AGE OF HIGH GROWTH RATE IN ADOLESCENT PERIOD OF DEVELOPMENT

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ABSTRACT

The aim of this study was to assess the chronological age of different skeletal maturity events in young adolescents. A total of 100 subjects (50 males 50 females) visiting the children's hospital and the Institute of Child Health, Lahore, were included in the study. The mean age of these subjects was 12.23+2.33 years. Skeletal maturity was assessed with left hand-wrist radiograph through method described by Fishman. Chronological age was determined by knowing the exact date of birth of adolescent. Result showed that the females were advanced than males in about 1.2 years in attaining peak growth velocity. The peak growth velocity of females arrived at the age 12.78+1.73 and that of males is at 13.9+1.37 years.

The study also showed racial differences. Through these results the simple information of patient's chronological age aids the clinician in evaluating the patient's growth potential and facilitates establishment of appropriate timing and types of orthodontic treatment, retention needs, and proper timing for surgical intervention.

Key words: Skeletal maturity indicators, hand-wrist radiograph, peak growth velocity.

INTRODUCTION

Considerable variations in the development among children of the same chronological or calendar age had led to the concept of the biological or physiological age. Physiological age was the registry of the rate of progress toward maturity that can be estimated by somatic, sexual, dental and skeletal maturity.1-4 Skeletal maturation referred to the degree of development of ossification in bone.5

Assessing maturational status was of primary importance in the practice of clinical orthodontics. Maturational status could have considerable influence on diagnosis, treatment goals, treatment planning, and the eventual outcome of orthodontic treatment. Clinical decisions regarding use of extraoral traction forces, functional appliances, extraction versus nonextraction treatment, or orthognathic surgery were at least partially, based on growth considerations. Prediction of both the times and the amounts of active growth, especially in the craniofacial complex, would be useful to the orthodontist.6

Many investigators had established both positive and negative relationships between general body growth and areas of facial growth. A review of the literature demonstrated that the adolescent peak growth velocity in body height was closely related in timing to peak growth velocities in the facial dimension.7-11 Nanda9 and Bambha11 demonstrated that facial growth tended to lag only slightly behind general body growth in statural height during adolescence, and growth in body height was completed before growth of the face. On identifying different rates of growth within different craniofacial components, Nanda concluded, "the ortho-
odontist needs to adapt his methods of treatment to fit with and take advantage of these basic growth patterns."

Significant variation existed between individual children in the ages at which they attained similar developmental events. For example mean age at menarche among white participants was 12.7 years, and among black participants, 12.0 years. Puberty appears approximately a year earlier in Japanese girls than white girls. The children of Naze, Amami-Oshima Island (southern island in Japan) were advanced in skeletal maturity in relation to the British standard. In addition marked advanced carpal maturation was observed in girls compared with that of Western Kyushu children.

In 1942, Ito emphasis on environmental factors and reported that, in Japanese girls born and reared in California, menarchal age was more than 1.5 yr earlier than in Japanese girls born in California or Japan and reared in Japan. Hunter found that boys demonstrate a 4-year range of time for the onset of puberty, with a mean value of 12.8 years. In the female group, he identified a 5-year range of onset, with a mean value of 10.4 years. Therefore girls usually begin their adolescent period an average of 2.4 before boys. Tanner found that the annual height (stature) growth increments in children reached a plateau at 16 years in boys and 14 years in girls. Racial difference is observed in different events of maturation.

Skeletal maturity, perhaps the most commonly used index in routine clinical work, is closely related to sexual and somatic maturity. Girls who are skeletal advanced also menstruate early. Interrelationships between skeletal, somatic and sexual maturity have been shown to be consistently strong. Sexual maturation characteristics, chronological age, dental development, height, weight, and skeletal development were some of the more common means that had been used to identify stages of growth.

During growth, every bone went through a series of changes that could be seen radiographically. The sequence of changes was relatively consistent for a given bone in every person. The timing of the changes varies because each person had his or her own biologic clock. There were some exceptions, but generally speaking, the events were reproducible enough to provide a basis for comparison between different persons.

Various areas of the skeleton had been used: the foot, the ankle, the hip, the elbow, the hand-wrist, and the cervical vertebrae. One important diagnostic tool used in determining whether the pubertal growth started, was occurring, or had been finished was the hand-wrist radiographic evaluation.

Basically three common approaches had been used in the past to assess the hand-wrist radiographs. First was the atlas system involved the matching of a hand-wrist radiograph with a standard series of chronologically oriented radiographic images. A second assessment variation involved matching features of many individual bones and then assigning point scores to the stages revealed. Third method emphasized alteration in bony shapes and establishes ratios between linear measurements of the long bones of the hand and wrist; the grading of the indicators and ratios was then calculated to determine the skeletal age. Now a day's skeletal maturation system of Fishman was commonly used. This technique offers an organized and relatively simple approach to determine the level of maturation. According to Fishman maturational stage referred to the amount of progressive skeletal development that had occurred toward adulthood.

**MATERIALS AND METHODS**

This research was designed as a descriptive study. Study material consists of 100 subjects, 50 were males and 50 were females visiting orthodontic department of Children's Hospital & Institute of Child's Health Lahore. The age range of the subjects was 9-16 years. For equal distribution of girls and boys of all ages, three age groups of all patients were made. The sample was collected according to these groups. The three age groups were:

- **Group 1** Age range was 9-11 years. It included 15 male and 15 female.
- **Group 2** Age range was 11-14 years. It included 20 male and 20 female.
- **Group 3** Age range was 14-16 years. It included 15 male and 15 female.

Selection was performed after taking medical history. All subjects were Pakistani, well nourished, and free of any serious illness. The subjects had no previous history of trauma or injury to the hand and wrist region.
Radiograph of left hand and wrist were taken following parental consent.

**ASSESSMENT OF CHRONOLOGICAL AGE**

Exact chronological age of all participants was taken. Educated parents tell the exact date of birth of their children. Some parents didn't remember or confused in knowing the date of birth so they were asked to bring birth certificate for exact date of birth.

**ASSESSMENT OF SKELETAL MATURITY STAGES**

The skeletal maturation was based on the system of Fishman. This technique offered an organized and relatively simple approach to determine the level of maturation. The system used only 11 anatomical sites located on the phalanges, the adductor sesamoid, and the radius, all of which exhibit consistency in the time of onset of ossification. It was also an advantage to exclude the carpals from the system since irregularity in the order of onset of ossification occurs more frequently in the carpal than in the metacarpal or phalangeal epiphyses.

The adolescent skeletal maturity indicators (SMI 1 to 11) involved stages of development of specific phalanges, the adductor sesamoid of the thumb, and the radius bone. The adolescent period of development could be arbitrarily divided into periods of accelerating growth (SMI 1 to 3), high growth rate including peak velocity of growth (SMI 4 to 7), and decelerating growth (SMI 8 to 11).

The SMI stages were:

- SMI 1: Third finger, proximal phalanx, width of epiphysis as wide as or wider than diaphysis.
- SMI 2: Third finger, middle phalanx, width of epiphysis as wide as or wider than diaphysis.
- SMI 3: Fifth finger, width of epiphysis as wide as or wider than diaphysis.
- SMI 4: Ossification of adductor sesamoid of thumb.
- SMI 5: Third finger, distal phalanx, capping of both sides of epiphysis.
- SMI 6: Third finger, middle phalanx, capping of both sides of epiphysis.
- SMI 7: Fifth finger, middle phalanx, capping of both sides of epiphysis.
- SMI 8: Third fingers, distal phalanx, complete fusion.
- SMI 9: Third fingers, proximal phalanx, complete fusion.
- SMI 10: Third fingers, middle phalanx, complete fusion.
- SMI 11: Complete fusion of radius (skeletal growth completed).

To facilitate clear discrimination between the stages and to provide a good description relative to growth status, only 5 out of 11 skeletal maturity indicators used in the system were selected in the present study.

- MP3 (SMI 2): The middle phalanx of the third finger, the epiphysis equals its diaphysis.
- S stage (SMI 4): The first mineralization of the ulnar sesamoid bone.
- MP3CAP (SMI 6): The middle phalanx of the third finger, the epiphysis caps its diaphysis.
- DP3u (SMI 8): The distal phalanx of the third finger, complete epiphysis union.
- MP3u (SMI 10): The middle phalanx of the third finger, complete epiphysis union.

**RESULTS**

The present study was carried out on total number of 100 adolescents, comprising 50 males and 50 females with mean age 12.23 years with S.D of 2.33 years. (Table 2)

**DISTRIBUTION OF ADOLESCENTS ACCORDING TO SKELETAL MATURITY INDICATORS**

Out of the 100 adolescents 52 (52%) were in MP3 stage. 19(19%) subjects were in S stage. MP3CAP comprised 6 (6%) subjects. DP3u stage comprised 6 (6%) subjects and lastly MP3u had total of 17(17%) subjects. (Table 3)

**DISTRIBUTION OF SKELETAL MATURITY INDICATORS ON THE BASIS OF GENDER**

The MP3 stage included 32 males and 20 females.

The SMI stage S included 8 males 11 females and MP3CAP stage had 3 males 3 females. In DP3u stage 3
males 3 females were included. Lastly MP3U stage had 4 males and 13 females. (Fig 1)

MEAN CHRONOLOGICAL AGE OF MALES AND FEMALES AT DIFFERENT SKELETAL MATURITY INDICATOR

At SMI stage MP3 the mean chronological age of males was 10.97+1.33 years and that of females was 10.75+0.95 years. The difference of age between male and females was 0.22 years.

At SMI stages S and MPcap the mean chronological age of males was 13.96+1.37 years and that of females was 12.78+1.73 years. The difference age between male and females was 1.18 years.

Lastly at SMI stages DP3U and MP3U the mean chronological age of males was 15.56+0.39 years and that of females was 14.12+1.28 years. The difference age between male and females was 1.44 years. (Table 4)

MEAN CHRONOLOGICAL AGE OF MALES AND FEMALES AT ADOLESCENT PERIODS OF DEVELOPMENT

The mean chronological age of period of accelerating growth in males is 10.97+1.33 years and in females 10.75+0.95 years.

Peak growth rate in males is observed at years 13.69+1.37 and in females 12.76+1.73 years.

TABLE 1: DISTRIBUTION OF SUBJECTS (MALES AND FEMALES) IN THREE AGE GROUPS

<table>
<thead>
<tr>
<th>Age limit</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>9-11 Yrs</td>
<td>15</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>11-14 Yrs</td>
<td>20</td>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td>14-16 Yrs</td>
<td>15</td>
<td>15</td>
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</tr>
<tr>
<td>TOTAL</td>
<td>50</td>
<td>50</td>
<td>100</td>
</tr>
</tbody>
</table>

TABLE 2: PERCENT DISTRIBUTION OF GENDER WITH MEAN AGE AND STD. DEVIATION

<table>
<thead>
<tr>
<th>Gender</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>50</td>
<td>50.0</td>
</tr>
<tr>
<td>Female</td>
<td>50</td>
<td>50.0</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Mean Age, Std. Deviation. 12.23+2.33 years.

TABLE 3: PERCENTAGE DISTRIBUTION SKELETAL MATURITY INDICATORS

<table>
<thead>
<tr>
<th>Skeletal maturity indicators</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>MP3</td>
<td>52</td>
<td>52.0</td>
</tr>
<tr>
<td>S</td>
<td>19</td>
<td>19.0</td>
</tr>
<tr>
<td>MP3cap</td>
<td>6</td>
<td>6.0</td>
</tr>
<tr>
<td>DP3u</td>
<td>6</td>
<td>6.0</td>
</tr>
<tr>
<td>MP3u</td>
<td>17</td>
<td>17.0</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100.0</td>
</tr>
</tbody>
</table>

TABLE 4: MEAN CHRONOLOGICAL AGE AT RESPECTIVE SKELETAL MATURITY INDICATORSTAGE

<table>
<thead>
<tr>
<th>Skeletal maturity stages</th>
<th>Male mean age (years)</th>
<th>Female mean age (years)</th>
<th>Difference in age (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MP3</td>
<td>10.97+1.33</td>
<td>10.75+0.95</td>
<td>0.22</td>
</tr>
<tr>
<td>SMP3cap</td>
<td>13.96+1.37</td>
<td>12.78+1.73</td>
<td>1.18</td>
</tr>
<tr>
<td>DP3u MP3u</td>
<td>15.56+0.39</td>
<td>14.12+1.28</td>
<td>1.44</td>
</tr>
</tbody>
</table>

The decelerating growth period in males is seen at 15.56+0.39 years and in females at age 14.12+1.28 years.
DISCUSSION

The present study was carried out on 100 subjects (50 males and 50 females). Average age of the total sample subjects was 12.23 ±2.33 years with a range of 9-16 years.

The relationship between skeletal maturity and peak adolescent height velocity (PHV) was well established.30-35

According to Kopecky and Fishman,36 MP3 stage was accelerated stage, S and MP3eAp stages were peak growth stage, DP3U and MP, stages were decelerating stages. In our study the result showed that mean age of peak growth stage in males is 13.96 + 1.33 years and in females 12.78 +1.73 years. Females are advanced than males in attaining SMIs by a period of 1.18 years. The decelerating stages in males come at mean chronological age of 15.56 + 0.39 years and in females 14.12 + 1.28 years. So again females attain these SMIs earlier than males about duration of 1.44 years.

The chronological age of these periods of development might be used as a first level diagnostic tool to estimate the timing of the pubertal growth spurt. Ease of knowing age of patient by general dentist, orthodontic or pediatric dental practitioner helps them for attempting to assess a person's physiologic maturity without resorting to hand-wrist radiograph and other diagnostic tools.

The results explain that girls are advance and attain peak growth velocity 1.2 years earlier than boys. The difference of age becomes 1.44 years at decelerating stage showing boys accomplish the skeletal maturity slowly as compare to the girls. It means girls complete growth spurts quickly and mature earlier than males. In other words females grow for a shorter period of time than males during postnatal growth.37

Racial variation in the relationship has also been suggested. Abbassi38 concluded peak height velocity in American boys is 13.5 years and girls' 11.5 years. Pawloski39 found PHV in American girls 12 years. Belgian boy have PHV 13.5.40 Norwegian children” have PHV 12.2 in girls and 13.6 in boys. According to Hagg42 Swedish urban children have PHV in girls 12.0 and boys 14.1 years. Lindgren” on large Swedish urban children concluded PHV in girls 11.9 and in boys 14.0 years. From the present study we find that age of peak growth in our sample is higher than that of Americans. This result is supported by another study44, according to which bone age in Pakistan is lower than Americans around puberty. The difference of age in peak height velocity is due to socio-economical and regional factors. For example boys and girls on south of Sweden had spurt half a year later than children in middle Sweden. Other way Malian girls demonstrate a longer growth spurt than the American girls.39

In addition to constitutional differences in the timing of maturation, there were diseases, systemic disorders, and environmental factors that may affect a child’s physiologic maturity.45

The results of our study that represent age of high growth rate in our population, can help an orthodontists to take timely decision for having better orthopedic effect. Treatment rendered after this stage will result in more dental rather than skeletal effects.

Unfortunately, little is known of pubertal growth periods in Pakistani children and adolescent. The finding from this study may be used to establish a valid clinical tool for pubertal growth period in Pakistani adolescent.

CONCLUSIONS

The skeletal maturation among adolescent population was evaluated through hand-wrist radiographs. A total of 100 with mean age 12.23+ 2.33, were included in study.

The conclusions of the study are;

- The girls attain high growth rate at age 12.78+ 1.73 years.
- The males attain high growth rate at age 13.9+1.37 years.
- Girls are advance in skeletal maturity than males about by 1.2 years at peak growth velocity, and 1.44 year advance at decelerating stage of development. (Girls complete growth spurts quickly than males)

As seen from the discussion, the study may not be a representative of whole population and in view of this, further study should be conducted on a larger sample on the basis of socioeconomic status of the population.

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