Original Research
Cariology

Is obesity associated to dental caries in Brazilian schoolchildren?

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Abstract: This cross-sectional study aimed to determine the association between dental caries and weight status, and between dental caries and physical activity in Brazilian schoolchildren aged 8 to 12 years. A multi-stage sample of children enrolled in 20 private and public schools in 2010 in Pelotas, Southern Brazil, were invited to participate in the study. Socioeconomic data were collected from parents, and data regarding children characteristics were collected from children using a questionnaire and anthropometric measures. The Body Mass Index was obtained, and children were classified as overweight/obese considering age and sex. Dental examinations were performed to assess the presence of gingival inflammation, dental caries prevalence (DMFT≥1) and dental caries experience (mean DMFT). Multivariate Poisson Regression was used to assess factors associated with dental caries prevalence and experience. A total of 1,210 children were included in the study. Dental caries prevalence was 32.4% (95% CI 29.7-35.2), while the mean DMFT was 0.64 (± SD 1.00). Children who practiced less than 300 minutes per week of physical activity and overweigh/obese children had lower prevalence of dental caries, while children with obesity or overweight presented lower dental caries experience. Obesity/overweight and physical activity level presented an inverse relationship with dental caries. Longitudinal studies investigating the complexity of this relationship are required.

Keywords: Dental Caries; Obesity; Oral Health; Exercise; Overweight.

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Introduction

Oral health is an important part of general health and well-being. A healthy mouth enables an individual to speak, eat and socialize without discomfort or embarrassment.[1] Although caries prevalence and severity has declined substantially over the years, dental caries remains the most prevalent public oral health problem, and the most prevalent chronic infectious disease in the world.[2,3] Dental caries still presents a high prevalence in preschoolers and schoolchildren in several countries[4] and is the main cause of dental pain in children,[5] causing fear and anxiety,[6] and negatively contributing for oral health habits. Consequently, presence of dental caries increases the number of dental appointments, which can lead to tooth loss in latter ages, affecting aesthetics, nutritional intake, and decreasing the individuals' quality of life.[7,8] In addition, dental caries

treatment has a heavy financial impact for individuals and public health services.[9]

Investigating the occurrence and risk factors of dental caries is important to help establish preventive strategies,[10] identify treatment needs in a population, and compare the results with other studies worldwide. Possible variables associated with dental caries have been extensively investigated, and some are well known in children, such as sex, skin color, diet, tooth brushing habits, along with socioeconomic factors such as family income and type of school.[7,11] On the other hand, discussions on the relationship between dental caries experience and other less studied factors like overweight, obesity or physical activity have increased only recently.[12]

Overweight and obesity are a serious public health problem,[13,14] commonly defined as an excess amount of body fat in relation to lean body mass, caused when energy intake far outweighs energy expenditure. In Brazilian children, obesity has surpassed malnutrition as the most prevalent nutritional disorder.[15] Decreasing physical activity, increasing sedentary lifestyles[16] and dietary changes are factors strongly associated with the development of overweight.[17]

Dental caries and obesity share similar risk factors, most notably, diet and socio-economic status.[18] Environmental factors and some lifestyle behaviours associated with increased risk of obesity are also associated with oral health diseases. In children, the school environment may be responsible for inadequate control of food choices and insufficient practice of physical activity. Considering that caries is associated with poor dietary habits, especially with intake of sucrose, and that an inappropriate diet promotes obesity, a biologically plausible association between obesity and dental caries along with socio-demographic aspects has been inferred in the literature.[13,19] However, studies investigating a possible association between dental caries and weight or nutritional status have conflicting findings and the relationship between obesity and dental caries is still unclear.[17,20] A systematic review conducted by Hayden et al in 2013 concluded that a small association exists between obesity and increased level of dental caries in permanent dentition but not in primary dentition, suggesting more studies with subgroup analyses to understand this unclear relationship.[17] Furthermore, another systematic review conducted in 2013 did not find sufficient evidence regarding the association between obesity and dental caries, and the authors did not explain the possible role of diet and other effect modifiers on this association.[21]

Considering these controversial results and the need for further investigation about this topic, this cross-sectional study aimed to determine the prevalence and distribution of dental caries in Brazilian schoolchildren aged 8–12 years and to test the association between dental caries and nutritional status and level of physical activity, controlling for potential confounders.

Methods

This study was reported using the "Strengthening the Reporting of Observational studies in Epidemiology (STROBE)" guidelines.

Study settings and population

This study was a cross-sectional epidemiological survey on the oral health condition of children aged 8–12 years, attending both private and public schools in Pelotas, a Southern Brazilian city located near the border with Uruguay and Argentina. The population of the city is estimated to be 330,000 inhabitants and the city has 25 private and 91 public schools, where 25,628 children within the age range of interest were enrolled in 2010.

A two-stage stratified design was adopted to select the sample. To ensure variability of the characteristics,[22] 20 schools were randomly selected, with the probability proportional to school size. Five private and 15 public schools were selected in order to ensure proportionality. In each school, five classes from 2nd to 6th grade were randomly selected and all children in these classes were initially eligible for the study. Children with physical or mental impairment were not included. Detailed information on the methods of this survey is reported elsewhere.[23]

The minimum sample size was estimated using the Epi Info 6.0 software, considering a prevalence of 10% of the main outcome of the multidisciplinary study (dental trauma), a standard error of 3% or less

and a confidence level of 95%. Since the cluster sample selection method was adopted, a design effect of 2 was estimated. Based on this calculation, 922 children were needed. Since the final sample comprised 1,210 children, the study achieved 80% power to detect prevalence ratios of 1.56 or greater as significant to a 95% level of confidence.

Data collection

Data collection included a questionnaire sent to parents, along with the informed consent agreement. After the authorization and questionnaire were returned by the parents, schools were visited as many times as needed to ensure that no more than 10% of the children were absent from data collection, which included dental examinations, anthropometry measurements and interview with the children.

Socio-economic and socio-cultural information on the children and their families were collected from the parents. The mother's educational level was assessed by comparing mothers that had completed 8 years of formal education, which in Brazil corresponds to primary school, with those who had not. Family income was recorded in Brazilian Reals (BRL) and categorized in quartiles.

The interviews included information on demographic characteristics (age and sex), consumption of sweets after lunch (never, occasionally or daily) and levels of physical activity (PA), classified as insufficient if < 300 min/week.[24]

Trained and standardized (within the margins of error from the National Center for Health Statistics) examiners measured the children's height (in meters) and weight (in kilograms) for the calculation of body mass index (BMIs; kg/m^2). Height and weight were measured using a portable free-standing stadiometer and a WHO electronic scale (capacity: 130 kg) respectively. Participants were measured wearing school uniforms and no shoes. BMI data were categorized considering the age- and sex-specific cut off points[25] and children were classified as normal or overweight/obese accordingly.

Clinical examinations were performed in regular school chairs, by six dentists. Dentists used a headlamp, a buccal mirror and a CPI probe for the examinations. Dental caries were assessed by DMFT (Decayed, Missing and Filled Teeth) Index, which measures lifetime experience of dental caries in permanent dentition. The index is calculated by adding the number of decayed (D), missing (M), and Filled (F) teeth. To assess the presence of gingival inflammation, the visible gingival bleeding index, described by Ainamo and Bay,[26] was used. Randomly chosen contra-lateral incisors and first molars were assessed for gingival bleeding,[27] which was categorized as 0–2 or ≥ 3 sites.

Prior to data collection, a pilot study was conducted with mothers and children at Pelotas Dental School and the findings led to some modification of the instruments and provided an estimate of the time needed for data collection. To ensure study reliability, a training and calibration process was performed with the dentists and interviewers. The degree of agreement among examiners was assessed using weighted kappa statistics. A mean kappa value of 0.74 (range, 0.62–0.79) was achieved for dental caries assessment. To assess the consistency of interview responses, 10 children in each school were re-interviewed with 10 questions 1 week after the initial interviews.

Data analysis

Data analysis was performed using STATA 12.0 software (Stata Corporation, College Station, TX, USA). Descriptive analyses were conducted, and the Chi-squared test was used to assess prevalence of dental caries according to nutritional status and PA level, stratified by school type. Two outcomes were used in this study: prevalence of dental caries (DMF-T > 0), and caries severity (total DMF-T). Poisson regression analyses with robust variance were performed to assess the association between predictor variables and the outcomes. In the analyses, we calculated the prevalence ratio (PR; 95%CI) to assess the predictors of caries prevalence and the rate ratios (RR; 95%CI) to assess the predictors of caries severity (mean DMF-T). Rate ratio is the ratio of the arithmetic mean of DMF-T scores between exposed and unexposed groups. Poisson regression has been described as an appropriate analytical resource to assess factors associated with both count and binary outcomes. Multivariable analyses included three different models to adjust the association between interest variables and the outcomes. Model 1 included

socioeconomic variables (family income, type of school and mother's education). In model 2 adjustment by sex and age was added, and in model 3 an oral health (gingival inflammation) and consumption of sweets variables were added.

Ethics

The study protocol was approved by the Human Research Ethics Committee of the Federal University of Pelotas. All parents signed an informed consent form prior to data collection. All schools received information about the study protocol and agreed to participate. Children requiring dental treatment were referred to the Dental School.

Results

Of the 1,744 children eligible for the study, 419 (24.0%) did not return the signed informed consent form and 114 (6.7%) were not in the school in the days of data collection. Thus, a response rate of 69.3% was achieved, totalling a final sample of 1,210 children. Response rate of public and private schools did not differ.

Distribution of children by demographic, socioeconomic, behavioral and oral health characteristics can be observed in Table 1. Out of 1,210 individuals examined, 392 [32.4% (95% CI 29.7–35.2)] had at least one tooth affected by dental caries. The mean DMFT was 0.40, 0.37, 0.64, 0.81 and 1.14 among the 8-, 9-, 10-, 11- and 12-year-olds respectively.

The results of the crude and adjusted associations between dental caries presence and nutritional status and physical activity level are presented in Table 2. Obese/overweight and inactive children had a lower prevalence of dental caries compared with eutrophic and active children. When further adjustments were made (Models 1, 2 and 3), associations remained statistically significant.

Table 3 describes crude and adjusted analysis for the association between dental caries severity (mean DMFT) and nutritional status and physical activity level. Children that were obese or overweight and that practiced less than 300 minutes per week of physical activity experienced less dental caries. After adjustments, only nutritional status remained associated with dental caries.

Table 1. Distribution of participants by socioeconomic, familiar and biological characteristics. Absolute (n) and relative (%) frequencies. Pelotas, Brazil. (n = 1,210)

Variables/Categories	n	%
Sex		
Male	574	47.4
Female	636	52.6
Age		
8	181	15.0
9	312	25.8
10	295	24.4
11	259	21.4
12	163	13.5
Familiar income (quartiles)		
0–510.00 BRL**	246	23.7
511.00–740.00 BRL	271	26.1
744.00–1,200 BRL	241	23.2
> 1,200.00 BRL	279	26.9
Maternal schooling (years)		
≥ 8	750	63.8
≥ 8	425	36.2
Type of school		
Private	253	20.9
Public	957	79.1
Body Mass Index (BMI)		
Eutrophic	786	65.3
Overweight/obese	417	34.7
Physical Activity (min/week)		
≥ 300	342	30.9
< 300	766	69.1
Gingival Inflammation (Bleeding sites)		
0–2 sites	680	56.0
≥ 3 sites	534	44.0
DMFT		
0	818	67.6
≥ 1	392	32.4
Consumption of sweet after lunch		
Daily	123	10.2
Occasionally	662	54.8
Never	423	35.0

*Values different than 1210 are due to missing information;
**BRL= Brazilian Reals (1 USD = 1.7 BRL)

Table 2. Crude (c) and adjusted (a) prevalence ratios (PR) for dental caries prevalence (DMFT ≥ 1) and interest variables in Brazilian schoolchildren. Poisson regression analysis. (n = 1,210).

Variable	Body Mass Index (obese/ overweight vs eutrophic)	Physical activity (inactive vs active)
	Prevalence Ratios (95%CI)	
Crude	0.79 (0.66–0.95)	0.72 (0.60–0.86)
Model 1	0.80 (0.65–0.97)	0.76 (0.63–0.91)
Model 2	0.79 (0.65–0.97)	0.73 (0.60–0.88)
Model 3	0.79 (0.65–0.97)	0.73 (0.60–0.88)

Model 1: Adjusted for socioeconomic variables (type of school, family income and mother's education); Model 2: Adjusted for Model 1 + demographic variable (sex and age); Model 3: Adjusted for Model 2 + oral health variable [(Gingival inflammation (Bleeding sites)] + diet.

Table 3. Crude (c) and adjusted (a) rate ratios (RR) for dental caries severity (mean DMFT) and interest variables in Brazilian schoolchildren. Poisson regression analysis. (n = 1,210).

Variable	Body mass index (obese/ overweight vs eutrophic)	Physical activity (inactive vs active)
	Rate ratios (95%CI)	
Crude	0.72 (0.57–0.90)	0.78 (0.62–0.98)
Model 1	0.74 (0.58–0.94)	0.86(0.68–1.09)
Model 2	0.73 (0.57–0.94)	0.83(0.65–1.06)
Model 3	0.73 (0.57–0.94)	0.83(0.65–1.06)

Model 1: Adjusted for socioeconomic variables (family income and mother's education); Model 2: Adjusted for Model 1 + demographic variable (sex and age); Model 3: Adjusted for Model 2 + oral health variable [(Gingival inflammation (Bleeding sites)].

Discussion

Dental caries and childhood obesity are complex conditions influenced by multiple factors. Since caries is associated with poor dietary habits and inappropriate diets promote obesity, this study aimed to investigate the association between dental caries and obesity. Nevertheless, the results of this cross-sectional study provide no evidence that overweight children are at increased risk for dental caries. Indeed, while not entirely consistent, the data from this survey suggest that overweight status may be associated with a somewhat decreased risk for caries. Overweight/obese children had a lower experience of dental caries than children who had normal weight after adjusting for well-known risk factors for caries. These findings confirm the data described by Kopycha-Kedzierawsi,[28] which showed that overweight status might be associated with decreased rates of caries in older children. In the study by Jürgensen and Petersen,[2] the highest caries level (DMFT = 2.3) was found among children with normal weight while overweight children had the lowest caries level (DMFT = 1.6). Other studies found no correlation between BMI and caries experience in Brazilian schoolchildren and adolescents.[29,30] Similarly, approximately half of the studies in a systematic review of caries and adiposity failed to identify any significant association between overweight assessed by BMI and dental caries experience.[20] There are, however, studies that found a positive correlation between caries experience in the permanent dentition and overweight status, suggesting that overweight children had higher caries scores than children with normal weight.[31,32,33] Hayden et al.[17] in a systematic review confirms a positive association between obesity and dental caries in the permanent dentition, despite the unclear causative direction of this relationship. Conflicting results also have been reported in primary dentition. Macek and Mitola, in their study with 1,719 children, concluded that there was no statistically significant association between BMI and dental caries for the primary dentition, as determined by multiple linear regression models.[34] Other investigations, however, have reported an association between high weight and caries in the primary dentition.[14,35]

It is difficult and complex to speculate on the mechanism by which obesity and dental caries were not associated, as it is well known that the high consumption of refined carbohydrates can be related both to the development of dental caries and obesity[16,33]. One way to explain the negative association between overweight and dental caries is the relationship between habits concerning main meals and snacks. Usually, snacks have low nutritional value, include carbonated soft drinks and packaged snacks, and can lead to decreased intake at the main meal. Main meals are usually higher in protein and fat, and lower in sugar content than snacks. Even though a common line of thought would suggest that people who consume soft drinks or snacks in greater proportion or frequency would have increased risk of obesity and dental caries, some studies have shown no association

between consumption of snacks and obesity.[5,14] The majority of studies that investigated whether there is a relationship between snacking behaviour and weight status either found no association or found evidence indicating that young people who more often consumed food or beverages between meals were less likely to be obese.[36,37] Furthermore, Marshall et al.[35] in 2005 showed a higher frequency of snacking among thin and normal weight children than obese children, and found that higher exposure to sugar from snacks increased caries risk than exposure to food sugar at mealtime. Perhaps overweight children consume more fatty foods, but fewer high sugary foods than normal weight children.

In addition, the period of critically low pH needed for caries to occur is mainly a function of the type and frequency of carbohydrates consumed.[38] Therefore, the amount of energy intake provided by fermentable carbohydrates that can be critical for development of obesity might not be influential to caries, depending on frequency and consistency of ingested sugars. A high frequency consumption of low amounts of carbohydrates could lead to development of dental caries without consequences on children weight. Perhaps the cause of the inverse relationship between body weight and caries is related to physiological differences between obese and healthy children that have yet to be uncovered. More research is needed in this area to investigate whether being overweight is truly protective against dental caries.

Other hypotheses suggest that the high carbohydrate intake that initially led to early childhood caries also resulted in higher weights; however, weight decreased as caries progressed and pain and infection altered eating and sleeping patterns.[39] Nonetheless, this reasoning is inconsistent with the one described by Hayden et al, who did not find an association between obesity and dental caries in primary teeth, suggesting that obesity tends to be more prevalent in older children, as a result of the increasingly sedentary lifestyle with age.[17] Socioeconomic status is the second factor that, besides age, could act as a moderator of the relationship between obesity and dental caries, since the differential pattern of caries and obesity observed in children might be explained by the socioeconomic position.[17] The lack of association between obesity and dental caries is mainly a characteristic of developing countries.[29,30] A possible explanation for these results might be that obesity in Latin American countries is related to high socioeconomic status.[40] Thus, despite the inappropriate nutritional status, the children with access to better education might present more positive oral health behaviors, including oral hygiene habits, leading to overall lower caries occurrence in this population group.

Dietary practices are not the only factors that contribute to the obesity epidemic among children and adolescents worldwide. Considering that sedentary lifestyles combined with excess energy intake are primarily linked to obesity,[41] this study also assessed the association between physical activity and dental caries. A relationship was found between insufficient frequency of physical activity of children and dental caries prevalence and experience, reinforcing the inverse association between obesity and dental caries. Physical inactivity seems to act as a mediating agent between obesity and underprivileged lifestyle factors. A possible hypothesis for this inverse relationship could be that children who practice more sports or who are more active may in turn be less disciplined, more restless and spend less time in the home, and consequently have poor oral hygiene habits. In this context, a study in Japanese athletic children showed that excessive game-playing behavior, not TV-viewing behavior, was significantly associated with a lower daily frequency of tooth brushing (less than twice per day.[42] However, the possible relationship between caries and physical activity has so far been neglected.[43]

Although the cross-sectional study design is not indicated for the establishment of causal relationships, this type of study is of outmost value to estimate prevalence of the outcomes in a representative sample of the population and it provides useful data for further longitudinal investigations or to monitor oral health conditions of Pelotas' children over time.

One possible limitation of this study is the use of BMI to assess the children's weight status. Although BMI is widely used to screen adults for obesity, its use in adolescents is controversial. Furthermore, it does not distinguish fat mass from muscle mass or bone mass. BMI is a commonly used measure of adiposity

because it is easy to calculate, quick to measure, and non-invasive. Unfortunately, it is a fairly poor index in individual children unless age and gender are taken into consideration. Therefore, we used Cole's criteria, considering age and sex to obtain nutritional status[24]. The lack of criteria to diagnose gingivitis might be an obstacle for comparison among different studies in the literature. The Gingival Bleeding indexes[26] used in this study followed the same protocols already defined in previous epidemiologic evaluations conducted with schoolchildren population.[44] Diet is an important factor that affects both obesity and dental caries. Little information about consumption of sugars was collected in this study. We added information about sweet consumption after lunch on multivariate models to include some information about diet, although we recognize that this is not the best way to measure consumption of sugars. It is important to highlight that there is no reliable instrument to assess dietary habits with accuracy in this age range.[45]

Some strengths of this study should be highlighted. The sampling method and the use of a validated instrument and questionnaires are major strengths of the study, which provide internal validity. The number of sampling sites also ensured variability of the sample, and it can be considered representative of the population of scholars in the city. Thus, sampling bias is unlikely to be present. Regarding oral health conditions, the selected criteria allow comparison with previous worldwide studies. The level of physical activity was obtained by means of a questionnaire developed and validated in the city of Pelotas, thus adequate to regional habits.

Conclusions

In the present sample of Brazilian children, negative associations between dental caries and overweight, and between dental caries and obesity were observed. Future longitudinal research investigating the complexity of this relationship are required.

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