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ORIGINAL RESEARCH

Comparative Analysis between Three Methods of Bone Estimating Age in Individuals with Down Syndrome by Mode of the Hand and Wrist Ray

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ABSTRACT

The wrist and hand region has been the most commonly used for estimating age and osseous development due to the great number of ossification centers. The aim was to determine which method, Tanner & Whitehouse's (TW3), Greulich & Pyle's (GP) or Eklof & Ringertz's, more closely relates to the chronological age in subjects with Down syndrome with chronological ages between 61 and 180 months, using wrist and hand radiographs. The sample consisted of 85 radiographs, 52 of males and 33 of females. Eklof & Ringertz's method was computerized (Radiomemory). Greulich & Pyle's atlas was used and compared with the wrist and hand radiographs. For the TW3 method, 13 ossification centers were evaluated; for each one of them, there are seven or eight development stages to which scores are assigned; these scores are then added and the results are transformed into osseous age values. No statistically significant differences were observed between the male and female genders for methods TW3 and GP, contrasting with the observed differences for the Eklof & Ringertz method. Correlation (r^2) between osseous and chronological ages was 0.8262 for TW3 and 0.7965 for GP, while for the method of Eklof & Ringertz, it was 0.7656 for females and 0.8353 for males. The author concluded that the osseous age assessment method that better related to the chronological age was the TW3, followed by Greulich & Pyle's and Eklof & Ringertz's.

Keywords: Down syndrome, Hand bones, Age determination by skeleton, Bone development, Hand, Wrist, Radiography.

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INTRODUCTION

Hand and wrist are the most widely used region to estimate age and bone development due to the large amount of ossification centers. The methods of Greulich and Pyle,[7] Tanner and Whitehouse, Fels. Moreover, Moraes[11] are frequently used techniques to estimate skeletal age. These authors performed a comparative study to verify the fidelity of some development indicators and showed that dental and bone age, respectively, are the most indicated methods to estimate chronological age. There are few studies that evaluated bone and dental age in Down syndrome (DS) patients.

DS is a genetic alteration affecting chromosome XXI, resulting in bone alterations. Psychomotor development of these patients is usually delayed, there is mental retardation and muscular hypotonia. As for oral abnormalities the following alterations may be present: Agenesia, conoids, microteeth, enamel hypocalcification, delayed tooth eruption, malocclusion and temporomandibular joint disorders.[1-3,5,10,16]

According to ECLAMC (Latin American Collaborative Study of Malformations) 40% of newborns with DS have a mother between 40 and 44 years old.[8] This malformation affects one child in every 700 live births.[5] Although these patients may present several limitations they deserve, seek and may need orthodontic and orthopedic treatment.

Hand and wrist bones are used to estimate chronological age and are important factors to plan and execute orthodontic/orthopedic therapy in young DS patients. The aim of this study is to compare different methods to estimate chronological age using hands and wrist X-rays and determine which method are more accurate in patients with DS aged between 61 and 180 months.

MATERIALS AND METHODS

The sample consisted of 85 hand-wrist radiographs of individuals with Down syndrome, being 52 for males and

33 females, aged between 61 months (5 years 1 month) and 180 months (15 years). Major alterations during the development of human beings are in this age range.

Radiographs of hands and wrists were digitalized with a resolution of 75 DPI in a 100% scale on a flatbed scanner, HPScanjet 4C/T (Hewlett-Packard Co., Colorado, USA) with a HP 6100C transparency (Hewlett-Packard Co., Colorado, USA) suitable for scanning X-rays. The software DeskScan II scanner Hawlett Packard (Hewlett-Packard Co., Colorado, USA) was used in the sharp mode and black and white photo.

After radiographs were digitalized, the files were saved in the file extension *.pcx and it was performed the assessments for the estimation of bone age. The proposed methods were compared with chronological age in order to determine which was closer to the patient age.

Evaluation Method of Greulich and Pyle

Thirty ossification centers in the hand and wrist region are evaluated in the Greulich & Pyle atlas and the most similar pattern was used to compare with the patient X-ray.

Evaluation Method of Eklöf and Ringertz[6]

Ten linear measurements are analyzed in eight ossifications centers in the hand and wrist bones. The software Radiocef 4.0 (Radio Memory, Belo Horizonte, Minas Gerais, Brazil) was used to assist in estimating bone age by providing bone age of each particular bone from the markings set by the examiner.

Method of Assessment of Tanner and Whitehouse (TW3)

In this method the bones radius, ulna, short caps (RUS) were evaluated and thirteen ossification centers were assessed. Each center of ossification has seven or eight stages of development. This method is based on a scoring system, after obtaining the individual values these scores are summed and the result is transformed into bone age.

Statistical Analyses

The results were statistically analyzed in order to obtain means, standard deviations, correlation coefficients and multiple linear regression. To compare the ages of females and males it was used a multiple linear regression mathematical model. This model studied the behavior of a dependent variable y (bone age) as a function of one or more independent variables x (female and male).[9]

RESULTS AND DISCUSSION

When studying the bone age by the hand and wrist radiographs in patients with Down syndrome, the following results were obtained:

Table 1 shows that the mean bone age estimated by the methods TW3 and Greulich & Pyle were higher when compared to the individual chronological age. As for the Eklöf & Ringertz method the opposite result was acquired, wherein the mean bone age were always lower compared with the chronological ages.

The mean of delay in bone age obtained by the method of Eklöf & Ringertz, in relation to chronological age was 1.72 years for females and 1.59 years for males (Table 2). This result was similar to those obtained by Sannomiya & Calles[16] studying individuals with Down syndrome, these authors found a difference of 2.87 years for females and 2.35 years for males. However, by gender, these authors disagree, because this work, we observed a statistically significant difference between female and male for the method of Eklöf & Ringertz.

The average delay of chronological age obtained by the method of Greulich & Pyle, in relation to bone age, this study was 1.13 years for females and 1.32 years for males.

Table 1: Descriptive analysis of female and male patients

Studied methods		*TW3*	*Greulich and Pyle*	*Eklöf and Ringertz*	*Chronological age*
Female	N	33	33	33	33
	Average (years)	10.87	10.88	8.03	9.75
	Standard deviation	2.87	3.74	2.09	2.78
Male	N	52	52	52	52
	Average (years)	12.19	12.20	9.29	10.88
	Standard deviation	3.39	3.81	2.70	2.71

Table 2: Mean differences between the methods studied in bone age—female and male

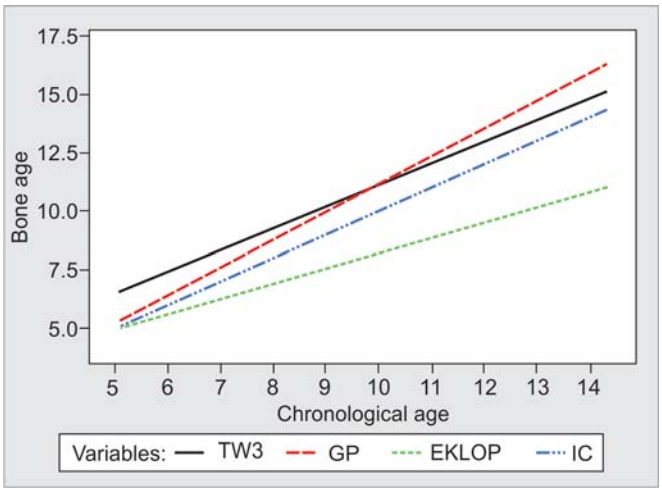
Studied methods	*TW3*		*Greulich and Pyle*		*Eklöf and Ringertz*	
Chronological age (years)	Female	Male	Female	Male	Female	Male
	1.12[a]	1.31[a]	1.13[a]	1.32[a]	1.72[b]	1.59[b]

[a,b]Means followed by different letters are statistically significant at the 5% level of significance

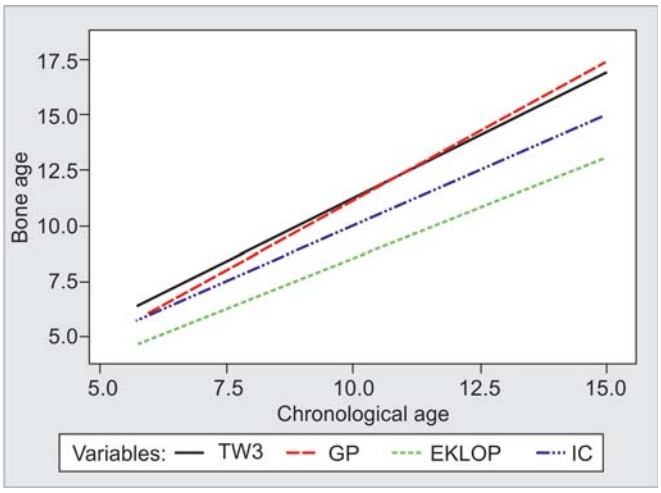
The mean chronological age of the delay obtained by the TW3 method in this work, in relation to bone age was 1.12 years for females and 1.31 years for males. The bone age was higher than the chronological ages and found no statistically significant differences between female and male.

The sample was divided into four groups to examine bone age in the age proposals. Tables 3 & 4 and Graphs 1 & 2 are described the means, standard deviations and paired t-test between bone and chronological ages for each method studied for females and males separately.

Tables 3 and 4 show the mean bone age were not statistically significant between 61 and 90 months (p = 0.570) and 91 to 120 months (p = 0.550), however, for higher chronological age, i.e. 121 to 150 months (p = 0.001) and 151 to 180 months (p = 0.001) the results were statistically significant. Sannomiya et al[19] in 1998 to compare the bone



Graph 1: Lines between IO (TW3, Greulich & Pyle and Eklöf & Ringertz) and IC for the females



Graph 2: Lines between IO (TW3, Greulich & Pyle and Eklöf & Ringertz) and IC for the males

Table 3: Means, standard deviations and paired t-test between bone and chronological ages for the studied methods—female

Studied methods		*TW3*	*Greulich and Pyle*	*Eklöf and Ringertz*	*Chronological age*
Group 1 (61-90 months)	Average (years)	7.75	7.08	5.78	6.53
	Standard deviation	2.09	2.55	1.11	0.67
	t-test (p-value)	0.051	0.570	0.057	–
Group 2 (91-120 months)	Average (years)	10.12	9.42	7.51	8.74
	Standard deviation	1.26	2.16	1.76	0.84
	t-test (p-value)	0.001	0.055	0.034	–
Group 3 (121-150 months)	Average (years)	12.91	13.68	9.64	11.53
	Standard deviation	1.25	1.48	0.75	0.67
	t-test (p-value)	0.001	0.001	0.001	–
Group 4 (151-180 months)	Average (years)	13.84	14.78	9.99	13.48
	Standard deviation	0.91	1.25	0.66	0.54
	t-test (p-value)	0.001	0.001	0.001	–

Table 4: Means, standard deviations and paired t-test between bone and chronological ages for the methods studied—male

Studied methods		*TW3*	*Greulich and Pyle*	*Eklöf and Ringertz*	*Chronological age*
Group 1 (61-90 months)	Average (years)	7.10	6.66	5.37	6.87
	Standard deviation	1.31	0.81	1.02	0.92
	t-test (p-value)	0.051	0.570	0.002	–
Group 2 (91-120 months)	Average (years)	9.96	9.61	7.50	8.81
	Standard deviation	1.75	2.15	1.34	0.66
	t-test (p-value)	0.001	0.055	0.001	–
Group 3 (121-150 months)	Average (years)	13.09	13.41	10.04	11.63
	Standard deviation	1.64	1.80	1.32	0.65
	t-test (p-value)	0.001	0.001	0.001	–
Group 4 (151-180 months)	Average (years)	15.93	16.28	12.20	14.14
	Standard deviation	1.04	1.54	1.28	0.79
	t-test (p-value)	0.001	0.001	0.001	–

and chronological age using the method of Greulich & Pyle, divided the sample into three groups: (I) 72 to 119 months; (II) 120 to 155 months, and (III) 156 to 180 months. The present results corroborate the data obtained by Sannomiya et al[19] only for females in groups II and III males.

When comparing the results of bone ages obtained by the methods of Greulich & Pyle TW3 and in Tables 3 and 4, were found in this paper that the most tender age, i.e., group I (61-90 months of chronological age) and group II (91-120 chronological months old), the bone age estimated by the TW3 were higher than the method of Greulich & Pyle, unlike the older age groups, group III (121-150 chronological months of age) and group IV (151-180 chronological months of age) in the bone age estimated by the TW3 were lower than the method of Greulich & Pyle, probably due to a longer interval of the evaluation of Atlas Greulich & Pyle and greater accuracy of the analysis method TW3 . We agree with Haiter Neto et al.[9], only more tender ages, despite having studied patients without Down syndrome.

For the method of Greulich & Pyle, both female and male, there was a trend initiated in bone age was delayed in relation to chronological age in young people early and finish around 15 years. The period of maturation tends to be shorter in individuals with Down syndrome.[12,15,17]

And the method of Eklöf & Ringertz, statistically significant differences between female and male, it is noted that there is a strong difference between bone age and chronological accentuate it, both for females and for males.

The result of estimation of bone age by the method of Eklöf & Ringertz chronological age was lower than for all groups for both the female and male, it is appropriate to emphasize that this result is probably due to the fact that children with Down syndrome, the length of the bones of the hand and wrist is smaller in relation to children who do not have the syndrome, as evidenced Chumlea et al,[4] Myrelid et al.[13] Children with Down syndrome have short stature. It is possible that this fact is due to the higher incidence of bone disease in these individuals, for example, vitamin D deficiency, also known as rickets, therefore, leads to a reduction of osteoblastic activity, therefore, there may be a defective growth of bones.[14,18,20]

The mathematical equations generated by multiple linear regression analysis are shown below:

a.	TW3 method:	y = 1.1143 x
b.	Method of Greulich & Pyle:	y = 1.1263 x
c.	Method of Eklöf & Ringertz:	y = 0.6562 + 1.6313 x (female). y = 0.8572 x (male).

y = bone age (years) x = chronological age (years)

Bull et al[3] compared two methods of assessing bone age: Greulich & Pyle and Tanner & Whitehouse in British children and suggested that the bone age was verified by the method of Tanner & Whitehouse due to greater accuracy and precision, we agree with this fact, because the method that was closest in chronological age of the patients with Down syndrome studied in this work was the TW3 method, moreover, is a current method (2001) compared with Greulich & Pyle (1959) and Eklöf & Ringertz (1966).

So in addition to verify which method of estimation of bone age is more accurate to chronological age, the equations generated by multiple linear regression analysis is a major topic in this research work, therefore, using this mathematical formula is possible to apply the methods studied in individuals with Down syndrome.

CONCLUSION

Results obtained in this research work, we conclude that: (a) bone ages, by the methods of Greulich & Pyle and TW3 are advanced relative to chronological age and there were no statistically significant differences between female and male; (b) bone ages by the method of Eklöf & Ringertz are delayed relative to chronological age and there were no statistically significant differences between female and male; (c) The methods of verification and TW3 bone age of Greulich & Pyle were statistically equal and different method of Eklöf & Ringertz; (d) the methods of Greulich & Pyle and TW3 are those that more closely match their chronological ages, followed by Eklöf & Ringertz.

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