Published in final edited form as:
Obesity (Silver Spring). 2012 October ; 20(10): 2070–2074. doi:10.1038/oby.2012.23.

The Association Between childhood Obesity and Tooth Eruption

Aviva Must[1], **Sarah M. Phillips**[1], **David J. Tybor**[1], **Keith Lividini**[2], and **Catherine Hayes**[3]

[1]Department of Public Health & Community Medicine, Tufts University School of Medicine, Boston, Massachusetts, USA

[2]HarvestPlus/International Food Policy Research Institute, Washington, DC, USA

[3]Frances Stearns Nutrition Center, Tufts Medical Center, Boston, Massachusetts, USA

Abstract

Obesity is a growth-promoting process as evidenced by its effect on the timing of puberty. Although studies are limited, obesity has been shown to affect the timing of tooth eruption. Both the timing and sequence of tooth eruption are important to overall oral health. The purpose of this study was to examine the association between obesity and tooth eruption. Data were combined from three consecutive cycles (2001–2006) of the National Health and Nutrition Examination Survey (NHANES) and analyzed to examine associations between the number of teeth erupted (NET) and obesity status (BMI *z*-score >95th percentile BMI relative to the Centers for Disease Control and Prevention (CDC) growth reference) among children 5 up to 14 years of age, controlling for potential confounding by age, gender, race, and socioeconomic status (SES). Obesity is significantly associated with having a higher average NET during the mixed dentition period. On average, teeth of obese children erupted earlier than nonobese children with obese children having on average 1.44 more teeth erupted than nonobese children, after adjusting for age, gender, and race/ethnicity ($P < 0.0001$). SES was not a confounder of the observed associations. Obese children, on average, have significantly more teeth erupted than nonobese children after adjusting for gender, age, and race. These findings may have clinical importance in the area of dental and orthodontic medicine both in terms of risk for dental caries due to extended length of time exposed in the oral cavity and sequencing which may increase the likelihood of malocclusions.

Introduction

Childhood obesity is increasingly recognized as a public health concern in the United States and globally. Data from the 2007–2008 NHANES show that the prevalence of obesity in the United States is 16.9% among all children ages 2–19, and the prevalence has been reported as high as 29% among certain racial/ethnic groups (1). Obesity in childhood is associated with an increased risk for many adverse physical and psychosocial health outcomes (2). As a growth-promoting process that affects almost every organ system in the human body (3), obesity has been shown to affect the timing of puberty in boys and girls (4). Before puberty, overweight children are significantly taller than their age-matched peers (5). Given its association with accelerations in growth and maturation it is reasonable to hypothesize that obesity affects the timing of tooth eruption.

Correspondence: Aviva Must (aviva.must@tufts.edu).

Disclosure: The authors declared no conflict of interest

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Tooth eruption is the movement of a tooth from its position in the osseous crypt into the oral cavity. Although the exact mechanisms underlying this process are not entirely known, many factors appear to play a role. Demographic factors, such as race, sex, and age may influence the process (6). Physiologic factors thought to be involved include molecular signaling (7) and several hormones and mediators that affect growth (8). Growth of the mandible is known to be influenced by pubertal timing (9). Deciduous tooth eruption may be altered in conjunction with certain systemic disorders, such as diabetes mellitus and congenital abnormalities (10,11). Alterations in the timing of tooth eruption can significantly impact oral health due to its potential to cause malocclusion (the improper positioning of the teeth and jaws) and/or crowding, which may in turn lead to poor oral hygiene and periodontal disease (12,13). In addition, the length of time a tooth is present in the oral cavity affects its risk for dental caries. Furthermore, sequencing of eruption may impact occlusion which may have consequences for periodontal and temporomandibular joint disorders.

A relationship between the timing of a child's primary teeth and both postnatal growth (14,15) and nutritional status (16–18) has been observed; however, few studies have been conducted to examine the effects of obesity on the timing of permanent tooth eruption. One longitudinal study conducted in Mexico City found that among 110 children, obese children had more erupted teeth than nonobese children, after accounting for sex and age at baseline (19). A US study of 104 children found that obesity was associated with accelerated dental development (assessed as the difference between chronologic age and dental age) after adjusting for age and gender (20). Tooth eruption has been linked to developmental stage, which in turn is also related to body fatness (21,22). A cross-sectional study of 102 12-year-old girls from Hong Kong found that sexual maturity was related to body weight, height, and tooth eruption. Girls who were classified as “early maturers” had more erupted permanent canines, premolars, and second molars compared to “late maturers” (23). These aforementioned studies were limited by the study of small nonrepresentative samples of children.

The purpose of the current study was to perform a cross-sectional analysis of the association between childhood obesity and tooth eruption, accounting for age, sex, and race in a nationally representative data set, the NHANES. Differences in the average number of permanent teeth erupted (NET) between obese and nonobese children by age were examined. We hypothesized that obesity would be associated with accelerated tooth eruption, and that differences in age-specific tooth eruption would differ by race/ethnicity and by gender.

Methods and Procedures

Study population

Data were obtained from the NHANES, a continuing survey of the civilian, noninstitutionalized US population (24). The oral health examination in the NHANES is completed by a dentist who has undergone extensive training, including a calibration phase in which the degree of correlation between the dental examiners and a standard examiner is assessed. Complete information on procedures and assessment included in the oral health component can be found at http://www.cdc.gov/nchs/data/nhanes/oh-e.pdf. To achieve a sample size required for reliable estimates for testing differences between sub-domains (25), three cycles of NHANES (2001–2002, 2003–2004, and 2005–2006) were combined for this analysis. Variables for this analysis were extracted from the demographic, body measures, and dental health publicly available data files, and merged based on the sequence number (SEQN) (ID) variable for each relevant cycle for this analysis and one file was created by appending the 2003–2004 and 2005–2006 cycles to the 2001–2002 file.

Overall 31,509 participants comprise the combined data file. All analyses were restricted to the 5,838 participants between 5 (the minimum age at the dental exam) up to 14 years of age (the end of the mixed dentition period). Excluded from the analytic data set were participants who were not both interviewed and examined ($n = 200$), pregnant ($n = 1$), and those who were missing data on tooth count or BMI ($n = 203$). After these exclusions, 5,434 participants remained for analysis.

Selection of variables

Several key variables were created for this analysis. The NET was calculated by taking the sum of all permanent teeth erupted for each subject (excluding the 3rd molars). A permanent tooth was considered to be erupted if it was coded as a “permanent tooth” or a “permanent dental root fragment” and considered to be non-erupted otherwise. Obesity status was defined based on BMI *z*-score as being greater than or equal to the 95th percentile (obesity) or between the 85th and 95th percentile (overweight), based on the 2000 Centers for Disease Control and Prevention (CDC) growth charts (26). Age, race/ethnicity, gender, and the poverty income ratio (PIR), were examined as independent predictors or con-founders of the association between NET and obesity. Race/ethnicity was categorized as other, non-Hispanic black, Mexican American, other Hispanic, or non-Hispanic white. PIR is a measure of socioeconomic status (SES) and is calculated as the ratio of household income to the poverty threshold after accounting for inflation and family size.

Domain variables were created for subpopulation analyses and specified the study population of interest while retaining all other observations from the data set. To incorporate the sample weighting in this study, a new sample weight was calculated for the merged 6-year sample by multiplying the 2-year examination sample weight by one-third (1/3), as recommended (27). This approach utilizes the sampling scheme in NHANES and properly estimates variance.

Statistical analyses

Analyses were accomplished using SAS (Version 9.2; SAS, Cary, NC). Exploratory data analyses were performed by examination of visual representations and summary statistics for the variables of interest. Comparisons of the two groups (obese and nonobese) were made using independent samples *t*-test for continuous variables and χ^2 tests for categorical variables. We also examined the relationship between NET and weight status using three categories: normal weight (<85th percentile), overweight (≥85th and <95th percentile), and obese (≥95th percentile). Normal weight subjects were used as the reference category in this secondary analysis.

Simple linear regression was used to explore the association between the NET and obesity. To assess secular trends across the three waves of data, a variable representing the cycle year was added to the model, including an interaction term for obesity and cycle year.

The association between the NET and each potential confounder (age, gender, race, and PIR) was evaluated using simple linear regression analysis. Each predictor was then added to a model that included obesity to check for confounding. All significant predictors and confounders were included in an adjusted model, and collinearity was examined. Effect modification was evaluated by including all two-way interaction terms between obesity and age, gender, race, and PIR. An α of 0.05 was used to declare statistical significance.

Results

Table 1 shows the differences in sociodemographic characteristics between obese and nonobese children. Obese subjects had a higher mean age than nonobese subjects. In addition, there was a higher proportion of Mexican Americans in the obese group and a lower proportion of non-Hispanic white Americans. Obese subjects also had a lower median PIR. There was no significant difference in the proportion of males and females in the two groups.

Bivariate analyses revealed several differences in NET. NET was significantly associated with obesity status ($P < 0.0001$). Obese subjects had a higher median NET. NET was also significantly associated with being female ($P < 0.0001$) and race/ethnicity ($P < 0.0001$). As expected, there was a strong positive correlation between NET and age (Pearson $r = 0.93$, $P < 0.0001$). NET was not significantly correlated with PIR ($P = 0.30$; Spearman correlation), however.

Table 2 and Figure 1 show NET by age category and obesity status at the mean and median, respectively. In all age categories from age 7 onward, obese subjects had significantly greater mean NET than nonobese subjects. The greatest differences in NET are seen at age 10 and age 11, with obese subjects exceeding nonobese subjects by a mean of 2.7 and a median of six teeth.

Table 3 shows the results of the linear regression analyses. In an unadjusted analysis (model 1) obesity is significantly associated with NET, and 1% of the variation in tooth eruption explained by this model. Cycle year was not significantly associated with NET in the presence of obesity. When potential confounders were examined independently, age, gender, and race/ethnicity were all significant confounders of the association between obesity and NET. PIR was not significantly associated with NET in the presence of obesity. In a full model adjusting for significant confounders, age, gender and race/ethnicity all remained statistically significant, with no evidence of collinearity, secular trend across the survey cycles, or other two-way interactions.

The final model is presented as model 2 in Table 3. On average, obese subjects have 1.44 more teeth erupted than nonobese subjects after controlling for age, gender, and race/ethnicity ($P < 0.0001$). The R^2 for this model is 0.85 and represents a significantly better fit compared to the unadjusted model. Racial differences in tooth eruption, after adjusting for obesity, were also observed. Participants classified as Mexican American, non-Hispanic black, and of other race have significantly greater NET on average compared to participants classified as non-Hispanic white.

In secondary analyses, overweight subjects had 0.52 more teeth erupted on average compared to normal weight subjects, after adjusting for age, gender, and race/ethnicity ($P = 0.02$). With these same statistical adjustments, subjects classified as obese had 1.55 more teeth erupted than normal weight subjects ($P < 0.0001$).

Discussion

In this study, the NET was significantly and positively associated with obesity after controlling for age, gender, and race/ethnicity. The predictive model that includes obesity status, age, gender, and race explains almost 85% of the variability in NET. Some variability may be attributable to characteristics not included in the current analysis, such as nutrition, temporal variations, season of birth, climate, and/or developmental conditions such as Down's syndrome. We also found the NET was elevated in association with overweight, but the magnitude of the positive association was smaller.

An association between the timing of tooth eruption and BMI has been observed previously in nonrepresentative samples. A recent longitudinal study conducted over a 4-year period in 88 Mexican school children found a significant relationship between BMI category and tooth eruption patterns (19). At baseline (mean (s.d.) age 7.1 (0.32) years), children in the overweight category had 4.29 more teeth erupted on average than children classified as "thin" (BMI between the 5th and less than the 50th percentiles). Based on the results of a longitudinal mixed model, the overweight group had about 5 more teeth at age 11 than the thin group, after adjustment for age at baseline, sex, SES, and primary teeth present. This difference far exceeds the 1.44 difference in the NET observed in our analysis; however, the reference category (children classified as thin) used for both the baseline and longitudinal analyses was very different than the one used in our study. In a small cross-sectional study that assessed the difference between dental age and chronologic age in relation to BMI, dental age difference significantly increased with increases in BMI (mean (s.d.) dental age difference was 0.63 (1.31) for normal weight subjects, 1.51 (1.22) for overweight subjects, and 1.58 (1.28) for obese subjects) (20).

The findings in this study have clinical importance in the area of caries risk and risk for malocclusion. Disturbances in the timing of tooth eruption can affect new emerging teeth (28), which influences timing of treatment. Failure to treat early enough may lead to increased oral health problems such as malocclusion, crowding, and impaired oral hygiene (10). Failed planning in the timing of treatment may also necessitate additional treatments later on. The results of this study indicate that teeth may be erupting sooner in obese children, underscoring the need for comprehensive periodic oral evaluation.

Several limitations to our study are noteworthy. First, during the tooth count portion of the dental exam, teeth are coded as "not present" if they have not yet emerged. This is often the situation for very young subjects. However, teeth are also coded as not present if they have been extracted. This might be the case for slightly older subjects who have had orthodontic surgery. This dual coding likely leads to misclassification for subjects who have had teeth extracted. In addition, tooth emergence itself is a gradual process, with potential for some misclassification in coding a tooth as erupted or not. Both of these sources of error would be expected to be non-differential (similar by obesity status), and would attenuate the differences observed. Furthermore, tooth extraction itself can lead to alterations in the timing of tooth eruption (29). However, due to the young age of the study population, the number of extracted teeth is likely very small and similar in both groups and thus would not be expected to affect the results of this study. After the third cycle (1988–1994), NHANES did not assess maturational timing, such as Tanner stage, which precluded our ability to explore maturation as a mechanism for accelerated eruption. The PIR has been criticized for its failure to include tax burden or account for regional differences in cost of living (30). Nonetheless, it remains the measure of choice in analyses of nationally representative data in the United States (31,32). It is important to note that 404 participants (7% of the analytic sample) missing values on one or more variables were not included in the linear regression analysis. These subjects were older, were of higher SES, and included a higher proportion of whites and Hispanic Americans. Our analysis was able to examine only the cross-sectional association between obesity status and tooth eruption; it was not able to explore the timing of the onset of obesity. Variations in this timing may affect this association and should be explored in future studies. Among the study's strengths was the use of a nationally representative sample of US children whose dental examination followed a standardized research protocol. Obesity status was similarly based on a standardized anthropometric examination with BMI defined based on the CDC growth reference. The sample available for these analyses was large enough to examine age-specific comparisons between obese and non-obese participants.

Our results suggest that obese children's teeth erupt earlier than nonobese children's teeth. In this analysis, obesity was shown to be significantly associated with the NET during the mixed dentition period, independent of gender, age, and race/ethnicity. Differences in NET were greatest before puberty; the later onset of puberty among nonobese subjects may provide time for them to “catch-up”. On average, obese children had 1.44 more teeth erupted than nonobese children.

This difference is substantial and noteworthy because these findings may have implications for the planning and timing of oral health care for obese children. It is not clear from this study whether the altered timing in tooth eruption affects the oral health of obese children, but future studies should explore this potential outcome. Future research should also examine the timing of the onset of obesity with respect to tooth emergence to establish how incidence will affect this association. Finally, more research is needed to examine the association between obesity and the order of tooth emergence, as this may also impact oral health. These findings may have implications for dental and orthodontic health care.

Acknowledgments

The authors gratefully acknowledge Jeanne P. Goldberg for her suggestion to pursue this research and Kenneth Kwan Ho chui for his statistical support.

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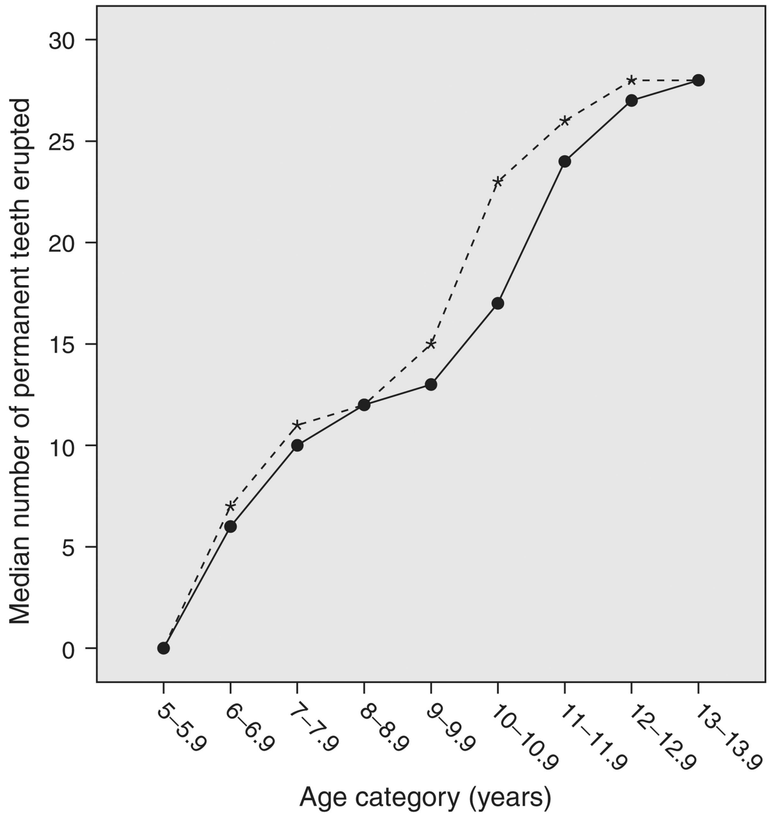

Figure 1.
Median number of teeth erupted by age category and obesity status. Closed circles with solid lines, nonobese; Stars with short dashes, obese.

Table 1

Descriptive statistics by obesity status (unweighted estimates)

	Nonobese (N = 4,361)				Obese (N = 1,073)				
	N	Mean (s.d.)	Median (IQR)	%	*N*	Mean (s.d.)	Median (IQR)	%	*P* value
Age (years)	4,361	9.7 (2.7)		–	1,073	10.2 (2.6)		–	<0.001[a]
Poverty income ratio	4,178	2.1 (1.5)	1.65 (2.35)	–	1,016	1.8 (1.4)	1.37 (1.8)	–	<0.001[a]
Gender									
Male	2,136	–	–	49	535	–	–	49.9	0.58[b]
Female	2,225	–	–	51	538	–	–	50.1	
Race/ethnicity									
Mexican American	1,290	–	–	29.6	387	–	–	36.1	<0.01[b]
Other Hispanic	158	–	–	3.6	31	–	–	2.9	
Non-Hispanic white	1,252	–	–	28.7	241	–	–	22.5	
Non-Hispanic black	1,430	–	–	32.8	364	–	–	33.9	
Other	231	–	–	5.3	50	–	–	4.7	

Obesity is defined as >95th percentile BMI from the CDC 2000 growth reference. CDC, Centers for Disease Control and Prevention; IQR, interquartile range.

[a] Independent samples *t*-test.

[b] χ^2 test.

Table 2

Mean (s.e.m.) number of permanent teeth erupted by age category and obesity status (weighted estimates)

	Nonobese		Obese		
Age category	***N***	**Mean (s.e.m.)**	***n***	**Mean (s.e.m.)**	***P* value[a]**
5.0–5.9 years	485	1.2 (0.14)	93	2.1 (0.37)	<0.05
6.0–6.9 years	458	5.3 (0.19)	72	6.3 (0.47)	0.05
7.0–7.9 years	437	9.4 (0.24)	83	10.6 (0.39)	<0.05
8.0–8.9 years	440	12.0 (0.17)	96	13.1 (0.34)	<0.05
9.0–9.9 years	437	14.7 (0.20)	113	15.9 (0.51)	<0.05
10.0–10.9 years	409	17.3 (0.33)	124	20.0 (0.64)	<0.01
11.0–11.9 years	399	22.1 (0.31)	131	24.8 (0.49)	<0.01
12.0–12.9 years	640	25.2 (0.23)	185	26.4 (0.32)	<0.01
13.0–13.9 years	656	26.6 (0.12)	176	27.4 (0.20)	<0.01

s.e.m., standard error of the mean.

[a] *P* value from PROC SURVEYREG.

Table 3

results from linear regression models predicting number of permanent teeth erupted (weighted estimates)

	β (s.e.)	*P* value	R^2	RMSE
Model 1				
Intercept	14.89 (0.19)	<0.0001	0.0107	9.06
Obesity	2.49 (0.48)	<0.0001		
Model 2				
Intercept	−16.22 (0.25)	<0.0001	0.8489	3.54
Obesity	1.44 (0.20)	<0.0001		
Age	0.27 (0.002)	<0.0001		
Female	0.97 (0.13)	<0.0001		
Mexican American	0.40 (0.13)	0.003		
Other Hispanic	0.30 (0.34)	0.384		
Non-Hispanic black	1.37 (0.12)	<0.0001		
Other race	0.79 (0.29)	0.010		

RMSE, root mean square error.