age in the estimation of the developmental status of a child. Skeletal maturation assessed from hand and wrist radiographs is one of the commonly used physiological or developmental indices.[1-8] Change in the skeletal age is of decisive and far greater importance to the occurrence of menarche than is an increase in the chronological age, as it might be assumed that factors (probably hormonal) which determine the onset of menstruation, are partially identical to those which regulate skeletal maturation.[9] The development of other secondary sexual characteristics, like breast, pubic and axillary hairs, is also controlled by the gonadal and related hormones. Consequently their developmental status is also determined by that of the reproductive system.[10]

This paper is concerned with the correlation between several stages of skeletal maturation assessed from left hand and wrist radiographs by the Greulich and Pyle Atlas Method,[11] and four secondary sexual characteristics (age of menarche, first appearance of axillary and pubic hair, and breast development), in a group of Southern Chinese girls aged from 11 years 9 months to 12 years 3 months, who were born and brought up in Hong Kong.

Materials and Methods

The sample consisted of female patients registered in the Department of Children's Dentistry and Orthodontics of the Prince Philip Dental Hospital in Hong Kong. Exact chronological age was verified with the birth certificate on registration at the hospital.

The selection criteria included:

1. The chronological age is 12 years (±3 months) on the day of examination.
2. The subject must be a local resident in Hong Kong; that is, born and brought up in Hong Kong.
3. Both parents are of Southern Chinese province ancestry.
4. The subject is physically and mentally healthy without a past history of chronic and severe illnesses.
5. The subject is right-handed with no previous history of trauma or injury to the left hand and wrist region.

Left hand and wrist radiographs were taken in a standardized manner to ensure correct positioning of the hand and wrist, and to avoid differences in bone appearance due to faulty positioning. The subject sat comfortably with both thighs horizontal to the floor and both feet resting on the floor, and with full back support. Lead aprons were worn to shield the thyroid and gonads from radiation. Any watches and rings were removed from the left hand. The shirt sleeves were rolled up to elbow level.

The palm faced downward, in contact with the cassette, with the axis of the middle finger in a direct line with the axis of the forearm. The upper arm and forearm were in the same horizontal plane at shoulder level. The left arm was 90 degrees abducted, with the forearm in 90 degrees flexion, and the hand in complete pronation. The fingers were slightly apart, with each in line with its metacarpal. 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 subject gently pressed the palm downward, flat and steady on the film cassette. The tube was centred above the third metacarpal

with the central beam perpendicular to the mid-point of the third metacarpal.

Princeps neuro-radiological unit (GCR Medical Corporation), originally designed for skull radiography, was used for taking the left hand and wrist radiograph. The rotating L arm of the machine was tilted 90 degrees so that the anode cone was perpendicular to the film cassette table, and centred at the mid-point of the left third metacarpal. The anode-film distance was 100 cm. Ortho.-G Kodak film and a 24 x 30 Lanex Detail screen were used. The exposure was made with 50 milliamperage, 48 kilovoltage and a 0.1 second exposure time.

There are 30 bones in the hand and wrist region. The wrist bones include distal epiphyses of radius and ulna, capitate, hamate, triquetral, pisiform, lunate, scaphoid, trapezium, trapezoid and ulnar/adductor sesamoid (at the first metacarpophalangeal joint). The hand bones are the metacarpals I, II, III, IV and V; the proximal phalanges I, II, III, IV and V; the middle phalanges II, III, IV and V; and the distal phalanges I, II, III, IV and V.

Each bone of the hand and wrist radiograph was examined and traced on 0.003" matt acetate tracing films (Unitek 701-204) with a 3H pencil using viewing-box illumination with extraneous light blocked out and in a darkened room. The general outline, shape, size, articulation with adjacent bones, and the density of each bone were studied and compared with the standard plates for females in the *Radiographic Atlas of Skeletal Development of the Hand and Wrist*[11] and a bone age assigned.

Skeletal age for each radiograph was assessed by averaging the thirty assigned bone ages. The mean skeletal age, standard deviation and range were calculated for the sample group.

Indications of sexual maturation were based on four secondary sexual characteristics: (1) age of menarche, (2) age of first appearance of pubic hair, (3) age of first appearance of axillary hair, and, (4) breast development.

In order to ensure the privacy of the subjects, these factors were investigated by questionnaires presented to the subject after the clinical examination which was performed in a dental surgery. The subjects were asked to record the dates of menarche, and the first appearance of axillary and pubic hairs. Occasionally, some subjects did not understand the questions; the operator would explain or help to recall the dates. Breast development was done by clinical observation and classified as either "with" or "without" breast development.

Table 1. Number of subjects and the mean ages for the sexual maturity indices.

	No. of Subjects	Chronological Age (in years) Mean ± S.D.	Range
Menarche	32	11.50 ± 0.47	12.20 - 10.32
Pubic Hair	44	11.40 ± 0.47	12.12 - 9.76
Axillary Hair	27	11.46 ± 0.56	12.22 - 9.76

Table 2. Comparison of skeletal age of the early and late sexual maturers.

Sexual Maturity		Number of Subjects	Skeletal Age (in years) Mean ± S.D.	Standard Error of Mean	Range	Difference
Menarche	Yes	32	13.73 ± 0.86	0.15	11.74 - 15.30	1.60[1]
	No	85	12.13 ± 0.85	0.09	8.86 - 13.88	
Pubic Hair	Yes	44	13.31 ± 1.00	0.15	11.04 - 15.30	2.79[1]
	No	73	10.52 ± 0.93	1.10	8.86 - 14.58	
Axillary Hair	Yes	27	13.54 ± 0.97	0.19	11.74 - 15.30	1.26[1]
	No	90	12.28 ± 0.98	0.10	8.86 - 14.58	
Breast Development	Yes	40	13.31 ± 1.08	0.17	10.50 - 15.30	1.16[1]
	No	77	12.15 ± 0.80	0.10	8.86 - 14.58	

[1] *p<0.001*

Table 3. Bone ages for the sesamoid and distal phalanges for girls with (n = 32) and without menarche (n = 85)

Bones		Menarche (Yes/No)	Bone Age (in years) Mean ± S.D.	Standard Error of Mean	Range	Difference
Sesamoid		Yes	13.78 ± 0.84	0.15	12.00 - 16.00	1.83[1]
		No	11.96 ± 0.32	0.32	0.00 - 13.50	
Distal Phalanges	*I*	Yes	13.88 ± 1.13	0.20	11.00 - 16.00	1.50[1]
		No	12.38 ± 1.11	0.12	8.75 - 14.00	
	II	Yes	13.81 ± 0.89	0.16	12.00 - 15.00	1.54[1]
		No	12.27 ± 1.11	0.12	8.75 - 14.00	
	III	Yes	13.81 ± 0.89	0.16	12.00 - 15.00	1.54[1]
		No	12.27 ± 1.11	0.12	8.75 - 14.00	
	IV	Yes	13.75 ± 0.94	0.17	12.00 - 15.00	1.47[1]
		No	12.28 ± 1.11	0.12	8.75 - 14.00	
	V	Yes	13.81 ± 0.89	0.16	12.00 - 15.00	1.54[1]
		No	12.27 ± 1.11	0.12	8.75 - 14.00	

1 p<0.001

Results and Discussions

One-hundred and thirty-five girls were examined. Eighteen subjects were excluded from the skeletal age assessments. Of these, two were born in China; nine were of non-Southern Chinese ancestry; one was mentally retarded; and six reported a past history of trauma and injury to the left hand and wrist region. The relation between skeletal maturation and the four secondary sexual characteristics of the remaining 117 girls were studied.

Data on sexual maturation were obtained by the recollection method. No physical examination of naked subjects was performed to ascertain the data as it may have embarassed those brought up in a culture which does not discuss any sexually-related events, not even among family members. It was believed that these girls could still remember fairly well the date of such change.[12]

The number of subjects with the various secondary sexual characteristics and their mean ages were tabulated (Table 1). Subsequently, the subjects were divided into early and late sexual maturers with reference to each characteristic. The difference in skeletal ages between the two sub-groups was studied. Highly statistically significant differences were found for all four secondary sexual characteristics (Table 2). The early sexual maturers were also more advanced in skeletal maturation.

Bone ages of the sesamoid and the five distal phalanges were also studied in the two sub-groups with reference to menarche. In the "early menstruated" group, bone ages were all significantly more advanced than the "late menstruated" group at the $p<0.001$ level (Table 3). The differences ranged from 1.47 years to 1.83 years, coinciding with studies on Caucasians.[5, 13, 14]

Summary

Correlation of skeletal maturation with four secondary sexual characteristics was studied in 117 Southern Chinese girls aged 12 years ± 3 months, born and brought up in Hong Kong. The skeletal maturation was assessed from left hand and wrist radiographs, by the Greulich and Pyle Atlas Method.[11] Ages of menarche, appearance of pubic and axillary hairs, and breast development were studied. The early maturers in sexual maturation were also significantly more advanced in skeletal maturity with $p<0.001$.

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