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Correlation of the Ossification Present in Hand-Wrist Bone Radiography with Chronological Age in Students of the Elementary School Federico Stallforth in Parral, Chihuaha

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Abstract

Objective: *Test the hypothesis that there is a relationship between the ossification of the bones of the hand and wrist with chronological age.*

Material and methods: *The collection of hand and wrist radiographs were obtained from children between 6 and 13 years old, of both genders. The study was longitudinal for two years, two x-rays of the left hand and wrist were taken; one at the beginning of the study and the other one a year later. The radiographs were taken in the same device and by a single observer. Bone maturation was measured according to Björk's Analysis through 9 stages.*

Results: *It was found that the Chi-square value (61.09) and the significance of P = 0.000 indicate that there is a high dependence between bone age and gender and the Chi-square value (73.16) and the significance of P = 0.000 indicate that there was a high dependence between bone age and gender for 2008. According to the Wilcoxon test, it was found that the Z value (9.60) and the significance P= (0.000), indicate that there was a high significant difference between the stages for women. The Z value (9.51) and significance (0.000) indicate that there was a high significant difference between the stages for men.*

Conclusion: *It was concluded that chronological age was highly related to bone age since in the second x-ray taken the following year, all children had a change from 1 to 2 stages. Girls grew faster than boys, a small percentage had already finished growing by the age of 12.5, while boys were about to enter their growth peak.*

Keywords: Bone, Radiography, Chronological, Age

Introduction

The main tool currently used to determine when pubertal growth has begun, is occurring or has ended is the assessment of wrist and hand x-rays. Due to individual variation in timing, duration, and speed of growth, determining maturation and subsequently evaluating growth potential during pre-adolescence and adolescence is extremely important, since in most orthodontic patients' growth pubertal needs to be added to the diagnostic equation.

The maturation of sexual characteristics, chronological age, dental and skeletal development, height and weight are some of the most commonly used terms to identify the stages of growth of the individual.

Growth and maturation in human beings is the result of the genetic-environmental interrelationship, which determines that in the general population there are children with different rates of growth and maturation.

The true biological age of an individual during growth can only be obtained from its bone age, and estimated from the neonatal period to the end of growth. Growth is not only understood as the increase in height, but also all changes in body proportions, and the bone, visceral, biochemical and neuropsychic maturation of the child. It is an evolutionary phenomenon from the beginning of intrauterine life to the end of adolescence.

There are so-called critical periods that correspond to moments of maximum growth in the size and number of cells, in which the organism is much more vulnerable if any alteration occurs.

The assessment of bone age results from the analysis of an x-ray of the wrist and hand, which indicates whether there is advance or delay in maturation, and if this is normal for the reference population. Likewise, it is important in the prediction of adult height, which together with the height of the child or adolescent and the genetic potential in height of both parents, allows the normal variants of growth and maturation to be characterized, and is useful to the health professional. health to differentiate them from pathological variants.

In practice, the wrist and hand are the most convenient areas to assess bone maturation because there are ossification centers there that provide great information for growth and development.

In this study, the relationship between bone maturation and biological age in children between 6 and 13 years of age was analyzed through an x-ray of the hand and wrist that was taken periodically. This will help identify the stage of bone maturation. the child is found.

Materials and Methods

The compilation of hand and wrist x-rays was obtained from children between 6 and 13 years of age at the Federico Stall forth 2102 primary school of both genders, located in Parral, Chihuahua. All radiographs were taken in a single radiology cabinet and one technician.

The exclusion criteria were children who present any syndrome, children with hormonal and metabolic problems.

Children who changed schools were taken as the elimination criterion.

The sample was taken in a single stage. Talks were given periodically in schools, brushing techniques were strengthened, and fluoride application was strengthened as a method to lose the minimum number of individuals during the study.

The sampling was non-random (by accident), the total number of cases selected was 224 hand and wrist x-rays of patients who met the inclusion criteria. With this, the relationship between chronological age and bone age was determined.

The study was longitudinal for 2 years, 2 x-rays of the left hand and wrist were taken; one at the beginning of the study and the other one year later; The radiographs were taken in the same device and by a single observer. Bone maturation was measured according to Bjork's Analysis through 9 stages.

The stage in which each child was (1-9) was obtained in patients (female, male) to compare bone age with chronological age and the difference between boys and girls [1-9].

The population was divided into two strata: Female and Male. The variables that were captured were: ages from 6 to 13 years, Gender (male, female), Time 1, Stage, Time 2, Stage that served to determine which stage each child was in. Bone stages were observed (hand and wrist x-ray), ages and genders were taken through the medical history with non-parametric techniques.

To determine the degree of evolution of the stages, the Wilcoxon test was applied to all individuals, by gender and age.

A number was assigned to each of the genders (Female 1, Male 2), to differentiate between the first and the second x-ray taking (age 1, age 2, stage 1, stage 2). The degree of dependence and association between the variables (age vs. gender) and (stage vs. gender) was determined through a statistical analysis that was based on contingency tables. (Table 1,2,4 and 6) 10-20].

Results

as a result of the hand and wrist 13 years old who attended Federico Stall forth Primary School 2102.

of the total x-rays observed, the most frequent ages were 8, 9 and 10 years with a total of 99 x-rays, 7 and 11 years with a total of 48 x-rays, 8.5 and 10.5 years with a total of 34 x-rays, 9.5 and 6 years of age with a total of 25 x-rays, 6.5 and 7.5 years with a total of 17 x-rays, 12.5 years with a total of 1 x-ray. (Table 1) [30-35].

Table1: Age 1 Genus Crosstabulation

			Genero		Total
			Mujer	Hombre	
Edad1	6.0	Count	6	3	3
		% within Edad1	66.7%	33.3%	100.0%
		% within Genero	5.2%	2.8%	4.0%
		% of Total	2.7%	1.3%	4.0%
	6.5	Count	5	4	9
		% within Edad1	55.6%	44.4%	100.0%
		% within Genero	4.3%	3.7%	4.0%
		% of Total	2.2%	1.8%	4.0%
	7.0	Count	14	10	24
		% within Edad1	58.3%	41.7%	100.0%
		% within Genero	12.1%	9.3%	10.7%

		% of Total	6.3%	4.5%	10.7%
	7.5	Count	4	4	8
		% within Edad1	50.0%	50.0%	100.0%
		% within Genero	3.4%	3.7%	3.6%
		% of Total	1.8%	1.8%	3.6%
	8.0	Count	6	20	26
		% within Edad1	23.1%	76.9%	100.0%
		% within Genero	5.2%	18.5%	11.8%
		% of Total	2.7%	8.9%	11.6%
	8.5	Count	8	9	17
		% within Edad1	47.1%	52.9%	100.0%
		% within Genero	6.9%	8.3%	7.6%
		% of Total	3.6%	4.0%	7.6%
	9.0	Count	23	20	43
		% within Edad1	53.5%	46.5%	100.0%
		% within Genero	19.8%	18.5%	19.2%
		% of Total	10.3%	8.9%	19.2%
	9.5	Count	10	6	16
		% within Edad1	62.5%	37.5%	100.0%
		% within Genero	8.6%	5.6%	7.1%
		% of Total	4.5%	2.7%	7.1%
	10.0	Count	16	14	30
		% within Edad1	53.3%	46.7%	100.0%
		% within Genero	13.8%	13.0%	13.4%
		% of Total	7.1%	6.3%	13.4%
	10.5	Count	7	10	17
		% within Edad1	41.2%	58.8%	100.0%
		% within Genero	6.0%	9.3%	7.6%
		% of Total	3.1%	4.5%	7.6%
	11.0	Count	16	8	24
		% within Edad1	66.7%	33.3%	100.0%
		% within Genero	13.8%	7.4%	10.7%
		% of Total	7.1%	3.6%	10.7%
	11.5	Count	1	0	1
		% within Edad1	100.0%	.0%	100.0%
		% within Genero	.9%	.0%	4%
		% of Total	4%	.0%	4%
		Count	116	108	224
Total		% within Edad1	51.8%	48.2%	100.0%
		% within Genero	100.0%	100.0%	100.0%
		% of Total	51.8%	48.2%	100.0%

it was found in this study that the maximum age was 12.5 years, the minimum age was 6 years with a standard deviation of 1.26 in the first X-ray shot and 1.45 in the second shot, an average of 2.32 in the first shot and 3.35 in the second take. (Table 2).

Age 2* Genus Crosstabulation

			Genero		Total
			Mujer	Hombre	
Edad2	7.0	Count	6	3	3
		% within Edad1	66.7%	33.3%	100.0%
		% within Genero	5.2%	2.8%	4.0%
		% of Total	2.7%	1.3%	4.0%
	7.5	Count	5	4	9
		% within Edad1	55.6%	44.4%	100.0%
		% within Genero	4.3%	3.7%	4.0%
		% of Total	2.2%	1.8%	4.0%
	8.0	Count	14	10	24
		% within Edad1	58.3%	41.7%	100.0%
		% within Genero	12.1%	9.3%	10.7%
		% of Total	6.3%	4.5%	10.7%
	8.5	Count	4	4	8
		% within Edad1	50.0%	50.0%	100.0%
		% within Genero	3.4%	3.7%	3.6%
		% of Total	1.8%	1.8%	3.6%
	9.0	Count	6	20	26
		% within Edad1	23.1%	76.9%	100.0%
		% within Genero	5.2%	18.5%	11.8%
		% of Total	2.7%	8.9%	11.6%
	9.5	Count	8	9	17
		% within Edad1	47.1%	52.9%	100.0%
		% within Genero	6.9%	8.3%	7.6%
		% of Total	3.6%	4.0%	7.6%
	10.0	Count	23	20	43
		% within Edad1	53.5%	46.5%	100.0%
		% within Genero	19.8%	18.5%	19.2%
		% of Total	10.3%	8.9%	19.2%
	10.5	Count	10	6	16
		% within Edad1	62.5%	37.5%	100.0%
		% within Genero	8.6%	5.6%	7.1%
		% of Total	4.5%	2.7%	7.1%
	11.0	Count	16	14	30
		% within Edad1	53.3%	46.7%	100.0%
		% within Genero	13.8%	13.0%	13.4%
		% of Total	7.1%	6.3%	13.4%
	11.5	Count	7	10	17
		% within Edad1	41.2%	58.8%	100.0%
		% within Genero	6.0%	9.3%	7.6%
		% of Total	3.1%	4.5%	7.6%
	12.0	Count	16	8	24
		% within Edad1	66.7%	33.3%	100.0%
		% within Genero	13.8%	7.4%	10.7%
		% of Total	7.1%	3.6%	10.7%
	12.5	Count	1	0	1
		% within Edad1	100.0%	.0%	100.0%
		% within Genero	.9%	.0%	4%
		% of Total	4%	.0%	4%
Total		Count	116	108	224
		% within Edad1	51.8%	48.2%	100.0%
		% within Genero	100.0%	100.0%	100.0%
		% of Total	51.8%	48.2%	100.0%

Table 2: The Chi-square value (73.16) and the significance of =0.000 indicate that there is a high dependence between bone age and gender.

Genero Mujer		Edad1	Edad2
Mujer	N	116	116
	Mean	8.927	9.927
	Std. Deviation	1.5098	1.5098
Hombre	N	108	108
	Mean	8.801	9.801
	Std. Deviation	1.3289	1.3289
Total	N	224	224
	Mean	8.866	9.866
	Std. Deviation	1.4237	1.4237

Table 3: Genero Crosstabullation

			Genero		Total
			Mujer	Hombre	
Estadio 1	1	Count	15	49	64
		% within Estadio1	23.4%	76.6%	100.0%
		% within Genero	12.9%	45.4%	28.6%
		% of Total	6.7%	21.9%	28.6%
	2	Count	36	48	84
		% within Estadio1	42.9%	57.1%	100.0%
		% within Genero	31.0%	44.4%	37.5%
		% of Total	16.1%	21.4%	37.5%
	3	Count	27	9	36
		% within Estadio1	75.0%	25.0%	100.0%
		% within Genero	23.3%	8.3%	16.1%
		% of Total	12.1%	4.0%	16.1%
	4	Count	25	1	26
		% within Estadio1	96.2%	3.8%	100.0%
		% within Genero	21.6%	.9%	11.6%
		% of Total	11.2%	.4%	11.6%
	5	Count	10	1	11
		% within Estadio1	90.9%	9.1%	100.0%
		% within Genero	100.0%	.9%	4.9%
		% of Total	4.5%	.4%	4.9%
	7	Count	3	0	3
		% within Estadio1	100.0%	.0%	.0%
		% within Genero	2.6%	.0%	1.3%
		% of Total	1.3%	.0%	1.3%
Total		Count	116	108	224
		% within Estadio1	51.8%	48.2%	100.0%
		% within Genero	100.0%	100.0%	100.0%
		% of Total	51.8%	48.2%	100.0%

When comparing gender with chronological age at the first x-ray, it was found that 15 girls and 49 boys were in stage 1, 36 girls and 48 boys in stage 2, 27 girls and 9 boys in stage 3, 25 girls and 1 boy in stage 4, 10 girls and 1 boy in stage 5, 3 girls in stage 7. (Table 4) [36-40].

Table 4: Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	61.086a	5	.000
Likelihood Ratio	70.151	5	.000
Linear-by-Linear Association	54.609	1	.000
N of Valid Cases	224		

When comparing gender with chronological age in the second x-ray, it was found that 1 girl and 1 boy were in stage 1, 10 girls and 56 boys in stage 2, 46 girls and 42 boys in stage 3, 16 girls and 7 boys in stage 4, 26 girls and 1 boy in stage 5, 6 girls in stage 6, 8 girls and 1 boy in stage 7, 1 girl in stage 8 and 2 girls in stage 9. (Table 5).

Table 5: The Chi-square value (61-09) and the significance of =0.000 indicate that there is a high dependence between bone age and gender.

			Genero		Total
			Mujer	Hombre	
Estadio 2	1	Count	1	1	2
		% within Estadio2	50.0%	50.0%	50.0%
		% within Genero	.9%	9%	9%
		% of Total	4%	4%	9%
	2	Count	10	58	66
		% within Estadio2	15.2%	84.8%	100.0%
		% within Genero	8.6%	51.9%	51.9%
		% of Total	4.5%	25.0%	29.5%
	3	Count	46	42	88
		% within Estadio2	52.3%	47.7%	100.0%
		% within Genero	39.7%	38.9%	39.3%
		% of Total	39.3%	18.8%	39.3%
	4	Count	16	7	23
		% within Estadio2	69.6%	30.4%	100.0%
		% within Genero	100.0%	6.5%	10.3%
		% of Total	7.1%	3.1%	3.1%
	5	Count	26	1	27
		% within Estadio2	96.3%	3.7%	100.0%
		% within Genero	22.4%	9%	12.1%
		% of Total	11.6%	4%	12.1%
	6	Count	6	0	6
		% within Estadio2	100.0%	0%	100.0%
		% within Genero	5.2%	0%	2.7%
		% of Total	2.7%	0%	2.7%
	7	Count	8	1	9
		% within Estadio2	88.9%	11.1%	100.0%
		% within Genero	8.9%	9%	4.0%
		% of Total	3.6%	4%	4.0%
	8	Count	1	0	1
		% within Estadio2	100.0%	.9%	4%
		% within Genero	1	0	1
		% of Total	100.0%	.9%	4%
	9	Count	2	0	2
		% within Estadio2	100.0%	0	100.0%
		% within Genero	1.7%	0	.9%
		% of Total	9%	0	9%
Total		Count	116	108	224
		% within Estadio2	51.8%	48.2%	100,0%
		% within Genero	100.0%	100,0%	100,0%
		% of Total	51.8%	48.2%	100,0%

it was found that the Chi-square value (61.09) and the significance of P = 0.000 indicate that there is a high dependence between bone age and gender for 2007. (Table 6). And that the Chi-square value (73.16) and the significance of P = 0.000, indicate that there is a high dependence between bone age and gender for 2008. (Table 7) [41-45].

Table 6: Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	73.164[a]	8	.000
Likelihood Ratio	86.416	8	.000
Linear-by-Linear Association	57.543	1	.000
N of Valid Cases	224		

Table 7: The Chi-square value (73.16) and the significance of =0.000 indicate that there is a high dependence between bone age and gender.

Genero		Estadio1	Estadio2
Mujer	N	116	116
	Mean	2.92	4.06
	Std. Deviation	1.346	1.568
Hombre	N	108	108
	Mean	1.68	2.58
	Std. Deviation	.747	.799
Total	N	224	224
	Mean	2.32	3.35
	Std. Deviation	1.261	1.456

According to the Wilcoxon test, it was found that the Z value (9.60) and the significance P= (0.000) indicate that there is a high significant difference between the stages (bone age of 2007 and 2008) for women. (Table 8). The Z value (9.51) and significance (0.000) indicate that there is a high significant difference between the stages (bone age) for men. (Table 9).

Table 8: Wilcoxon: Estadio1 vs Estadio2 (mujeres)[b]

	Estadio2 - Estadio 1
Z Asymp. Sig. (2-tailed)	-9.599a .000

Table 9: The Z value (9.60) and significance (0.000) indicate that there is a high significant difference between the stages for women.
Wilcoxon: Estadio1 vs Estadio2

	Estadio2 - Estadio 1
Z Asymp. Sig. (2-tailed)	-9.508* .000

The Z value (9.51) and significance (0.000) indicate that there is a high significant difference between the stages for men.

The final result was obtained that bone maturation is closely related to chronological age and that girls grow faster than boys in the students of the Federico Stall forth school in Parral Chihuahua.

Discussion

Currently, one of the most necessary tools to determine when pubertal growth has begun, is occurring or has ended, is the assessment of wrist and hand x-rays [46-50].

This study coincides with that done by Greulich and Pyle 17 in which they demonstrated that during growth each bone goes through a series of changes that can be seen radiographically, that the sequence of these changes is relatively consistent for each bone in each person, and that the time of the changes varies due to the "biological clock" of each individual.

To obtain the objective of this study, a pair of hand x-rays of the wrist were required since, like Leite 16, different areas have been examined, such as the wrist and hand, the elbow, the shoulder, the knee, the foot and the cervical vertebrae. Of these areas, the most complete are the wrist, hand and foot, due to the diversity of growth centers they have. The standards we traditionally use are wrist and hand, because there are fewer overlapping structures than in standing radiography [51-54].

In the same way as in the present study, Ceglia 6 carried out a study with 10,313 x-rays of the left wrist and hand, of children and young people up to 19 years of age and all social strata, it turned out that girls from high and middle social strata urban areas have more advanced bone maturation.

The study carried out by García, Torre, Flores and Rea 28in which they used lateral skull x-rays and hand and wrist x-rays to assess the growth of an individual in 113 patients between 9 and 18 years of age coincided with this study since it was found that there is no significant difference between the assessment of cervical vertebrae and that of the hand and wrist.

In this study, as in the study by Velásques and Correa 48n, it was concluded that physical growth indicators are useful parameters for an adequate diagnosis and it is important to take advantage of the maximum growth peak to achieve the best results in orthodontics and pediatric dentistry.

This study coincides with that done by Soegiharto, Cunningham and Moles 33 in which they demonstrated that there is a significant difference in the growth of individuals of different races. Skeletal maturation was compared in Indonesian children and white children by means of hand and wrist and lateral skull radiography, the result confirmed that white children grow 6 months to 1 year earlier than Indonesian children. These differences must be considered when planning orthodontic diagnosis and treatment.

Conclusions

In the study carried out on 224 children from the Federico Stallforth 2102 primary school in Parral, Chihuahua, of which 116 were girls and 108 boys between 6 and 13 years of age, it was concluded that chronological age was highly related to bone age, since that in the second x-ray taken the following year, all the children had a change of 1 to 2 stages.

Girls grew faster than boys, a small percentage had already finished growing by the age of 12.5, while boys were about to enter their growth peak.

Therefore, we conclude that the hand and wrist x-ray is a great aid to determine what stage of growth a child is in and thus be able to intervene to redirect it, giving our patients a better alternative and orthodontic treatment.

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