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Associations of duration of smoking cessation and cumulative smoking exposure with periodontitis

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Abstract: This cross-sectional study investigated associations of cumulative smoking exposure and duration of smoking cessation with periodontitis and evaluated the effects of biological, behavioral, and social risk variables on these associations. The sample comprised 705 adults of both sexes (age, 35-65 years) who underwent a full-mouth periodontal examination. Subjects were classified according to smoking status as nonsmokers, former smokers, and current smokers, and univariate and multivariate analysis was used to evaluate associations between periodontitis prevalence and potential risk variables. The rates of periodontitis among nonsmokers, former smokers, and current smokers were 25.6%, 29.3%, and 45.1% respectively. After adjusting for other periodontal risk variables the odds ratio (95% confidence interval) for periodontitis was 3.09 (1.98-4.92) for former smokers and 5.24 (2.61-8.97) for current smokers. A significant dose-response relationship between pack-years of smoking and periodontitis prevalence was observed, as was a significant decrease in the risk of periodontitis as years of smoking cessation increased. Cumulative smoking exposure and duration of smoking cessation were significantly associated with periodontitis.
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Introduction

Numerous epidemiologic studies have reported higher periodontitis prevalence and severity among current smokers (CS) and former smokers (FS) (1-10). Smoking has been identified as the most important modifiable risk factor for periodontitis, followed by dental biofilm (11-12).

However, despite extensive research on this subject, consensus is lacking on important issues. The limitations of published research include (a) a wide range of risk estimates for the relation between smoking and periodontitis, from 2 to 11 times for clinical attachment and/or bone loss (12-20), (b) use of non-robust criteria to define periodontitis (2,10,21) and the fact that some association studies evaluated only one clinical parameter for periodontal diagnosis, such as clinical attachment level and bone/tooth loss (4,22), (c) use of questionable criteria to measure smoking exposure (21), (d) inclusion of small study samples (2), and (e) lack of adequate statistical adjustment for confounders (5).

Although some evidence suggests that cumulative smoking exposure and duration of smoking cessation are directly associated with periodontitis (23,24), data on these issues are inconsistent, especially for FS (7,15,22-24).

Studies should attempt to clarify some of these issues to provide more accurate risk estimates for periodontitis among smokers and determine the effects of cumulative

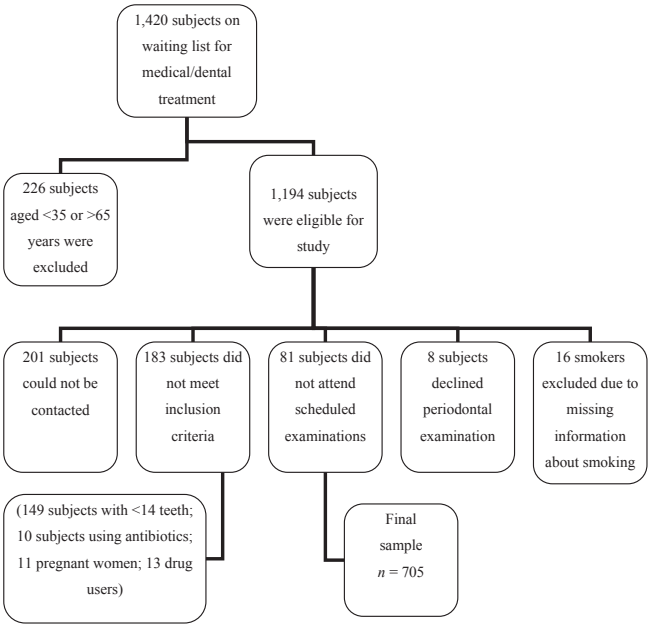

Fig. 1 Study flow diagram

exposure and duration of smoking cessation on periodontitis. We investigated the association of cumulative smoking exposure and duration of smoking cessation with periodontitis and analyzed the effects of risk variables on this association.

Material and Methods

Study sample

The present cross-sectional study comprised a convenience sample of 705 individuals. From June 2008 to December 2010, full-mouth periodontal examinations and interviews were performed to collect data on biological, behavioral, and social variables. This research was approved by the Ethics Research Committee of the Federal University of Minas Gerais (COEP/UFMG protocol #0094.0.203.000-10).

All individuals were selected from a single waiting list of 1,420 adults seeking medical and dental care at three general-care health centers in western Belo Horizonte City, Brazil. After analyzing medical records and excluding individuals younger than 35 years and older than 65 years, 1,194 individuals were deemed eligible for the study and were invited by telephone to participate. At that time, 201 individuals could not be reached and 993 individuals were scheduled for clinical examinations and interviews. From this total, 183 did not satisfy the inclusion criteria, 81 did not attend scheduled exams or interviews, and 8 declined to undergo periodontal examination, due to concerns regarding potential discomfort; 16 smokers and former smokers were excluded due to lack of information on pack-years of smoking. A flowchart of the sampling strategy is shown in Fig. 1. The final sample consisted of 705 adults (341 men and 341 women; age range, 35 to 65 years; mean ± SD age, 52.3 ± 4.2) with heterogeneous socioeconomic (family income, ±5.8 Brazilian minimum salary (BMS), ie, approximately 280 Euros) and educational levels. To reduce age-related variations, we chose to focus on the age group 35-65 years.

Definition of smoking status

Two of the authors (F.O.C. and E.J.P.L.) used a structured questionnaire to collect information on smoking habits. Participants were classified into three groups: nonsmokers (NS) – those who had smoked fewer than 100 cigarettes during their lifetime and did not currently smoke; FS – those who had smoked more than 100 cigarettes during their lifetime and did not currently smoke; and (c) CS – those who had smoked more than 100 cigarettes during their lifetime and did currently smoke (3). Cumulative smoking exposure in the FS and CS groups was determined by taking the number of cigarette packs smoked in a year (packs/year) and multiplying the number of smoking years by the mean number of packs a day. In addition, on the basis of number of packs/year, individuals were classified as nonsmokers (0.0 packs/year), light smokers (0.1-20.0 packs/year), moderate smokers (20.1-40.0 pack/year), and heavy smokers (>40.0 packs/year) (25). Duration of smoking cessation among FS was categorized as <5 years, 6-10 years, 11-15 years, or >15 years of cessation.

Exclusion criteria

Criteria for exclusion included: (a) pregnancy, (b) presence of debilitating diseases that compromise the immune system (eg, HIV/AIDS, neoplasms, and autoimmune diseases), (c) drug-induced gingival enlargement, (d) age younger than 35 years or older than 65 years, (f) history of using illegal drugs (cannabis, cocaine, crack cocaine, and others), (g) antibiotic therapy within 3 months of the clinical examinations, and (h) having <14 teeth in the oral cavity.

Characterization of sample

After signing the informed consent form, individuals completed the Alcohol Use Disorders Identification Test (AUDIT) and Cut down, Annoyed, Guilty, Eye-opener (CAGE) questionnaires and underwent a clinical examination conducted by examiners blinded to the interview results. Data on medical history, sociodemographic characteristics, and smoking habits were also collected, namely, sex, age, family income (BMS <5 or ≥5),

educational level (<8, 8, or >8 years), cohabitation status (with or without a companion), most recent dental visit (within the past 2 years, 2 to 5 years before, >5 years before), tooth loss (mean number of lost teeth), alcohol use (2 questionnaires were used to determine frequency and intensity of alcohol consumption: the AUDIT (26) consists of 10 questions, and a score higher than 8 indicates alcohol misuse; the CAGE (27,28) consists of 4 questions, and a score higher than 2 indicates alcohol dependence), diabetes (fasting glucose value >126 mg/dl or use of a hypoglycemic agent for >2 weeks) (29), and body mass index (BMI; ≤25 to >25 kg/m^2).

Clinical periodontal examination

The following periodontal parameters were collected for all individuals at four sites (vestibular, lingual, mesial, and distal) in all teeth: probing depth (PD), clinical attachment level (CAL), bleeding on probing (BOP; evaluated 30-60 s after probing measurements and recorded as present or absent), lost teeth, and plaque index (30). The complete periodontal examination was performed using a manual periodontal probe (PCPUNC15BR; Hu-Friedy, Chicago, IL, USA). Two trained periodontists (F.O.C. and E.J.P.L.) performed all examinations and interviews.

Periodontitis definition

Periodontitis cases were defined by the sum of the two threshold levels of disease proposed by the European Consensus, ie, presence of proximal attachment loss ≥3 mm in ≥2 nonadjacent teeth and presence of proximal attachment loss ≥5 mm in ≥30% of teeth (31).

Intra- and inter-examiner agreement

Measurement of PD and CAL was performed and repeated after 1 week in 12 individuals randomly selected from the pilot study sample (n = 60). Data were evaluated by nonparametric κ test and intraclass correlation coefficients. The presence or absence of periodontal alterations were dichotomized by a cut-off point ≥4 mm for PD and 3 mm for CAL measurements. The weighted κ values were >0.89, and the intraclass correlation coefficient was >0.87 for intra- and inter-examiner agreement

Table 1 Characteristics of participants by smoking status

Variables Total n (%)	Nonsmokers (NS) n = 335 (47.5%)	Former smokers (FS) n =166 (23.5%)	Current smokers (CS) n = 204 (29.0%)	Total sample n = 705
Sex [1]				
Women	241 (71.9)	54 (32.5)	69 (33.8)	364 (51.7)
Men	94 (28.1)	112 (67.5)	135 (66.2)	341 (48.3)
Age, y [1]				
≥35-45	150 (44.8)	58 (34.9)	91 (44.6)	299 (42.4)
>45-65	185 (55.2)	108 (65.1)	113 (55.4)	406 (57.6)
Family income [1]				
<5 BMS	161 (48.0)	74 (44.5)	82 (40.2)	317 (44.9)
≥5 BMS	174 (52.0)	92 (55.5)	122 (59.8)	388 (55.1)
Educational level, y [1]				
<8	189 (56.4)	56 (39.8)	88 (43.1)	343 (48.7)
≥8	146 (43.6)	100 (61.2)	116 (56.9)	362 (51.3)
Cohabitation status [1]				
With companion (family/friends)	191 (57.0)	107 (64.5)	87 (42.6)	385 (54.6)
Without companion	144 (43.0)	59 (35.5)	117 (57.4)	320 (45.4)
Body mass index [1]				
≤25 kg/m^2	119 (35.5)	63 (37.9)	78 (38.2)	260 (36.9)
>25 kg/m^2	216 (64.5)	103 (62.1)	126 (61.8)	445 (63.1)
Last dental visits [1]				
Last 2 years	124 (37.0)	53 (31.9)	68 (33.3)	245 (34.8)
2-5 years	71 (21.2)	33 (19.9)	47 (23.0)	151 (21.4)
>5 years	140 (41.8)	80 (48.2)	89 (43.7)	309 (43.8)
Diabetes [1]				
Yes	19 (5.7)	9 (5.4)	15 (7.3)	43 (6.1)
No	355 (94.3)	157 (94.6)	189 (92.7)	662 (93.9)
Alcohol Use [1]				
No/occasional	237 (70.7)	107 (64.5)	126 (61.8)	470 (66.7)
Use (AUDIT ≥ 8)	98 (29.3)	59 (35.5)	78 (38.2)	235 (33.3)
Mean duration of smoking , y [2]	NA	28.6 (±12.7)	35.3 (±14.8)	

[1] χ^2 test (P < 0.001); [2] ANOVA (P < 0.05); NA = not applicable; BMS = Brazilian minimum salary (approximately 280 Euros)

Table 2 Periodontal variables by smoking status

Total sample *n* = 705	Nonsmokers (NS) *n* = 335	Former smokers (FS) *n* = 166	Current smokers (CS) *n* = 204
Plaque index (%) [1]	49.4 ± 20.7	53.3 ± 23.4	62.9 ± 26.7
Mean BOP [2]	11.3 ± 14.1	11.8 ± 8.4	10.9 ± 9.3
Mean PD (mm) [2]	2.3 ± 0.9	2.9 ± 0.9	3.3 ± 0.9
Mean CAL (mm) [2]	3.1 ± 0.7	3.3 ± 1.5	3.8 ± 1.9
Sites with PD ≥ 5 mm (%) [2]	4.0 ± 7.4	6.3 ± 11.2	7.1 ± 9.8
Sites with CAL ≥ 5 mm (%) [2]	10.4 ± 13.3	14.2 ± 19.3	19.4 ± 20.9
Lost teeth [2]	1.61 ± 2.4	1.65 ± 3.2	1.96 ± 3.7

[1] Significant differences ($P < 0.05$) between smoking groups, ANOVA and Bonferroni post-hoc analysis; [2] Significant differences ($P < 0.001$) between smoking groups, Welch test and Tamhane post-hoc analysis; BOP = bleeding on probing; PD = probing depth; CAL = clinical attachment level

($P < 0.001$). Before beginning the study, training was conducted, using pretest questionnaires administered orally with easily understandable speech (32). The κ coefficients obtained for the items on smoking, alcohol, and drug use were 0.91 and 0.95, respectively.

Statistical analysis

Descriptive analysis including variables of interest was performed to characterize the sample. When appropriate, group comparisons were performed using the χ^2 test and ANOVA. When equal variances were assumed, the variables were compared using ANOVA and the Bonferroni post-hoc test. When equal variances were not assumed, the variables were compared using the Welch test and Tamhane post-hoc test.

Distributions of the independent variables (smoking and explanatory variables) by periodontitis status and crude odds ratios (ORs) and 95% confidence intervals (CIs) were calculated. Analysis of covariance and multiple logistic regression were used to evaluate the associations of smoking characteristics (smoking status, cumulative smoking exposure, and duration of smoking cessation) with periodontitis. Mean (± standard error) or odds ratio (95% CI) were calculated in unadjusted, age-adjusted, and multivariate-adjusted models that accounted for age, sex, family income, educational level, cohabitation status, BMI, last dental visit, diabetes status, and alcohol status.

Multivariate-adjusted models of cumulative smoking exposure were further adjusted for current smoking status (yes/no), and multivariate-adjusted models of duration of smoking cessation were additionally adjusted for pack-years of smoking. The trend in the association between smoking characteristics and periodontitis was determined after considering smoking categories as ordinal variables.

All analyses was performed using STATA statistical software (Data Analysis and Statistical Software, version 12, StataCorp LP, College Station, TX, USA) or SPSS (Statistical Package for Social Sciences, Version 16.0 for Windows, SPSS Inc., Chicago, IL, USA). A P value < 0.05 was considered to indicate statistical significance.

Results

Table 1 shows the characteristics of the study groups with regard to the variables of interest. The proportion of CS was 29.0% ($n = 204$). Mean duration of smoking was 28.6 (±12.7) and 35.3 (±14.8) years in the FS and CS groups, respectively ($P < 0.05$).

The periodontal variables are presented in Table 2. As compared with NS, FS, and CS had higher plaque index values and a higher mean number and percentage of sites with a PD ≥ 5 mm and a CAL ≥ 5 mm. These differences were significant for all pairwise group comparisons, ie, CS vs FS, CS vs NS, and FS vs NS. The mean number of sites with BOP was lower among CS than among NS and FS.

Individuals in all groups had a high mean number of present teeth (21.8 ± 2.8). A total of 64,860 sites were examined, yielding a mean of 93.1 sites per subject. As shown in Table 2, the average number of lost teeth among FS and CS was significantly higher than that among NS.

Using the present definition of periodontitis, which is based on the European Consensus, 27.1% of the sample had periodontitis: 7.9% with disease of substantial extent and severity and 19.2% with incipient periodontitis. Periodontitis was diagnosed in 191 individuals (cases) (Table 3). The prevalences of periodontitis in the NF, FS, and CS groups were 25.6% (reference), 29.3% (crude OR for smoking = 2.97; 95% CI, 1.91-4.62), and 45.1% (crude OR for smoking = 4.25; 95% CI, 2.82-6.41), respectively. In univariate analysis, individuals who reported that their most recent dental visit was 2-5 years or >5 years before, those who lived without a companion, and those who

Table 3 Distribution of independent variables by periodontitis status

Variables	Periodontitis Cases[2] (n = 191)		Periodontitis Non-cases (n = 514)		Crude OR (95% CI)	P [1]
	n	%	n	%		
Smoking						
Nonsmokers	49	25.6%	286	55.6%	-	-
Former smokers	56	29.3%	110	21.4%	2.97 (1.91-4.62)	<0.001
Current smokers	86	45.1%	118	23.0%	4.25 (2.82-6.41)	<0.001
Sex						
Women	90	47.2%	274	53.3%	1.28 (0.91-1.78)	0.071
Men	101	32.8%	240	46.7%		
Age, y						
≥35-45	62	32.5%	237	46.1%	-	0.279
≥45-65	129	67.5%	277	53.9%	1.12 (0.80-1.57)	
Family income						
<5 BMS	80	41.9%	201	39.1%	0.94 (0.66-1.32)	0.390
≥5 BMS	111	58.1%	313	60.9%		
Educational level, y						
<8	90	47.2%	253	49.2%	0.91 (0.65-1.28)	0.340
≥8	101	52.9%	261	50.8%		
Cohabitation status						
Without companion	106	55.5%	214	41.6%	1.76 (1.25-2.44)	0.001
With companion	85	44.5%	300	58.4%		
Body mass index						
≤25 kg/m^2	58	30.4%	182	35.4%	1.25 (0.87-1.79)	0.122
>25 kg/m^2	133	69.6%	332	64.6%		
Last dental visit						
Last 2 years	51	26.7%	197	38.3%	-	
2-5 years	42	22.0%	90	17.5%	1.80 (1.11-2.90)	0.010
>5 years	98	51.3%	227	44.2%	1.66 (1.13-2.45)	0.006
Diabetes (Yes)	16	8.4%	27	5.2%	1.64 (0.86-3.13)	0.086
Diabetes (No)	175	91.6%	487	94.8%		
Alcohol status						
No/occasional	99	51.8%	331	64.4%	-	-
Use	92	48.2%	183	35.6%	1.94 (1.39-2.72)	<0.001

BMS = Brazilian minimum salary; [1] χ^2 test; [2] Total periodontitis (sum of 2 threshold levels: presence of proximal attachment loss of ≥3 mm in ≥2 nonadjacent teeth, and presence of proximal attachment loss of ≥5 mm in ≥30% of teeth present), based on Tonetti and Claffey (2005).

Table 4 Odds ratios (ORs) for periodontitis according to smoking status

Periodontitis	Smoking status		
	Nonsmokers (n =335)	Former smokers (n = 166)	Current smokers (n = 204)
Prevalence, n (%)	49 (25.6)	56 (29.3)	86 (45.1)
Unadjusted OR	1.00 (reference)	2.97 (1.91-4.62) [3]	4.25(2.82-6.41) [3]
Age-adjusted OR	1.00 (reference)	3.08 (1.98-4.80) [2]	5.49 (2.75-8.58) [3]
Multivariate-adjusted [1] OR	1.00 (reference)	3.09 (1.98-4.92) [3]	5.24 (2.61-8.97) [3]
Unadjusted OR	-	1.00 (reference)	1.49 (0.97-2.19) [4]
Age-adjusted OR	-	1.00 (reference)	2.82 (1.22-3.45) [5]
Multivariate-adjusted [1] OR	-	1.00 (reference)	2.55 (1.69-3.95) [5]

Data are presented as means (standard error) or odds ratios (95% confidence interval).
[1] Adjusted for age, sex, family income, educational level, cohabitation status, body mass index, last dental visit, diabetes status, and alcohol status; [2] $P < 0.01$; [3] $P < 0.001$: compared with never smokers; [4] $P < 0.05$; [5] $P < 0.01$: compared with former smokers.

reported drinking alcohol were significantly more likely to have periodontitis (Table 3).

The ORs for periodontitis by smoking status are shown in Table 4. The FS and CS groups had significantly higher risks for periodontitis as compared with the NS group. The OR (95% CI) for periodontitis was 3.09 (1.98-4.92) for FS and 5.24 (2.61-8.97) for CS in the multivariate-adjusted model. The risk for periodontitis was significantly higher among CS than among FS in the multivariate-adjusted model (OR 2.55; 95% CI,

Table 5 Odds ratios (ORs) for periodontitis according to cumulative smoking exposure

Periodontitis [1]	Nonsmokers (NS; *n* = 335)	Cumulative smoking exposure (pack-years of smoking) *n* = 370 (CS = 204 + FS = 166)			*P*-trend [2]
		Light smokers (0.1-20.0 pack-years) (*n* = 134)	Moderate smokers (20.1-40.0 pack-years) (*n* = 112)	Heavy smokers (>40.0 pack-years) (*n* = 124)	
Prevalence (*n* (%))	49 (25.6%)	35 (26.1%)	48 (42.8%)	59 (47.6%)	
Unadjusted OR	1.00 (reference)	2.06 (1.26-3.36) [3]	4.27 (2.70-7.08) [4]	5.29 (3.32-8.43) [4]	<0.001
Age-adjusted OR	1.00 (reference)	2.26 (1.17-3.69) [3]	5.12 (1.78-8.04) [4]	5.18 (3.06-8.31) [4]	<0.001
Multivariate-adjusted [1] OR	1.00 (reference)	2.12(1.29-3.46) [3]	4.05 (2.56-6.72) [4]	4.23 (2.65-6.74) [4]	0.004

Data are presented as means (standard error) or odds ratios (95% confidence interval).
[1] Adjusted for age, sex, family income, educational level, cohabitation status, body mass index, last dental visit, diabetes status, alcohol status, and current smoking (yes/no); [2] *P*-trend estimated from analysis of covariance or logistic regression using the categories of cumulative smoking exposure as an ordinal variable; [3] $P < 0.01$;[4] $P < 0.001$: compared with never smokers.

Table 6 Odds ratios (ORs) for periodontitis according to duration of smoking cessation

Periodontitis	Current smokers (CS; *n* = 204)	Duration of smoking cessation (years since quitting smoking) (FS; *n* = 166)				Nonsmokers (NS; *n* = 335)	*P*-trend [2]
		≤5 years (*n* = 29)	6-10 years (*n* = 51)	11-15 years (*n* = 46)	≥15 years (*n* = 40)		
Prevalence (*n* (%))	86 (45.1%)	13 (44.8)	18 (35.3)	15 (32.6)	10 (25.0)	49 (25.6)	-
Unadjusted OR	1.00 (reference)	0.89 (0.41-1.96)	0.74 (0.39-1.41)	0.66 (0.33-1.30)	0.45 [3] (0.21-0.98)	0.23 [4] (0.15-0.35) [4]	0.001
Age-adjusted OR	1.00 (reference)	0.80 (0.36-1.76)	0.67 (0.35-1.26)	0.59 (0.29-1.17) [3]	0.31 (0.14-0.68) [3]	0.20 (0.11-0.66) [4]	<0.001
Multivariate-adjusted [1] OR	1.00 (reference)	0.80 (0.11-1.52)	0.59 (0.34-1.03)	0.52 (0.17-0.89) [3]	0.31 (0.22-0.97) [3]	0.18 (0.11-0.58) [4]	<0.001

Data are presented as means (standard error) or odds ratios (95% confidence interval).
[1] Adjusted for age, sex, family income, educational level, cohabitation status, body mass index, last dental visit, diabetes status, and alcohol status; [2] *P*-trend estimated from analysis of covariance or logistic regression using the categories of years since quitting smoking as an ordinal variable; [3] $P < 0.05$, [4] $P < 0.01$: compared with current smokers.

1.69-3.95).

Table 5 shows the ORs for periodontitis by cumulative smoking exposure. Periodontitis risk significantly increased with pack-years of smoking in all models (*P*-trend < 0.001 [Unadjusted OR], < 0.001 [Age-adjusted OR], and 0.004 [Multivariate-adjusted OR]). In the multivariate-adjusted model the ORs (95% CI) for periodontitis were 2.12 (1.29-3.46), 4.05 (2.56-6.72), and 4.23 (2.65-6.74) for light, moderate, and heavy smokers, respectively, as compared with never smokers.

Table 6 shows the ORs for periodontitis by years of smoking cessation. A significant dose-response association was found between smoking cessation and periodontitis in all models (*P*-trend < 0.001). In other words, the risk for periodontitis decreased with increased years since smoking cessation. As compared with CS, periodontitis risk was significantly lower among FS who had quit 11-15 years (OR = 0.52; 95% CI, 0.17-0.89) or >15 years (0.31; 0.22-0.97) before.

Discussion

The present cross-sectional study investigated the association of cumulative smoking exposure and duration of smoking cessation with periodontitis in a sample of Brazilian adults aged 35-65 years. Cumulative smoking exposure was strongly positively associated with periodontitis. Moreover, duration of smoking cessation was inversely associated with periodontitis independently of the risk variables evaluated. It is important to emphasize that smoking is a known important risk factor in periodontitis (11,12,33,34) and that its adverse effects on periodontal tissues have been extensively reported (1-4,8,9,19).

The present prevalence rates and OR estimates for periodontitis among CS and FS were high: 33.7% (adjusted OR = 3.09) and 42.1% (adjusted OR = 5.24), respectively.

However, previously reported risk estimates vary greatly, from 1.4-11.8 times higher among CS as compared with NS (13-18). The present findings are consistent with those of previous studies, which show that smoking was associated with a 2- to 5-times increase in periodontitis risk among CS (20), and a 3-times increase among FS, as compared with NS (1,7,12,22).

Methodologic issues could have significantly influenced the data used to calculate previously reported risk estimates. Many studies used small samples and had substantial methodologic variability both in the definitions used for cumulative smoking exposure and the cut-off points for amount and frequency of smoking exposure (5). Moreover, previous studies varied greatly in their definition of periodontitis (2,8,18) and in their use of diagnostic criteria that rely on small changes in only one clinical periodontal parameter, such as CAL (5,7,35), bone level, (4) or PD (2).

The present definition of periodontitis (31) is appropriate for identifying risk factors. The proposed criterion has two threshold levels for periodontitis: 1) presence of proximal attachment loss of ≥3 mm in ≥2 nonadjacent teeth (which enables use of a sensitive case definition) and 2) presence of proximal attachment loss of ≥5 mm in ≥30% of present teeth (which permits the more specific definition of a case with substantial disease extent and severity).

The case definition of periodontitis is relevant and controversial in epidemiologic research because parameters of the extent and severity of PD and CAL might have had important effects on previously reported prevalence estimates (36-38). Therefore our research group evaluated the effects of using two other current periodontitis definitions in the present study sample. When using Centers for Disease Control – American Academy of Periodontology (CDC–AAP) criteria (presence of >2 interproximal sites with >3 mm CAL and >2 interproximal sites with 4 mm PD [not on the same tooth] or 1 site with >5 mm PD) (38), 29.7% of the sample satisfied the definition of periodontitis: 6.9% had minor disease, 15.4% had moderate disease, and 7.4% had advanced disease. Using the criteria of Lopez et al. (36) (presence of ≥4 teeth with ≥1 sites with PD ≥4 mm, and CAL ≥3 mm at the same site) the proportion of periodontitis was 24.2% (data not shown). Using these criteria for periodontitis, the proportions of periodontitis cases and the OR estimates did not substantially differ from those calculated using the European Consensus criteria. These present results could be due to the greater extent and severity of PD and CAL among individuals in the present study sample or from small variations in the number of cases of minor disease.

Number of pack-years smoked and duration of smoking cessation were also important risk factors for periodontitis. This detailed analysis of exposure in relation to pack-years and duration of smoking cessation is crucial because the findings could be substantially altered if, for example, a heavy smoker who recently ceased smoking were classified as a FS or a subject who recently started smoking were classified as a CS, or if lower cut-off points were used to classify light, moderate, and heavy smokers (25).

Similar to the findings of previous studies, (7,20,21) we observed a significant positive association between packs-year smoked and periodontitis, which provides additional evidence of a dose-response relation between cumulative smoking exposure and periodontitis development.

Previous studies found that smoking cessation has beneficial effects on periodontal status and that periodontitis significantly decreases as duration of smoking cessation increases (7,8,12,20,24,39,40). However, few studies have attempted to determine the threshold interval of smoking cessation that is associated with these beneficial effects. Studies by Torrungruang et al. (7) and Thomson et al. (8) proposed 10 years of smoking cessation as a threshold. In the present study the risk of periodontitis was significantly lower when duration of smoking cessation was >11 years, whereas smoking cessation of ≤10 years was not associated with lower risk of periodontitis, which suggest that a long interval is required to reduce the adverse effects of smoking on periodontal status.

The few previously reported longitudinal studies used shorter monitoring periods (23,24). These studies showed gains in clinical attachment among individuals who ceased smoking and were periodontally treated and monitored over 12 months.

In addition to the higher prevalences of periodontitis among CS and FS, we observed worse values for BOP, PD, and CAL. Similar findings were reported in previous studies (1,2,23,34,39).

Measurements of exposure and time of smoking are complex and subject to bias. A structured questionnaire was used in the present study, and interviews were pretested and conducted using clear, appropriate language. Therefore, agreement estimates were satisfactory. Nevertheless, studies using measurements of nicotine levels and expired-air carbon monoxide yield more accurate exposure data (24,41). However, such measurements are difficult in large epidemiologic studies, due to logistic and cost restraints.

The sample in the present study was composed of a

large number of adults aged 35-65 years. Some studies have reported age as a risk indicator for periodontitis, (42,43) so our strategy of limiting the age range (35-65) might have reduced variation in data collection and minimized the confounding effects of this risk indicator on associations with other variables of interest. Moreover, all logistic regression models were adjusted for age.

Regarding assessment of diabetes status, a known risk factor for periodontitis susceptibility and severity (10,15,22), only individuals with a fasting glucose level >126 mg/dL were classified as having diabetes. This cut-off point was chosen to avoid overestimation of diabetes prevalence, since it is the same level recommended for cross-sectional studies (29).

Smoking prevalence was lower among women. For social and behavioral reasons, Brazilian women have a low rate of cigarette consumption (44). Sex as a nonsignificant variable in the final multivariate models, ie, when explanatory factors and confounders are controlled, strengthens the power of the association between smoking and periodontitis. Do et al (42) reported similar findings in a sample of the Vietnamese population.

Recent studies (43,45,46) show a strong positive association between periodontitis and alcohol use. Thus, we used two validated questionnaires (AUDIT and CAGE) as part of a rigorous methodology to collect data on alcohol use. The crude OR was 1.94 (95% CI, 1.39-2.72) for periodontitis associated with alcohol use.

This study had limitations. The study sample can be considered well-founded but is nevertheless a convenience sample. In addition the cross-sectional design did not permit evaluation of the temporal influence of smoking on periodontitis. However, the sampling strategy of the present study improved the internal and external validity of data, and the power of inference.

In conclusion, periodontitis prevalence was high among CS and FS and, in a dose-response manner, cumulative smoking exposure was positively associated with periodontitis. Educational and preventive strategies in general health services must attempt to reduce the adverse effects of cumulative smoking exposure and explore the beneficial effects of smoking cessation on periodontal status.

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