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Effects of nutrition on the estimation of dental age in Argentinian children by radiographic methods

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Abstract

Objective: to analyze the influence of the nutritional status on the estimation of the chronological age from radiographs through the degree of dental calcification using the methods of Demirjian *et al*., Willems *et al*., Nolla and Haavikko in children of both sexes from Tucuman, Argentina.

Methods: 223 children (115 females and 108 males) who assisted to radiological studies previous to dental treatment were selected. Panoramic X-rays were taken. Dental ages were calculated using the corresponding tables of the methods of Demirjian *et al*., Willems *et al*., Nolla and Haavikko. Chronological ages were calculated between the date of birth and the date of the study. Children were grouped according to their sex and nutritional status.

Results: For normal weight girls, the mean difference between dental and chronological age was: Demirjian *et al.:* 0.26±0.93; Willems *et al*: 0.43±0.95; Nolla: -0.31±0.84; Haavikko: -0.13±0.82. For normal weight boys: Demirjian *et al*.: 0.16±0.77; Willems *et al*.: 0.20±0.79; Nolla: -0.23±0.65; Haavikko: -0.255±0.73. For overweight girls: Demirjian *et al*.: 0.53±0.91; Willems *et al*.: 0.31±0.88; Nolla: -0.44±0.69; Haavikko: 0.09±0.81. For overweight boys: Demirjian *et al*.: 0.38±0.86; Willems *et al*.: 0.36±0.80; Nolla: 0.06±0.75; Haavikko: 0.06±0.94. For obese girls: Demirjian *et al*.: 0.92±0.75; Willems *et al*.: 0.83±1.37; Nolla: -0.47±0.57; Haavikko: 0.31±0.16. For obese boys: Demirjian *et al*.: 0.85±0.95; Willems *et al*.: 0.50±0.94; Nolla: 0.32±0.82; Haavikko: 0.50±0.77. For underweight boys and girls: Demirjian *et al.:* -0.36±0.82; Willems *et al*.: -0.25±0.70; Nolla: -0.85±0.87; Haavikko: -0.85±0.92.

Conclusion: In normal boys and girls the methods of Demirjian *et al.* and Willems *et al.* overestimated the chronological age; those of Nolla and Haavikko underestimated it. In overweight boys and girls, the overestimation (Demirjian *et al*. and Willems *et al*.) doubled the chronological age, while in obese boys and girls, both methods tripled it.

Keywords: Dental age; Radiographic images; Age estimation; Nutritional status

1. Introduction

Morphological and radiological methods of teeth can be used for the estimation of the chronological age and they have become essential in Pediatric Dentistry, Orthodontics, legal Dentistry and Anthropology. Dental maturation is a complex sequence of events from the onset of mineralization, crown formation, root formation, eruption in the oral cavity and maturation and closure of the root apex. The estimation of the dental age is adequate because it has less variation compared to other indices and is less affected by environmental factors (1-3). Among the different methods to estimate the dental age (anatomical, histological, dental eruption, radiological) the radiological method is the most practical and

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reliable. Several radiological methods have been described (4-10). One of the most accepted and widespread method for estimating the dental age and subsequently applied to other populations was that developed by Demirjian *et al.* (4) and later modified in 1976 (11).

The method of Demirjian *et al*. (4) was developed in panoramic radiographic studies of French-Canadian children (1446 boys, 1482 girls) of 2-20 years' age range. The inclusion criteria were healthy children without developmental alterations and with complete permanent dentition. Subsequently, Demirjian and Goldstein in 1976 (11), expanded the sample which allowed the inclusion of two new dental development stages that were excluded in the previous study (stage A of the first premolar, and stage C of the central incisor). Although this method has shown maximum efficiency in its universal application, some researchers believed that when converting the score to dental age, specific standards should be elaborated for each population, since it has been observed that they tend to overestimate the age (12-14).

The method of Nolla (6) was developed in 1960, whose sample included a series of intraoral radiographs belonging to 25 girls and 25 boys from Michigan. The application of the method of Nolla in European children, between 3 to 18 years old, showed that the development of the mandibular teeth was more advanced than that of the upper elements, with the greatest differences being found in the age group of 6-8 years (15). The application of the method in a sample of Andalusian population showed greater accuracy in estimating the dental age in 43, 44, 46, 47 teeth for boys and 43, 44, 47 for girls. In this way, the Nolla standards were acceptable to determine the development degree in these patients; it was directly applied without adapting specific norms for the population. However, they observed a tendency to underestimate the real age in girls and in an accentuated way in the 10 years old group.

Some authors considered this method as one of the most reliable procedures for estimating the development of the permanent dentition (16).

In a study carried out in children from Fortaleza, Brazil, applying to the Nolla method to estimate the chronological age in panoramic images, an underestimation was found, difference that is more pronounced in older children (17).

The method of Haavikko (5) based on the dental development of Finnish children in radiographic images, categorized 12 stages of development for both girls and boys in each dental elements of both jaws. Its scores, according to the development of the permanent teeth estimated the dental age. Studies on British and Bangladesh children showed that the method of Nolla underestimated the chronological age using the first mandibular premolar and second mandibular molar, being more accurate in males. In that study, the accuracy of the methods of Nolla, Demirjian *et al*, Willems *et al*. and other radiographic methods to estimate dental age were compared. The latter, which adjusted the scores of the method of Demirjian *et al*., in the Belgian population where the sum of the scores of the seven left permanent mandible teeth, excluding the third molar, directly results in the estimated dental age (7). The result of the determination of the accuracy of the dental age through the 4 methods, that one of Willems *et al*. was the most accurate(18). The same results were obtained in the Malaysian population, where the method of Willems *et al*. was more accurate in estimating the dental age than the method of Demirjian *et al*. which overestimated the age; that could be due to the advanced development of the mandibular second premolar and mandibular molars (19).

The four applied methods in a study in Indian girls and boys in an age range of 5 to 15 years old showed that the method of Willems *et al*. had the least discrepancy in the estimation of the dental age, while the least accurate was the method of Haavikko with underestimation of the dental age. The method of Demirjian *et al*. overestimated it and Nolla's underestimated the dental age (20).

In girls and boys from the Spanish population, the application of the method of Demirjian *et al*. overestimated the dental age with a discrepancy of 0.853 years, while the Nolla method underestimated it with a difference of -0.213 years (21).

Studies carried out in Venezuelan girls and boys in the estimation of the dental age found an overestimation of age, with the method of Demirjian *et al*., while Nolla's underestimated it (22).

In the Brazilian population, the methods of Nolla and Demirjian *et al*. were applied to boys and girls, where the former was more accurate, while because of the overestimation of the method of Demirjian *et al*. authors recommend not applying it in this population (23,24).

Study in Hispanic boys and girls (6 to 12 years old) of low weight, overweight and obese, in the estimation of dental age in panoramic images, an advance of dental age was found: 11.7 months in those of overweight and obesity, while in underweight girls and boys it was 3.4 months. Thus, overweight in obese Hispanic boys and girls were approximately 3.5 times earlier in dental age, and the higher the chronological age, the greater the difference (29).

A study carried out in girls and boys with extreme malnutrition and normal weight, the estimation of dental age through the dental development in panoramic radiographic images did not show significant differences in the estimation of age between both groups. The authors considered dental elements stable in extreme nutritional conditions, in relation to other organs of the body (25).

The nutritional analysis carried out in Argentina between 2014 to 2016, of malnutrition due to deficiency vs. malnutrition due to excess, in children and adolescents, showed that low weight remained stable in the three years considered, with a slight downward trend until reaching 8.1% in 2016. Overweight and obesity increased from 26.9% in 2014 to 31.3% in 2016. Malnutrition due to excess (overweight-obesity) is the most frequent problem within the child and adolescent population reported by the program tracers SUMAR from Argentina (26).

There is a wide discrepancy between the different radiographic methods to estimate the dental age in different populations and the influence of nutritional status (underweight, overweight and obesity).

The purpose of the present study was to analyze the influence of the nutritional status on the estimation of the chronological age from radiographic images of permanent dental elements by the radiographic methods of Demirjian *et al*., Haavikko, Nolla and Willems *et al.,* on a sample of children from Tucuman, in northern Argentina.

2. Material and methods

In this retrospective study, panoramic radiographs, Orthophos X3D, Digital SIRONA (Siemens-Alemania) were taken to children attending the Department of Pediatric Dentistry, Dentistry Faculty, National University of Tucumán, Argentina. They were selected for their known chronological age and gender; 108 were males and 115 were females, ranged ages from 8 to 10 years and for always been living in Tucuman, Argentina.

The inclusion criteria were a general healthy state of the patients and the adequate quality of the panoramic radiographs. For the exclusion criteria the image deformity affecting the mandible permanent teeth visualization was considered, as hypodontia, gross pathology, previous or undergoing orthodontic treatment and history of medical or surgical disease that could affect the presence and development of the mandible permanent teeth. All experiments were undertaken with the understanding and written consent of each subject or parents and according to the principles of the World Medical Association Declaration of Helsinki (version 2002). The study was independently reviewed and approved by the ethical board of Medicine Faculty of National University of Tucumán.

The panoramic images were standardized and examined under good lighting conditions, screen brightness and resolution. All the radiographs were examined by an experienced clinician in order to eliminate inter examiner differences. Repeatability was tested on 15 randomly selected radiographs examined at least 3 weeks after the initial examination. The chronological age for each subject was calculated by subtracting the date when the panoramic radiograph was taken from the date of birth, after converting both dates to a decimal number.

The stages of the seven permanent teeth, excluding the third molars, were assessed from panoramic radiographs, applying the following radiographic methods of: Demirjian *et al*. (4); Haavikko (8); Nola (6); Willems *et al*. (7)

Anthropometric techniques from the Argentine Society of Pediatrics (SAP) (27) were used to determine the nutritional status, recording the weight and height of each of the children.

The weight/age and height/age data of each boy and girl are listed in tables, being grouped into: underweight, normal weight, overweight and obese in both sexes (Table 1).

Table 1 Proportional distribution of children in the sample, according to their nutritional status

Nutritional Condition		**Underweight**		**Normal weight**		**Overweight**		**Obese**		**Total**	
		n	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Sex	female	5	(2.2)	71	(31.8)	33	(14.8)	6	(2.7)	115	(51.6)
	male	1	(0.4)	63	(28.3)	30	(13.5)	14	(6.3)	108	(48.4)
Total		6	(2.7)	134	(60.1)	63	(28.3)	20	(9)	223	(100)

All data were then filled into the Statistical Package for Social Sciences program. Separate files for females and males were created. A Kolmogorov Smirnov Test indicated that the distribution was normal. Thus, for comparing means of variables, a paired t-test was used. P-values less than 0.05 were considered statistically significant.

3. Results

3.1. Female

The proportion of normal nutritional girls in the sample was 31.8% (n=71); 14.8% (n=33) for overweight girls; 2.7% (n=6) for obese and 2.2% (n=5) for underweight.

For the group of normal weight girls, the chronological age was x=8.68 ± 1.79, while the dental age with the methods was: Demirjian *et al*. 8.95 ± 1.84; Willems *et al*. 9.11 ± 1.84; Nolla 8.37 ± 1.46; Haavikko 8.55 ± 1.81 (Table 2) (Figure 1).

For the group of overweight girls, the chronological age was x=9.67 ± 1.53, while the dental age with the methods was: Demirjian *et al*. 10.21 ± 1.74; Willems *et al*. 9.98 ± 1.75; Nolla 9.22 ± 1.39; Haavikko 9.77 ± 1.84 (Table 3) (Figure 2).

For the group of obese girls, the chronological age was x=9.08 ± 1.80, while the dental age with the methods was: Demirjian *et al*. 10.01 ± 2.21; Willems *et al*. 9.92 ± 2.35; Nolla 9.04 ± 1.35; Haavikko 9.40 ± 1.79. (Table 4) (Figure 3).

For the group of underweight boys and girls, the chronological age was x=8.09 ± 2.85, while the dental age with the methods was: Demirjian *et al*. 7.72 ± 2.59; Willems *et al*.7.84 ± 2.36; Nolla 7.23 ± 2.32; Haavikko 7.23 ± 2.41 (Table 5) (Figure 4).

Table 2 Chronological and estimated ages through the methods of Demirjian *et al*., Willems *et al*., Nolla and of Haavikko for normal weight girls

Age of Normal weight Girls	Mean	n	SE	SD
Chronological	8.68	71	0.21	1.79
Estimated (Demirjian)	8.95	71	0.21	1.84
Estimated (Willems)	9.11	71	0.21	1.84
Estimated (Nolla)	8.37	71	0.17	1.46
Estimated (Haavikko)	8.55	71	0.21	1.81

n: number of children; SE: Standard error; SD: Standard deviation

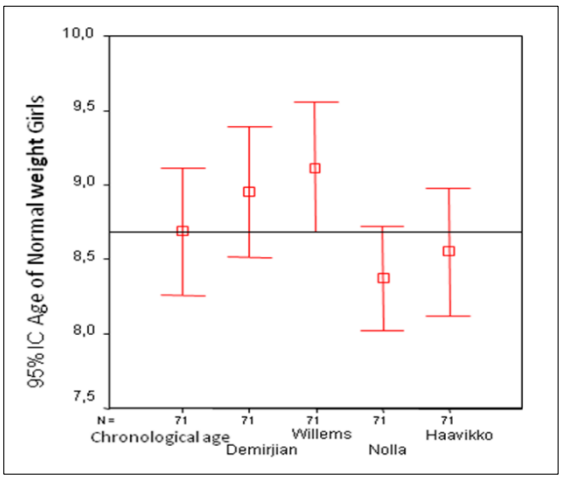

Figure 1 Limit of confidence interval (95%) of the mean of the chronological age and the dental age obtained with the radiographic methods of Demirjian et al., Willems et al., Nolla and Haavikko in normal weight girls

Table 3 Chronological and estimated ages through the methods of Demirjian *et al.*, Willems *et al.,* Nolla and of Haavikko for overweight girls

Age of Overweight Girls	Mean	n	SE	SD
Chronological	9.67	32	0.27	1.53
Estimated (Demirjian)	10,21	32	0.30	1.74
Estimated (Willems)	9.98	32	0.31	1.75
Estimated (Nolla)	9.22	32	0.24	1.39
Estimated (Haavikko)	9.77	32	0.32	1.84

n: number of children; SE: Standard error; SD: Standard deviation

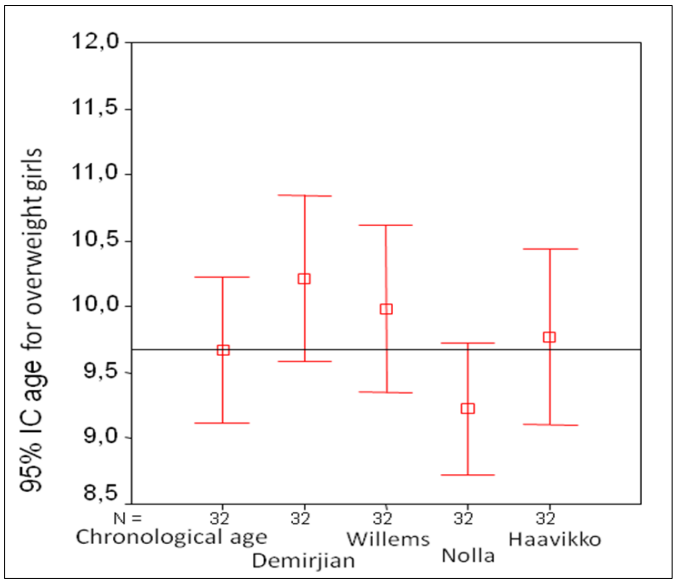

Figure 2 Limit of confidence interval (95%) of the mean of the chronological age and the dental age obtained with the radiographic methods of Demirjian *et al.*, Willems *et al.*, Nolla and Haavikko in overweight girls

Table 4 Chronological and estimated ages through the methods of Demirjian *et al.*, Willems *et al.*, Nolla and of Haavikko for obese girls

Age of Obese Girls	Mean	n	SE	SD
Chronological	9.08	6	0.73	1.80
Estimated (Demirjian)	10,01	6	0.90	2.21
Estimated (Willems)	9.92	6	0.96	2.35
Estimated (Nolla)	9.04	6	0.55	1.35
Estimated (Haavikko)	9.40	6	0.73	1.79

n: number of children; SE: Standard error; SD: Standard deviation

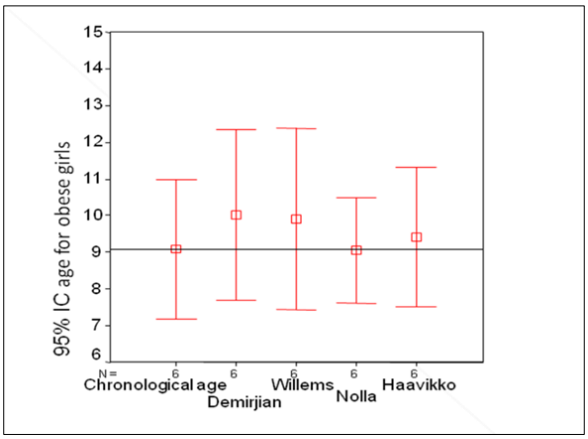

Figure 3 Limit of confidence interval (95%) of the mean of the chronological age and the dental age obtained with the radiographic methods of Demirjian *et al*., Willems *et al*., Nolla and Haavikko in obese girls

Table 5 Chronological and estimated ages through the methods of Demirjian *et al*., Willems *et al*., Nolla and of Haavikko for underweight boys and girls

Age Underweight Boys and Girls	Mean	n	SE	SD
Chronological	8.09	6	1.16	2.85
Estimated (Demirjian)	7.72	6	1.05	2.59
Estimated (Willems)	7.84	6	0,96	2.36
Estimated (Nolla)	7.23	6	0.94	2.32
Estimated (Haavikko)	7.23	6	0.98	2.41

n: number of children; SE: Standard error; SD: Standard deviation

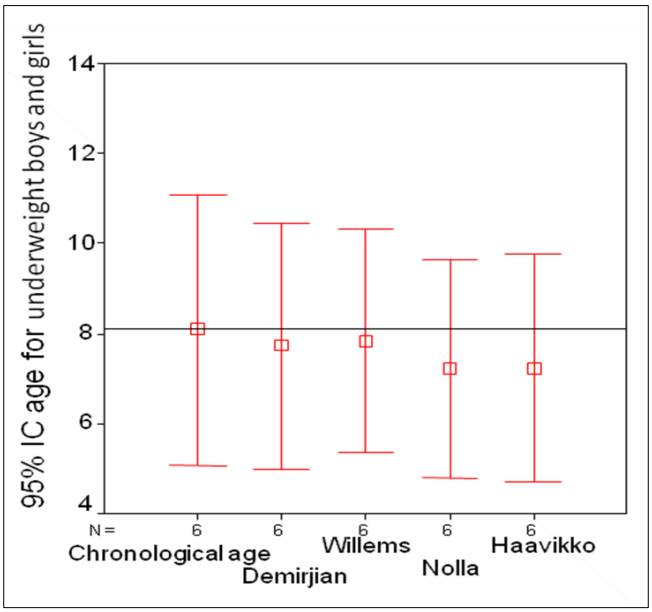

Figure 4 Limit of confidence interval (95%) of the mean of the chronological age and the dental age obtained with the radiographic methods of Demirjian *et al*., Willems *et al*., Nolla and Haavikko in underweight boys and girls

3.1.1. Normal weight girls

The method of Demirjian *et al*. overestimated the chronological age with a discrepancy of 2.6 months, while the method of Willems *et al*. overestimated it with 4.3 months (p<0.01).

The method of Nolla underestimated the chronological age with a discrepancy of -3.1 months (p<0.05).

The method of Haavikko showed an underestimation of -1.3 months, where there were no significant differences (p>0.05) (Table 6).

Table 6 T pared test of related samples between the chronological and the dental ages using the methods of Demirjian, Willems, Nolla, and Haavikko for normal weight girls

	Related Differences					t	gl	Bilateral Significance
	Mean	SD	SE	95% confidence for the difference				
				Low	High			
Pair: Demirjian estimated age - Chronological age	0.2662	0.93613	0.1111	0.0446	0.4878	2.396	70	0.019*
Pair: Willems estimated age - Chronological age	0.4302	0.95363	0.1131	0.2044	0.6559	3.801	70	0.000*
Pair: Nolla estimated age - Chronological age	-0.315	0.84763	0.1006	-0.516	-0.115	-3.138	70	0.002*
Pair: Haavikko estimated age - Chronological age	-0.137	0.82927	0.0984	-0.334	0.584	-1.401	70	0.166 NS

SD: standard deviation; SE: standard error; t: t-Test; gl: freedom degrees; *: significant differences (p<0,05) ns: no significant differences

3.1.2. Overweight girls

The method of Demirjian *et al*. overestimated the chronological age with a discrepancy of 5.3 months, while the method of Willems *et al*. overestimated it with 3.1 months (p<0.05).

The method of Nolla underestimated chronological age with a discrepancy of -4.4 months (p<0.05).

The method of Haavikko showed an overestimation of 0.9 months, where there were no significant differences (p>0.05) (Table 7).

Table 7 T pared test of related samples between the chronological and the dental ages using the methods of Demirjian, Willems, Nolla, and Haavikko for Overweight girls

	Related Differences					t	gl	Bilateral Significance
	Mean	SD	SE	95% confidence for the difference				
				Low	High			
Pair: Demirjian estimated age - Chronological age	0.5395	0.91980	0.1626	0.2078	0.8711	3.318	31	0.002*
Pair: Willems estimated age - Chronological age	0.3110	0.88304	0.1561	-0.007	0.6229	1.992	31	0.049*
Pair: Nolla estimated age - Chronological age	-0.448	0.69904	0.1235	-0.700	-0.196	-3.628	31	0.001*
Pair: Haavikko estimated age - Chronological age	0.0979	0.81894	0.1447	-0.197	0.3932	0.676	31	0.504 NS

SD: standard deviation; SE: standard error; t: t-Test; gl: freedom degrees; *: significant differences (p<0.05) ns: no significant differences

3.1.3. Obese girls

The method of Demirjian *et al*. overestimated the chronological age with a discrepancy of 9.2 months (p<0.05), while the method of Willems *et al*. overestimated it with 8.3 months (p>0.05).

The method of Nolla underestimated the chronological age with a discrepancy of -0.4 months, where there were no significant differences (p>0.05).

The method of Haavikko showed an overestimation of 3.1 months, where there were significant differences (p<0.05) (Table 8).

Table 8 T pared test of related samples between the chronological and the dental ages using the methods of Demirjian, Willems, Nolla, and Haavikko of for obese girls

	Related Differences					**t**	**gl**	**Bilateral Significance**
	Mean	**SD**	**SE**	**95% confidence for the difference**				
				Low	**High**			
Pair: Demirjian estimated age - Chronological age	0.9205	0.75971	0.3101	0.1232	1.7178	2.968	5	0.031*
Pair: Willems estimated age - Chronological age	0.8305	1.37802	0.5625	-0.615	2.2766	1.476	5	0.200 NS
Pair: Nolla estimated age - Chronological age	-0.478	0.57958	0.2366	-0.656	0.5604	-0.202	5	0.848 NS
Pair: Haavikko estimated age - Chronological age	0.3172	0.16238	0.0662	0.1468	0.4876	4.784	5	0.005 *

SD: standard deviation; SE: standard error; t: t-Test; gl: freedom degrees; *: significant differences (p<0,05) ns: no significant differences

3.1.4. Underweight boys and girls

The method of Demirjian *et al*. underestimated the chronological age with a discrepancy of -3.6 months, while the method of Willems *et al.* underestimated it with -2.5 months. There were no significant differences between both ages with both methods (p>0.05).

The methods of Nolla and Haavikko underestimated the chronological age with a discrepancy of -8.5 months for both methods, where there were no significant differences (p>0.05) (Table 9).

Table 9 T pared test of related samples between the chronological and the dental ages using the methods of Willems, Nolla, and Haavikko of for Underweight boys and girls

	Related Differences					**t**	**gl**	**Bilateral Significance**
	Mean	**SD**	**SE**	**95% confidence for the difference**				
				Low	**High**			
Pair: Demirjian estimated age - Chronological age	-0.363	0.82824	0.3381	-1.233	0.5053	-1.076	5	0.331 NS
Pair: Willems estimated age - Chronological age	-0.250	0.70560	0.2880	-0.991	0.4900	-0.870	5	0.424 NS
Pair: Nolla estimated age - Chronological age	-0.855	0.87327	0.3565	-1.771	0.0609	-2.400	5	0.062 NS
Pair: Haavikko estimated age - Chronological age	-0.858	0.92940	0.3794	-1.834	0.1165	-2.264	5	0.073 NS

SD: standard deviation; SE: standard error; t: t-Test; gl: freedom degrees; *: significant differences (p<0,05) ns: no significant differences

3.2. Males

The proportion of nutritionally normal children in the sample was 28.3% (n=63); 13.5% (n=30) of overweight children and 6.3% (n=14) of obese children.

For the group of normal weight boys, the chronological age was x=8.91 ± 1.99, while the dental age with the methods was: Demirjian *et al.* 9.07 ± 2.05; Willems *et al*. 9.11 ± 2.16; Nolla 8.67 ± 1.89; Haavikko 8.65 ± 2.12. (Table 10) (Figure 5).

For the group of overweight boys, the chronological age was x=8.85 ± 1.62, while the dental age with the methods was: Demirjian *et al*. 9.23 ± 1.89; Willems *et al*.9.21 ± 1.69; Nolla 8.91 ± 1.65; Haavikko 8.91 ± 1.86. (Table 11) (Figure 6).

For the group of boys with obesity the chronological age was x=9.23 ± 1.54, while the dental age with the methods was: Demirjian *et al.* 10.09 ± 1.60; Willems *et al*. 9.74 ± 1.21; Nolla 9.56 ± 1.19; Haavikko 9.74 ± 1.71. (Table 12) (Figure 7).

Table 10 Chronological and estimated ages through the methods of Demirjian, Willems, Nolla and of Haavikko for normal weight boys

Age of Normal weight Boys	Mean	n	SE	SD
Chronological	8.91	62	0.25	1.99
Estimated (Demirjian)	9.07	62	0.26	2.05
Estimated (Willems)	9.11	62	0.27	2.16
Estimated (Nolla)	8.67	62	0.24	1.89
Estimated (Haavikko)	8.65	62	0.26	2.12

n: number of children; SE: Standard error; SD: Standard deviation

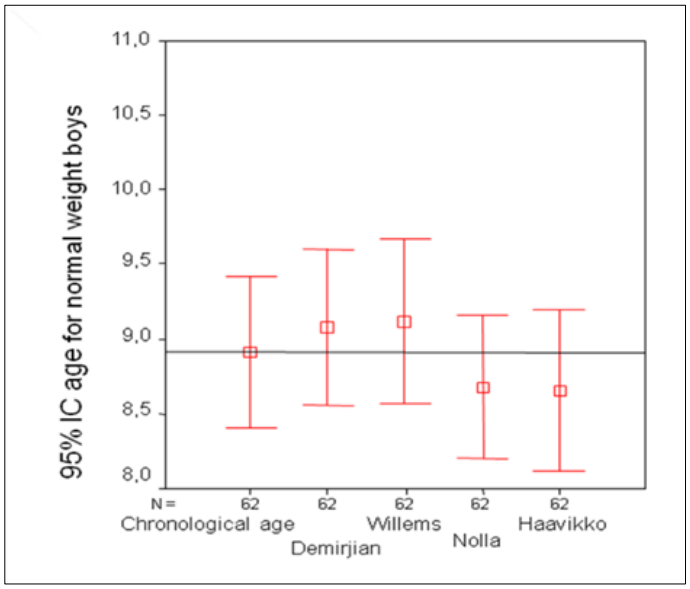

Figure 5 Limit of confidence interval (95%) of the mean of the chronological age and dental age obtained with the radiographic methods of Demirjian *et al.,* Willems *et al*., Nolla and Haavikko in normal weight boys

Table 11 Chronological and estimated ages through the methods of Demirjian, Willems, Nolla and of Haavikko for overweight boys

Age of Overweight Boys	Mean	n	SE	SD
Chronological	8.91	62	0.25	1.99
Estimated (Demirjian)	9.07	62	0.26	2.05
Estimated (Willems)	9.11	62	0.27	2,16
Estimated (Nolla)	8.67	62	0.24	1.89
Estimated (Haavikko)	8.65	62	0.26	2.12

n: number of children; SE: Standard error; SD: Standard deviation

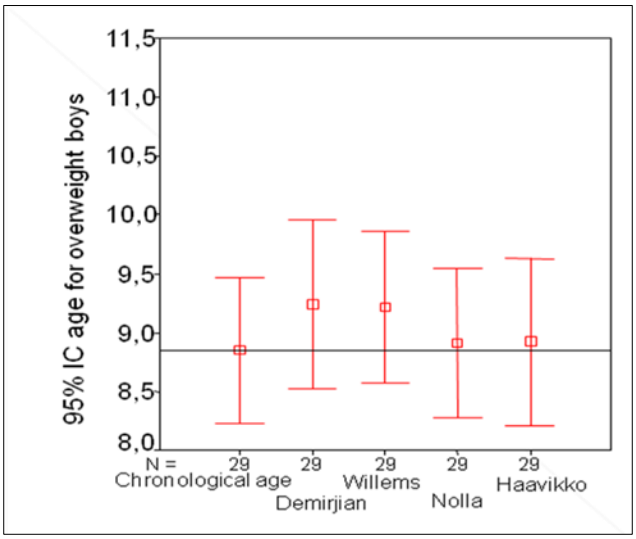

Figure 6 Limit of confidence interval (95%) of the mean of the chronological age and dental age obtained with the radiographic methods of Demirjian *et al*., Willems *et al.*, Nolla and Haavikko in overweight boys

Table 12 Chronological and estimated ages through the methods of Demirjian, Willems, Nolla and of Haavikko for obese boys

Age of Obese Boys	Mean	n	SE	SD
Chronological	9.23	14	0.41	1.54
Estimated (Demirjian)	10.09	14	0.42	1.60
Estimated (Willems)	9.74	14	0.32	1.21
Estimated (Nolla)	9.56	14	0.31	1.19
Estimated (Haavikko)	9.74	14	0.45	1.71

n: number of children; SE: Standard error; SD: Standard deviation

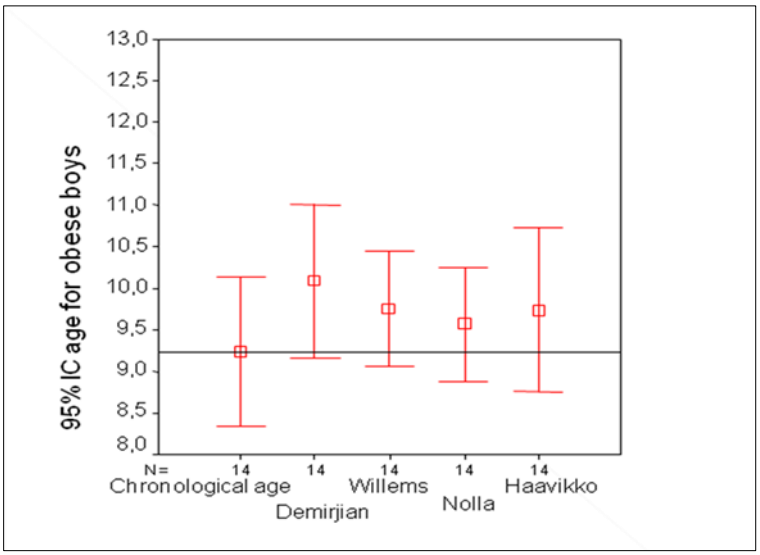

Figure 7 Limit of confidence interval (95%) of the mean of the chronological age and dental age obtained with the radiographic methods of Demirjian *et al*, Willems *et al*, Nolla and Haavikko in obese boys

3.2.1. Normal weight boys

The method of Willems *et al*. overestimated the chronological age with a discrepancy of 2.04 months, while the methods of Nolla and Haavikko underestimated it with a negative discrepancy of -2.33 months for the first and -2.55 months for the second, respectively ($p<0.05$).

The method of Demirjian *et al*. showed an overestimation of the chronological age of 1.6 months and there were no significant differences ($p>0.05$) (Table 13).

Table 13 T pared test of related samples between the chronological and the dental ages using the methods of Demirjian, Willems, Nolla, and Haavikko of for normal weight boys

	Related Differences					**t**	**gl**	**Bilateral Significance**
	Mean	**SD**	**SE**	**95% confidence for the difference**				
				Low	**High**			
Pair: Demirjian estimated age - Chronological age	0.1633	0.77002	0.0977	-0.032	0.3588	1.670	61	0.100 NS
Pair: Willems estimated age - Chronological age	0.2047	0.79716	0.1012	0.0023	0.4072	2.022	61	0.048*
Pair: Nolla estimated age - Chronological age	-0.233	0.65328	0.0829	-0.399	-0.067	-2.810	61	0.007*
Pair: Haavikko estimated age - Chronological age	-0.255	0.73280	0.0930	-0.441	-0.069	-2.743	61	0.008*

SD: standard deviation; SE: standard error; t: t-Test; gl: freedom degrees; *: significant differences ($p<0,05$) ns: no significant differences

3.2.2. Overweight boys

The method of Demirjian *et al*. overestimated the chronological age with a discrepancy of 3.8 months, while the method of Willems *et al*. overestimated it with a difference of 3.6 months, with significant differences being found ($p<0.05$).

The methods of Nolla and Haavikko showed an overestimation of the chronological age of 0.6 months and there were no significant differences ($p>0.05$) (Table 14).

Table 14 T pared test of related samples between the chronological and the dental ages using the methods of Demirjian, Willems, Nolla, and Haavikko of for Overweight boys

	Related Differences					t	gl	Bilateral Significance
	Mean	SD	SE	95% confidence for the difference				
				Low	High			
Pair: Demirjian estimated age - Chronological age	0.3851	0.86565	0.1607	0.0558	0.7143	2.396	28	0.024*
Pair: Willems estimated age - Chronological age	0.3616	0.80770	0.1499	0.0544	0.6689	2.411	28	0.023*
Pair: Nolla estimated age - Chronological age	0.0613	0.75424	0.1400	-0.225	0.3482	0.437	28	0.665 NS
Pair: Haavikko estimated age - Chronological age	0.0654	0.94078	0.1747	-0.292	0.4233	0.374	28	0.711 NS

SD: standard deviation; SE: standard error; t: t-Test; gl: freedom degrees; *: significant differences (p<0,05) ns: no significant differences

3.2.3. Obese boys

The method of Demirjian *et al*. overestimated the chronological age with a discrepancy of 8.5 months, while the method of Willems *et al.* overestimated it with 5.0 month. (p<0.05).

The method of Nolla overestimated the chronological age with a discrepancy of 3.2 months, where there were no significant differences (p>0.05).

The method of Haavikko showed an overestimation of 5.0 months, where there were significant differences (p<0.05) (Table 15).

Table 15 T pared test of related samples between the chronological and the dental ages using the methods of Demirjian, Willems, Nolla, and Haavikko of for Obese boys

	Related Differences					t	gl	Bilateral Significance
	Mean	SD	SE	95% confidence for the difference				
				Low	High			
Pair: Demirjian estimated age - Chronological age	0.8509	0.95408	0.2549	0.3000	1.4017	3.337	13	0.005*
Pair: Willems estimated age - Chronological age	0.5094	0.94092	0.2514	-0.338	1.0527	2.026	13	0.064*
Pair: Nolla estimated age - Chronological age	0.3280	0.82010	0.2191	-0.145	0.8015	1.496	13	0.158 NS
Pair: Haavikko estimated age - Chronological age	0.5030	0.77984	0.2084	0.0527	0.9533	2.413	13	0.031*

SD: standard deviation; SE: standard error; t: t-Test; gl: freedom degrees; *: significant differences (p<0,05) ns: no significant differences

4. Discussion

The overestimation of the chronological age by the methods of Demirjian *et al*. and Willems *et al*., and the underestimation by the methods of Nolla and Haavikko in normal weight boys and girls in our population, were

coincident with the findings in samples of populations from India (20), Thailand (28), Spain (21), Brazil (24) and Venezuela (22).

In our work, the method of Haavikko had an underestimation of -1.3 months in girls, being the most accurate of the applied methods in girls for estimating the dental age. In boys the method with the least discrepancy was Demirjian *et al*., with an overestimation of 1.6 months. Few studies compared the four methods together (18).

Those carried out in Spanish children (29) in the estimation of the dental age with the different radiographic methods in relation to the different nutritional groups, an advanced dental age of 11.7 months was found in boys and girls with overweight and obesity, while in our study the advancement of age was 9.2 months in overweight girls, and 5.3 months in obese girls.

In underweight Spanish children, the discrepancy was an overestimation of dental age between 3 and 4 months, while in this study, with the different methods, an underestimation of age between 3 and 8 months was found.

In our work, the methods that underestimated the dental age in normal weight children (Nolla, Haavikko) become more accurate in overweight and obese groups.

The methods of Demirjian *et al*. and Willems *et al*. overestimated the chronological age in normal weight boys and girls. The methods of Nolla and Haavikko underestimated the age in normal weight boys and girls.

In overweight boys and girls, the overestimation (Demirjian *et al*. and Willems *et al*.) is doubled, while in obese children, both methods tripled it. The underestimating methods (Nolla and Haavikko) showed a higher accuracy in estimating the age in both overweight and obese groups. In underweight children, all four methods underestimated the chronological age.

The statistical parameters obtained in the different nutritional groups and dental ages in radiographic images can be indicators of the development of school and preschool children in Tucuman-Argentina.

5. Conclusion

The development of the permanent dental elements is influenced by the nutritional status of the children in both sexes. This influence modifies the estimation of dental age, through panoramic radiographic images, doubling the overestimation of age in overweight children and tripling it in obese children, in relation to normal nutritional children. The advancement of the dental development of the permanent dental elements in overweight and obese children may alter the position of the dental elements at an early age, causing positional, orthodontic and aesthetic alterations in this population of children. These variables should be related in subsequent studies in order to apply prevention and public health strategies.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare no conflict of interests.

Statement of ethical approval

The study project was approved by the ethic committee at the Faculty of Dentistry of the National University of Tucumán.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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