Assessment of Applicability of Gleurich and Pyle (GP) Method for Determination of Age of Children in 14-18 Years Age-Group at S.M.S. Medical College, Jaipur

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Abstract

Background, Aim and Objective: Age estimation is also one of the important factors to establish individual's identity and radiological investigations play a phenomenal role in estimation of age in conjunction with clinical examination. The aim of this study to assess the applicability of Greulich and Pyle (GP) method for determination of age in 14-18 years of age group healthy population of Jaipur region. And objective is to assess the skeletal age determined by GP method using hand radiography of study population.

Method: This study was carried out on total 80 subjects at the Department of Forensic Medicine in association with the Department of Radiology after obtaining due permission and approval from the RRB and IEC of SMS Medical College, Jaipur during the period from 1st July, 2020 to 31st August, 2021 of subjects between 14-18 years of age. All subjects recruited from each age sub-group category viz 14-15 years (Group A), 15-16 years (Group B), 16-17 years (Group C) and 17-18 years (Group D) including equal number of members from both sexes (10 males and 10 females of each age sub group category). After obtaining valid informed consent for age estimation all details, general physical & dental examination was done and recorded in proposed Pro forma. The skeletal age (bone age) was determined using Greulich and Pyle Atlas (2nd edition, 1959). X-ray image on computer was compared with images on GP Atlas according to sex and most matching image to assess the skeletal age. Images were separated in two groups according to their sex and examined by both observers at different occasions to determine skeletal age of subjects and result derived.

Result: Among all (n=80), of 81.2% Hindus (34 males and 31 females), 12.5% Muslims (4 males and 6 females) and 6.25% Jains (2 males and 3 females). Correlation of estimated skeletal age by GP method to the chronological age in both females and males showed a strong positive correlation. (r value=0.987 (females) & 0.974 (males)) and for both p<0.001 which indicates that the correlation of estimated skeletal age and chronological age was statistically significant.

Conclusion: Study reveals skeletal age lagged behind chronological age in all age subgroups in both boys and girls but the difference of CA and SA is less in girls as compared to boys. The G-P atlas method, although very old but used with caution can yield good results for assessment of bone age in Indian boys and girls, better for

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Delay in skeletal maturation was observed in both males and females, but the females in the sample matured earlier than the males. Thus, G-P atlas method seems applicable on Indian children. However, studies on larger sample sizes considering other factors may yield better insight into its forensic application.

**Key Words:** Age Estimation, Greulich and Pyle (GP), Chronological Age (CA), Skeletal Age (SA)

**Introduction**

Forensic age estimation is a scientific process in forensic medicine which aims to determine in the most precise way possible, the chronological age of a person of an unknown or doubtful age involved in medical or legal proceedings such as unregistered children, asylum seekers, immigrants, marriage, sporting events and criminals. Various methods have been constructed and tested to estimate the age of young individuals. Among them are the physical examinations using anthropometric measurements, skeletal maturation, dental age estimation, a combination of dental development and anthropometric measurements and a combination of skeletal and tooth eruption. The essential components of age estimation are the history, physical and clinical examination, dental examination and radiological examinations ranging from plain X-rays to Computed Tomographic scans and ultrasonography films as per requirement of cases. Multiple methods are always used in combination for optimal accuracy.

Age estimation is also one of the important factors to establish individual’s identity and radiological investigations play a phenomenal role in estimation of age in conjunction with clinical examination. The aim of this study to assess the applicability of Greulich and Pyle (GP) method for determination of age in 14-18 years of age group healthy population of Jaipur region. And objective is to assess the skeletal age determined by GP method using hand radiography of study population.

Such age estimation examinations for legal/governmental purpose may be requested for any age group, but, the adolescents/ young adults are most frequently encountered issues in Forensic practice for reasons that this age range includes considerable milestones of medico-legal importance like the legal age of attainment of Majority, legal age for employment, legal age for consent, etc. The scientific basis of forensic age assessment in adolescents and young adults is the predetermined temporal progression of defined developmental stages of various characteristics that are identical for all people, such as physical development, skeletal maturation, and dental development. For age assessment, reference studies are used in which these defined developmental stages have been correlated with both the sex and the known age of the examined persons from a reference population.

The forensic application on the reliability of Greulich and Pyle method has been sparsely valuated over the globe including India although the method is utilized for determination of age. Thus, this study was undertaken to assess the reliability of Greulich and Pyle (GP) method for determination of age of children between 14-18 years to look for the prospect of its application in forensic practice to increase the reliability and accuracy of age estimation for legal opinions.

**Material and Method**

This study was conducted at the Department of Forensic Medicine & Toxicology in association with the Department of Radiology after obtaining due permission and approval from the Research Review Board and Institutional Ethics Committee of SMS Medical College and Attached Hospitals, Jaipur during the period from 1st July, 2020 to 31st August, 2021, on total of n=80 subjects between 14-18 years of age.

After obtaining informed consent for age estimation examination and participation in the study, all personal details and general physical examination and dental examination was done and recorded in proposed Proforma. At the time of examination of subjects their name, age, sex details were also recorded. Then X-rays (wrist, Elbow and Pelvis) were taken. The skeletal age (bone age) was determined using Greulich and Pyle Atlas (2nd edition, 1959). X-ray image on computer was compared with images on GP Atlas according to sex and most matching image to assess the skeletal
Images were separated in two groups according to their sex and examined by both observers at different occasions to determine skeletal age without disclosure of the chronological age of subjects and result derived.

The data so collected from 80 subjects was then subjected to statistical analysis using Epi info version 7.2.1.0 statistical software. The chronological age (CA), skeletal age as per GP method (SA) and their difference (CA-SA) were noted. The mean value and standard deviation (SD) of chronological age (CA), skeletal age (SA) and their difference (CA-SA) was calculated for each age group. Correlation Coefficient (r value) was deduced for correlating the estimated skeletal age by G-P method and chronological age to determine the relation between the two. p-value was determined using chi square test to know the significance of the results in age group of the study. Level of significance was kept at 95% to determine statistical significance. (p<0.05 as statistically significant). Bland Altman analysis was done to determine the difference between estimated skeletal age by G-P method and chronological age of both male and female study subjects.

**Observations and Discussion**

The present study included subjects of 14-18 years with equal number of subjects recruited from each age sub group category as shown in table no 1 viz 14-15 years (Group A), 15-16 years (Group B), 16-17 years (Group C) and 17-18 years (Group D) including equal number of members from both sexes (10 males and 10 females of each age sub group category). Patil ST, et al. (2012) and Tiwari PK, et al (2020) studied 1 day-19 years and 0-19 years age groups whereas Mohammed RB, et al (2015) studies 9-20 years age groups. However, there is a great difference in the sample size if the present study in comparison to other studies- 660 cases [Mohammed RB, et al (2015)] & 375 cases [Patil ST, et al (2012)]; but it is quite near to that of Tiwari PK, et al (2020) who studied on 100 cases. The study subjects in the present study were sub grouped according to their chronological ages in to four age subgroups.

**Table 1: Age & Gender wise distribution of study population**

<table>
<thead>
<tr>
<th>Group</th>
<th>Age Group (Years)</th>
<th>Minimum Age(years)</th>
<th>Maximum Age(years)</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>14-15</td>
<td>14.23</td>
<td>14.72</td>
<td>10</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>B</td>
<td>15-16</td>
<td>15.13</td>
<td>15.70</td>
<td>10</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>C</td>
<td>16-17</td>
<td>16.27</td>
<td>16.72</td>
<td>10</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>D</td>
<td>17-18</td>
<td>17.11</td>
<td>17.68</td>
<td>10</td>
<td>10</td>
<td>20</td>
</tr>
</tbody>
</table>

**Table 2: Gender wise comparison of mean weight (kg) of the study subjects of different age sub groups**

<table>
<thead>
<tr>
<th>Group</th>
<th>Group Age</th>
<th>Males Mean ± SD</th>
<th>Females Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>14-15</td>
<td>38.18 ± 1.79</td>
<td>44.1 ± 1.8</td>
</tr>
<tr>
<td>B</td>
<td>15-16</td>
<td>44.25 ± 1.96</td>
<td>50.08 ± 1.65</td>
</tr>
<tr>
<td>C</td>
<td>16-17</td>
<td>44.68 ± 1.8</td>
<td>52.95 ± 1.57</td>
</tr>
<tr>
<td>D</td>
<td>17-18</td>
<td>50.22 ± 7.28</td>
<td>58.45 ± 4.4</td>
</tr>
<tr>
<td>P value</td>
<td></td>
<td>&lt;0.001 (S)</td>
<td>&lt;0.001 (S)</td>
</tr>
</tbody>
</table>

Correlation of the study subjects of different age sub groups to mean weight for both genders was statistically significant for both genders. (P<0.001). (as shown in Table no.2)

This study showed that skeletal ages were delayed than the chronological ages in adolescent boys and adolescent girls (14-18 years) and the females in the study sample matured earlier than the
males. *Sheikh AH, et al. (1998)*\(^{15}\) determined skeletal age by Greulich-Pyle method in normal Pakistani children aged 8-18 years. On an average, the males were 1 year and the females were 0.5 years retarded from 8-15 years and from 8-13 years respectively. However, males after 15 years and females after 13 years (round about puberty and afterwards) were found advanced in their skeletal age indicating earlier maturity in Pakistani children as compared to western children. *Mora S, et al. (2001)*\(^{16}\) assessed the value of the Greulich and Pyle method in determining the skeletal ages of healthy American children of European (EA) and African (AA) descent born after the year 1980 aged between 0 to 19 year. Mean difference between skeletal and chronological age in pre-pubertal children of African descent was 0.09 ±/-. 0.66 year, while that in children of European descent was -0.17 ±/-. 0.67 year; \(t = 3.13; p = 0.0019\). Variations in skeletal maturation in prepubertal children were greater than those reflected in the Greulich and Pyle atlas.

**Conclusion**

The study concludes, skeletal age lagged behind chronological age in all age subgroups in both boys and girls but the difference of CA and SA is less in girls as compared to boys. The G-P atlas method is quite well correlated to skeletal age assessments in Indian boys and girls with mean difference of 3.87 months for girls and 7.14 months for boys. The G-P atlas method, although very old but used with caution can yield good results for assessment of bone age in Indian boys and girls, better for girls. Delay in skeletal maturation was observed in both males and females, but the females in the sample matured earlier then the males. Thus, G-P atlas method seems applicable on Indian children.

**Limitations of Study**

Resource constraints (time, availability of scans, budget) limited the total sample to 80 individuals. W.W. Greulich (1957)\(^{11}\) has stated that to derive age estimation standards a minimum of 1000 scans for each sex is required, evenly distributed by age group, although less can be used if the scans are from a longitudinal study.

Another potential limitation of this study is the lack of assessment of bilateral asymmetry. The radiographs used in this study were a mixture of left- and right-hand wrists, while the age estimation methods applied were designed for the left-hand wrist. There was a lack of radiographs of both hands obtained from the same individual at the same time for an assessment of asymmetry to be performed owing to the ethical barrier of higher exposure to harmful radiations to each particular individual belonging to the adolescent age groups.

**Ethical Clearance:** Taken from Institutional Ethical Committee of SMS Medical College, Jaipur

**Conflict of Intrest:** Nil

**Source of Funding:** Self

**References**


