

Association Between Childhood Obesity and Smooth-surface Caries in Posterior Teeth: A Preliminary Study

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Abstract

Purpose: The purpose of this study was to determine if increased body mass index (BMI) is associated with an increased risk for dental caries.

Methods: Caries severity averages were calculated for a convenience sample of 178 children, ages 8 to 11 years, who participated in the University of Louisville Dental School-based dental treatment program "Smile Kentucky." Caries severity averages were then analyzed against the children's BMI, with gender and age used as covariates.

Results: The mean caries average for permanent molars significantly increased with increased BMI, even after adjusting for age and gender. The mean overall caries average did not vary significantly with patient age, BMI, or gender and may be due to confounding mixed dentition events such as eruption, extraction, variable teeth exfoliation, etc.

Conclusions: Elevated body mass index is associated with an increased incidence of permanent molar interproximal caries. (*Pediatr Dent* 2006;28:23-28)

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Obesity has become an increasing problem in pediatrics.¹⁻³ Medical problems commonly related to obesity during childhood and adolescence affect the cardiovascular system, respiratory system,⁴ skeletal system,⁵ gastrointestinal system,⁶ and endocrine system.⁷⁻⁹ Additionally, it can result in accelerated linear growth, early onset of puberty,⁴ and increased risk of breast cancer¹⁰⁻¹² and polycystic ovary disease⁴ in adulthood. Aside from the physical problems, mental status is often adversely affected, as many who are obese also suffer from depression and low self-esteem.^{13,14} The escalating obesity problem is so severe that the Surgeon General anticipates that future obesity-related health care costs and morbidity and mortality may exceed those associated with cigarette smoking.^{15,16}

In 2003, the American Academy of Pediatrics published a policy statement to help guide pediatricians for the early detection and prevention of childhood obesity.¹⁷ The risk factors discussed include genetic as well as environmental issues. Genetic differences are not well understood, but are linked with variability in genes coding for hormones and neurotransmitters such as growth hormone, leptin, ghrelin, neuropeptide Y, melanocortin, and others.¹⁸ Syn-

dromes related to obesity include Prader-Willi syndrome, Bardet-Biedl syndrome, and Cohen syndrome.¹⁷

Several characteristics of today's society contribute to the widespread childhood obesity problem. First, children today lead more sedentary lifestyles. On average, children watch over 4 hours of television per day,^{19,20} which has been positively correlated with both the increased consumption of soda and obesity.²¹ National survey data also reports that 20% of US children 8 to 16 years old are involved 2 or fewer bouts of physical activity per week.²⁰ Other factors contributing to the increasing problem include the:

1. excessive consumption of soda²²⁻²⁴ and juice²⁵;
2. larger sized portions of food served over the past 10 years²²;
3. fewer meals eaten together as a family; and
4. consumption of fewer fruits and vegetables.^{17,26}

Both the development of childhood obesity and dental caries²⁷⁻³⁰ have been associated with lower socioeconomic groups and particular ethnicities,^{21,26} but can affect anyone. Therefore, health care providers play a vital role in educating parents and their children regarding the ill effects of excessive/frequent consumption of high caloric and cariogenic foods.^{17,27,31,32} Such anticipatory guidance has become the standard of care in both pediatric medicine¹⁷ and pediatric dentistry.³³

Childhood obesity and childhood dental caries are co-incident in many populations, probably due to common confounding risk factors such as intake frequency, cariogenic diet, and poor oral hygiene. The only studies to evaluate whether a relationship exists were not performed in the

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United States and found conflicting results. In China, Chen et al examined cross sectional data to determine whether obese children were more prone to develop dental caries. They found no significant difference in dft among different body mass index (BMI) groups.³⁴ Tuomi used weight to predict caries experience in Finish children, but found that obesity alone was not a good predictor.³⁵ In Sweden, Larsson et al evaluated the relationship between dental caries and risk factors for atherosclerosis in children.

Subjects with increased caries experience had significantly higher BMI values than caries-free subjects.³⁶ Unfortunately, there are no published studies that have investigated the relationship between obesity and dental caries in United States children. Therefore, the purpose of this study was to determine if increased BMI (kg/m^2) is associated with an increased risk for interproximal dental caries in a western population.

Methods

"Smile Kentucky" is a one-day, annual, dental school-based program aimed at providing comprehensive dental treatment to children with dental needs within the Louisville Metropolitan area. The program selects children with untreated dental caries through screenings conducted prior to the event. Only children who have no dental insurance and do not receive Kentucky Medicaid dental benefits are invited to participate.

On the treatment day, "Smile Kentucky" provides all participating children with transportation from their schools to the University of Louisville School of Dentistry, Louisville, Ky. All children receive: (1) comprehensive dental exams; (2) height and weight measurements; and (3) prescribed dental radiographs. Treatment is then provided by: (1) participating dental school faculty; (2) volunteer pediatric dentists; and (3) volunteer general dentists.

This study consisted of a chart review of all patients seen on February 6, 2004, while participating in the Smile Kentucky Program. Appropriate Institutional Review Board approval was received by the University of Louisville.

Body adiposity status was determined by calculating BMI (kg/m^2)³⁷⁻³⁹ and by using the international classification system for childhood obesity recommended by the International Obesity Task Force (IOTF).⁴⁰ Published age- and sex-matched tables defined subjects as "overweight" or "obese" to define the study groups. "Normal weight" subjects who were age- and sex-matched to the study groups were the control group.

Charts were excluded from review if:

1. the radiographs were undiagnostic, including films:
 - a. with overlapped contacts;
 - b. which did not capture all posterior teeth; or
 - c. with processing errors; or
2. the patient's parent reported a:
 - a. history of chronic infectious disease;
 - b. nutritional disturbance; or
 - c. endocrine disorder which may relate to weight gain.

Bitewing radiographs from each subject were reviewed by the primary investigator (who was blinded for each subject's BMI status) for interproximal caries on all primary and permanent molars. A published caries index, developed by Pitts in 2001 ("iceberg of dental caries"), was modified and used to rank caries severity.⁴¹ Caries was ranked by severity for each tooth as such: 0=caries; 1=incipient; 2=dentin involvement; 3=pulpal involvement; and 4=nonrestorable or prematurely missing.

Since subjects were in various stages of the mixed dentition, naturally exfoliated teeth were not taken into consideration. A caries severity average was calculated by adding together all caries index scores and dividing them by the number of teeth evaluated for each subject. All permanent and primary molars present determined "c-avg," while all permanent molars present determined "C-avg." Both were then analyzed against BMI using gender and age as covariates.

Statistical analysis

The relationship between BMI and C-avg and between BMI and c-avg were analyzed for statistical significance using analysis of variance (ANOVA), with age and gender as covariates. The interaction terms involved all 3 variables (BMI, gender, and age). Therefore, the design was broken up and run as 3 separate analyses using one *t* test and 2 one-way ANOVAs. Using reliability statistics (Cronbach's alpha), intraexaminer reliability was evaluated for BMI measurements, with the heights and weights of 27 subjects re-assessed. Also, 12 randomly selected sets of bitewings were reassessed after 2 weeks by the primary investigator.

Results

The study included 178 children who met all inclusion criteria. The table describes subject demographics, with 85 males and 93 females. Ages ranged from 8 years to 11 years, and BMI ranged from 11.43 to 35.7. The overall caries average (c-avg) ranged from 0.00 to 4.40, but did not vary significantly with patient age, BMI, or gender. The permanent molar caries average (C-avg) ranged from 0.00 to 4.00 and significantly increased with increases in BMI. Subjects with a low BMI significantly differed from those with a high BMI ($P=.004$), as did those with a normal BMI ($P=.05$). When evaluating overall caries and permanent caries by age and gender, no significant differences were observed.

When evaluating intraobserver variability, there was a high degree of consistency. Cronbach's alpha was: (1) 0.99 for measuring subject BMI; (2) 0.96 for measuring c-avg; and (3) 0.98 for measuring C-avg.

Discussion

Previously, no US study has evaluated a potential relationship between caries and obesity. Contrary to the current results on permanent molars, a study performed in China found no relationship between increased caries and childhood obesity. This was surprising, since the frequent consumption of high caloric and cariogenic substances are 2 of the many factors associated with caries and obesity.⁴²⁻⁴⁵ The study design differed

from the current study, because only 3-year-old Chinese children were evaluated clinically (deciduous teeth only) to calculate their caries index using dft scores. Furthermore, standard BMI levels were used—which could not take into account gender and age, since the study was performed prior to the development of the international standards developed by the International Obesity Taskforce in 2000.⁴⁰ Additionally, obvious ethnic and cultural differences between China and the western countries exist, which make the study less applicable to our western culture.

Other studies performed outside the United States have evaluated the association between caries and obesity, but the studies found conflicting results. Tuomi evaluated 516 Finnish children between the ages of 7 and 16 years. They found that obesity alone was not a good predictor of dental decay. Controlling for past caries experience and earlier obesity, however, raised the sensitivity of prediction.³⁵ Larsson, et al evaluated the relationship between dental caries and risk factors for atherosclerosis in Swedish adolescents. They compared DFS scores with obesity in 15-year-old children and found a significant positive correlation for the DFS scores and BMI index using a univariate correlation test and multiple linear regression analysis. Furthermore, they recommended that dietary counseling may help reduce the caries risk as well as the risk for developing cardiovascular disease in adolescents who are moderately obese.³⁶

Although municipal water fluoridation has significantly decreased the incidence of childhood caries, the disease currently affects a large number of children. In 2003, Hardison et al evaluated Kentucky preschool children in pediatrician and pediatric dental offices and found that: (1) 43% had untreated caries; (2) 47% had caries experience; and (3) 39% had never visited the dentist.⁴⁶

Several caries indices exist, but all are complicated by subjects' stages of dental development and the level of diagnostic information available. Unfortunately, practitioner clinical caries charting was insufficient in the current study, and practitioners were unavailable for calibration prior to the event. Therefore, occlusal caries could not be taken

into account. This restricted the use of DMFS/DMFT and dmfs/dmft, which are commonly used standards—although the measures can be crude and may overinflate caries estimates in restored teeth.

Bitewing radiographs were available, which allowed the primary investigator to assess proximal caries severity and eliminated interobserver variability. The current study used a modified form of Pitts' "iceberg of dental caries." The "iceberg" levels relating to radiologic detection included lesions into pulp (4), lesions into dentin (3), and lesions limited to enamel (1 and 2).⁴¹ Unfortunately, the iceberg breaks incipient decay into 2 individual categories and considers them both "caries free." For clarity and ease of diagnostic interpretation, the authors placed incipient lesions and caries-free teeth into separate categories (1 and 0, respectively). Furthermore, the authors added one category for nonrestorable caries or prematurely missing teeth (4), as the authors were evaluating patients in the mixed dentition who often have primary teeth extracted due to severe caries.

For each subject, overall molar proximal caries (c-avg) as well as permanent molar proximal caries (C-avg) were taken to compare between subjects. Anterior teeth could not be considered because most patients did not have any radiographs taken in the anterior unless lesions were clinically detectable.

This method only evaluated proximal caries without assessing pit and fissure caries, because information regarding the occlusal surfaces was not available. Municipal water fluoridation has proportionately decreased smooth-surface caries incidence relative to pit and fissure caries, but smooth-surface caries continues to be problematic.⁴⁷ Proximal caries is a relatively important indicator of caries progression to adjacent teeth. Vanderas et al found that the presence of proximal caries on primary second molar distal surfaces significantly affected the development of proximal caries on the corresponding permanent first molar's mesial surfaces.

Unlike this study's results, age significantly exerted a highly positive impact (only a trend in young males to be higher in both studies), but gender had no significant effect.⁴⁸ The

current study found no difference in c-avg with increases in BMI, but many subjects were in various stages of the mixed dentition. Many children had missing primary molars without the eruption of their successors. To account for this, missing teeth that were appropriate for the stage of the dentition did not affect the c-avg or C-avg. Teeth that were missing due to extraction, however, or which were prematurely missing (eg, delayed premolar eruption, complete bony enclosure of an unerupted premolar, nonexfoliating contralateral primary molar) were rated

Table. Mean Overall and Permanent Interproximal Caries by Gender, BMI, and Age

		n	Mean overall caries (c-avg)±SD	Mean permanent caries (C-avg)±SD
Gender	Male	85	0.81±0.10	0.15±0.06
	Female	93	0.96±0.10	0.37±0.06
Age (yrs)	8	31	1.16±0.15	0.50±0.09
	9	67	0.61±0.12	0.18±0.07
	10	45	0.88±0.13	0.20±0.08
	11	35	0.88±0.13	0.17±0.08
BMI status	Low	67	0.73±0.10	0.08±0.06†
	Normal	82	0.86±0.09	0.19±0.05*
	High	29	1.06±0.15	0.51±0.09

**P*<.05.

†*P*<.01.

a 4, which was equivalent to nonrestorable caries. Teeth extracted for spacing deficiency or those lost to ectopic eruption could inflate the caries averages (c-avg). This was unlikely, since most children had no previous regular dental care.

Subject demographics, including socioeconomic status (SES) and ethnicity, were not evaluated, but the subjects had no access to regular dental care and most likely came from lower-income families. Ethnicity and low SES have been associated with increased risk of caries, but recent studies report that the effect is related to SES rather than ethnicity. Reid et al reported that Mexican American and non-Hispanic African Americans 20 to 50 years old were at increased risk for untreated caries when compared to non-Hispanic Caucasians when adjusted for age, sex, and missing teeth. Controlling for material factors (ie, income, education, employment status, dental insurance status, and urban residence) eliminated most excess risk, while controlling behavioral factors (ie, marital status, tobacco use, alcohol use, obesity, and social support) resulted in no risk reduction.⁴⁹

Reisine and Psoter also found an inverse relationship between socioeconomic status (SES) and the prevalence of caries among children under age 12.⁵⁰ Burt and Satishchandra reported that children of low birth weight subsequently developed more caries in the primary dentition than children with normal to high birth weight. They concluded that this may be related to social deprivation factors during the development of the primary dentition.⁵¹

Although BMI is widely used to screen adults for obesity, its use in adolescents is controversial. BMI is a commonly used measure of adiposity, because it is easy to calculate, quick to measure, and noninvasive. Unfortunately, it is a fairly poor index in individual children unless age and gender are taken into consideration.

Childhood BMI significantly changes with age. At birth, the median is as low as 13 kg/m², increasing to 17 kg/m² at age 1, decreasing to 15.5 kg/m² at age 6, and increasing to 21 kg/m² at age 20. The age increases in BMI during both later childhood and adolescence can be attributed primarily to increases in fat-free tissue rather than fat.⁵² Therefore, to more accurately define childhood obesity, a cutoff point relative to age is necessary. In the United States, the 85th and 95th percentiles of BMI for age and sex are commonly used and are based on nationally represented survey data. Unfortunately, however, BMIs are increasing in children nationwide and many children are not properly categorized as overweight due to a relatively heavy American population.

An international survey recommended by the International Obesity Task Force⁵³ has established a standard definition for childhood obesity for global monitoring,⁴⁰ as well as clinical practice and public health measures.⁵⁴ It was developed after surveying 97,876 males and 94,851 females from birth to 25 years of age for 6 large, nationally representative cross-sectional growth studies from Brazil, Great Britain, Hong Kong, the Netherlands, Singapore, and the United States. It provides cutoff points for BMI in

childhood that are based on international data and linked to the widely accepted adult cutoff points of a BMI of 25 and 30 kg/m².⁴⁰ Neovius et al evaluated the sensitivity and specificity of this BMI-based classification system and found BMI to be highly specific in both sexes.⁵³

More accurate methods than BMI are available to assess adiposity, but they are impractical for epidemiological use. The ideal definition of obesity is based on body fat percentage, which requires more sophisticated measures such as X ray densitometry⁵⁵ or other multicomponent techniques.⁵² Triceps skinfold thickness is even a more sensitive assessment than BMI, but has its limitations. It still uses 85th and 95th percentiles operationally to define obesity and super-obesity, respectively, and requires the use of population-based, race-specific, or age-specific criteria. Furthermore, its use is not practical in a dental setting.⁵⁶

This study's sample size was fairly limited in that the authors only had 29 subjects at or above a BMI of 25. Therefore, the authors grouped the overweight and obese subjects as "high BMI."¹⁷ If a larger sample were available allowing the "high BMI" group to be separated into overweight and obese groups, differences in overall caries averages (c-avg) between BMI groups may have been evident.

An increased awareness of the consequences of childhood obesity is necessary, with the most effective treatment being prevention. Health professionals such as pediatricians and pediatric dentists should educate parents on current dietary guidelines. These guidelines recommend that children consume 2 or more servings of dairy foods daily, limiting their intake of 100% juice to 4 to 6 ounces daily, restricting intake frequency, and reducing other sugared beverages to occasional use only.⁴²

Future nationwide studies are warranted to assess the effect of obesity on caries types (eg, smooth surface vs pit/fissure, anterior vs posterior), taking into account patient demographics and behavioral patterns (eg, oral hygiene, diet). Such studies should consist of larger sample sizes to allow a breakdown by caries type and tooth type and to include occlusal caries. Furthermore, investigators should attempt to determine if a relationship exists between accelerated dental development and obesity.

Conclusions

Based on this study's results, the following conclusions can be made:

1. Children with increased body mass indices had an increased interproximal caries incidence in their permanent molars.
2. Neither age nor gender was found to be related to the incidence of proximal caries. A trend, however, was evident, showing young males having a higher proximal caries incidence than older males.

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