ORIGINAL ARTICLE

BONE AGE DETERMINATION WITH GREULICH-PYLE METHOD IN 1 TO 20-YEAR-OLD PAKISTANI INDIVIDUALS; A REGIONAL STUDY

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ABSTRACT

Objective: To determine the correlation of mean Bone age (BA), estimated with Greulich-Pyle(GP) method, with Chronological age (CA) in Pakistani individuals.

Study Design: Cross-sectional study.

Place and Duration of Study: Department of Diagnostic Radiology, KRL General Hospital, Islamabad, 06 months (April to September 2017).

Methodology: A cross-sectional, observational study was done in Islamabad, comprising 250 individuals of both genders, selected through a non-probability consecutive sampling. Data were gathered on a prescribed proforma, and analysed by SPSS version 23.

Results: Total of 250 individuals participated in this study. Skeletal age (SA) was estimated by observation of hand-wrist radiographs, using the GP atlas. Pearson correlation showed a significant correlation of SA & CA ($r = 0.91$; p-value < 0.0005). Stratification analysis was performed. Pearson correlation was found to be positive and highly significant for different CAs, gender and ethnicity groups.

Conclusion: A positive correlation was found between GP atlas method in assessing SA and CA in the population of Pakistan. It can be used as quick, inexpensive and reliable method for SA estimation.

Key words: *Chronological age, Greulich-Pyle method, Skeletal age.*

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INTRODUCTION

Bone age (BA) indicates skeletal & biological maturity. This differs from the chronological age (CA), based on an individual's date of birth [1]. In Paediatric radiology, the BA assessment is a routine procedure. The BA is evaluated and compared with the CA based on the radiological analysis of the left wrist-hand skeletal development [2,3]. A difference between these two numbers implies improper bone development. The method is commonly used in the management and diagnosis of endocrine problems, and it can also act as an indicator of treatment efficacy [4,5]. In South Asia, over 50% of births are registered after 12 months, highlighting significant delays in birth registration [6]. The precise age estimation is crucial in any situation when a child's age must be accurately determined, such as for immigration, legal proceedings, and competitive sports. Skeletal age (SA) or BA is employed to offer the most accurate estimate of CA [7,8]. Although there are several ways to calculate BA, the Greulich-Pyle(GP) and Tanner-Whitehouse-II methods use radiographs (X-rays) of left hand and wrist for BA assessment [9,10]. Dr. William W Greulich and Dr. Sarah I Pyle created this atlas in 1959. The extent of ossification in different hand & wrist bones is compared, independently for children of both genders, with the closest matching GP Atlas plate to determine BA [11]. Numerous other techniques for evaluating BA are available, such as computerized ultrasonography and magnetic resonance imaging (MRI)[12,13,14,15]. In this study, we used the GP atlas method to assess BA among the Pakistani population. This method is quick, inexpensive, non-invasive and has proven useful in legal and clinical settings. Our objective was the determination of correlation between BA, estimated through the GP method, and CA. Establishing this

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correlation can help to reliably use the GP method for SA estimation, particularly in patients with various endocrine and metabolic disorders.

METHODOLOGY

A cross-sectional, descriptive study was undertaken in the Department of Diagnostic Radiology, KRL General Hospital, Islamabad, from April 2017 to September 2017. It comprised 250 individuals of both male and female genders by non-probability consecutive sampling. The subjects were within the CA range of 1 to 20 years. Individuals with any metabolic disorder confirmed through history and inspection of prior investigation and treatment records. History and inspection of prior investigation and treatment records were performed to exclude Individuals with any nutritional deficiency or with trauma to the wrist or hand. Ethical permission for research work was sought from the hospital. Parents of all children, adults themselves (above 18 years of age), consented to the study(informed consent). Skeletal age by the GP method was estimated by a consultant radiologist, blinded to the CA of the individuals. The consultant examined hand-wrist radiographs of the individual, using the GP atlas. Each radiographic image of the wrist/hand was gender-wise compared with images on the GP atlas, and the closest images were taken into account for SA.

Statistical Analysis: Data were analysed using SPSS 23. Quantitative variables, like CA and SA, were described as mean ± SD and the qualitative ones, like gender, as frequencies and percentages. The correlation coefficient was calculated and interpreted by using Pearson's correlation. Effect modifiers like gender and ethnicity were controlled (by stratification). Any p-value < 0.05 was significant.

RESULTS

The mean CA was 9.24±4.02 years, and the mean SA computed by GP method was 9.98±3.94 years as shown in Table 1. There were 128(51.2%) males and 122(48.8%) females. Major ethnicity was Punjabi. Pearson correlation was significant between SA and CA (r= 0.91; p-value 0.001) as shown in Figure1. Stratification analysis was performed. Pearson correlation was found to be positive and highly significant with respect to different CA, gender and ethnicity groups, as shown in Table 2, 3and 4 respectively.

Table 1: Descriptive statistics of groups

		CA (Years)	SA by GP method (Years)
Mean		9.24	9.98
95% Confidence Interval	**Lower Bound**	8.74	9.48
	Upper Bound	9.74	10.47
Median		8.90	9.20
Std. Deviation(SD)		4.02	3.94
Interquartile Range		6.0	5.8

Table 2: Correlation of CA and SA with respect to CA groups

CA Groups (Years)	n	[r]	p-value
1-5	36	0.874	0.001
6-10	118	0.673	0.001
>10	96	0.664	0.001

Table 3: Correlation of CA & SA for gender

Gender	n	[r]	p-value
Male	128	0.907	0.001
Female	122	0.917	0.001

Table 4: Correlation of CA & SA for ethnicity

Ethnicity	n	[r]	p-value
Urdu Speaking	44	0.865	0.001
Sindhi	72	0.975	0.001
Punjabi	126	0.866	0.001
Pathan	8	0.885	0.003

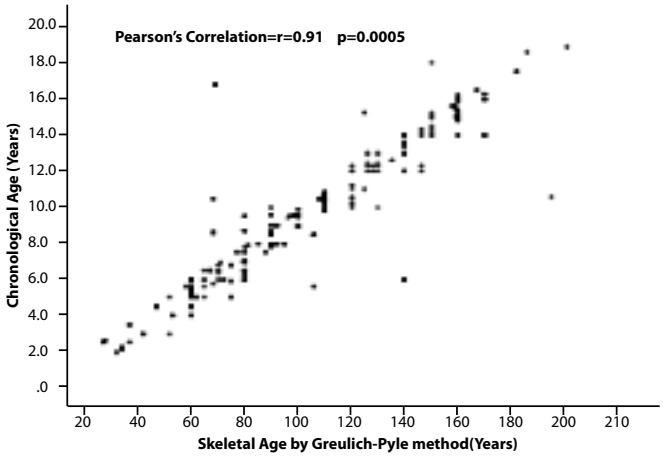

Figure1: Correlation of CA & SA estimated by GP method (n=250).

DISCUSSION

The calculation of BA is frequently used to evaluate childrens' bone growth status. Paediatricians utilise it to diagnose growth problems, for which serial measures are necessary while the patient is under treatment[16]. Moreover, it is required in medico-legal issues like court trials, sports and immigration, and to approximate CA in case of non-availability of a child's birth certificate [17,18,19]. Normal BA criteria ought to fairly depict CA for these reasons. Wrong estimation of BA can lead to unfair punishment, improper growth condition diagnosis & treatment, misplacement in school, or unfair advantages in sports. Different techniques are available to compute BA. In Pakistan, the most commonly used is the GP Atlas[20,1]. Dr. William W Greulich & Dr. Sarah I Pyle created GP Atlas in 1959 with the help of the information from the "Brush foundation study of human growth and development," (led by Professor Wingate Todd), and focused on Caucasian children from higher social stratum of the United States [21] Radiographic pictures of the left wrist and hand from birth to age 19 for men, and age 18 for women, are included for reference in the atlas. Its foundation is the sequential and fixed appearance of ossification centers in the hand and wrist bones. BA is calculated by comparing ossification in hand and wrist bones with the match on the GP Atlas, for males and females. The atlas's applicability varies around the globe because the children chosen for its creation belonged to a specific ethnic and social class. It is thought to calculate BA that is similar to CA in children from Western and Middle Eastern wealthy nations, but there are significant differences between the two in the children from developing nations like India and Iran [22,23,24,25,26,27]. Some studies from Pakistan have assessed the reliability of the GP Atlas. Recall bias may arise from the retrospective study design of one of them; the other has considered only older children (8 to 18 years of age) [11,26,27].

In our study, the mean CA was 9.24±4.02 years and the mean SA computed by the GP method was 9.98±3.94 years. The SA and CA were significantly correlated ($r = 0.91$; $P < 0.0005$) on Pearson correlation.

A recent cross-sectional study with the Egyptian children (aged 8–16 years) using the GP Atlas showed a mean overestimation of SA by 0.04 ± 0.86 years in boys, and a mean underestimation of 0.15 ± 1.32 years in girls, with average error margins slightly exceeding one year in both sexes [28]. A recent systematic review of 20,100 children across different ethnic groups evaluated the GP atlas and found that it overestimates BA in Asian and Arab adolescents and in African youth, highlighting the population-specific variability in skeletal maturation [29]. Other local and regional studies have also reported the reliability GP Atlas for BA assessment [30,31].

CAPSULE SUMMARY

Bone age (BA) indicates skeletal & biological maturity, and it differs from the chronological age (CA). The correlation of mean BA, estimated with the Greulich-Pyle(GP) method, with Chronological age (CA) was determined in Pakistani individuals. This correlation can help reliably use the GP method for SA estimation for various purposes. A strong positive correlation was found in this study.

Nang KM et al reported consistent underestimation with GP Atlas CA by 0.7 years in Sabah, Malaysia, with minimal errors, contrasting with findings from Australia, where males are ahead (by 0.4 years) and females are delayed (by 0.3 years) [32]. Another study in the Canary Islands validates the GP atlas for BA assessment, noting significant underestimation in preschool and school-age groups, while showing closer agreement in teenagers, particularly highlighting the differences between girls and boys [11]. However, statistically significant differences between means and SD of up to 01 year are reported between CA and BA of the Turkish children [33]. Insufficient literature is available on BA assessment in Pakistani children. Our findings agree with Yuh Ys et al, who found significant discrepancies in BA compared to CA for Taiwanese children, with boys showing delayed BA between 6-9 years and girls generally advanced between 7-15 years, differing from the GP standards [32].

CONCLUSION

A strong positive correlation is found between GP atlas method in assessing SA and CA in the population of Pakistan. We can reliably use it in SA estimation in various endocrine and metabolic disorders. This method is quick, inexpensive and non-invasive which provides valuable information in legal cases aswell.

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AUTHORS' CONTRIBUTION

- ***Sameeha Ismail:*** *Conception and design, Acquisition of data, Drafting the article*
- ***Maryam Amjad:*** *Acquisition of data*
- ***Muhammad Wasim Awan:*** *Acquisition of data*
- ***Rabia Waseem Butt:*** *Aanalysis and interpretation of data, Drafting the article*
- ***Muhammad Salman Khan:*** *Acquisition of data*
- ***Farkhanda Jabeen:*** *Acquisition of data, Aanalysis and interpretation of data, Critical revision*

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