Association between body mass index and dental age in Hispanic children

Dina A. Chehab, DDS ■ Thomas Tanbonliong, DDS ■ Joshua Peyser, DMD ■ Richard Udin, DDS

The purpose of this prospective cross-sectional study was to determine whether body mass index (BMI) is associated with dental development in Hispanic children when compared to their chronologic age and expected dental development. The study enrolled 265 healthy (American Society of Anesthesiology Class I), 6- to 12-year-old Hispanic children. A BMI was calculated from each child's height and weight, and a panoramic radiograph was taken at the same appointment. Subjects were enrolled into 1 of 2 groups: a control group with BMIs classified as underweight/average (less than 85th percentile) and a group with BMIs classified as overweight/obese (85th percentile or greater). Dental age was determined using both panoramic radiographs and the Demirjian dental maturity scale to examine the stage of root development in the dentition. Chronologic age was obtained from each child's birthdate. Results showed a high correlation between chronologic and dental ages ($P < 0.001$), although dental age was significantly greater in the total sample. The mean difference in dental age among all children was 7.4 months, but the difference was significantly greater ($P < 0.001$) in children who were overweight/obese (11.7 months) than in underweight/average subjects (3.4 months). Overweight/obese Hispanic children were approximately 3.5 times more dentally advanced. The older the chronologic age, the greater the difference.

Received: November 1, 2016
Accepted: January 4, 2017

Key words: BMI, body mass index, children, dental, development, Hispanic

GENERAL DENTISTRY SELF-INSTRUCTION CE CREDIT
Exercise No. 406, p. 59
Subject code: Pediatric Dentistry (430)

The American Academy of Pediatrics Committee on Nutrition has stated that "…obesity is the most prevalent chronic health condition in the pediatric population."[1] *Obesity* is defined as a body mass index (BMI) greater than or equal to the 95th percentile. An age- and sex-standardized BMI is the most commonly used indicator to assess a child's size.[2,3]

Dental development and skeletal development are common indicators for determining an individual's overall maturation, due to their high reliability and resistance to environmental effects.[4] Several different methods are available for assessing a child's dental age, including tooth emergence and tooth formation stages. Tooth eruption is known to be inferior for evaluating dental age due to variables such as lack of space and systemic factors (nutritional status).[4] Methods of assessing skeletal maturation include hand-wrist radiographs and cervical vertebral maturation (CVM) analysis.[5] Hand-wrist radiographs are considered the gold standard for skeletal maturation; however, their use for dental purposes exposes the patient to increased radiation. Among orthodontists especially, CVM has lately become popular for assessing skeletal maturation.[5]

The dental maturity scaling system proposed by Demirjian et al is arguably the most common way to assess dental age in children.[6] According to Demirjian et al, tooth formation is a more reliable indicator of dental maturity.[6] In their original study, the researchers used panoramic radiographs of approximately 3000 healthy children, aged 2-20 years, who were of French Canadian descent, free from disorders, and had complete permanent mandibular dentitions.[6] The Demirjian rating system is based on the shape of teeth and root closure as opposed to the length of tooth roots. They determined that using the mandibular left side (7 teeth) would be just as accurate as using all teeth.[6] Each tooth in the mandibular left quadrant of teeth is evaluated and assigned to a stage ranging from A to H (A, at the beginning of calcification; H, when the apical end of root canal is completely closed). The stage is then converted to a numerical score based on a table created by Demirjian et al.[6] After the scores of all the teeth on the mandibular left side are added, the total is converted into an approximate dental age (maturity score).

The Demirjian scale has been used in countless studies in assessing the dental age of patients and is sometimes coupled with CVM to assess a patient's overall dental and skeletal maturity. Overall, the Demirjian method has been shown to be an accurate, reliable method for assessing dental age.[4,7,8]

The relationship between obesity and dental age has been previously examined, but a definitive relationship has yet to be established. DuPlessis et al found that BMI percentile and ethnicity are poor predictors of dental age and chronologic age.[9] However, their study did not focus on the Hispanic population.[9]

Table 1. Characteristics of 265 Hispanic children[a] included in the study.

Characteristic	Mean	SD
Age (y)	9.3	1.5
Height (in)	53.8	4.7
Weight (lb)	83.3	30.6
BMI *Z* score	0.8	1.2
BMI percentile	70.3	30.0

Abbreviation: BMI, body mass index.
[a]The sample comprised 131 boys (49.4%) and 134 girls (50.6%).

Table 2. Distribution of 265 Hispanic children by body mass index category.

Category	n	%
Underweight	7	2.6
Average weight	127	47.9
Overweight	61	23.0
Obese	70	26.4

Hilgers et al found a direct relationship between an increased BMI and accelerated growth and development among children 7-15 years old.[10] Many studies have used retrospective data in assessing BMI and its relation to dental growth and development, yet none of these studies sought to find whether there was a correlation between BMI and craniofacial development in the Hispanic pediatric population. Knowledge of this relationship would allow a dentist to offer anticipatory guidance and timely orthodontic treatment to Hispanic children. Additionally, improved anticipatory guidance related to nondental factors—such as an earlier onset of puberty—could be provided to both parent and patient.

The purpose of this prospective cross-sectional investigation was to determine whether BMI has an impact on dental development in Hispanic children when compared to their chronologic age and their expected dental development.

Materials and methods

Patient sample

Approval was obtained from the Protection of Human Patients Committee of the Herman Ostrow School of Dentistry, University of Southern California, Los Angeles. Patients who presented for comprehensive or recall examination and needed a panoramic radiograph (per American Dental Association guidelines) were recruited to participate in this study. Informed consent was obtained from the legal guardian of each patient. Patient demographics and dental examination data were gathered from patients who matched the following inclusion criteria: American Society of Anesthesiologists Class I, 6-12 years of age, and Hispanic, as disclosed by the parent or guardian in the patient information sheet.

Ultimately 265 children were recruited for the study. The BMI of each subject was calculated from the child's height and weight on the same day the radiograph was obtained. The Centers for Disease Control (CDC) defines BMI categories as follows: underweight, BMI less than 5th percentile; normal (average), 5th percentile to less than 85th percentile; overweight, 85th percentile to less than 95th percentile; and obese, 95th percentile or greater.[11] The patients were grouped into either underweight/average or overweight/obese pairings to create a more definitive classification system. Chronologic age was calculated from each patient's birthdate, and the sex of each patient was also recorded. The dental age was then calculated by a single investigator who used the panoramic radiograph and the Demirjian dental maturity scale to determine the stage of root development in the child's dentition.

Statistical analysis

Patient characteristics were computed using number and percentage for categorical outcomes and mean (with standard deviation) for continuous outcomes. Age variables (chronologic, dental, and difference) were examined for normality and were deemed parametric. BMI percentile and *Z* scores were calculated for sex- and age-matched norms using the guidelines provided by the 2000 CDC growth charts.[12] Pearson correlations revealed the association of chronologic and dental ages. Paired *t* tests compared chronologic age with dental age, and a repeated-measures analysis of variance (ANOVA) was performed to test whether there was an effect of weight status (underweight/average versus overweight/obese) on the differences found between chronologic and dental ages. Sex was also examined as a potential confounder. A Bland-Altman plot was created to examine whether the concordances were similar across the chronologic age range.

Results

Approximately 80% of the 265 children who participated in the study were of Mexican descent. Table 1 shows the characteristics of the patients included in the analyses. Ages ranged from 6.0 to 12.9 years, and patients were evenly distributed between boys (131; 49.4%) and girls (134; 50.6%). Approximately half (47.9%) of the participants (n = 127) were deemed to be of average weight (Table 2). These patients, combined with the 7 (2.6%) who were underweight, made up the underweight/average (control) category (n = 134). Sixty-one of the patients (23.0%) were deemed to be overweight, and these patients, combined with the 70 (26.4%) who were obese, made up the overweight/obese group (n = 131).

There was a strong correlation between chronologic and dental ages ($r = 0.82$; $P < 0.001$), although the dental age was significantly higher in the total sample—estimated to be 7.4 months (95% confidence interval [CI] = 5.7-9.2 months) higher than chronologic age ($t_{264} = 8.51$; $P < 0.001$). A repeated-measures ANOVA showed that obesity had a significant effect on concordance ($F_{1,263}$ = 24.6; $P < 0.001$). Table 3 reports the results (in years) stratified by group and sex. For overweight/obese children, the mean difference was approximately 1 year (11.7 months; 95% CI = 9.2-14.2 months; $P < 0.001$), while the difference in underweight/average children was 3.4 months (95% CI = 1.2-5.5 months; $P = 0.002$). Sex was neither a confounder nor an effect modifier.

A Bland-Altman plot demonstrated that variability in the differences increased with chronologic age, although the correlation between the difference and chronologic age was slight ($r = 0.12$) (Chart 1). Chart 2 shows the distribution of the combined BMI groups in relation to age. Chart 3 shows the distribution of BMI percentile categories in relation to age.

Table 3. Comparison of chronologic and dental ages in the total sample and stratified by BMI and sex.

	Paired *t* test				
Age (y)	Mean	SD	*t*	*df*	*P* value
Total sample					
Dental	9.96	2.04	8.51	264	< 0.001
Chronologic	9.33	1.52			
Difference	0.63	1.19			
BMI ≥ 85th percentile (n = 131)					
Dental	10.49	2.15	–9.15	130	< 0.001
Chronologic	9.52	1.59			
Difference	0.97	1.21			
BMI < 85th percentile (n = 134)					
Dental	9.44	1.80	–3.08	133	0.002
Chronologic	9.16	1.44			
Difference	0.28	1.06			
Boys (n = 131)					
Dental	9.80	1.84	–5.91	130	< 0.001
Chronologic	9.23	1.46			
Difference	0.57	1.10			
Girls (n = 134)					
Dental	10.11	2.22	–6.14	133	< 0.001
Chronologic	9.44	1.58			
Difference	0.67	1.27			

Abbreviation: BMI, body mass index.

Discussion

It is well known that the prevalence of obesity in children has steadily increased throughout the world.[1,2] According to the World Health Organization, obesity is a "global epidemic disease."[2] Several factors have been suggested as a cause for childhood obesity, including poor nutrition, decreased physical activity, metabolic factors, and lower socioeconomic status.[3] Specific consequences of obesity include type 2 diabetes, osteoporosis, hypertension, and cardiovascular disease.[13] In the United States, Hispanic children experience higher rates of obesity than white children.[14] With obesity increasing worldwide, it is important to distinguish how body weight affects the dentition of children.[15] This prospective cross-sectional study examined the relationship between obesity and dental development in a young Hispanic population. The majority of the children in this study were of Mexican descent.

In children and adolescents, physical development—including parameters such as skeletal maturity, height, and the onset of puberty—is commonly used to determine the overall age.[6] However, physical development can be influenced by several factors—such as diet and environmental conditions—that may make it a less reliable measurement tool. Dental age estimation is accepted because it is less variable than other determinants for overall age.[7] Major determinants for dental age estimation include the timing of tooth eruption and patterns of tooth development. However, estimation via tooth eruption, while accepted in the past, has fallen out of favor as it has been found to be unreliable.[7] The Demirjian method, which utilizes tooth development patterns, has been established as reliable.[4,7,8]

There have been numerous studies utilizing the Demirjian assessment method to determine a relationship between dental development and BMI.[16,17] In 2013, Mack et al conducted a study in which they found that dental age and CVM were more advanced in patients with increased BMI percentiles.[16] The authors found a mean difference of 1.17 years between dental and chronologic ages, while a difference of 0.63 years was found in the current study. Possible contributions to the variance between the results of the present study and the Mack et al study include patients of different races and an older patient pool (8-17 years) in the latter study.[16] Additionally, Mack et al found that boys were significantly more advanced from a dental standpoint, whereas the current study did not find a significant difference between sexes.[16] Mack et al concluded that orthodontists should consider weight status when evaluating children and adolescents, as it can impact skeletal and dental development.[16]

In a 2014 study examining the relationship between BMI and dental development in younger Iranian orthodontic patients, it was determined that overweight/obese children had accelerated dental development.[17] More specifically, the difference between dental and chronologic ages was 0.73 years for underweight/average children and 1.8 years for overweight/obese children, highlighting the correlation between accelerated dental maturity and higher BMI percentiles.[17] The difference in the overweight/obese children was approximately 2.5 times that in the underweight/average children. The current study, with its findings of a 0.28-year difference between dental and chronologic ages in underweight/average children and a 0.97-year difference in overweight/obese children, produced an even greater disparity between groups—3.5 times.

Similar studies have noted that an increase in a child's BMI has an accelerated effect on tooth eruption.[9,10] This effect is seen among African American, Hispanic, and white children. Interestingly, the 2014 Iranian study found that girls were more advanced in dental age, whereas the current study did not.[17] The current study found that sex was not a factor. In contrast, DuPlessis et al have documented that sex differences exist in dental development.[9]

Chart 1. Age difference, by chronologic age, stratified at the 85th percentile of body mass index.

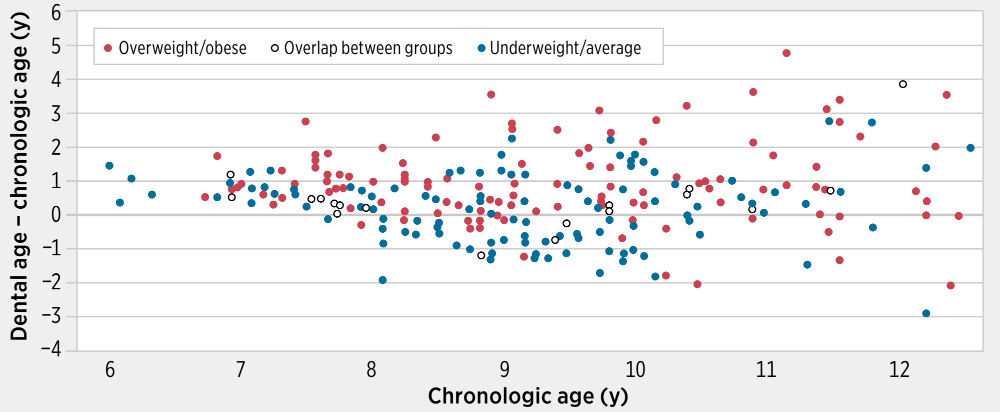
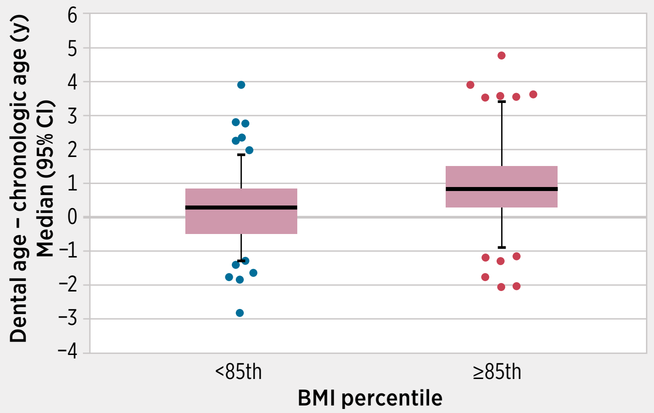
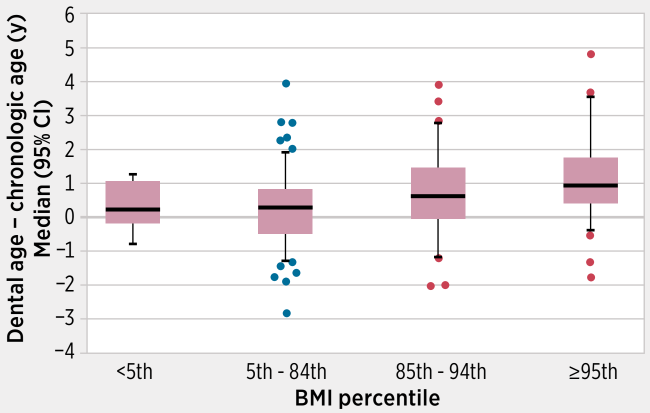


Chart 2. Distribution of combined BMI groups in relation to age.



Abbreviations: BMI, body mass index; CI, confidence interval.
Red and blue circles represent outliers in their respective groups.

Chart 3. Distribution of BMI percentiles in relation to age.



Abbreviations: BMI, body mass index; CI, confidence interval.
Red and blue circles represent outliers in their respective groups.

Analysis based on the Demirjian scale revealed subtle differences between teeth and their stages of development. In general, the order of root closure (earliest to latest) is central incisor, first molar, lateral incisor, first premolar, canine, second premolar, and second molar. In the current study, the most common order of root closure for the underweight/average population was the expected order. However, among the overweight/obese population, the canine developed ahead of the first premolar. The possible causation of this effect would need to be examined in further detail, as this has not been reported in previous studies.

Obesity in childhood can be a driver of early puberty, creating a potential mismatch between sexual and psychosocial maturation with resultant implications for self-perception. However, the direct relationship between obesity in childhood and the onset of puberty has not been definitively established, as inconsistencies still exist.[18] A study by Biro et al examined the onset of breast development and the possible correlations with BMI and other factors.[19] It was concluded that a higher BMI was the strongest predictor of earlier breast development. This could also be translated to dental development. Specifically, female patients with a BMI greater than the 85th percentile exhibited earlier maturation.[19]

With the knowledge that increased BMI can cause earlier dental development, the general dentist can provide better anticipatory guidance, such as timely orthodontic referral, and implement different restorative philosophies, including more conservative restorations in the primary teeth of dentally advanced patients because tooth exfoliation will occur earlier. In future studies, other populations should be examined to determine if BMI plays a role in their dental and skeletal development.

One limitation of the current study is sample size, as only Hispanic children aged 6-12 years were included, and the majority of them were of Mexican descent. It would be beneficial to find out if the same trend exists among Hispanic children from different countries.

Another limitation is the fact that the Demirjian method has its shortcomings. In previous studies, it has been shown to overestimate dental age in some populations.[20,21] Alternatives exist, including the Willems method, which uses a modified variation of the Demirjian maturity table. However, Mani et al demonstrated that the Willems method may also overestimate dental age.[7] The current study yielded a slight overestimation of age when examining the underweight/average population (9.16 chronologic versus 9.44 dental); however, this difference was not found to be statistically significant. A study by Aissaoui et al examined the Demirjian method in Tunisian children and found the gap between the chronologic and dental ages to be approximately 0.26-1.37 years in females (and nearly the same in males).[4] Those authors found that a scale developed using French Canadian children as a baseline may not be best suited for other populations, and each population could benefit from its own specific standard for an accurate estimation of age.[4]

In the current study, a single investigator assessed the root development in the panoramic images as it relates to the Demirjian scale. This could have introduced bias, which needs to be considered as a limitation.

Conclusion

This study evaluated the effect of obesity on dental development in Hispanic children with mixed dentition. The obese/overweight group had a significantly greater mean difference between chronologic and dental ages than did underweight/average patients. The disparity was approximately 3.5 times greater (11.7 months' difference between chronologic and dental ages for the overweight/obese patients and 3.4 months' difference for the underweight/average group). In addition, this study found that the older the chronologic age, the greater the gap. Sex was not a confounding factor.

Author information

Dr Chehab is a clinical assistant professor, Dr Tanbonliong is an associate professor of clinical dentistry and graduate clinic director of pediatric dentistry, and Dr Udin is a professor of clinical dentistry, Herman Ostrow School of Dentistry, University of Southern California, Los Angeles. Dr Peyser is in private practice in Charleston, South Carolina.

Acknowledgments

The authors would like to acknowledge Dr Christianne Lane for providing statistical support and Dr Rachel Rittenberg for her contribution to this article.

This publication was supported by NIH/NCRR SC CTSI grant No. UL1TR000130. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the National Institutes of Health.

References

1. Daniels SR, Hassink SG; Committee on Nutrition. The role of the pediatrician in primary prevention of obesity. *Pediatrics.* 2015;136(1):e275-e292.
2. Costacurta M, Sicuro L, Di Renzo L, Condò R, De Lorenzo A, Docimo R. Childhood obesity and skeletal-dental maturity. *Eur J Paediatr Dent.* 2012;13(2):128-132.
3. Wright KN. Influence of body mass index, gender, and Hispanic ethnicity on physical activity in urban children. *J Spec Pediatr Nurs.* 2011;16(2):90-104.
4. Aissaoui A, Salem NH, Mougou M, Maatouk F, Chadly A. Dental age assessment among Tunisian children using the Demirjian method. *J Forensic Dent Sci.* 2016;8(1):47-51.
5. Giri J, Shrestha BK, Yadav R, Ghimire TR. Assessment of skeletal maturation with permanent mandibular second molar calcification stages among a group of Nepalese orthodontic patients. *Clin Cosmet Investig Dent.* 2016;8:57-62.
6. Demirjian A, Goldstein H, Tanner JM. A new system of dental age assessment. *Hum Biol.* 1973;45(2):211-227.
7. Mani SA, Naing L, John J, Samsudin AR. Comparison of two methods of dental age estimation in 7-15-year-old Malays. *Int J Paediatr Dent.* 2008;18(5):380-388.
8. Yan J, Lou X, Xie L, Yu D, Shen G, Wang Y. Assessment of dental age of children aged 3.5 to 16.9 years using Demirjian's method: a meta-analysis based on 26 studies. *PLoS One.* 2013;8(12):e84672.
9. DuPlessis EA, Araujo E, Behrents RG, Kim KB. Relationship between body mass and dental and skeletal development in children and adolescents. *Am J Orthod Dentofacial Orthop.* 2016;150(2):268-273.
10. Hilgers KK, Akridge M, Scheetz JP, Kinane DE. Childhood obesity and dental development. *Pediatr Dent.* 2006;28(1):18-22.
11. Centers for Disease Control and Prevention. *Defining Childhood Obesity.* Updated June 16, 2015. https://www.cdc.gov/obesity/childhood/defining.html. Accessed May 19, 2017.
12. Kuczmarski RJ, Ogden CL, Guo SS, et al. 2000 CDC growth charts for the United States: methods and development. *Vital Health Stat.* 2002;246:1-190.
13. Centers for Disease Control and Prevention. *Childhood Obesity Causes & Consequences.* Updated December 15, 2016. https://www.cdc.gov/obesity/childhood/causes.html. Accessed May 19, 2017.
14. Zilanawala A, Davis-Kean P, Nazroo J, Sacker A, Simonton S, Kelly Y. Race/ethnic disparities in early childhood BMI, obesity and overweight in the United Kingdom and United States. *Int J Obes (Lond).* 2015;39(3):520-529.
15. Markovic D, Ristic-Medic D, Vucic V, et al. Association between being overweight and oral health in Serbian schoolchildren. *Int J Paediatr Dent.* 2015;25(6):409-417.
16. Mack KB, Phillips C, Jain N, Koroluk LD. The relationship between body mass index percentile and skeletal maturation and dental development in orthodontic patients. *Am J Orthod Dentofacial Orthop.* 2013;143(2):228-234.
17. Hedayati Z, Khalafinejad F. Relationship between body mass index, skeletal maturation, and dental development in 6- to 15-year-old orthodontic patients in a sample of Iranian population. *J Dent.* 2014;15(4):180-186.
18. Wagner I, Sabin MA, Pfäffle RW, et al. Effects of obesity on human sexual development. *Nat Rev Endocrinol.* 2012;8(4):246-254.
19. Biro FM, Greenspan LC, Galvez MP, et al. Onset of breast development in a longitudinal cohort. *Pediatrics.* 2013;132(6):1019-1027.
20. Maber M, Liversidge HM, Hector MP. Accuracy of age estimation of radiographic methods using developing teeth. *Forensic Sci Int.* 2006;159(Suppl 1):S68-S73.
21. Cameriere R, Ferrante L, Liversidge HM, Prieto JL, Brkic H. Accuracy of age estimation in children using radiograph of developing teeth. *Forensic Sci Int.* 2008;176(2-3):173-177.