Original Article

Association between Growth Stunting with Dental Development and Skeletal Maturation Stage

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Abstract: The aim of this study was to determine the influence of growth stunting on the maturation stage of the medium phalanx of the third finger (MP3) and the dental development of the left mandibular canine in 280 high school children (140 stunted and 140 normal controls; equally distributed by sex) between 9.5 and 16.5 years of age, from a representative Peruvian school. Periapical radiographs of the MP3 from the left hand were used to determine the skeletal maturity stage, according to an adaptation of the Hägg and Taranger method. Panoramic radiographs were used to determine the dental maturity stage of the lower left canine, according to Demirjian method. Stunting was determined by relating height and age, according to the World Health Organization recommendations. There was no statistically significant difference in the skeletal maturation stage ($P = .134$) and the dental development stage ($P = .497$) according to nutritional status, even when considering different age groups ($P > .183$). A high correlation ($r = 0.85$) was found between both maturity indicators regardless of the nutritional status (growth stunted, $r = 0.855$ and normal controls, $r = 0.863$) or sex (boys, $r = 0.809$ and girls, $r = 0.892$). When skeletal level was considered, correlations values were similar between advanced ($r = 0.903$) and average ($r = 0.895$) maturers but lower ($r = 0.751$) for delayed maturers. Growth stunting was not associated with dental development and skeletal maturity stages in Peruvian school children. (*Angle Orthod* 2005;75:935–940.)

Key Words: Stunting; Dental development; Skeletal maturation; Peruvian

INTRODUCTION

Growth stunting, defined as reduction in final stature, is an index of past or chronic malnutrition.[1] Controversy exists regarding poor nutrition because of skeletal maturation stage and rate delay.[2–4] Animal studies[5–8] have shown that undernourishment alters skeletal maturation stage and growth. In humans, undernourished infants and children have shown significantly slower skeletal maturation rate and delayed puberty.[9–12] However, controversy still exists regarding the possibility for stunted children to partially catch up to growth because of a delayed and longer skeletal maturation period.[12–15]

Successful growth modification in orthodontics is dependent on skeletal maturation.[16] Because chronological age is not a reliable indicator of skeletal maturation, other indicators have been proposed to determine skeletal maturation stage and rate. Although peak growth velocity in standing height is the most valid representation of rate of overall skeletal growth, it has a limited value to predict future growth rates or remaining relative percentage of growth.[17] Other physiological indicators like staging of dental development, secondary sexual characteristics, or radiographic assessment of bone maturation have been proposed to evaluate the facial skeletal development.[18–21] A recent systematic review concluded that bone staging as well as ossification events should be considered for facial growth prediction.[17]

Although tooth eruption has a poor correlation with general body and facial growth,[22,23] controversy exists

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Accepted: January 2005. Submitted: December 2004.

TABLE 1. Descriptive Data From the Grouping

		Male		Female	
Group	Age (y)	Nourished	Stunted	Nourished	Stunted
1	9.5–10.5	10	10	10	10
2	10.6–11.5	10	10	10	10
3	11.6–12.5	10	10	10	10
4	12.6–13.5	10	10	10	10
5	13.6–14.5	10	10	10	10
6	14.6–15.5	10	10	10	10
7	15.6–16.5	10	10	10	10

regarding whether dental development stages can be used clinically to determine skeletal maturation stages.[24–26] However, calcification patterns of the lower cuspids has been suggested as highly correlated with skeletal maturation events.[27–29]

To our knowledge, no previous study has simultaneously analyzed the possible influence of growth stunting on skeletal maturation and dental development evaluated through radiographs in preadolescents and adolescents. The objective of this study was to evaluate whether stunting was associated with maturation stages of the medium phalanx of the third finger (MP3) and dental development of the left mandibular canine in Peruvian high school children.

MATERIALS AND METHODS

This study was approved by the Ethics Committee from the Universidad Peruana Cayetano Heredia, Lima, Peru. A convenience sample of 280 school children aged between 9.5 and 16.5 years were selected from the whole population of a representative public school from Lima, Peru. They were sequentially examined and grouped according to sex, age, and nutritional status until 10 children were available per group cell (Table 1). All the children were from at least two previous generations of Peruvian ancestors, without any clinically determined chronic medical condition or syndrome conditions.

Skeletal maturation was evaluated through a periapical radiograph of the MP3 from the left hand. A customized wood device was used to warrant that the finger was perpendicular to the X-ray beam. Periapical radiographs were taken and developed at the Dental Clinic of the Universidad Inca Garcilazo de la Vega, according to the manufacturer's instructions. Previous studies have shown the reliability of this approach.[30–32] The Hägg and Taranger[33] classification for this finger was used. The maturation stage relative to the peak of height velocity (PHV) was determined for each individual using the following five-point ordinal scale.

- Stage F: The epiphysis is as wide as the metaphysis. About 40% of the individuals are before PHV. Very few are at PHV.
- Stage FG: The epiphysis is as wide as the metaphysis, and there is a distinct medial or lateral (or both) border of the epiphysis forming a line of demarcation at right angles to the border. About 90% of the individuals are one year before or at PHV.
- Stage G: The sides of the epiphysis are thickened, and there is capping of the metaphysis, forming a sharp edge distally at one or both sides. About 90% of the individuals are at or one year after PHV.
- Spurt H: Fusion of the epiphysis and metaphysis has begun. About 90% of the girls and all the boys are after PHV but before the end of the pubertal growth spurt.
- Spurt I: Fusion of the epiphysis and metaphysis is completed. All individuals except a few girls have ended the pubertal growth spurt.

According to Fishman,[16] not only bone staging (skeletal maturation stage) but also skeletal maturation level (advanced, normal, or delayed) should be considered for growth prediction. Skeletal level was determined using the mean age and standard deviations of the subjects grouped according to Hägg and Taranger[33] classification. Any subject whose age was more than one standard deviation from the group's mean age was classified as advanced (if they were younger than this time frame) or delayed (if they were older than this time frame). One standard deviation was chosen to follow Fishman's[16] skeletal maturation assessment method.

Dental maturation was evaluated through panoramic radiographs. Panoramic radiographs were taken and developed in the Dental Clinic of the Universidad Inca Garcilazo de la Vega, according to the manufacturer's instructions. The Demirjian et al[34] classification for the lower canine was used. Only five of the reported stages were used because they had been previously related to the pubertal growth spurt.[26,29,35] The definitions for these stages in the canines were as follows.

- D: Crown completed up to the cement-enamel junction. Beginning of root formation.
- E: The walls of the pulp chamber are well defined. Root length is smaller than crown length.
- F: The root apex is open. Root length is equal or larger than crown length.
- G: The walls of the pulp chamber are parallel, and the apex is still open.
- H: The root apex is closed. The periodontal ligament is uniform around the root.

Use of height by age and weight by height was recommended by the World Health Organization (WHO) as primary indicators of nutritional status in children.[36] Height was taken for each child dressed in light clothes and without shoes, following the WHO rec-

TABLE 2. Crosstabs Between Skeletal Maturation Stage of the Medial Phalanx of the Third Finger in the Right Hand and Dental Development Stage of the Left Lower Canine for the Total Sample

		Dental Development Stage				
		E	F	G	H	Total (%)
	F	14	35	19	0	68 (24.3)
Skeletal	FG	2	19	28	0	49 (17.5)
Maturation	G	0	2	47	2	51 (18.2)
Stage	H	0	0	19	12	31 (11.1)
	I	0	0	5	76	81 (28.9)
Total (%)		16 (5.7)	56 (20.0)	118 (42.1)	90 (32.1)	280 (100.00)

ommendations. Children whose height for age was <95% of the median (50th percentile) were classified as stunted.[1] Reference curves published by Frisancho[37] were used because of the age of the sample.

All the data were analyzed with the SPSS statistical package (SPSS v.11.5; Chicago, Ill). Descriptive statistics were calculated for skeletal maturation stage, dental development of the lower canine, and nutritional status. Kolmogorov-Smirnov (normality of distribution) and Levene tests (homogeneity of variances) were used to evaluate whether the sample came from a normally distributed population. Because these criteria were not satisfied, nonparametric statistical tests were used. Mann-Whitney *U*-tests were used to compare the distribution of skeletal maturation and canine development stages according to nutritional status. Spearman correlation test was used to determine the correlation between skeletal maturation stage and dental development of the lower canine and to evaluate differences in the correlation values according to skeletal level.

RESULTS

The distribution of the sample according to skeletal maturity stage is provided in Table 2.

There was no statistically significant difference for the skeletal maturation ($P = .134$) and the dental development ($P = .497$) stages according to nutritional status, even when considering different age groups ($P > .183$). There was a statistically significant difference for the skeletal maturation stage ($P < .001$) and the dental development stage ($P < .001$) according to sex.

A high correlation ($r = 0.859$; $P < .001$) was found between both maturity indicators regardless of nutritional status (growth stunted, $r = 0.855$ and normal controls, $r = 0.863$; all $P < .001$) or sex (boys, $r = 0.809$ and girls, $r = 0.892$; both $P < .001$) (Table 3).

When skeletal level was considered, correlations values were similar between advanced ($r = 0.903$) and average ($r = 0.895$) maturers but lower ($r = 0.751$) for delayed maturers (Table 4).

TABLE 3. Spearman Correlation Between Skeletal Maturation Stage of the Medial Phalanx of the Third Finger in the Right Hand and Dental Development Stage of the Left Lower Canine for the Total Sample, According to Nutritional Status and Sex

	Number of School Children	*r* of Spearman	Significance (*P* value)
Total sample	280	0.859	<.001
Stunted	140	0.855	<.001
Nourished	140	0.863	<.001
Boys	140	0.809	<.001
Girls	140	0.892	<.001

TABLE 4. Spearman Correlation Between Skeletal Maturation Stage of the Medial Phalanx of the Third Finger in the Right Hand and Dental Development Stage of the Left Lower Canine for the Total Sample, According to Skeletal Level

	Number of School Children	*r* of Spearman	Significance (*P* value)
Advanced	39	0.903	<.001
Average	208	0.895	<.001
Delayed	33	0.751	<.001

DISCUSSION

A study of growth stunting in developing countries established a 34% prevalence in Latin America.[38] In view of these percentages, it was considered important to determine the amount of association between growth stunting and maturation stages and dental development in a sample of undernourished school children from Peru. If nutritional status (stunting) is associated with altered skeletal and dental maturity, the nutritional status may potentially affect the timing of growth modification treatment planning.

This study did not identify an association between growth stunting and altered skeletal maturation stage. Previous studies in Indian[9–11] and American[12] preschool children, on the contrary, showed that skeletal maturation stage may be delayed in growth-stunted children. These contradictory results may be explained because these four studies[9–12] evaluated only younger nonadolescent samples, whereas our study encompasses an adolescent sample.

Controversially, some previous longitudinal studies[12,39–41] found that a complete maturational catch-up could potentially occur; although a great individual variability was found and severe growth stunted cases were evaluated. In one of the longitudinal studies, Tanner[42] stated that human growth is capable of self-stabilization, and disturbances such as malnutrition were sufficient to cause deflections in the growth pattern that stimulated the development of restoring forces. This was later rejected in another longitudinal study,[14] which found that although stunted girls had the potential to catch up growth during puberty, their stature was never recovered.

A comprehensive review[13] proposed that the potential for catch-up growth increased because the prolongation of the growth period can usually partially compensate for the earlier growth retardation. However, this increase is limited to a couple of years, which makes only partial use of this potential. Another point to be considered when evaluating the different results is that the Dreizen[12] sample was from a developed country, whereas Benefice[14] sample and the review's samples[13] were from developing countries. Also, differences in the methodology, growth secular changes, and height potential may also partially explain the discrepancies. In conclusion, several individual factors may influence the potential for catch-up growth.

WHO recommendations regarding the use of height for age (stunting) as one of the primary indicators of nutritional status has been previously used in Peruvian[43,44] and Chilean[45] undernourished populations of similar, racial background to evaluate tooth eruption and dental caries. Although a single measurement such as height by age does not measure the current nutritional status of a child and does not indicate whether current growth is proceeding normally, it does measure achievement to date or cumulative growth.[46]

Hand-wrist radiographs have been usually used as a reliable method for assessing skeletal maturation.[17] In recent years, evaluation of cervical vertebrae in lateral cephalograms has been increasingly used to determine the skeletal maturation.[47–51] Use of periapical[30,32,52,53] or digital radiographs[31] from ossification centers in different fingers also have been found to be as reliable as more complex methods for skeletal maturation. Wide access to in-office intraoral radiographic imaging devices and reduced radiation exposure with digital imaging represents distinct advantages.

Maturation of the same permanent teeth has been reported to be able to replace skeletal maturity stage in some studies[25,27–29] but not in others.[24,26] Calcification patterns of the lower permanent cuspids revealed the highest degree of correlation with maturation events for some authors[27–29] but was not necessarily the case for others.[25,26] Our results showed that lower cuspid calcification was highly correlated with skeletal maturation even in growth-stunted subjects. No previous studies were identified, which evaluated dental maturation in growth-stunted subjects. These studies only evaluated delayed tooth eruption,[43,44] and therefore, comparisons in this regard were not possible.

Correlations values were very high and similar between advanced ($r = 0.903$) and average ($r = 0.895$) maturers but lower ($r = 0.751$) for delayed maturers. This may prove that skeletal level (how an individual is relative to the same maturational stage) may have treatment implications. A possible explanation is that during the accelerating and high-velocity periods in adolescence, advanced maturers grow faster and more than average and delayed maturers; whereas they grow significantly less during the decelerating period of late adolescence.

A possible limitation with this approach is that of inheritance of short stature. Previous research[54] has shown than the effect of malnutrition may operate through generations, ie, nutritional-stunted mothers giving birth to stunted babies. It was assumed in our study that growth stunting was mainly a consequence of chronic malnutrition. It was not within the scope of this study to determine how long the subjects lived in the environment where they became stunted or to determine the timing and extent of stunting. Also, comparisons against values of external reference populations may be not completely reliable. Although growth potential in early childhood is very similar across ethnic groups, little is known about growth potential during puberty.[13] Unfortunately, lack of Peruvian growth standards impeded the use of more appropriate reference values. Caution should be exercised in comparison of the present results with previous studies.

CONCLUSIONS

- No influence of growth stunting on skeletal maturation stage and dental development stage in preadolescents and adolescents was found.
- There was a high correlation between the skeletal maturation stages MP3 and the calcification of the mandibular canine for both sexes.
- Skeletal level did influence the correlation values between the skeletal maturation stages MP3 and the calcification of the mandibular canine.

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