Original Research
Cariology

Obesity and dental caries among South Brazilian schoolchildren: a 2.5-year longitudinal study

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Abstract: The aim of this study was to assess the association between weight status and ΔDMFS among 12-year-old schoolchildren from South Brazil. A total of 801 12-year-old schoolchildren were followed-up for 2.5 ± 0.3 years. Data collection included questionnaire, recording of anthropometric measures (height and weight), and caries examination. The outcome was the difference between DMFS (number of decayed, missing or filled surfaces) at follow-up and baseline (ΔDMFS). Weight status, based on body mass index-for-age Z-scores, was considered the main predictor variable. Negative binomial regression models were used to model the association, and rate ratios and their 95% confidence intervals were estimated. A multivariable fractional polynomial model was used to further explore the relationship between obesity and dental caries. DMFS increased by 0.86 (95%CI = 0.65–1.07), 0.91 (95%CI = 0.59–1.23), and 0.42 (95%CI = 0.03–0.80) for normal weight, overweight, and obese schoolchildren, respectively. Obese adolescents had significantly lower ΔDMFS than normal weight ones ($p < 0.05$). No significant association between categories of weight status and ΔDMFS was found (overweight, IRR=0.92, 95%CI = 0.69–1.21, $p = 0.54$; obese IRR = 0.75, 95%CI = 0.51–1.12, $p = 0.16$). However, the multivariable fractional polynomial model showed an inverted U shaped relationship with a decreasing ΔDMFS with increasing BMI ($p < 0.05$). This population-based longitudinal study showed an inverse association between obesity and ΔDMFS over a 2.5-year period among South Brazilian adolescents.

Keywords: Dental Caries; Epidemiology; Obesity; Longitudinal Studies.

Introduction

Obesity is a very prevalent chronic disease that affects children as well as adults in developing and developed countries. According to recent reports from the World Health Organization, over 340 million children and adolescents aged 5-19 were overweight or obese in 2016.[1] The prevalence of excessive body weight among 5-19-year-olds has increased dramatically from 4% in 1975 to approximately 18% in 2016.[1] National data from Brazil showed that 31.2% of children aged 12–13 years were overweight or obese in 2008-2009.[2] Obese children are more likely to become obese adults, which highlights the importance

of establishing healthy habits in childhood in order to prevent several diseases that have been associated with obesity, including diabetes and cardiovascular disease.[3] Poor dietary habits including the consumption of high-sugar food and soft drinks may be common risk factors to dental caries and obesity among children and adolescents.[4] Studies investigating the association between overweight/obesity and dental caries in children and adolescents have shown inconsistent results. Whereas most cross-sectional studies have shown a lack of association between obesity and dental caries,[4,5,6] a direct[7,8,9] and even an inverse association have been reported.[10,11,12] Regarding the impact of obesity on the incidence of dental caries, a systematic review of longitudinal studies by Li et al.[13] showed conflicting evidence. Most studies analyzed the effect of birth weight on caries incidence[14,15] commonly focusing on the association between malnutrition and caries.[16,17] To the best of our knowledge, only two longitudinal studies investigated the association between obesity and caries in adolescents.[18,19] Basha et al.[18] observed that overweight/obese 13-year-old adolescents from India had a 3.7-fold increased risk for developing dental caries over 3 years. On the other hand, Li et al.[19] found no significant association between obesity at 12 years of age and caries after 3 years of follow-up among a sample of 282 adolescents from Hong Kong.

Considering the limited longitudinal evidence regarding the relationship between overweight/obesity and dental caries among adolescents in different populations worldwide, the aim of this study was to assess the association between weight status and ΔDMFS among 12-year-old schoolchildren from South Brazil followed up for 2.5 years.

Methods

Study design and sample

This is a longitudinal study. A probabilistic sample of the population of 12-year-old schoolchildren from Porto Alegre, South Brazil was drawn. The primary sampling unit consisted of five geographical areas organized according to the municipal water fluoridation system. Within each area, the schools were randomly selected proportional to the number of public and private schools (42 schools: 33 public and 9 private). Schoolchildren born in 1997 or 1998 were then randomly selected proportional to school size.[20] The following parameters were used for the sample calculation: caries prevalence of 60%,[21] precision level of 3%, design effect of 1.3, and a nonresponse rate of 40%. A final sample size of 1,528 12-year-old schoolchildren was included and examined. Following a mean period of 2.5 ± 0.3 years, 801 out of 1,528 (52.4%) schoolchildren (14.8 ± 0.5 years old) were re-examined, as shown in Figure 1.

Data collection

Baseline data collection was carried out from September 2009 to December 2010. A structured questionnaire containing questions on socio-demographics and oral hygiene habits was sent to the parents/legal guardians of the selected students. Each schoolchild provided information on the frequency of consumption of soft drinks.

Anthropometric parameters were measured and used to assess adolescents' weight status. A 150 kg digital scale was used for weight recording. Initially, two consecutive readings were made. When a difference > 0.3 kg was observed, a third assessment was made. The mean of the two closest measurements was used to calculate the body mass index (BMI). Height was measured to the nearest full centimeter using an inelastic metric tape attached to a flat wall with no footer. Anthropometric measures were collected by a single researcher with the students wearing light clothes and no shoes.

Oral examination was conducted at the schools, with the students in a supine position, using artificial light, air compressor, and suction. After tooth cleaning and drying, a single calibrated examiner recorded the presence of non-cavitated and cavitated, inactive and active caries lesions[22]. Missing and filled teeth were also recorded.

Follow-up examinations were performed between August 2012 and May 2013 by another calibrated examiner, who was trained and calibrated by the first examiner. Schoolchildren were reexamined at the schools, following the same protocol previously described.

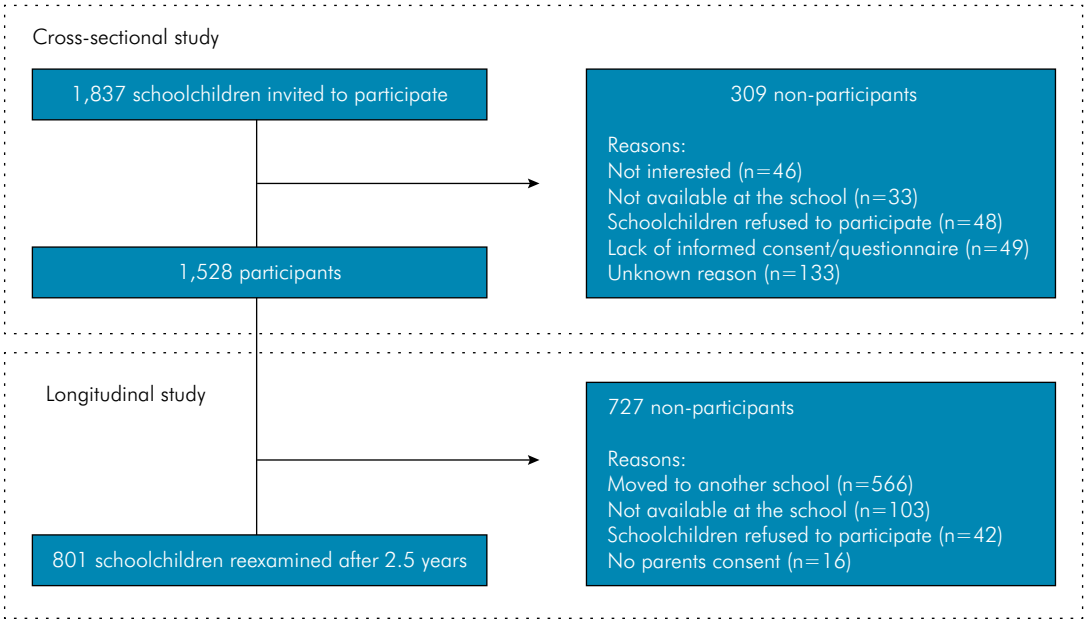

Figure 1. Flowchart of the study.

Reproducibility

Training and calibration for dental caries examination were performed before the beginning of the study. During the survey, calibration was monitored by means of repeated examinations conducted on 5% of the sample. The lowest intra-examiner unweighted Cohen's kappa value observed were 0.80 and 0.81. The inter-examiner unweighted Cohen's kappa value was 0.78.

Data analysis

The primary outcome of this study was ΔDMFS, defined as the difference between follow-up and baseline DMFS. DMFS was calculated as the sum of decayed, missing, or filled surfaces. The decayed component included active non-cavitated caries lesions and cavitated ones.

Body mass index (BMI)-for-age Z-scores were calculated using specific software (AnthroPlus, WHO, Geneva, Switzerland). BMI-for-age Z-scores are a measure of the standard deviation (SD) away from standardized mean BMI. The sample was categorized using cutoffs recommended by the WHO,[23] as follows: normal weight (BMI-for-age Z-score ≤ +1 SD), overweight (BMI-for-age Z-score > +1 SD to ≤ +2 SD), and obese (BMI-for-age Z-score > +2 SD).

Socioeconomic status was assessed according to the standard Brazilian economic classification[24], which takes into account the educational level of the head of the family and the purchase power of the family. It was used to classify families into low (≤ 13 points), mid-low (≥ 14 to ≤ 22 points), mid-high (≥ 23 to ≤ 28 points) and high (≥ 29 points) socioeconomic status. For analytical purposes, socioeconomic status was dichotomized into high/mid-high and mid-low/low. Soft drinks consumption was classified as non-daily or daily. Brushing frequency was categorized into ≤1 time/day, 2 times/day, or 3 times/day.

Data analysis was performed using STATA (Stata 14.2 for Windows; Stata Corporation, College Station, USA). Baseline characteristics of followed individuals and those lost to follow-up were compared using the chi-square and Wald tests. A weight variable considering the inverse probability of participation at follow-up according to sex and socioeconomic status was used in the statistical analysis. Preliminary analysis was performed to compare baseline DMFS and ΔDMFS according to predictor variables using the Wald test. The association between categories of weight status and ΔDMFS was assessed using negative binomial regression models (unadjusted and adjusted). Rate ratios and their 95% confidence intervals were

estimated. Sex, socioeconomic status, school, soft drinks consumption, and brushing frequency were included in the adjusted model due to their possible association with dental caries. The chosen level of statistical significance was 5%. Negative ΔDMFS were converted to zero to allow risk assessment analysis. It is important to highlight that negative ΔDMFS can be considered as biologically plausible reversals of non-cavitated lesions that were clinically diagnosed as sound surfaces at the follow-up examination.[22,25]

A multivariable fractional polynomial model was used to further explore the relationship between obesity and dental caries. An algorithm that selected the linear regression model that best predicted ΔDMFS was used to select polynomial transformations of independent variables. BMI-for-age Z-scores (modeled as a continuous variable), sex, socioeconomic status, school, soft drinks consumption, and brushing frequency were entered in the multivariable linear regression model. The fractional polynomial fitting algorithm converged after 2 cycles and the BMI-for-age Z-scores were transformed using the powers 1 and 2, indicating a non-linear relationship with ΔDMFS.

Ethical aspects

The study protocol was approved by the Federal University of Rio Grande do Sul Research Ethics Committee (299/08) and by the Municipal Health Department of Porto Alegre Research Ethics Committee (process number 001.049155.08.3/register number 288 and process nº 001.028618.12.2/register nº 807). All participants and their parents/legal guardians provided written informed consent.

Results

Table 1 shows a comparison of baseline characteristics of followed individuals and those lost to follow-up. There were a significantly higher proportion of public school attendees among participants than among those lost to follow-up. No significant differences were observed for sex, socioeconomic status, soft drinks consumption, brushing frequency or weight status. In regards to baseline caries experience, individuals lost to follow-up had significantly higher caries prevalence and mean DMFS at baseline than those followed-up.

Table 2 shows the baseline DMFS, and ΔDMFS by predictor variables. Overall, this schoolchildren population had a baseline DMFS of 2.66 (95%CI = 2.38–2.94), and an overall ΔDMFS of 0.81 (95%CI = 0.65–0.98). Schoolchildren attending public schools showed significantly higher ΔDMFS than their counterparts from private schools. Regarding weight status, DMFS increased by 0.86 (95%CI = 0.65–1.07), 0.91 (95%CI = 0.59–1.23), and 0.42 (95%CI = 0.03–0.80) for normal weight, overweight, and obese schoolchildren, respectively. Obese adolescents had significantly lower ΔDMFS than normal weight ones ($p < 0.05$).

The association between predictor variables and ΔDMFS is shown in Table 3. A trend of lower risk for ΔDMFS among obese adolescents have been found in the unadjusted analysis (IRR = 0.70; 95%CI = 0.47–1.03, p = 0.07); however, no significant association between categories of weight status and ΔDMFS was found in the adjusted model (overweight, IRR = 0.92, 95%CI = 0.69–1.21, p = 0.54; obese IRR = 0.75, 95%CI = 0.51–1.12, p = 0.16). Brushing frequency was significantly associated with ΔDMFS in the adjusted model.

The relationship between obesity and caries was further explored using a multivariable fractional polynomial model, which showed a significant non-linear relationship between BMI-for-age Z-scores and ΔDMFS after adjusting for sex, socioeconomic status, school, soft drinks consumption, and brushing frequency. Figure 2 presents the predicted ΔDMFS according to BMI-for-age Z-scores showing an inverted U-shaped relationship with ΔDMFS decreasing with increasing BMI ($p < 0.05$).

Discussion

This population-based longitudinal study assessed the association between obesity and changes in caries experience among South Brazilian schoolchildren over 2.5 years. In the risk assessment analysis, this association did not reach statistical significance; however, an exploratory analysis found an inverse relationship between ΔDMFS and BMI. To the best

Table 1. Baseline characteristics of individuals according to participation at the follow up.

Variable	Present sample (n = 801)		Lost to follow-up (n = 727)		p-value**
	n	%	n	%	
Socio-demographics					
Sex					
Female	387	48.3	371	51.0	0.29
Male	414	51.7	356	49.0	
Socioeconomic status					
High/Mid-high	258	32.2	241	33.1	0.70
Mid-low/Low	543	67.8	486	66.9	
School					
Private	117	14.6	144	19.8	0.01
Public	684	85.4	583	80.2	
Behavioral characteristics					
Soft drinks consumption*					
Non-daily	574	71.7	505	69.6	0.37
Daily	227	28.3	221	30.4	
Brushing frequency					
≤ 1 time/day	177	22.1	164	22.6	0.70
2 times/day	349	43.6	328	45.1	
≥ 3 times/day	275	34.3	235	32.3	
Weight status					
Normal	515	64.3	471	64.8	0.64
Overweight	182	22.7	153	21.0	
Obese	104	13.0	103	14.2	
Caries experience					
Prevalence	%	95% CI	%	95% CI	p–value***
	53.8	50.3–57.3	59.7	56.1–63.3	0.02
Extent (DMFS)	Mean	95% CI	Mean	95% CI	p–value***
	2.06	1.83–2.29	2.42	2.17–2.67	0.04

*Missing data; **Chi-square test; *** Wald test; CI = Confidence Interval.

of our knowledge, this is the first longitudinal study assessing the relationship between obesity and dental caries in adolescents from developing countries.

Limitations of our study include reduced participation rate and lack of dietary information. Of the original sample, 801 out of 1,528 (52.4%) were reexamined after 2.5 years; 566 schoolchildren had moved to another school. Schoolchildren lost to follow-up had a significantly higher caries experience at baseline than those followed-up (2.42 vs. 2.06, p = 0.04). To mitigate the impact of non-response, a weight variable taking into consideration the probability of participation was used to adjust the estimates. With regards to dietary habits, we only collected the frequency of soft drinks consumption. The availability of more dietary information could help to explain the relationship between obesity and caries. Conversely, strengths of this study include its sample size, longitudinal design, follow-up period of 2.5 years, and high intra- and inter-examiner reproducibility.

In our preliminary analysis, we found that obese individuals had a significantly lower ΔDMFS than normal weight ones over a 2.5-year period. Nonetheless, in the risk assessment analysis, no significant association was observed between BMI categories and ΔDMFS, which is consistent with our previous cross-sectional study on the original

Table 2. Baseline DMFS and ΔDMFS by predictor variables (n = 801).

Variable	Baseline DMFS		ΔDMFS	
	Mean	95% CI	Mean	95% CI
Socio-demographics				
Sex				
Female	2.73[a]	2.31–3.14	0.89[a]	0.65–1.12
Male	2.59[a]	2.22–2.97	0.74[a]	0.53–0.96
Socioeconomic status				
High/Mid-high	2.03[a]	1.55–2.50	0.63[a]	0.39–0.87
Mid-low/Low	2.96[b]	2.62–3.31	0.90[a]	0.70–1.11
School				
Private	1.44[a]	0.94–1.94	0.38[a]	0.03–0.74
Public	2.87[b]	2.56–3.18	0.89[b]	0.71–1.07
Behavioral characteristics				
Soft drinks consumption				
Non-daily	2.51[a]	2.20–2.83	0.87[a]	0.68–1.05
Daily	3.03[a]	2.44–3.62	0.68[a]	0.36–1.00
Brushing frequency				
≤ 1 time/day	3.68[a]	2.95–4.41	1.07[a]	0.63–1.52
2 times/day	2.72[b]	2.28–3.15	0.83[a]	0.60–1.05
≥ 3 times/day	1.94[c]	1.58–2.31	0.64[a]	0.40–0.87
Weight status				
Normal	2.80[a]	2.41–3.18	0.86[a]	0.65–1.07
Overweight	2.40[a]	1.92–2.88	0.91[ab]	0.59–1.23
Obese	2.43[a]	1.82–3.04	0.42[b]	0.03–0.80
Total	2.66	2.38–2.94	0.81	0.65–0.98

Different letters indicate a statistically significant difference between categories using Wald test ($p < 0.05$).

sample of 1,528 12-year-old schoolchildren[5]. This finding contradicts the notion that sugar consumption could be a common risk factor for obesity and caries. Only two previous studies have investigated the association between obesity and caries in adolescents using a longitudinal design. Li et al.[19] investigated the association between obesity and dental caries among 12-year-old adolescents from Hong Kong. Two rounds of follow-up were performed when the participants were aged 15 and 18 years. The authors found no relationship between BMI and dental caries at 15 and 18 years, which is in agreement with our finding. In contrast, the study by Basha et al.[18] found that obese and overweight Indian adolescents were at a higher risk for developing caries in a 3-year follow-up. Differences in oral hygiene habits and access to fluoridated products could explain, at least in part, the difference between our results and those found in India. We have a low caries prevalence population of adolescents, widely exposed to fluoride in water and toothpaste, with the vast majority of individuals reporting a brushing frequency of ≥ 2 times/day. In the study by Basha et al.[18], around 90% of the included adolescents reported a brushing frequency of ≤ 1 time/day and a portion of them used no fluoridated dentifrice. Deficiencies in the data collection on sugar consumption in both studies hamper a deeper discussion on this issue. In addition, we must also acknowledge that differences in cultural habits and access to industrialized food/drinks may also have played a role in the studies' results.

Systematic reviews showed that the association between obesity and caries is very inconsistent in the literature.[13,26,27] Hooley et al.[26] suggested

Table 3. Association between predictor variables and ΔDMFS (unadjusted and adjusted Negative binomial regression analysis, n = 801).

Variable	Unadjusted		Adjusted	
	IRR (95% CI)	p-value	IRR (95% CI)	p-value
Socio-demographics				
Sex				
Female	1.00		1.00	
Male	0.92 (0.72–1.17)	0.48	0.87 (0.69–1.10)	0.24
Socioeconomic status				
High/Mid-high	1.00		1.00	
Mid-low/Low	1.37 (1.06–1.78)	0.01	1.15 (0.87–1.52)	0.32
School				
Private	1.00		1.00	
Public	1.59 (1.10–2.30)	0.01	1.37 (0.92–2.02)	0.12
Behavioral characteristics				
Soft drinks consumption				
Non-daily	1.00		1.00	
Daily	1.01 (0.77–1.32)	0.93	1.01 (0.78–1.32)	0.92
Brushing frequency				
≤ 1 time/day	1.00		1.00	
2 times/day	0.70 (0.52–0.94)	0.02	0.76 (0.57–1.03)	0.07
≥ 3 times/day	0.60 (0.44–0.82)	0.001	0.63 (0.46–0.86)	0.01
Weight status				
Normal	1.00		1.00	
Overweight	0.97 (0.72–1.29)	0.83	0.92 (0.69–1.21)	0.54
Obese	0.70 (0.47–1.03)	0.07	0.75 (0.51–1.12)	0.16

CI = Confidence interval; IRR = Incidence Risk Ratio.

that this relationship might be nonlinear or even inverse in certain populations. In this regard,

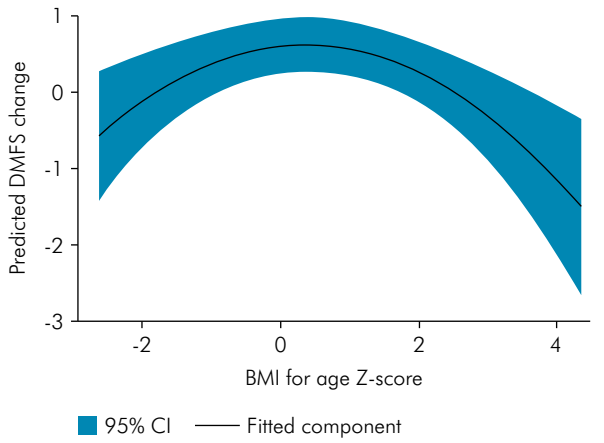

Figure 2. Predicted ΔDMFS according to BMI-for-age Z-score adjusted for sex, socioeconomic status, school, soft drinks consumption and brushing frequency.

Kopycka-Kedzierawski et al.[10] examined the relationship between obesity and dental caries using data from 2,777 12–18-year-old U.S. adolescents that had participated in the NHANES III (1988-1994). After adjusting for important factors, it was found that being overweight was associated with decreased caries risk (OR = 0.5, 95%CI = 0.3–0.9, p = 0.02). Corroborating these findings, Narksawat et al.[11] showed that normal weight Thai adolescents were more likely to had a DMFT≥1 than overweight/obese individuals (OR = 1.94, 95%CI = 1.25–3.00, p = 0.004). A recent study by Fernández et al.[12] conducted in Brazil that evaluated 1,210 schoolchildren aged 8 to 12 years, found lower dental caries in obese and overweight children. In order to further explore these issues, and owning to fact that a trend towards lower DFMS was observed with increasing BMI categories, an exploratory analysis using BMI-for-age Z-scores as a continuous variable was carried out. A non-

linear relationship was observed and polynomial transformations of the BMI-for-age Z-scores were used. After adjusting for possible confounders, we found an inverse U-shaped relationship between BMI and ΔDMFS with obese schoolchildren having lower ΔDMFS than normal weight children. Considering that fat is an important promoter of obesity, we could speculate that the excessive body weight observed in our population may be related to a high consumption of fatty food in the Southern Brazil. According to national data evaluating nutrient consumption, the caloric participation of lipids in the Southern Brazilian region is higher than the national mean.[28] A possible protective effect of fat against dental caries has been previously suggested in the literature.[29,30]

Conclusion

In conclusion, this population-based longitudinal study showed an inverse association between obesity and ΔDMFS over a 2.5-year period among South Brazilian adolescents.

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