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Association between tooth loss and obesity in Brazilian adults: a population-based study

Associação entre perda dentária e obesidade em adultos: estudo de base populacional

ABSTRACT

OBJECTIVE: To examine the association between tooth loss and general and central obesity among adults.

METHODS: Population-based cross-sectional study with 1,720 adults aged 20 to 59 years from Florianópolis, Southern Brazil. Home interviews were performed and anthropometric measures were taken. Information on sociodemographic data, self-reported diabetes, self-reported number of teeth, central obesity (waist circumference [WC] > 88 cm in women and > 102 cm in men) and general obesity (body mass index [BMI] ≥ 30 kg/m^2) was collected. We used multivariable Poisson regression models to assess the association between general and central obesity and tooth loss after controlling for confounders. We also performed simple and multiple linear regressions by using BMI and WC as continuous variables. Interaction between age and tooth loss was also assessed.

RESULTS: The mean BMI was 25.9 kg/m^2 (95%CI 25.6;26.2) in men and 25.4 kg/m^2 (95%CI 25.0;25.7) in women. The mean WC was 79.3 cm (95%CI 78.4;80.1) in men and 88.4 cm (95%CI 87.6;89.2) in women. A positive association was found between the presence of less than 10 teeth in at least one arch and increased mean BMI and WC after adjusting for education level, self-reported diabetes, gender and monthly *per capita* income. However, this association was lost when the variable age was included in the model. The prevalence of general obesity was 50% higher in those with less than 10 teeth in at least one arch when compared with those with 10 or more teeth in both arches after adjusting for education level, self-reported diabetes and monthly *per capita* family income. However, the statistical significance was lost after controlling for age.

CONCLUSIONS: Obesity was associated with number of teeth, though it depended on the participants' age groups.

DESCRIPTORS: Tooth Loss, epidemiology. Obesity, epidemiology. Risk Factors. Socioeconomic Factors. Cross-Sectional Studies.

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RESUMO

OBJETIVO: Analisar a associação entre perda dentária e obesidade geral e central em adultos.

MÉTODOS: Estudo transversal de base populacional com 1.720 adultos (20 a 59 anos) de Florianópolis, SC, em 2009. Entrevistas e medidas antropométricas foram realizadas nos domicílios. Foram incluídos dados sociodemográficos, diabetes e número de dentes autorreferidos, obesidade central (circunferência da cintura > 88 cm em mulheres e > 102 cm em homens) e geral (índice de massa corporal ≥ 30 kg/m^2). Utilizou-se um modelo múltiplo por meio da regressão de Poisson para associações entre obesidade geral e central e perda dentária após controle pelas variáveis de confusão. Também foram realizadas análises de regressão linear simples e múltipla utilizando índice de massa corporal e circunferência da cintura como variáveis contínuas. A interação entre idade e perda dentária também foi investigada.

RESULTADOS: A média de índice de massa corporal foi 25,9 kg/m^2 (IC95% 25,6;26,2) em homens e 25,4 kg/m^2 (IC95% 25,0;25,7) em mulheres. A média de circunferência da cintura foi 79,3 cm (IC95% 78,4;80,1) nos homens e 88,4 cm (IC95% 87,6;89,2) nas mulheres. Observou-se associação positiva entre a presença de menos de dez dentes em pelo menos uma arcada e o aumento do índice de massa corporal e da circunferência da cintura após ajuste para escolaridade, diabetes autorreferida, sexo e renda mensal *per capita*. Entretanto, essa associação foi perdida quando a idade foi incluída no modelo. A prevalência de obesidade geral foi 50% maior em adultos que apresentavam menos de dez dentes em pelo menos uma arcada quando comparados àqueles com dez ou mais dentes em ambas as arcadas após ajuste para escolaridade, diabetes autorreferida e renda mensal *per capita*. Porém, a significância estatística foi perdida após controle pela idade.

CONCLUSÕES: Obesidade foi associada ao número de dentes, entretanto dependeu do grupo etário dos participantes.

DESCRITORES: Perda de Dente, epidemiologia. Obesidade, epidemiologia. Fatores de Risco. Fatores Socioeconômicos. Estudos Transversais.

INTRODUCTION

Obesity is a public health concern associated with chronic diseases such as diabetes and cardiovascular diseases. Its prevalence is increasing not only in high-income countries but also in medium- and low-income countries.[19]

In Brazil the prevalence of overweight and obesity increased progressively in the four national population-based surveys conducted between 1974-1975 and 2008-2009. In adults the prevalence of overweight increased from 15.7% to 37.7% in men and from 20.7% to 31.1% in women. During this same period, obesity increased from 2.8% to 12.4% and from 8.0% to 16.9% in men and women, respectively.[a]

Some studies have shown an association between obesity and tooth loss.[12,14] The most plausible explanation is an association between patterns of food intake with number of natural teeth. It has been documented that individuals who lost all their natural teeth may less frequently consume vegetables, dietary fiber, wholemeal bread than who those with natural teeth.[15] In 2003, the prevalence of edentulism – complete tooth loss – among Brazilian adults aged 35 to 44 years was 9%, with a median tooth loss of 11. Tooth loss was strongly associated with living in rural areas, female gender, poor socioeconomic condition, low schooling, and older age.[1] In this same age group, in 2010, mean tooth loss was 7.4 teeth and 9% had dental prosthesis.[b]

[a] Instituto Brasileiro de Geografia e Estatística. Pesquisa de Orçamentos Familiares 2008-2009. Antropometria e análise do estado nutricional de crianças, adolescentes e adultos no Brasil. Rio de Janeiro: IBGE, 2010.

[b] Ministério da Saúde. Secretaria de Atenção à Saúde. Departamento de Atenção Básica. Projeto SBBrasil 2010: resultados principais. Brasília; 2011.

Most studies that assessed the association between tooth loss and obesity were carried out in elderly populations[15] or only focused on the association between tooth loss and specific nutrient intake,[7] studied small samples,[10] and investigated specific populations.[2]

There are limited data associating tooth loss with obesity in adult populations. This is concerning because prevention and early detection programs may help reduce potential damage of tooth loss and related health effects later in life. Ostberg et al[12] found an association between tooth loss and general obesity in a defined Swedish rural adult population, regardless of age, gender, socioeconomic status, lifestyle and comorbidities. To the best of our knowledge there are no other well-designed, population-based studies that investigated the association of obesity and tooth loss in adults controlling for well-known confounders.

This study aimed to assess the association between tooth loss and general and central obesity in adults.

METHODS

A population-based cross-sectional study was carried out in Florianópolis, Southern Brazil, between September 2009 and January 2010. Florianópolis is the capital city of the state of Santa Catarina with a population of approximately 400,000 inhabitants[c]. It has the highest health and social indicators in Brazil, including an infant mortality rate of 8 per 1,000 live-borns and a Municipal Human Development Index of 0.875 compared with 19.5 per 1,000 and 0.813, respectively, for Brazil as a whole.[d] The target population of this study included all adults aged 20 to 59 years living in the urban area of the city (almost 96% of the entire population), totaling nearly 240,000 inhabitants.

This study is a part of a comprehensive large study *EpiFloripa* 2009, a health survey conducted in adults to investigate self-rated health, self-reported diseases, oral health, health services utilization and main risk factors for chronic diseases, such as socioeconomic and demographic characteristics, diet, physical activity, blood pressure, anthropometric measurements, and alcohol and tobacco use.

The sample size was calculated to estimate the prevalence of each of the above mentioned outcomes considering the following parameters: unknown prevalence (50%), 95% confidence level, a sample error of 3.5 percentage points, a design effect of 2 due to the cluster sampling and an additional 10% to compensate for refusals. The minimum sample size estimated was 1,720. As the study was nested in a larger health survey, the final sample was 2,016 after estimating each of the studied outcomes. *A posteriori* we calculated the minimum sample size required to investigate the association between tooth loss (exposure) and general and central obesity (outcomes) adopting a 95% confidence level (error type I of 5%), a power of 80% (error type II of 20%), a minimum relative risk to be detected of 1.4, and a prevalence of the outcomes of 14% among the unexposed population. Finally, we added 10% to compensate for refusals. The final sample to test the association between tooth loss and obesity was 1,615 adults.

A two-stage sample selection was performed. First, we selected 60 census tracts among all 420 tracts in the urban area of the city. Second, we selected the occupied households and then all adult residents living there. All 420 urban census tracts were ordered according to the average monthly income of the household head.[d] We used a systematic sample of 60 census tracts (60/420 or 1/7), i.e., six census tracts in each income decile. All selected census tracts were visited by the fieldwork team and all occupied houses were checked and counted in order to update the number of residents in the selected clusters. As the number of households ranged from 61 to 810 households, some census tracts were merged to reduce the variability among the number of households in each tract and ensure a self-weighting sample. There were 63 census tracts totaling 16,755 eligible households, of which 1,134 were selected for this study. There were selected on average 32 adults in each census tract.

All adults aged 20 to 59 years and living in the selected households were eligible. Exclusion criteria included amputees; bedridden individuals; individuals with casts; individuals who could not remain in the required position for measurements; and those who not able to answer the questionnaire. All respondents were the adults selected; no other unselected individual was allowed to answer the questionnaire. Anthropometric and blood pressure measurements were not taken from pregnant women and women up to six months after delivery.

Home visits included a face-to-face questionnaire applied with the use of personal digital assistants (PDA), two blood pressure measurements and anthropometric measurements including weight, height and waist circumference (WC). All 35 interviewers/evaluators were women previously trained for field work. The questionnaire was pre-tested with 35 adults not included in the sample and who were living within the coverage area of a local health center. The pilot study included almost 100 adults living close to the research headquarters within two unselected census tracts.

Anthropometric measurements were taken following the proposed Lohman et al[11] recommendations. Body weight (in kilograms, kg) was taken twice with portable scales (GAMA Italy Professional, HCM 5110 M®) with

[c] Instituto Brasileiro de Geografia e Estatística. Estimativa da população. Rio de Janeiro; 2009.
[d] Instituto Brasileiro de Geografia e Estatística. Censo Demográfico 2000. Rio de Janeiro; 2003.

capacity of 150 kg, sensitivity of 100 g, calibrated before the training and field work. They were placed on a level surface and respondents were weighted wearing light clothes and standing with their feet placed together and their arms hanging at sides. Height was measured twice with a stadiometer specifically made for the study with an inelastic measuring tape with 1-mm resolution. The respondents were placed in the orthostatic position, barefoot, with the head in the Frankfurt position without any ornaments, placing shoulders, gluteal muscles and heels against the wall and feet side-by-side. Height was the average of two measures. Body mass index (BMI) was calculated as weight in kg divided by the square height in meters.

WC measures were taken using an anthropometric inelastic tape with millimeter markings (Sanny®) with 1-mm resolution. They were taken at the narrowest waist level, or if this was not apparent, at the midpoint between the lowest rib and the top of the iliac crest. Evaluators were instructed when recording to make sure the tape was not too tight or too loose, was lying flat on the skin and horizontal. WC was the average of two measures. Reliability measures were calculated as recommended by Ulijaszek & Kerr[17] and Gore et al[6] using technical measurement errors in percent point for both intra- and interevaluator errors. The inter- and intra-examiner technical error of measurement (TEM) was calculated according to the recommendations of Gore et al.[6] The maximum inter-examiner TEM (1.86%) and intra-examiner TEM (1.18%) was found in the WC measure, which indicated an adequate level of interviewers for anthropometric measurements.

We analyzed two outcomes: general obesity using BMI as a binary variable (obese: ≥ 30 kg/m² and non-obese: < 30 kg/m²) and central obesity using WC (obese: ≥ 102 cm for men and ≥ 88 cm for women; non-obese: < 102 cm for men and < 88 cm for women).[18] In addition we used BMI and WC as continuous variables.

The number of self-reported remaining natural teeth for each dental arch was recorded as follows: ≥ 10 natural teeth; one to nine natural teeth; no natural teeth. A variable was created to include those with ≥ 10 natural teeth in both arches, < 10 teeth at least in one arch, and those completely edentulous.

The controlling variables included: gender; age (years); education level (years of schooling); monthly *per capita* income (in the Brazilian currency real: R$ 1.7 was U$ 1 at the time of data collection); self-reported skin color (white, black, brown); and self-reported diabetes. Skin color classification followed the *Instituto Brasileiro de Geografia e Estatística* (IBGE – Brazilian Institute of Geography and Statistics) recommendations. Monthly *per capita* income was calculated as the sum of incomes of all family members divided by the number of people living in the household. It was classified into tertiles (1st: ≤ US$ 333.34; 2nd: US$ 333.35 to US$ 764.71; 3rd: ≥ US$764.72). Age was also considered an effect modifier variable.

All eligible adults were visited at least four times, with at least one visit on weekends and one in the evening. If an individual was not located or refused to participate, it was considered a loss. We adopted a scheme of sampling with no replacement.

Data quality control consisted of applying a short version of the questionnaire (10 questions) through a telephone interview to 15% of the whole sample (n = 248). Among the variables investigated the intra-class correlation coefficient was 0.99 for age and the kappa value was 0.9 for self-reported diabetes.

Data stored in the PDAs were entered into Stata 9.0 software. Data analysis included the sample description and bivariate cross-tabulation of two binary outcomes (BMI and WC) against the main explanatory variable (number of natural teeth) and other covariates. For comparisons among groups, we used Pearson χ^2 tests and linear trends when appropriate. P-values of less than 0.05 were statistically significant. We used multivariable Poisson regression models to estimate prevalence ratios and 95% confidence intervals. In addition, we performed simple and multiple linear regressions using BMI and WC as continuous variables. The interaction between tooth loss and age was assessed using the heterogeneity test. All explanatory variables with a p-value of 0.20 or less were included in the multivariable models. All analyses were performed considering the cluster sample design and sampling weight using the Stata *svy* command.

The research project was approved by the Research Ethics Committee of Universidade Federal de Santa Catarina (protocol #351/08, December 15th, 2008). All respondents signed a consent before participating and for anthropometric and blood pressure measurements and examinations. Adults with high blood pressure levels or pain were referred to the nearest local health center.

RESULTS

Of a total of 2,016 eligible adults, 85.3% were studied (n = 1,720). Female to male ratio was 1.26. Approximately one-third were between 20 and 29 years of age. Most reported having white skin color, and the great majority (82%) had 10 or more teeth in both arches. General obesity was found in 15.8% of the sample, and the prevalence of central obesity was quite similar (15.1%) (Table 1).

The mean BMI was 25.9 kg/m² and 25.3 kg/m² among men and women, respectively. The mean WC was 88.1 cm in women and 79 cm in men (data not shown).

Table 1. Sample distribution and prevalence of general and central obesity according to independent variables in adults. Florianópolis, Southern Brazil, 2009.

Variable	Sample distribution		General obesity		Central obesity	
	n	%	%	95%CI	%	95%CI
Gender (n = 1,720)						
Male	761	44.5	14.7	11.9;17.5	10.6	8.2;13.0
Female	959	55.5	16.7	13.7;19.7	18.8	15.6;22.1
Age (years) (n = 1,720)						
20-29	540	32.7	9.5	6.6;12.5	6.9	4.7;9.1
30-39	392	22.9	15.9	11.3;20.6	14.0	10.2;17.8
40-49	438	25.0	18.3	13.9;22.6	16.0	12.1;19.9
50-59	350	19.4	22.6	17.3;27.9	28.7	23.0;34.4
Skin color (n = 1,678)						
White	1,444	85.8	15.8	13.1;18.6	15.3	12.9;17.7
Brown	147	9.1	15.8	8.5;23.1	13.0	7.5;18.5
Black	87	5.1	12.5	5.0;20.1	14.4	6.3;22.4
Education level (years of schooling) (n = 1,716)						
≤ 4	158	8.8	26.7	20.3;33.1	28.0	20.9;35.2
5-8	253	14.0	21.7	15.5;27.9	20.2	14.3;25.7
9-11	568	33.4	15.7	12.3;19.2	16.3	13.2;19.5
≥ 12	737	43.9	11.8	8.3;15.3	9.9	7.2;12.5
Monthly *per capita* income (tertiles) (n = 1,685)						
Lower	564	33.5	19.4	16.2;22.7	20.2	16.5;23.8
Intermediate	562	33.3	17.4	13.1;21.7	16.4	12.8;20.0
Upper	559	33.2	11.1	7.7;14.5	9.0	6.4;11.7
Number of natural teeth (n = 1,717)						
≥ 10 in both arches	1,394	82.0	13.6	11.1;16.2	12.6	10.6;14.6
< 10 teeth in at least one arch	279	15.6	24.9	19.5;30.3	24.9	18.7;31.2
Edentulous	44	2.4	23.8	7.9;39.6	35.0	15.9;54.0
Self-reported diabetes (n = 1,718)						
Yes	63	3.7	38.5	22.7;54.3	38.3	22.4;54.1
No	1,655	96.3	14.8	12.2;17.3	14.2	11.9;16.6
BMI (kg/m^2) (mean, 95%CI)	25.6	25.2;25.9	34.0	33.5;34.4	33.2	32.6;33.8
WC (cm) (mean, 95%CI)	83.1	82.1;84.2	101.7	100.0;103.4	103.4	101.8;105.0
Total	1,720	100.0	15.8	13.2;18.3	15.1	12.8;17.4

BMI: body mass index; WC: waist circumference

Figure 1 shows that the difference in mean BMIs among men with different numbers of teeth was not statistically significant ($p = 0.193$). Women with less 10 teeth in at least one arch and edentulous women had higher mean BMI than those with 10 or more teeth on both arches ($p < 0.001$). The mean BMI was lower in women than men with 10 or more teeth on both arches ($p < 0.001$). Also, compared to men, women with 10 or more teeth in both arches ($p < 0.001$) and less than 10 teeth in at least one arch ($p < 0.001$) had a lower mean WC. Among men mean BMI was higher in those with less than 10 teeth in at least one arch than those with 10 or more teeth on both arches ($p = 0.007$). In addition, women with less than 10 teeth in both arches and edentulous women had higher mean WC than those with 10 or more teeth on both arches ($p < 0.001$) (Figure 1).

Table 2 shows the multivariable linear regression analysis between BMI and number of teeth, as well as WC and number of teeth. A positive association was found between the presence of less than 10 teeth in at least one arch and increased mean BMI after adjusting for gender, monthly *per capita* income, self-reported diabetes and education level (model 5). However, this association lost its statistical significance when the variable age was included in the model (model 6). In the multivariable linear regression analysis, the lower the number of teeth the higher the WC after adjusting for gender, monthly

Table 2. Simple and multivariable linear regression models of the association between body mass index (kg/m²) and waist circumference (cm) and number of natural teeth in adults. Florianópolis, Southern Brazil, 2009.

Variable		Model 1[b] Coeff.(95%CI)	Model 1[b] p-value	Model 2[a] Coeff.(95%CI)	Model 2[a] p-value	Model 3[a] Coeff.(95%CI)	Model 3[a] p-value	Model 4[a] Coeff.(95%CI)	Model 4[a] p-value	Model 5[a] Coeff.(95%CI)	Model 5[a] p-value	Model 6[a] Coeff.(95%CI)	Model 6[a] p-value
BMI (kg/m^2)	Number of natural teeth		< 0.001		< 0.001		< 0.001		< 0.001		0.005		0.748
	≥ 10 in both arches	reference		reference		reference		reference		reference		reference	
	< 10 in at least one arch	1.9 (1.3;2.5)		1.9 (1.3;2.5)		1.8 (1.1;2.4)		1.7 (1.1;2.2)		1.4 (0.7;2.0)		0.4 (-0.4;1.1)	
	edentulous	2.1 (-0.3;4.5)		2.1 (-0.3;4.5)		1.8 (-0.5;4.2)		1.4 (-0.8;3.7)		0.9 (-1.4;3.3)		-0.4 (-2.7;1.9)	
WC (cm)	Number of natural teeth		< 0.001		< 0.001		< 0.001		< 0.001		< 0.001		0.512
	≥ 10 in both arches	reference		reference		reference		reference		reference		reference	
	< 10 in at least one arch	5.6 (3.6;7.6)		6.0 (4.0;8.0)		5.7 (3.8;7.7)		5.5 (3.6;7.3)		4.6 (2.6;6.7)		0.7 (-1.4;2.9)	
	edentulous	7.9 (2.8;13.1)		8.8 (3.2;14.5)		8.2 (2.6;13.9)		7.3 (1.9;12.7)		5.8 (0.3;11.2)		0.8 (-4.3;5.9)	

[a] Adjusted; [b] Unadjusted; Model 1: Crude analysis; Model 2: Number of natural teeth + gender; Model 3: Number of natural teeth + gender + monthly *per capita* income; Model 4: Number of natural teeth + gender + monthly *per capita* income + self-reported diabetes; Model 5: Number of natural teeth + gender + monthly *per capita* income + self-reported diabetes + education level; Model 6: Number of natural teeth + gender + monthly *per capita* family income + self-reported diabetes + education level + age. BMI: body mass index; WC: waist circumference

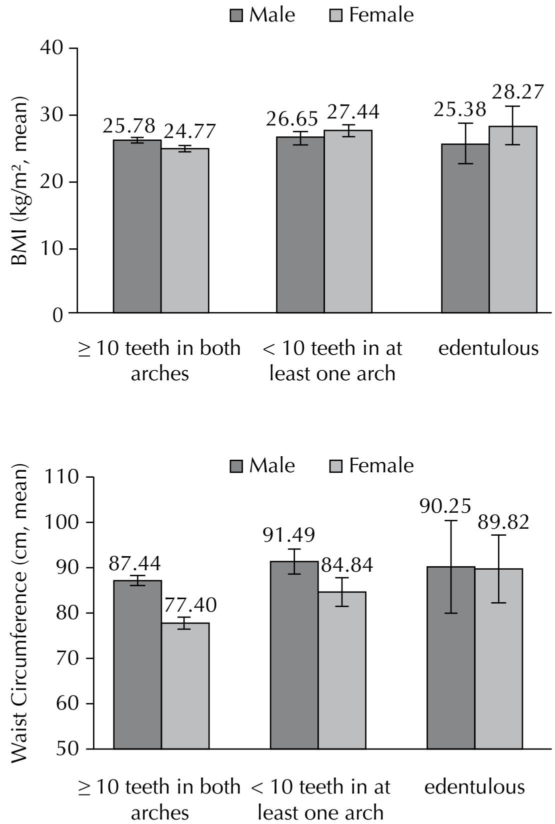

Figure 1. Distribution of mean body mass index (kg/m²) and waist circumference (cm) and their 95% confidence intervals according to number of natural teeth and gender among adults. Florianópolis, Southern Brazil, 2009.

per capita income, self-reported diabetes and education level (model 5). However, when the model was adjusted for age, the association between the number of teeth and WC lost its statistical significance.

The multivariable Poisson regression analysis between number of teeth and prevalence of general obesity showed that the prevalence of general obesity was 50% higher in those with less than 10 teeth in at least one arch when compared with those with 10 or more teeth in both arches after adjusting for monthly *per capita* income, self-reported diabetes and education level (model 5). However, it lost its statistical significance after controlling for age (model 6) (Table 3). Very similar results were observed when the prevalence of central obesity was analyzed in the multivariable Poisson regression model. The prevalence of central obesity was 50% higher in individuals with less than 10 teeth in at least one arch when compared with those with 10 or more teeth in both arches after adjusting for gender, monthly *per capita* income, self-reported diabetes and education level (model 5), but lost its statistical significance after including age in the model (model 6) (Table 3). The interaction between tooth loss and age was identified in adults with general and central obesity ($p < 0.001$) (Figure 2).

Table 3. Multivariable Poisson regression analysis of the association (prevalence ratio) between general and central obesity with number of natural teeth in adults. Florianópolis, Southern Brazil, 2009.

Variable		Model 1[b]		Model 2[a]		Model 3[a]		Model 4[a]		Model 5[a]		Model 6[a]	
		PR(95%CI)	p-value	PR(95%CI)	p-value	PR(95%CI)	p-value	PR(95%CI)	p-value	PR(95%CI)	p-value	PR(95%CI)	p-value
General obesity	Number of natural teeth		< 0.001		< 0.001		0.001		0.003		0.037		0.510
	≥ 10 in both arches	reference		reference		reference		reference		reference		reference	
	< 10 in at least one arch	1.8(1.4;2.4)		1.8(1.4;2.4)		1.7(1.3;2.3)		1.6(1.2;2.2)		1.5(1.1;2.0)		1.2(0.9;1.7)	
	Edentulous	1.7(0.9;3.4)		1.7(0.9;3.3)		1.6(0.8;3.0)		1.4(0.7;2.5)		1.2(0.6;2.3)		0.9(0.5;1.8)	
	Age*number of teeth												p < 0.001
Central obesity	Number of natural teeth		< 0.001		< 0.001		< 0.001		< 0.001		0.002		0.933
	≥ 10 in both arches	reference		reference		reference		reference		reference		reference	
	< 10 in at least one arch	2.0(1.5;2.6)		1.9(1.4;2.6)		1.8(1.3;2.4)		1.7(1.3;2.3)		1.5(1.1;2.1)		1.0(0.7;1.4)	
	Edentulous	2.8(1.6;4.7)		2.6(1.6;4.4)		2.2(1.3;3.6)		1.9(1.2;3.1)		1.6(1.0;2.6)		1.0(0.6;1.5)	
	Age*number of teeth												p < 0.001

[a] Adjusted; [b] Unadjusted; Model 1: Crude analysis; Model 2: Number of natural teeth + "gender"; Model 3: Number of natural teeth + "gender" + monthly *per capita* income. Model 4: Number of natural teeth + "gender" + monthly *per capita* income + self-reported diabetes; Model 5: Number of natural teeth + "gender" + monthly *per capita* income + self-reported diabetes + education level; Model 6: Number of natural teeth + "gender" + monthly *per capita* income + self-reported diabetes + education level + age. The between quotes variable showed a p-value > 0.20 after adjustment in the analysis between general obesity and number of natural teeth and was not included in the subsequent models.

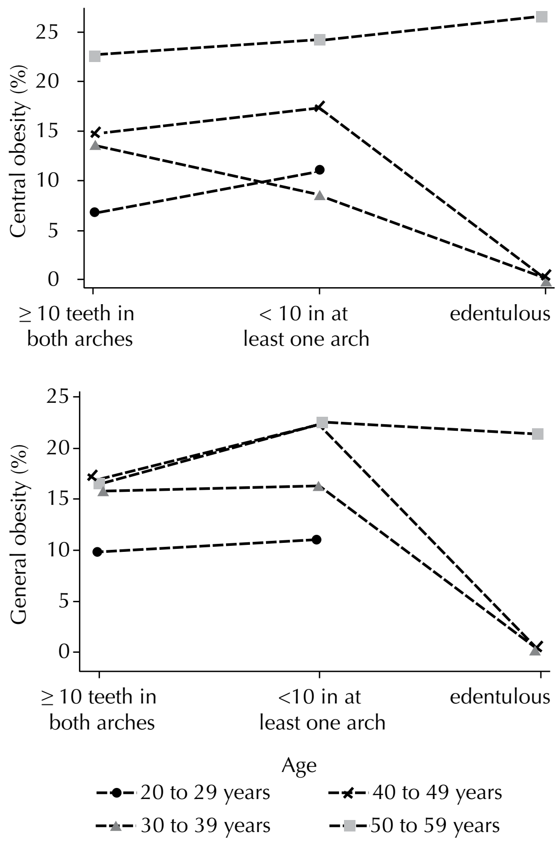

Figure 2. Heterogeneity test of the interaction between tooth loss and age in adults with general and central obesity. Florianópolis, Southern Brazil, 2009.

DISCUSSION

To our knowledge, this is the first population-based study carried out outside high-income countries that tested the association between tooth loss and general and central obesity among adults. We found that general and central obesity was associated with number of teeth after adjusting for monthly *per capita* income, self-reported diabetes and education level in both Poisson regression and linear regression analysis. However, when we added age in the model, the association between tooth loss and general and central obesity lost its statistical significance.

We carried out an analysis stratified by age despite the risk of losing the statistical power of the sample and found increased tooth loss with increasing age. The associations were similar to those in the entire sample, so we decided to show the analysis for the entire sample.

A similar study carried out in Sweden reported that in adults aged 30 to 59 years there was an association between tooth loss and both general and central obesity regardless of socioeconomic condition, lifestyle and comorbidities.[12] In this study the number of teeth was also self-reported. Our study found a higher proportion of adults with less than 10 teeth in at least one arch (25.7%)

compared to the Swedish study (10.6%) associated with central obesity. In addition, 24.8% of adults with general obesity had less than 10 teeth in at least one arch, which is higher than the 11% found in the Swedish study.[12]

Despite similar data collection on weight, height and number of teeth, the differences between the findings of these studies may be due to specific characteristics of the populations evaluated. For example, our sample comprised urban adults while rural adults were studied in the Swedish study. In addition, differences in cultural and socioeconomic characteristics and dietary patterns between these two populations should be taken into account.

Previous studies found an association between obesity and tooth loss in older people. Our purpose was to test whether this association occurs earlier in life so that prevention actions could be taken to prevent this health problem later.[8,14]

Obesity is a multifactorial, chronic, non-transmissible disease, and its etiology involves genetic and behavioral factors including inadequate food intake.[9] Dietary data were collected but were not included in this study because the food questionnaire was formulated only to compare with a national study that used the same questionnaire through telephone interviews. Therefore the issues of the food questionnaire did not represent the dietary pattern of the population and were inappropriate for this study. The effect of food intake on nutritional status and oral health is cumulative and requires a longer follow-up to capture trends and habits over time. It is well-known[16] that tooth loss leads to consumption of foods that are easy to chew and usually high in calorie density.

Our results suggest the external validity of the study. The prevalence of general and central obesity in this study was almost 16%, identical to that found in the Brazilian Household Survey 2008-2009 in Southern Brazil.[a] General obesity rates were similar in both men and women and higher in less educated, poorer, and older adults and those who self-reported diabetes. Similar central obesity results were found by age, education level, monthly *per capita* family income, and self-reported diabetes, but higher rates were seen in women than in men.

A comparison of our results with other studies is difficult since studies evaluating the association between obesity and tooth loss among young adults are scarce.

This study has some limitations. We relied on self-reported number of natural teeth. However, several validation studies showed there was no significant difference between self-reported number of teeth and actual number of teeth determined by clinical examination regardless of age and gender.[3-5,13]

Age was identified as a confounder of the relationship between number of teeth and obesity and was also an effect-modifying variable. We found an interaction between age and tooth loss in obesity. The prevalence of obesity varies across different age groups depending on the number of teeth. Individuals with less than 10 teeth in at least one arch and edentulous adults showed higher obesity rates by age, which suggests that age modified the effect of tooth loss on obesity. This result is not straightforwardly understood and the main explanation for this fact lies on dietary changes with aging and tooth loss. Food intake pattern changes according to the presence and number of natural teeth.

The prevalence of obesity is increasing in Brazil. Its known association with tooth loss in older adults calls for further studies that also examine food intake in young adults. Thus it is possible to provide insight for the promotion of oral health and healthy eating habits and earlier prevention of tooth loss and obesity.

A second wave of this study is to be carried out including a detailed dental examination, anthropometric measurements and dietary patterns to test the hypothesis formulated here. A longitudinal study can help better understand the complex relationship between tooth loss and obesity.

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