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Bone Age Measurement in Pediatric Patients of Universitas Airlangga Hospital from January 2018 to December 2019

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ABSTRACT

Introduction: Bone age is an indicator of biological and skeletal maturity in individuals. The differences in chronological age and bone age can indicate abnormalities in bone development. This study aimed to determine the profile of bone age in pediatric patients at Universitas Airlangga Hospital and the relationship between bone ages examined using the Tanner Whitehouse II (TW2-20) method and their chronological ages.

Methods: This was a cross-sectional observational analytic study. Secondary data were collected from medical records and X-Ray examination results from Department of Radiology Universitas Airlangga Hospital (RSUA) Surabaya from January 2018 to December 2019. From the collected X-ray results, bone age was examined using the TW2-20 method. Then, a normality test was performed using the Shapiro-Wilk for data less than 50 samples. Data processing of the difference between bone age and chronological age was performed using the parametric paired T-test with a confidence level of 95%.

Results: 32 samples were obtained from pediatric patients undergoing X-ray examinations from January 2018 to December 2019. The average bone age difference in male patients was 0.64 years old with the highest average difference found in the age range of 9-11.99 years old. The average bone age difference in female patients was 1.1 years old with the highest average difference found in the age range of 12-14.99 years old. There was a significant difference between bone age calculated using the TW2-20 method and chronological age ($p < 0.001$).

Conclusion: Based on the comparison of the average bone age in pediatric patients and their chronological age, all samples showed deceleration of bone age in pediatric patients at RSUA. Based on the analytical study, the TW2-20 method was not suitable for the sample examined.

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Introduction

Bone age is an indicator of biological and skeletal maturity in individuals.[1] Unlike chronological age which is calculated based on the time of birth, age measurements using skeletal maturity of the hand do not correspond to body size, as do menarche, as well as growth hormone and thyroid hormone.[2] Therefore, bone age is used to diagnose endocrine disorders that result in growth deceleration and to estimate the status of future development.[3,4]

There are many factors that affect bone maturation,[5,6] including nutrition,[7] endocrine, genetic, and disease status.[8–11] These can affect bone growth, whether as acceleration or deceleration.[12]

Guidelines for measuring bone age that are often used today include the Greulich Pyle (GP) atlas and the Tanner Whitehouse II (TW2-20) method. GP atlas is measured from a population of Caucasian children with middle to upper economic status in Cleveland, Ohio, United States. Several studies concluded that GP atlas can be applied to the population under study. However, most questioned the accuracy of the GP method, especially in developing countries such as Turkey, Malawi, and South Africa.[13] Meanwhile, the TW-20 method used a population of children with an average socioeconomic in the United Kingdom. The TW2-20 method has been applied to a variety of samples from many countries.[14] It can be concluded that population and geographical differences affect maturation rates.[15] Therefore, further research is needed to develop specific "standards" for each population. Such standards will help the diagnosis and treatment of children with growth disorders.[16,17]

Universitas Airlangga Hospital (RSUA), one of the type B hospitals in Surabaya, is one of the hospitals that treat quite a lot of pediatric patients. However, the profile of the children's bone age at RSUA has never been reported. Therefore, this study aimed to give a representation of bone age from pediatric patients who were referred to Department of Radiology from January 2018 to December 2019 and to verify the accuracy of the use of the TW2-20 method for the samples studied.

Methods

This was a cross-sectional observational analytic study aimed to describe the profile of bone age in pediatric patients at RSUA. Secondary data were collected from medical records and X-ray examination results from Department of Radiology RSUA Surabaya from January 2018 to December 2019.

The population of this study was all pediatric patients at RSUA. The sample of this study was children aged 2 months to 18 years old that underwent X-ray examination from January 2018 to December 2019 at RSUA who met the inclusion and exclusion criteria. The sampling technique used in this study was total sampling from January 2018 to December 2019 at RSUA.

The inclusion criteria were as follows: a). The patient had performed a plain photo examination of the hand with the radius bone area to the phalanges from January 2018 to December 2019; b). Patients aged 2 months to 18 years old.

Meanwhile, the exclusion criteria were: a). Patients with incomplete or unreadable medical record data; b). Patients who used fixations or other assistive devices to cover the bone included in the ROI.

The instruments used in this study were digital medical records and plain X-rays of the patient's hands and wrists. Data taken from the medical records were age, gender, and disease status. From those characteristics, a descriptive analysis was performed to determine the general description of the sample and the presence of comorbidities.

From the collected X-ray results, bone age was examined using the TW2-20 method.[5] The examination was accompanied by a radiology expert who was the supervisor of this study. RadioAnt DICOM Viewer software was used to display X-ray files. In this study, the scoring of each bone was performed to determine the maturity scores of each bone consisting of 20 regions of interest as shown in Table 1 and 2. Then, the total maturity score obtained was converted to bone age according to the TW2-20 guidelines. Furthermore, the bone age presented in the form of age in years in decimal numbers was compared to the age of the patients that was also converted to a decimal number.

Table 1. TW2-20 bone maturity scores for boys

Bone	Boys							
	B	C	D	E	F	G	H	I
Radius	15	17	21	27	48	77	96	106
Ulna	22	26	30	39	56	73	84	X
1st Metacarpal	4	5	11	19	24	28	30	32
3rd Metacarpal	3	4	6	10	16	22	23	25
5th Metacarpal	3	3	6	12	17	21	23	25
Proximal Phalanx Thumb	4	5	8	15	23	28	30	32
Proximal Phalanx 3rd Finger	3	4	6	13	20	23	24	26
Proximal Phalanx 5th Finger	3	3	6	13	19	22	23	25
Mid Phalanx 3rd Finger	3	4	7	13	19	22	23	25
Mid Phalanx 5th Finger	4	4	8	14	19	21	22	23
Distal Phalanx of the Thumb	4	4	7	14	23	30	31	33
Distal Phalanx 3rd Finger	3	4	6	10	16	21	22	24
Distal Phalanx 5th finger	3	4	7	11	16	20	21	23
Capitate	60	62	65	71	79	89	116	X
Hamate	42	44	49	59	70	81	92	106
Triquetral	7	10	17	28	38	45	62	X
Lunate	10	13	20	27	36	44	60	X
Scaphoid	14	18	23	30	35	42	58	X
Trapezium	12	15	21	28	34	39	47	59
Trapezoid	14	16	20	23	32	39	56	X

Table 2. TW2-20 bone maturity scores for girls

Bone	Girls							
	B	C	D	E	F	G	H	I
Radius	17	19	25	33	54	85	99	106
Ulna	22	26	30	39	60	73	80	X
1st Metacarpal	5	6	11	18	24	29	31	33
3rd Metacarpal	3	5	7	11	17	23	24	26
5th Metacarpal	3	4	7	12	18	22	24	25
Proximal Phalanx Thumb	5	5	8	14	24	29	30	32
Proximal Phalanx 3rd Finger	4	4	7	13	20	24	25	26
Proximal Phalanx 5th Finger	4	4	7	13	19	23	24	25
Mid Phalanx 3rd Finger	4	4	7	13	20	23	24	25
Mid Phalanx 5th Finger	4	5	8	14	20	22	22	23
Distal Phalanx of the Thumb	5	5	8	15	24	31	32	34
Distal Phalanx 3rd Finger	3	4	6	10	17	22	23	24
Distal Phalanx 5th finger	3	4	7	11	17	21	22	23
Capitate	53	56	61	67	76	85	113	X
Hamate	44	47	53	64	74	85	97	109
Triquetral	8	12	19	28	36	46	63	X
Lunate	10	14	20	27	35	46	60	X
Scaphoid	13	17	23	29	36	44	57	X
Trapezium	12	14	20	25	32	39	49	59
Trapezoid	13	16	20	24	31	40	57	X

Statistical analysis was performed using IBM SPSS Statistic 23 software. From the obtained results, to determine data distribution, normality test was performed using Shapiro-Wilk for data less than 50. Normality test results obtained p value = 0.419, meaning the data was normally distributed. Therefore, the paired T-test with a confidence level of 95% was performed to determine the difference between the bone age examined using the TW2-20 method and the chronological age.

Results

The total sample studied was 32 medical records and X-ray examination results.

Table 3. General characteristics of samples

Total		Male	Female
		17	15
Age (years old)	0-2.99	2	2
	3-5.99	1	2
	6-8.99	3	0
	9-11.99	1	4
	12-14.99	4	3
	15-17.99	6	4
History of Illness	Unknown	1	1
	Open Trauma	6	2
	Fracture	7	4
	Open Fracture	1	4
	Snake Bite	1	
	Syndactyl	1	
	Corpus Alienum		1
	Joint effusion		1
	Tumor		1
	Flexion contraction		1

General characteristics consisting of age, gender, and history of the illness were analyzed using descriptive analytic. The proportions of the gender of the pediatric patients who did a plain photo examination of the hand at RSUA were 54.5% male (17 patients) and 45.4% female (15 patients). The highest proportion of age according to the gender of the the pediatric patients who underwent X-ray radiographic examination of the hand in RSUA was males aged 15-17.99 years old as many as 6 patients (35.2%) and females aged 9-11.9 years old and 15 -17.99 years old as many as 4 patients (26.6%). Based on the history of the disease in each gender group, the highest percentage in males was fracture, which was 7 patients (41.1%), and in females, fractures and open fractures had the same percentage, which was 4 patients (26.6 %).

From the hand X-ray examination results, quantitative bone age was examined using the TW2-20. The results of examined bone age and comparison with chronological age are presented in graphical form in Figure 1 and Figure 2.

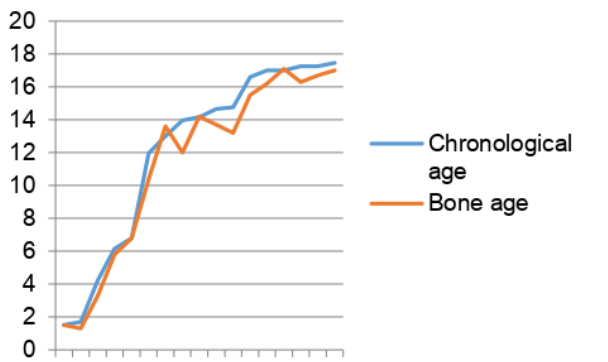

Figure 1. The comparison between chronological age and bone age in male patients

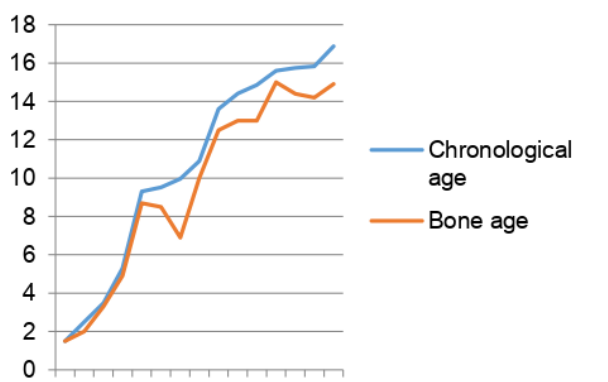

Figure 2. The comparison between chronological age and bone age in female patients

The examined bone age was then calculated by the difference in chronological age. This was performed to determine the existence of acceleration or deceleration of bone age.

Table 4. Numbers of pediatric patients with accelerated and decelerated bone age

	Acceleration	Deceleration	Normal
Males	3	14	
Females		14	1

From the obtained data, it was found deceleration or bone age less than chronological age in 15 patients (83%) of all male patients and 14 patients (93%) of all female patients; acceleration or bone age exceeding chronological age in 3 patients (17%) of all male patients; and normal bone age was or in line with chronological age in 1 patient (7%) of all female patients. Sample grouping was performed based on age range. It aimed to determine at what age range occurred the most significant bone age differences.

Table 5. Grouping by age range in male patients

No.	Age Group	Number	Mean Chronological Age (years old)	Mean Bone Age (years old)	Difference (years old)
1	0-2.99	2	1.61	1.4	0.21
2	3-5.99	1	4.23	3.3	0.93
3	6- 8.99	2	6.48	6.3	0.18
4	9-11.99	1	11.96	10.4	1.56
5	12-14.99	5	14.11	13.34	0.77
6	15-17.99	6	17.09	16.49	0.6
Mean difference in bone age					0.64

From Table 3, it can be seen that the highest bone age differences were found in the 9-11.99 years old age range. From the overall bone age calculation in male patients, the bone age difference was 0.64 years slower than the chronological age.

Table 6. Grouping by age range in female patients

No.	Age Group	Number	Mean Chronological Age (years old)	Mean Bone Age (years old)	Difference (years old)
1	0-2.99	2	2	1.75	0.25
2	3-5.99	2	4.39	4.1	0.29
3	6- 8.99	0	-	-	-
4	9-11.99	4	9.91	8.53	1.38
5	12-14.99	3	14.29	12.83	1.46
6	15-17.99	4	16.01	14.63	1.38
Mean difference in bone age					1.10

From Table 4, it can be seen that the highest bone age differences were found in the 12-14.99 years old age range. From the overall calculation of bone age in female patients, the difference in bone age was 1.1 years slower than chronological age.

The comparison of bone age and chronological age was performed by statistical tests. First, the Shapiro-Wilk normality test was performed for the amount of data less than 50. From this test, Sig = 0.419 was obtained. Thus, it was concluded that the data were normally distributed. After the normality test was performed, it is known that the data was normally distributed to the paired T-test. From the paired T-test, $p < 0.001$ was obtained.

Discussion

Profile of Bone Age of Pediatric Patients

This study aimed to determine the profile of bone age in pediatric patients. The instrument used was digital X-ray[18] data of patients who underwent X-ray examinations the hand. The position used in this study was Antero-Posterior (AP). This is opposite to the ideal position for doing wrist assessment which was Postero-Anterior.[19] However, the AP position was chosen because there were more medical records using this position.

Bone age examinations were performed by using the TW2-20 method. Afterwards, the difference between bone age and chronological age was calculated to determine whether there was an acceleration or deceleration in bone age. The acceleration or deceleration of bone age might indicate growth abnormalities.[12] In this study, it was concluded that there was a deceleration in bone age in 14 patients (82.3%) of all male patients, as well as acceleration in 3 patients (17.6%) of all male patients; bone age deceleration in 14 patients (93.3%) of all female patients; and normal bone age or aligned with chronological age was found in 1 patient (6.7%) of all female patients.The cause of the acceleration and deceleration of bone age was unknown because it was not examined in this study.

Sample grouping was performed based on the age range of 3 years. This age range was used because it is considered the most representative in the range of age, number, and distribution of the sample. In studies with more evenly distributed sample sizes and distributions, a smaller age range, such as in the Korean study[2] with 5400 samples used, was 2-3 months, and in Thailand[20] with 200 samples used was 1 year. Based on the age range, the most significant difference in bone age and chronological age in male patients was at the age of 9-11.99 years old, while in female patients was at the age of 12-14.99 years old. The limited number of samples made it difficult to generalize in this study. This is because not all age ranges had the same number of samples.

Comparison between Bone Age and Chronological Age

A paired T-test was performed to determine the relationship between bone age as measured by the TW2-20 method and the chronological age of the patient. Based on this test, a p-value < 0.001 was obtained, meaning that there was a significant difference between chronological age and bone age. Therefore, this guideline is not suitable to be applied to the sample under study. This is in line with a previous study conducted at Chulalongkorn University in Thailand which showed a significant difference between bone age and chronological age.[20]

Conclusion

Based on the comparison of the average bone age in pediatric patients and their chronological age, there was a deceleration of bone age in pediatric patients at RSUA.

There was a significant difference between bone age examined by the TW2-20 method and chronological age. Therefore, this method is not suitable to be applied to the sample studied.

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Conflict of Interest

The authors declared there is no conflict of interest.

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