

PUBERTY GROWTH SPURT AGE IN LOCAL POPULATION — A STUDY

¹GHULAM RASOOL, ²ZUBAIR HASSAN AWAISI, ³AWAIS KHALID

ABSTRACT

The biologic aspects of facial growth are fundamentally important in dentofacial orthopedics. The beginning, intensity, onset, and duration of the pubertal peak of facial growth have great variations among patients. The aim of the present study was to find the puberty growth spurt age in local population for diagnostic and optimum treatment planning issues. Hand-wrist radiographs of 200 patients were evaluated according to Bjork's method of assessment to determine the puberty growth spurt age. The spearman rank correlation between chronologic age and skeletal maturation intervals was 0.731 ($P < .001$) for both the genders combined. The mean chronological age of females in accelerating, peak and decelerating growth spurt was less than male subjects.

Key words: Growth spurt, growth prediction, Hand-wrist radiograph.

INTRODUCTION

Puberty is a period of development characterized by partially concurrent changes which includes growth acceleration, alteration in body composition and appearance of secondary sex characteristics. Puberty is characterized by an acceleration and then deceleration in skeletal growth. An important consideration is that the same pattern of skeletal growth can be found in almost every individual. However, initiation, duration and amount of growth vary considerably during the growth spurt.¹

Growth is a process that begins at the conception and continuous throughout life, though the rate slows considerably after second decade. The pattern of somatic growth during the first two decades is categorized into 4 intervals^{2,3} as shown in Fig I.

Infancy; Starting from birth to approximately 3 years of age.

Childhood; from 3 years to 12 years of age.

Adolescence; from 12 years to 18 years.

Adulthood; from 18 years onwards.

The typical growth pattern of a child is characterized by a growth rate that decrease from birth, with a minor mid growth spurt at approximately 6 to 8 years,

a prepubertal minimum and a pubertal growth spurt. After adolescence, the rate of growth decreases substantially, but does not stop.^{4,5} Although all of these intervals of growth occur in normally developing individuals, the adolescent growth spurt varies significantly in the initiation, duration and amount of growth. Some common reasons for such diversity in the growth spurt can be contributed to heredity, nutrition, morbidity, and socioeconomic status.^{2,3,6,7}

The timing of the growth events is far more important than the actual measurement. Tofani⁸ found the earlier the growth spurt, the greater its magnitude and less its intensity and vice versa for the late growth spurts. This is in agreement with Burstone⁹ where he noted that early maturer tend to have greater rate of adolescent growth than late maturer. Contrary to this, Hunter¹⁰ found no significant difference in the rate of growth in the early and late maturer during pubertal growth.

Maturation status can have considerable influence on diagnosis, treatment goals, treatment planning, and the eventual outcome of orthodontic treatment. Clinical decisions regarding functional appliances or orthognathic surgeries are modulated by the patient's degree of physiological maturity. That is why prediction of the time and the amount of active growth

¹ **Correspondence:** Dr Ghulam Rasool, Associate Professor & Head Dept of Orthodontics, Khyber College of Dentistry, Peshawar, House # 238, Street # 4, Sector J-1, Phase 2, Hayatabad. Phone No: 091-5830083, 0333-9126029 E-mail: malaika_bh@yahoo.com

² Asst Professor, Dept of Orthodontics, Margalla Institute of Health Sciences, Rawalpindi

³ Asst Professor, Dept of Orthodontics, Islamic International Dental College, Islamabad

is an important issue. Hence it would be desirable to have a reliable way of forecasting when the maximum growth of the jaw bone at puberty will occur in a patient. The classical and most widely used method for skeletal age evaluation is the highly reliable hand-wrist bone analysis performed by radiograph.^{11,12}

The growth spurt timing varies in different races, climate, and geographic areas. It is important to have an idea about the association of chronologic age with growth spurt period in local population. The aim of the present study was to find the puberty growth spurt age for diagnostic and optimum treatment planning issues.

METHODOLOGY

The study was carried out at the Orthodontic department Khyber College of Dentistry Peshawar. A total of two hundreds patients were selected in the age range of nine to fifteen years with Hand-wrist radiographs of high clarity and good contrast. The patients with history of Orthodontic / Orthopedic treatment, serious illness, trauma and craniofacial syndromes were excluded. The age was recorded according to the birth registry. The patients and their parents were informed about the amount of radiation exposure related to hand-wrist radiograph and consent was taken. All the X-rays were taken by the same operator and machine, at the same distance (X-ray source – film and film – subject distance) and intensity. After protecting the patient with protective aprons PA view of the left hand-wrist was taken with Toshiba TL-6 TL-3 at 50 kvp, 100ma and exposure time of 0.2 seconds using kodak green film 8×10 inch. Patient stood with his/her left forearm resting on the cassette placed on the table with fingers slightly separated and the axis of the hand wrist and forearm in a straight line. The center of the tube was half way between the tips of the fingers and distal end of the radius, perpendicular to the film.

Skeletal maturation was assessed according to Bork's method of assessment (Fig 2). The Bjork system offers an organized and relatively simple approach to determine the level of skeletal maturation from the hand wrist radiograph. Bjork utilized certain anatomical sites located on the phalanges, abductor sesamoid, carpal and radius bone, which have predictable and consistent time of onset of ossification.⁹

Bjork nine stages of skeletal maturation were reduced to five intervals and ranked 1 to 5 according to growth completion.

1. **Growth preceding acceleration**
(Bjork stage 1-3): _____ → **Interval A**
2. **Stage of growth acceleration**
(Bjork stage 4): _____ → **Interval B**
3. **Stage of peak growth**
(Bjork stage 5): _____ → **Interval C**
4. **Stage of growth deceleration**
(Bjork stage 6-7): _____ → **Interval D**
5. **Stage of growth completion**
(Bjork stage 8-9): _____ → **Interval E**

STATISTICAL ANALYSIS

Frequency and percentage were presented for discrete variable like gender and means ± SD was calculated for age. The stages in hand-wrist radiograph were ranked in five intervals (A-E). The outcome of data for radiographic assessment was ordinal and Spearman rank order correlation coefficient test was used to judge the strength of the relationship between the maturation stages of hand-wrist and chronological age. P value equal to or less than 0.05 was taken as statistically significant.

RESULTS

This study was conducted on total 200 orthodontic patients visiting to out patient department. The mean age of the patients was 12.77 ± 1.54 years with a range of 9-15 years. Cumulative percent shows low frequency in 9-11 years age (16%) and high frequency in 12-13 years (60%) as shown in table 1.

The most frequent hand-wrist skeletal maturation interval in both the sexes combined was maturation interval C (27%) ie stage of growth acceleration. The result suggested that the frequency of male subjects was high before peak growth, while that of the female in post spurt stages. So the females were advance in their skeletal maturation. Skeletal maturation intervals distribution by age is shown in table 2. Spearman rank correlation between chronologic age and skeletal maturation intervals was 0.731 (P<.001) for both the genders combined.

TABLE 1: FREQUENCY DISTRIBUTION OF AGE

Age	Frequency	Percent	Cumulative percent
9	8.0	8.0	8.0
10	12.0	12.0	20.0
11	12.0	12.0	32.0
12	46.0	46.0	78.0
13	62.0	62.0	140.0
14	28.0	28.0	168.0
15	32	32.0	200.0
Total	200	200.0	

TABLE 3: MEAN AGE DIFFERENCE IN BOTH GENDERS IN SKELETAL MATURATION INTERVALS

Skeletal maturation interval	Male Mean ages	Female Mean ages	Difference
A	11.42	9.40	2.02
B	12.70	12.00	.70
C	13.14	12.10	1.04
D	14.00	13.43	0.57
E	15.00	14.15	0.85

Mean difference in genders; 1.036 years

TABLE 2: AGE VERSUS SKELETAL MATURATION INTERVAL CROSS TABULATION

Age	Skeletal maturation intervals				
	A	B	C	D	E
9.00	8	0	0	0	0
10.00	8	2	2	0	0
11.00	4	2	6	0	0
12.00	10	10	22	4	0
13.00	4	14	20	18	6
14.00	0	0	2	4	22
15.00	0	2	2	10	18
Total	34	30	54	36	46

Symmetric Measures

Ordinal by Ordinal	Spearman correlation	Value	Std. error	Approx. sig.
		0.731	0.048	0.000

Spearman correlation (r) = 0.731
P < .001 (highly significant)

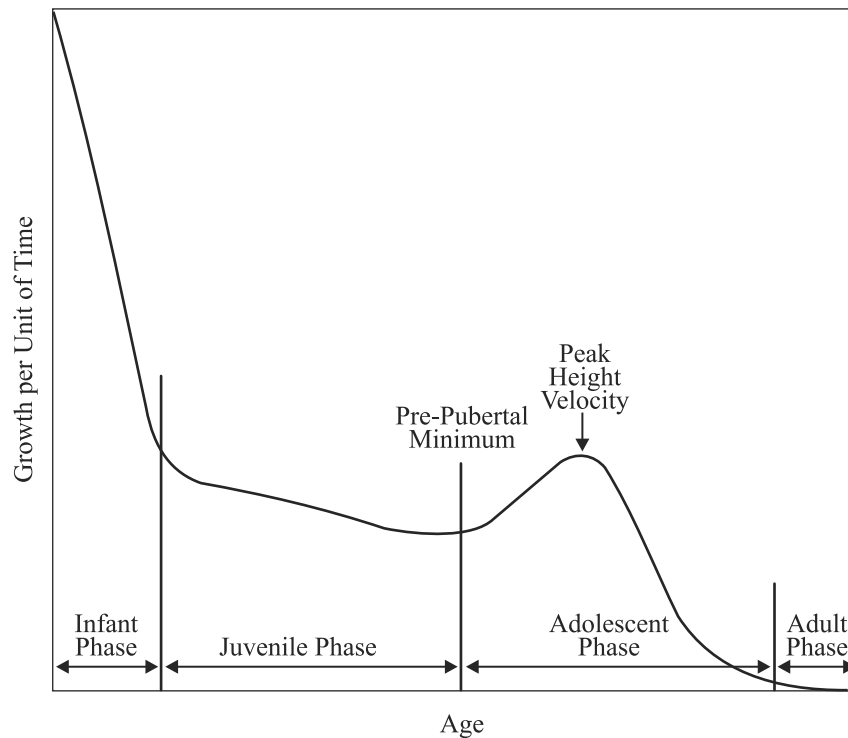


Fig 1: Human growth velocity chart for somatic tissues partitioned into the four major intervals of postnatal growth.²¹

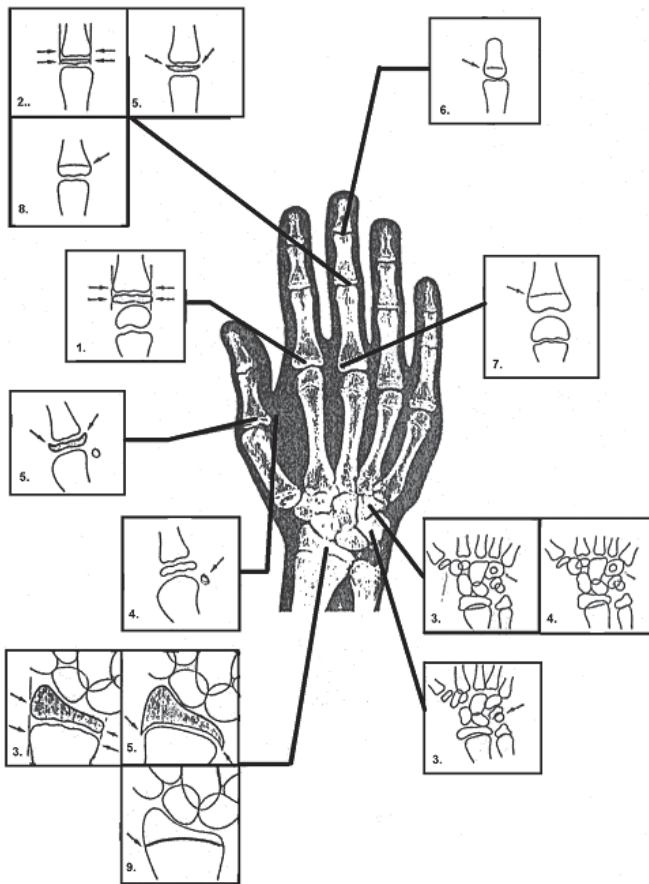


Fig 2: Nine stages of maturation: analysis of hand wrist radiograph according to Björk, Grave, and Brown

The mean chronological age of females in accelerating, peak and decelerating growth spurt was less than male subjects (Fig 3). Females were ahead of males at all levels of skeletal maturity, indicating early age of maturational development for females (table 3). The highest difference in genders was found in growth interval A (2.02 years), while the lowest difference at growth interval D(0.57years). The mean difference in chronological age between the two genders was 1.03 years in attaining the same level of maturation.

DISCUSSION

When a patient presents for orthodontic treatment, the orthodontist develop a problem list and appropriate treatment plan for that individual. In orthodontic and dentofacial orthopedics it is becoming increasingly evident that the timing of treatment onset may be as crucial as the selection of specific treatment protocol, because in the organization, differentiation, development, and growth of any somatic

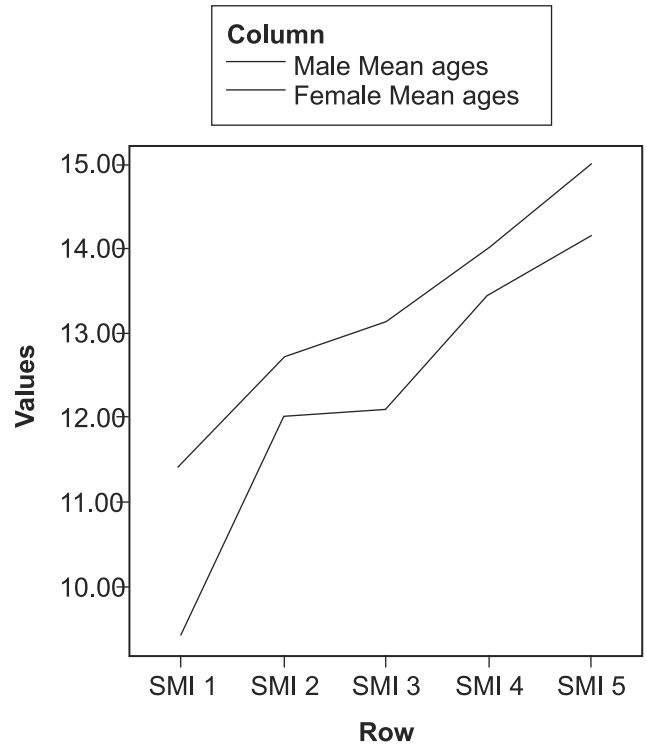


Fig 3: Mean chronological age of male and female at each skeletal maturation interval.

structure, time plays a viable role in determining the final morphological and dimensional results.¹³ Skeletal maturity among all is the most commonly used index in routine clinical work and is closely related to the sexual and somatic maturity. Fishman¹ stated that identifiable maturational indicators provide more reliable means of evaluating individualized maturational levels in the wide chronologic age ranges of normally growing children, thus the use of skeletal age would be more accurate and more clinically beneficial than chronologic age. When growth is examined on maturational age basis rather than chronological age, the gender and racial differences are eliminated.

The hand-wrist radiograph has been used conventionally to determine the level of maturation in a child. Bjork’s method is commonly used in related studies because of its simplicity, popularity and reliability. Bjork’s nine stages were reduced to five intervals (A-E) to correspond to the growth spurt stages and growth completion ranking. This reduction from nine to five stages did not entail the loss of significant data, as the goal was not represented by the identification of each single stage but by the interval of growth.

The PP₂ stage becomes visible well-ahead (about 2 years) of the adolescent growth peak.¹⁴ The MP₃ stage usually appears during the onset of accelerating growth period. The S-H2 is the stage of accelerating growth to get to the peak, Capping of Mp3, PP1 and Radius is the peak of growth. The DP_{3u} and PP_{3u} stages typically coincide with the time period of decelerating growth rate and fusion of epiphysis and diaphysis of MP3 and Radius shows the corresponding growth completion

Hunter¹⁰ found that girls were usually advance by an average of 2.4 years than boys for the onset of puberty, with a mean value of 12.8 years for boys and 10.4 years for girls. While our results showed 11.4 years for boys and 9.4 years for girls with a mean difference of 2 years. This shows that Pakistani subjects are advance in attaining skeletal maturity stages. Shaikh A, Rikhasor R, Qureshi A.¹⁵, also documented it previously.

The appearance of the abductor sesamoid had been highly correlated to peak height velocity and the start of the adolescent growth spurt.^{16,17,18} Hug and Taranger¹⁹ also demonstrated the attainment of accelerating growth spurt during appearance of Sesamoid. Zhang and Wang²⁰ estimated skeletal age from the cervical vertebrae on lateral cephalogram. They concluded that the appearance of the sesamoid of hand and the concavity of the second vertebral body at the same time showed the beginning of rapid growth period. The present study showed that growth spurt (sesamoid stage) appeared in mean chronological age of 12.7 years in males and 12 years in females. This is in agreement with the previous reports.

The relationship between skeletal maturity and peak adolescent height velocity was well established. Bjork⁸ found that capping of the epiphysis of the middle phalanx of third finger was very closely related to the age of pubertal maximum growth velocity. Other investigations have shown that capping of the third middle phalanx coincides closely with PHV. The present study revealed that at peak growth spurt (MP3 cap stage). chronological age of males and females was 13.14 and 12.10 respectively with a difference of 1 year

According to Bjork, the pubertal growth spurt ends with the complete fusion of the third distal phalanx (DP3_u) and according to the study of Kopecky and Fishman²¹ growth was complete at Ru stage. In the

present study the end of growth spurt was at the mean age of males was 15 years and females 14.15 years with mean difference of 0.85 years

Sierra²² found that the relationships between chronologic age and skeletal age proved to have relatively high correlation (0.58 to 0.71). In our study, the correlation between chronologic age and skeletal maturation assessed by hand-wrist method was 0.731 – higher than those reported by Sierra, but lower than those reported by Uysal²³ (0.72 and 0.79) and Al Hadiaq¹⁴ (r value = 0.80). In general, the differences reported in the present study in relating the mean chronological age to the skeletal maturity stage for samples from different populations can be attributed to differential racial backgrounds, distinct environmental conditions, and/or some research methodology disparity associated with the sample size and/or sample distribution.

The females are advance than male in skeletal maturation. This is supported by the previous studies of Tanner², Nanda²⁴, Bowden²⁵, Hägg and Taranger²⁶. Hunter¹⁰ and Kamal²⁷ in separate studies found similar results. The outcome of the present study showed difference of one year in males and females in attaining the same level of maturation in Pakistani subjects. Shamsheer²⁸ documented 1.2 years difference in local population previously. However, according to skeletal maturation, the sex differences were steadily significant at the skeletal maturity corresponding to about 12 years in the males and 10 years in the females (Table 3). Our results are in accordance with the findings of Kimura K²⁹ that was conducted in Japanese population and concluded the same. The age difference in the onset of the pubertal growth spurt adds to the sexual diversity in physiological maturity.

Since the use of individual ossification events is of limited use in predicting the pubertal growth spurt, an analysis that includes maturation level as well as ossification events should also be carried out. It must be remembered that the skeletal maturation is a continuous process. Skeletal maturity indicators in hand-wrist are categorized by distinct events in this continuum. Each stage of maturation blends into the next and it is sometimes difficult to differentiate borderline cases. Clinically these differences should not be of great importance.

REFERENCES

- 1 Fishman LS. Chronological versus skeletal age, an evaluation of craniofacial growth. *Angle Orthod* 1979; 49:181-89.
- 2 Tanner, JM: Fetus into man: Physical growth from conception to maturity. Cambridge, Harvard University press, 1978.
- 3 Bogin B. Patterns of human growth. Cambridge: Cambridge University Press, 1988.
- 4 Sadowsky PL. Craniofacial growth and the timing of treatment. *Am J Orthod Dentofacial Orthop* 1998; 113: 19-23.
- 5 Behrents RG. Atlas of growth in the aging of craniofacial skeleton. Monograph 18, Craniofacial Growth Series. Ann Arbor: Center for Human Growth and Development, University of Michigan, 1986.
- 6 Björk A, Helm S. Prediction of the age of maximum pubertal growth in body height. *Angle Orthod*. 1967; 37: 134-42.
- 7 Moore RN, Moyer BA, DuBois LM. Skeletal maturation and craniofacial growth. *Am J Orthod Dentofac Orthop*.1990; 98:33- 40..
- 8 Tofani M. Mandibular growth at puberty. *Am J Orthod* 1972; 62:176-94.
- 9 Burstone CJ. Process of maturation and growth prediction. *Am J Orthod*. 1963; 49:907-20.
- 10 Hunter WS. The correlation of facial growth with body height and skeletal maturation at adolescence. *Angle Orthod* 1966; 36:44–54.
- 11 Ozer T,Kama JD, Ozer SY. A practical method for determining pubertal growth spurt. *Am J Orthod Dentofac Orthop* 2006;130: 131.e1-e64
- 12 Mir CF, Nebbe B, Major PW. Use of Skeletal Maturation Based on Hand-Wrist Radiographic Analysis as a Predictor of Facial Growth: A Systematic Review: *Angle Orthod* 2004; 74:118-24.
- 13 Baccetti T, Franchi L, McNamara JA. The Cervical Vertebral Maturation (CVM) Method for the Assessment of Optimal Treatment Timing in Dentofacial Orthopedics. *Semin Orthod* 2005; 11:119-29.
- 14 AL Hadlaq A, Hashim H, Al-Shalan T, Al-Hawwas A, Al-Murtari N, Al-Zahrani T. Association between chronological and skeletal ages among a sample of Saudi male children. *Saudi Dent J* 2007; 19: 1-7
- 15 Shaik A, Rikhasor R, Qureshi A. Determination of skeletal age in children aged 8-18 years. *J Pak Med Assoc* 1998; 48: 104-06.
- 16 Bergersen EO. The male adolescent growth spurt: its prediction and relation to skeletal maturation. *Angle Orthod*. 1972; 42:319-38.
- 17 Demirjian A, Buschang PH, Tanguay R, Patterson DK. Interrelationships among measure of somatic, skeletal, dental, and sexual maturity. *Am J Orthod* 1985; 88:433-38.
- 18 Grave KC. Timing of facial growth: a study of relations with stature and ossification in the hand around puberty. *Aus Orthod J* 1973; 3:117-22.
- 19 Hagg U, Taranger J. Maturation indicators and the pubertal growth spurt. *Am J Orthod* 1982; 82:299-309.
- 20 Zhang Y, Wang B. Observation of cervical vertebrae and estimation of their bone age (Article in Chinese) *Zhonghua Kou Qiang Yi Xue Za Zhi*. 1997; 32: 152-54.
- 21 Santos EC, Bertoz FA, Arantes Fde M, Reis PM, de Bertoz AP. Skeletal maturation analysis by morphological evaluation of cervical vertebrae. *J Clin Pediatr Dent* 2006;30: 265-70.
- 22 Sierra AM. Assessment of dental and skeletal maturity. A new approach. *Angle Orthod*1987;57: 193-98.
- 23 Uysal T, Ramoglu SI, Basciftci FA, Sari Z. Chronological age and skeletal maturation of the cervical vertebrae and hand wrist: Is there a relationship? *Am J Orthod Dentofac Orthop* 2006; 130: 622-28.
- 24 Nanda RS. The rates of growth of several facial components measured from serial cephalometric roentgenograms. *Am J Orthod*. 1955; 41:658-73.
- 25 Bowden B. Sesamoid bone appearance as an indicator of adolescence. *Aus Orthod J* 1971; 2:242-48.
- 26 Hägg U, Taranger J. Skeletal stages of the hand and wrist as indicators of the pubertal growth spurt. *Acta Odontol Scand* 1980; 38:187-200.
- 27 Kamal M, Ragini, Goyal S. Comparative evaluation of hand wrist radiograph with cervical vertebrae for skeletal maturation in 10-12 years old children. *J Indian Soc Pedod Prev Dent* 2006;24:127-35
- 28 Shamsher RM, Ijaz A. Age of High Growth Rate in Adolescent period of development. *Pak Oral Dent J* 2005; 25: 53-58.
- 29 Kimura K. Growth of the second metacarpal according to chronological age and skeletal maturation. *Anat Rec* 1976; 184: 147-57.