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Sleep duration and periodontal health in older adults: an analysis of the Health, Aging and Body Composition Study

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Abstract

Objective: To analyze the association between sleep duration and periodontal parameters in older adults.

Materials and Methods: Data from 1,136 community-resident older adults participating in the Health, Aging and Body Composition (Health ABC) Study were used. Hours of sleep per night were determined by self-report. Probing pocket depth (PPD) and clinical attachment level (CAL) were evaluated for all teeth present. Periodontal disease was categorized, considering different cut-points of PPD (at least one site with ≥4mm, ≥5mm or ≥6mm) and CAL (≥3mm in >20%, >30% or >40% of the sites). Multivariate Poisson regression with robust variance was used to estimate the association of PPD and CAL with sleep duration (>5h/day, >6h/day and >7h/day). Analyses were adjusted by sociodemographic, behavioral, medical history and oral health factors.

Results: No association was observed between sleep duration and any level of PPD. However, older adults that sleep >7h/day presented 15% higher prevalence ratio (PR) of presenting CAL ≥3mm in ≥30% of the sites (95% confidence interval [CI]: 1.02–1.29). Similar trend was observed for CAL ≥3mm in ≥40% sites and sleep duration of >7h/day, but did not achieve statistical significance (PR: 1.17; 95% CI: 0.99–1.36).

Conclusion: Sleep duration was not consistently associated with periodontal parameters in older adults.

Keywords: Aged. Sleep deprivation. Periodontal diseases.

Introduction

Periodontitis is an infection and inflammatory condition that affects the tissues supporting the teeth. In susceptible individuals, biofilm accumulation induces an inflammatory response that causes connective tissue and alveolar bone breakdown, leading to lose teeth and, in the most severe cases, tooth loss (Meyle and Chapple, 2015). Epidemiologic data demonstrate that 50% of the world's population has impaired periodontal health (Tsioufis *et al*., 2011), with a higher prevalence in developing countries (Negrato *et al*., 2013; Oppermann *et al*., 2015). Periodontitis is a highly prevalent non-communicable disease, according to estimates of the Global Burden of Diseases Study of 2019, with more than one billion cases globally (Vos *et al*., 2020) and is strongly associated with worsening in oral health-related quality of life (Al-Harthi *et al*., 2013).

The pathogenesis of periodontitis is complex and multifactorial, and can be modified by several host-related immunological and anatomical factors, as well as behavioral and environmental conditions (Albandar *et al*., 2018). In this context, several chronic diseases have been associated with periodontitis, including diabetes (Nascimento *et al*., 2018), obesity (Khan *et al*., 2018), rheumatoid arthritis (Kaur *et al*., 2012) and obstructive sleep apnea (Al-Jewair *et al*., 2015). It has been reported that similar genetic and/or environmental factors may contribute to both periodontal disease and other systemic conditions.

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It also has been proposed that the low-grade systemic inflammation triggered by periodontitis could underlie the etiology of several disease manifestations (Josey and Merchant, 2016).

Sleep is defined as a reversible suspension of the sensorimotor interactions with the environment that is usually associated with rest and immobility. The main goal of sleep is to prevent exhaustion, and restore immune function, repair cell damage and foster brain development (Aldabal and Bahammam, 2011). Several studies have associated sleep duration with diabetes (Lee *et al*., 2017), childhood obesity (Felső *et al*., 2017) and higher all-cause mortality (García-Perdomo *et al*., 2019). The literature also shows an association between sleep duration and metabolic syndrome that has a U-shaped form (Li *et al*., 2015) indicating that both insufficient and excessive sleep duration may be contributing conditions. Both higher oxidative stress and systemic inflammation may be the mechanisms through which sleep duration is related to metabolic syndrome (Patel *et al*., 2009).

An association between sleep duration and periodontal disease has also been reported in the literature (Carra *et al*., 2017; Han and Park, 2018). A recent cross-sectional study found individuals who slept over 7 hours/night were less likely to exhibit severe periodontal disease (Alqaderi *et al*., 2019), and that this was stronger in individuals with diabetes. Worse stage-grade of periodontitis was also associated with short sleep duration, poor sleep quality and poor oral health-related quality of life (Karaaslan and Dikilitas, 2019). However, most studies have used small or convenience samples, and often only partial periodontal examination, which is recognized to produce both under- or overestimates of periodontal conditions (Kingman *et al*., 2008). Therefore, the present study aimed to assess the association between sleep duration and periodontal disease parameters in older adults. The tested hypothesis was that periodontal parameters, related to periodontal diseases, are significantly associated with fewer sleep hours per day.

Materials and Methods

Study design

This was a cross-sectional study, nested in the Health, Aging and Body Composition Study (Health ABC), a longitudinal cohort study initiated in 1997-1998 in Pittsburgh/PA, and Memphis/TN. All included participants provided written informed consent, and all protocols were approved by the institutional review boards at both study sites. This study was performed respecting the Declaration of Helsinki of 1975.

The present study is a secondary analysis of a larger interdisciplinary study that had the general objective of investigating if changes in body composition, weight-related health conditions and behavioral factors contribute to functional decline and loss of independence in older adults. A large number of papers have been published using this dataset, but only a few used the available data for oral disease.

Study Population, Inclusion and Exclusion Criteria

Further details of the sampling strategy of the Health ABC study may be found in the reported literature (Simonsick *et al*., 2001). Briefly, white older adults were randomly recruited from a sample of Medicare beneficiaries residing in the metropolitan areas of Pittsburgh, Pennsylvania or Memphis, Tennessee. Black individuals were recruited from all age-eligible residents in the same geographic areas. Participants were contacted by mail, followed by a phone interview to evaluate eligibility.

To be included, participants had to be well-functioning (*i.e.*, report no difficulty in walking one-quarter of a mile, climbing 10 steps without resting or performing basic activities, and report no need of an assistive walking device), be community-dwelling and aged 70-79 years, with no active treatment for cancer or plans to move out of the area in the next three years.

Oral health assessment

The oral health assessment comprised a periodontal examination, soft and hard tissue examination, and tooth count. The periodontal evaluation was performed at six sites per tooth, on all teeth, except for third molars, using a periodontal probe. Probing Pocket Depth (PPD), Clinical Attachment Level (CAL), visible plaque index (Ainamo and Bay, 1975) and gingival index (Löe, 1967) were evaluated by a trained dental hygienist or periodontist. Periodontal examination was performed with a UNC-15 periodontal probe. A minimum agreement percentage of 90% was achieved prior to data collection.

Outcomes assessment

This is a secondary data analysis, which used all available data. Based on the available information, a case definition of periodontal disease was not possible. For this reason, different thresholds of periodontal parameters were used to identify the different extent and severity of periodontal disease. Therefore, to assess the association between sleep duration and periodontal parameters, different cutoff points of PPD and CAL were established. For the PPD parameter, three different groupings were used. Individuals were categorized into those that presented at least one site with PPD ≥4mm, PPD ≥5mm or PPD ≥6mm.

Other analyses involved the number of sites with CAL ≥3mm. With these parameters, it was possible to assess the history and extent of periodontal disease. Again, three different groupings were used, considering individuals that presented >20%, >30%, or >40% of the sites with CAL ≥3mm.

Main exposure

The main exposure was self-reported daily sleep hours, which was assessed by the following question: "How many hours of sleep do you usually get at night?" For this study, the different cutoff points of sleep duration were: >5h/day (Romandini *et al*., 2017), >6h/day (Singla *et al*., 2016) and >7h/day (Beydoun *et al*., 2020).

Covariates

The sociodemographic, behavioral, and medical variables included sex (male or female), age (in years), self-designated race (white or black), marital status (single, married, widow or divorced), education (up to 8th grade, 9th to 12th grade or higher education), tobacco smoking (never, former or current smoker), diabetes (yes or no), body mass index (BMI) (low/normal, overweight or obese), toothbrushing frequency (<2 times per day or ≥2 times per day), daily use of dental floss (yes or no) and frequency of dental visits (≥ 2 times per year, once a year or less than once a year). Serum levels of C-reactive protein (CRP) (in μg/L) and interleukin-6 (IL-6) (in pg/ml) were analyzed as co-variates.

Two variables were combined to determine diabetes. Individuals who answered "yes" to the following question were considered to have diabetes: "Has a doctor ever told you that you have diabetes?" Use of oral hypoglycemic agents or insulin were also considered evidence of prevalent diabetes. BMI was determined dividing weight in kilograms by height in meters squared. Weight was measured by a balanced-beam scale, and height was assessed by a calibrated wall-mounted stadiometer. When considering BMI, the sample was categorized as low/normal (≤24.9 Kg/m^2), overweight (between 25 and 29.9 Kg/m^2) and obese (≥30 Kg/m^2) (WHO, 2000).

Levels of CRP and IL-6 were measured from frozen stored serum. CRP was analyzed in duplicate using the enzyme-linked immunosorbent assay (ELISA) based on purified protein and polyclonal anti-CRP antibodies (Calbiochem, San Diego, CA). The lowest limit for detection of CRP was 0.007 mg/L. Standardization was performed using the World Health Organization First International Reference Standard.

IL-6 was also determined by ELISA, using a high-sensitivity Quantikine colorimetric immunoassay kit (R&D Systems, Minneapolis, MN). The detectable limit for IL-6 was 0.10 pg/mL. For both biomarkers, dual wavelength was ascertained accordingly to the manufacturer guidelines using a microplate reader capable of measuring absorbance at 490 nm, with a dual wavelength correction set at 650 nm or 690 nm.

Statistical analysis

Only individuals that had complete information on sleep duration and periodontal examination were included in the present study. All analyses were performed using SPSS, version 21.0 (SPSS, version 21.0, IBM Corp., Armonk, NY, USA).

The number of sites with CAL ≥3mm was defined as the primary outcome of the present study. PPD was the secondary outcome. As previously stated, the sample was categorized using different cutoff points for CAL ≥3mm and PPD, such as CAL ≥3mm in >20% of sites, CAL ≥3mm in >30% of sites, CAL ≥3mm in >40% of sites, PPD ≥4mm (in at least one site), PPD ≥5mm (in at least one site) and PPD ≥6mm (in at least one site). An independent analysis was performed for each criterion of CAL and PPD.

Chi-square and Mann-Whitney tests were used to verify the association between the outcomes and independent variables. Visible plaque index and gingival index were used only to describe the sample, and were not included in the regression analyses. Uni- and multivariate analyses were also performed using Poisson regression with robust variance. For each PPD and CAL criteria, independent variables that presented a p-value <0.20 (Hosmer and Lemeshow, 2013) were included in the initial multivariate model. However, regardless of the p-value detected, the different cutoff points of sleep duration were included in the final multivariate analyses. The determination of cutoff points for sleep duration followed standards for epidemiological research, with a description of exposures concerning the outcome of periodontitis. Also, there is limited data for individuals who reported sleeping more than 8h when analyzing the crosstabs for the present outcomes.

A combination of p-value <0.05 and modification of effect analyses determined the inclusion of the covariates in the final multivariate model. Multicollinearity analyses were performed among the independent variables, and none were observed.

Results

Of the 3,075 participants enrolled in Year 1 of the Health ABC study, 1,843 received an oral examination at year 2 (between 1998 and 1999). Due to limited resources, the oral examinations did not occur every day. Only those whose Health ABC visit was scheduled on the days when a periodontal examiner was available received periodontal examination. From these individuals, 38 refused to participate, 208 were edentulous, and 441 needed prophylactic antibiotics to receive an oral examination. Those individuals were not included in the analyses of the present study. The remaining 1,136 (36.9% of the total sample) had sufficient information to be included in the analysis of PPD. Three individuals with insufficient data

to evaluate CAL were excluded from CAL-related analyses. Figure 1 provides a flowchart of study participant selection and exclusion.

The present study included 1,136 individuals, of whom 566 (49.8%) were men. The mean ±standard deviation age (at Year 1), number of present teeth, PPD and CAL were 73.5±2.8, 19.7±7.6, 2.1±0.8 mm and 2.3±1.5 mm, respectively. The respective prevalences of at least one site with PDD ≥4 mm, ≥5 mm and ≥6 mm were 80.4%, 56.3% and 37.7%. The percentages of individuals with CAL ≥3mm in >20%, >30% and >40% of periodontal sites were 63.6%, 48.2% and 35.8%, respectively. The sample was categorized into different cutoff points of sleep duration, with 88.4%, 63.2% and 35.3% of participants reporting sleep duration of >5h, >6h and >7h per day, respectively.

Table 1 presents the distribution of sociodemographic, dental, and behavioral information according to the three different cut-points of PPD. No statistically significant association was observed between PPD and sleep duration, regardless of the PPD or sleep cut-points used.

Regardless of the cut-point for PPD, plaque scores, gingival index, race, and level of education were significantly associated with PPD in the univariate analyses (Table 2). All variables that presented a p-value <0.20 in this analysis were included in the initial multivariate model. The different categories of sleep duration were also included in all multivariate models, regardless of their p-values. Table 3 presents the final multivariate analysis for the association between the different sleep duration categories and PPD. In all analyses performed, no statistically significant association between sleep duration and PPD was observed.

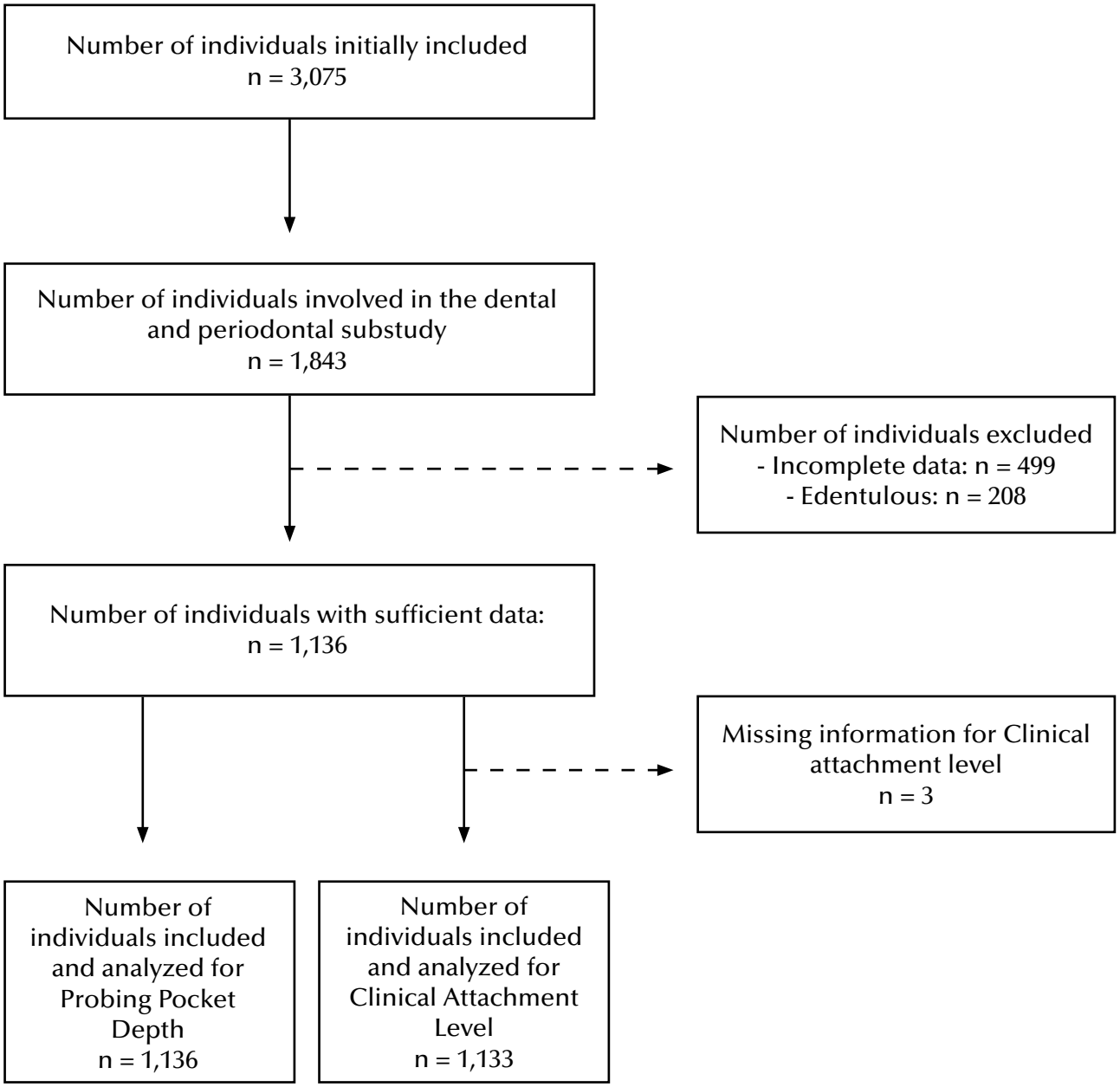

Figure 1. Participants flowchart.

Table 1. Demographic, medical, dental characteristics of the participants, classified according to different criteria of probing pocket depth (PPD).

Variables		PPD≥ 4mm		PPD≥ 5 mm		PPD≥ 6 mm	
		No (n=223; 19.6%)	**Yes (n=913; 80.4%)**	**No (n=497; 43.8%)**	**Yes (n=639; 56.3%)**	**No (n=708; 62.3%)**	**Yes (n=428; 37.7%)**
Plaque score (whole-mouth)	**Mean±SD**	0.67±0.52	0.84±0.56	0.68±0.51	0.90±0.58	0.71±0.52	0.96±0.58
	p-value	**<0.001#**		**<0.001#**		**<0.001#**	
Gingival Index (whole-mouth)	**Mean±SD**	0.70±0.63	1.07±0.66	0.77±0.60	1.17±0.67	0.85±0.63	1.23±0.67
	p-value	**<0.001#**		**<0.001#**		**<0.001#**	
Sex	**Male – n (%)**	99 (44.4)	467 (51.2)	215 (43.3)	351 (54.9)	323 (45.6)	243 (56.8)
	Female – n (%)	124 (55.6)	446 (48.8)	282 (56.7)	288 (45.1)	385 (54.4)	185 (43.2)
	p-value	0.070*		**<0.001***		**<0.001***	
Age at Year 1	**Mean±SD**	73.59±2.76	73.52±2.84	73.61±2.78	73.48±2.85	73.54±2.84	73.53±2.80
	p-value	0.710#		0.374#		0.968#	
Race	**White – n (%)**	159 (71.3)	574 (62.9)	368 (74.0)	365 (57.1)	515 (72.7)	218 (50.9)
	Non-white – n (%)	64 (28.7)	339 (37.1)	129 (26.0)	274 (42.9)	193 (27.3)	210 (49.1)
	p-value	**0.018***		**<0.001***		**<0.001***	
Marital status	**Single – n (%)**	9 (4.4)	49 (5.8)	19 (4.2)	39 (6.5)	37 (5.7)	21 (5.3)
	Married – n (%)	132 (64.1)	470 (56.0)	280 (62.2)	322 (54.0)	381 (58.9)	221 (55.4)
	Widow – n (%)	51 (24.8)	243 (28.9)	114 (25.3)	180 (30.2)	176 (27.2)	118 (29.6)
	Divorced/separated – n (%)	14 (6.8)	78 (9.3)	37 (8.2)	55 (9.2)	53 (8.2)	39 (9.8)
	p-value	0.193*		**0.047***		0.612*	
Schooling	**Up to Grade 8 – n (%)**	9 (4.1)	67 (7.4)	18 (3.6)	58 (9.1)	26 (3.7)	50 (11.7)
	Grade 9 to 12 – n (%)	85 (38.5)	336 (36.9)	173 (35.0)	248 (38.9)	254 (36.1)	167 (39.1)
	Higher – n (%)	127 (57.5)	507 (55.7)	303 (61.3)	331 (52.0)	424 (60.2)	210 (49.2)
	p-value	0.215*		**<0.001***		**<0.001***	
Tobacco smoking	**Never – n (%)**	99 (44.6)	436 (47.8)	251 (50.6)	284 (44.5)	346 (49.0)	189 (44.2)
	Current – n (%)	15 (6.8)	80 (8.8)	28 (5.6)	67 (10.5)	40 (5.7)	55 (12.9)
	Former (%)	108 (48.6)	396 (43.4)	217 (43.8)	287 (45.0)	320 (45.3)	184 (43.0)
	p-value	0.308*		**0.006***		**<0.001***	
Diabetes	**No – n (%)**	99 (44.6)	436 (47.8)	251 (50.6)	284 (44.5)	346 (49.0)	189 (44.2)
	Yes – n (%)	15 (6.8)	80 (8.8)	28 (5.6)	67 (10.5)	40 (5.7)	55 (12.9)
	p-value	0.083*		0.703*		0.124*	
BMI categories	**Low/Normal – n (%)**	78 (35.0)	297 (32.5)	175 (35.2)	200 (31.3)	235 (33.2)	140 (32.7)
	Overweight – n (%)	93 (41.7)	406 (44.5)	219 (44.1)	280 (43.8)	309 (43.9)	190 (44.4)
	Obese – n (%)	52 (23.3)	210 (23.0)	103 (20.7)	159 (24.9)	164 (23.2)	98 (22.9)
	p-value	0.724*		0.183*		0.970*	
C-reactive protein (in mg/L)	**Mean±SD**	2.72±4.38	2.54±3.64	2.55±3.72	2.60±3.85	2.51±3.66	2.69±4.01
	p-value	0.945#		0.261#		0.132#	
Serum interleukin-6 (in pg/ml)	**Mean±SD**	2.25±1.90	2.36±1.99	2.31±1.86	2.37±2.06	2.33±1.95	2.35±2.00
	p-value	0.536#		0.637#		0.989#	
Sleep duration	**≤5h/day – n (%)**	24 (11.0)	106 (11.8)	53 (10.8)	77 (12.2)	79 (11.3)	51 (12.1)
	>5h/day – n (%)	195 (89.0)	793 (88.2)	436 (89.2)	552 (87.8)	619 (88.7)	369 (87.9)
	p-value	0.731*		0.468*		0.677*	
Sleep duration	**≤6h/day – n (%)**	80 (36.5)	331 (36.8)	170 (34.8)	241 (38.3)	250 (35.8)	161 (38.3)
	>6h/day – n (%)	139 (63.5)	568 (63.2)	319 (65.2)	388 (61.7)	448 (64.2)	259 (61.7)
	p-value	0.937*		0.222*		0.398*	
Sleep duration	**≤7h/day – n (%)**	138 (63.0)	585 (65.1)	309 (63.2)	414 (65.8)	456 (65.3)	267 (63.6)
	>7h/day – n (%)	81 (37.0)	314 (34.9)	180 (36.8)	215 (34.2)	242 (34.7)	153 (36.4)
	p-value	0.568*		0.362*		0.551*	

Table 1. (continuation) Demographic, medical, dental characteristics of the participants, classified according to different criteria of probing pocket depth (PPD).

Variables		PPD≥ 4mm		PPD≥ 5 mm		PPD≥ 6 mm	
		No (n=223; 19.6%)	**Yes (n=913; 80.4%)**	**No (n=497; 43.8%)**	**Yes (n=639; 56.3%)**	**No (n=708; 62.3%)**	**Yes (n=428; 37.7%)**
Tooth brushing frequency	< 2 times/day – n (%)	70 (31.4)	283 (31.1)	138 (27.8)	215 (33.8)	208 (29.5)	145 (34.0)
	≥ 2 times/day – n (%)	153 (68.6)	626 (68.9)	358 (72.2)	421 (66.2)	498 (70.5)	281 (66.0)
	p-value	0.941*		**0.031***		0.107*	
Daily use of dental floss	No – n (%)	76 (34.1)	291 (32.1)	132 (26.7)	235 (37.1)	195 (27.7)	172 (40.6)
	Yes – n (%)	147 (65.9)	615 (67.9)	363 (73.3)	399 (62.9)	510 (72.3)	252 (59.4)
	p-value	0.575*		**<0.001***		**<0.001***	
Visit to the dentist	≥ 2 times/year – n (%)	121 (54.5)	527 (58.1)	309 (62.4)	339 (53.5)	440 (62.5)	208 (48.9)
	Once a year – n (%)	40 (18.0)	149 (16.4)	79 (16.0)	110 (17.4)	115 (16.3)	74 (17.4)
	Less than once a year – n (%)	61 (27.5)	231 (25.5)	107 (21.6)	185 (29.2)	149 (21.2)	143 (33.6)
	p-value	0.622*		**0.006***		**<0.001***	

*Chi-square; # Mann-Whitney. Bold p-values represent statistical significance (p<0.05).

Table 2. Crude prevalence ratio (PR) according to different criteria of probing pocket depth (PPD). Analyses were performed with Poisson regression with robust variance.

Variables		PPD≥ 4mm PR (95%CI)	p-value	PPD≥ 5 mm PR (95%CI)	p-value	PPD≥ 6 mm PR (95%CI)	p-value
Plaque score		1.11 (1.06 – 1.17)	**<0.001**	1.35 (1.25 – 1.46)	**<0.001**	1.58 (1.41 – 1.77)	**<0.001**
Gingival Index		1.17 (1.12 – 1.22)	**<0.001**	1.45 (1.35 – 1.55)	**<0.001**	1.70 (1.49 – 1.80)	**<0.001**
Sex	**Male**	Ref.	0.071	Ref.	**<0.001**	Ref.	**<0.001**
	Female	0.95 (0.90 – 1.01)		0.82 (0.73 – 0.90)		0.76 (0.65 – 0.88)	
Age		1.00 (0.99 – 1.01)	0.758	0.99 (0.97 – 1.01)	0.414	1.00 (0.97 – 1.03)	0.940
Race	**White**	Ref.	**0.014**	Ref.	**<0.001**	Ref.	**<0.001**
	Non-white	1.07 (1.02 – 1.14)		1.37 (1.24 – 1.51)		1.75 (1.52 – 2.03)	
Marital status	**Single**	Ref.		Ref.		Ref.	
	Married	0.92 (0.82 – 1.04)	0.191	0.80 (0.66 – 0.97)	**0.021**	1.01 (0.71 – 1.45)	0.940
	Widow	0.98 (0.87 – 1.11)	0.725	0.91 (0.74 – 1.11)	0.362	1.11 (0.77 – 1.60)	0.584
	Divorced	1.00 (0.87 – 1.16)	0.961	0.90 (0.70 – 1.14)	0.348	1.17 (0.77 – 1.78)	0.458
Schooling	**Up to Grade 8**	Ref.		Ref.		Ref.	
	Grade 9 to 12	0.91 (0.82 – 0.99)	**0.041**	0.77 (0.67 – 0.90)	**0.001**	0.60 (0.49 – 0.74)	**<0.001**
	Higher	0.91 (0.83 – 0.99)	**0.036**	0.68 (0.59 – 0.79)	**<0.001**	0.50 (0.41 – 0.61)	**<0.001**
Tobacco smoking	**Never**	Ref.		Ref.		Ref.	
	Current	1.03 (0.94 – 1.14)	0.503	1.33 (1.14 – 1.55)	**<0.001**	1.64 (1.33 – 2.01)	**<0.001**
	Former	0.96 (0.91 – 1.03)	0.964	1.07 (0.96 – 1.20)	0.211	1.03 (0.88 – 1.22)	0.692
Diabetes	**No**	Ref.	0.121	Ref.	0.699	Ref.	0.109
	Yes	0.92 (0.83 – 1.02)		1.03 (0.88 – 1.20)		1.19 (0.96 – 1.46)	
BMI categories	**Low/Normal**	Ref.		Ref.		Ref.	
	Overweight	1.03 (0.96 – 1.10)	0.429	1.05 (0.93 – 1.19)	0.416	1.02 (0.86 – 1.21)	0.823
	Obese	1.01 (0.94 – 1.10)	0.768	1.14 (0.99 – 1.30)	0.062	1.00 (0.82 – 1.23)	0.985
C-reactive protein		1.00 (0.99 – 1.01)	0.588	1.00 (0.99 – 1.02)	0.809	1.01 (0.99 – 1.02)	0.425
Serum interleukin-6		1.01 (0.99 – 1.02)	0.418	1.01 (0.98 – 1.03)	0.615	1.00 (0.97 – 1.04)	0.871
Sleep duration	**≤5h/day**	Ref.	0.724	Ref.	0.454	Ref.	0.673
	>5h/day	0.98 (0.90 – 1.07)		0.94 (0.81 – 1.10)		0.95 (0.76 – 1.20)	
Sleep duration	**≤6h/day**	Ref.	0.937	Ref.	0.217	Ref.	0.935
	>6h/day	1.00 (0.94 – 1.06)		0.94 (0.84 – 1.04)		0.94 (0.80 – 1.09)	

Table 2. (continuation) Crude prevalence ratio (PR) according to different criteria of probing pocket depth (PPD). Analyses were performed with Poisson regression with robust variance.

Variables		PPD≥ 4mm PR (95%CI)	p-value	PPD≥ 5 mm PR (95%CI)	p-value	PPD≥ 6 mm PR (95%CI)	p-value
Sleep duration	**≤7h/day**	Ref.	0.572	Ref.	0.366	Ref.	0.550
	>7h/day	0.98 (0.92 – 1.05)		0.95 (0.85 – 1.06)		1.05 (0.90 – 1.23)	
Tooth brushing frequency	**<2 times/day**	Ref.	0.941	Ref.	0.027	Ref.	0.103
	≥2 times/day	1.00 (0.94 – 1.07)		0.89 (0.80 – 0.99)		0.88 (0.75 – 1.03)	
Daily use of dental floss	**No**	Ref.	0.580	Ref.	**<0.001**	Ref.	**<0.001**
	Yes	1.02 (0.96 – 1.08)		0.82 (0.74 – 0.91)		0.71 (0.61 – 0.82)	
Visit to the dentist	**≥2 times/year**	Ref.		Ref.		Ref	
	Once a year	0.97 (0.89 – 1.05)	0.460	1.11 (0.97 – 1.28)	0.139	1.22 (0.99 – 1.51)	0.064
	Less than once a year	0.97 (0.91 – 1.04	0.436	1.21 (1.08 – 1.36)	**0.001**	1.53 (1.30 – 1.79)	**<0.001**

Bold p-values represent statistical significance (p<0.05).

Table 3. Multivariate prevalence ratio (PR), according to different criteria of probing pocket depth (PPD) and different cutoff points of sleep duration. Analyses were performed with Poisson regression with robust variance.

Sleep duration	PPD≥ 4mm[1] PR (95%CI)	p-value	PPD≥ 5 mm[2] PR (95%CI)	p-value	PPD≥ 6 mm[3] PR (95%CI)	p-value
≤5h/day	Ref.	0.933	Ref.	0.701	Ref.	0.763
>5h/day	0.99 (0.91 – 1.09)		0.97 (0.85 – 1.12)		1.04 (0.83 – 1.30)	
≤6h/day	Ref.	0.959	Ref.	0.324	Ref.	0.742
>6h/day	0.99 (0.94 – 1.06)		0.95 (0.86 – 1.05)		0.98 (0.84 – 1.13)	
≤7h/day	Ref.	0.247	Ref.	0.198	Ref.	0.804
>7h/day	0.96 (0.91 – 1.03)		0.93 (0.84 – 1.04)		1.02 (0.88 – 1.19)	

Bold p-values represent statistical significance (p<0.05).
Adjusted for: [1] Mean gingival index, sex, marital status, and diabetes. [2] Mean gingival index, sex, race, marital status, level of education, smoking exposure, and visit to the dentist. [3] Mean gingival index, sex, race, level of education, smoking exposure, diabetes, and toothbrush frequency

Table 4 shows demographical, medical, and dental characteristics of the participants by the different criteria of CAL ≥3mm. In this analysis, there was a statistically significant association between CAL ≥3mm in >30% and >40% of the sites and >7h/day of sleep (p-value = 0.007 and 0.019, respectively).

Plaque score, gingival index, sex, race, level of education, smoking exposure, use of dental floss, and dentist visits were significantly associated with all categorizations of CAL ≥3mm when using a univariate analysis (Table 5). Similar to the PPD analyses, all variables that presented a p-value <0.20 in this analysis were included in the initial multivariate model. The different categories of sleep duration were included in the multivariate model, regardless of p-value.

Table 6 shows the multivariate analysis results for the association between CAL and different categorization of sleep duration. In the analysis that used >20% of sites with CAL ≥3 mm, no statistically significant associations were detected with any cut-point of sleep duration. In contrast, individuals that reported sleeping >7h per day presented 15% higher prevalence ratio of having >30% of the sites with CAL ≥3 mm. No significant association was detected for the association between >40% of sites with CAL ≥3mm and >7h of sleep per day (p=0.055).

Table 4. Demographical, medical, dental characteristics of the participants, classified according to different criteria of probing depth.

Variables		CAL ≥ 3 mm in >20% of the sites		CAL ≥ 3 mm in >30% of the sites		CAL ≥ 3 mm in >40% of the sites	
		≤20% of the sites (n=412; 36.4%)	>20% of the sites (n=721; 63.6%)	≤30% of the sites (n=587; 51.8%)	>30% of the sites (n=546; 48.2%)	≤40% of the sites (n=727; 64.2%)	>40% of the sites (n=406; 35.8%)
Plaque score (whole-mouth)	**Mean±SD**	0.65±0.48	0.89±0.58	0.67±0.48	0.95±0.59	0.71±0.50	0.98±0.61
	p-value	**<0.001#**		**<0.001#**		**<0.001#**	
Gingival Index (whole-mouth)	**Mean±SD**	0.72±0.57	1.15±0.67	0.77±0.59	1.23±0.67	0.83±0.60	1.28±0.69
	p-value	**<0.001#**		**<0.001#**		**<0.001#**	
Sex	**Male – n (%)**	175 (42.5)	390 (54.1)	390 (54.1)	310 (56.8)	330 (45.4)	235 (57.9)
	Female – n (%)	237 (57.5)	331 (45.9)	331 (45.9)	236 (43.2)	397 (54.6)	171 (42.1)
	p-value	**<0.001***		**<0.001***		**<0.001***	
Age at Year 1	**Mean±SD**	73.27±2.74	73.68±2.85	73.43±2.79	73.63±2.84	73.52±2.81	73.54±2.83
	p-value	**0.020#**		0.264#		0.950#	
Race	**White – n (%)**	297 (72.1)	434 (60.2)	411 (70.0)	320 (58.6)	502 (69.1)	229 (56.4)
	Non-white – n (%)	115 (27.9)	287 (39.8)	176 (30.0)	226 (41.4)	225 (30.9)	177 (43.6)
	p-value	**<0.001***		**<0.001***		**<0.001***	
Marital status	**Single – n (%)**	25 (6.7)	33 (4.9)	33 (6.2)	25 (4.9)	40 (6.1)	18 (4.7)
	Married – n (%)	212 (57.0)	388 (57.8)	309 (58.4)	291 (56.6)	392 (59.5)	208 (54.2)
	Widow – n (%)	101 (27.2)	192 (28.6)	141 (26.7)	152 (29.6)	171 (25.9)	122 (31.8)
	Divorced/separated – n (%)	34 (9.1)	58 (8.6)	46 (8.7)	46 (8.9)	56 (8.5)	36 (9.4)
	p-value	0.642*		0.606*		0.160*	
Schooling	**Up to Grade 8 – n (%)**	18 (4.4)	57 (8.0)	28 (4.8)	47 (8.7)	40 (5.5)	35 (8.7)
	Grade 9 to 12 – n (%)	133 (32.3)	288 (40.2)	197 (33.6)	224 (41.4)	250 (34.4)	171 (42.5)
	Higher – n (%)	261 (63.3)	371 (51.8)	362 (61.7)	270 (49.9)	436 (60.1)	196 (48.8)
	p-value	**<0.001***		**<0.001***		**0.001***	
Tobacco smoking	**Never – n (%)**	218 (52.9)	314 (43.7)	311 (53.0)	221 (40.6)	373 (51.3)	159 (39.4)
	Current – n (%)	17 (4.1)	78 (10.8)	29 (4.9)	66 (12.1)	43 (5.9)	52 (12.9)
	Former (%)	177 (43.0)	327 (45.5)	247 (42.1)	257 (47.2)	311 (42.8)	193 (47.8)
	p-value	**<0.001***		**<0.001***		**<0.001***	
Diabetes	**No – n (%)**	374 (90.8)	624 (86.5)	522 (88.9)	476 (87.2)	643 (88.4)	355 (87.4)
	Yes – n (%)	38 (9.2)	97 (13.5)	65 (11.1)	70 (12.8)	84 (11.6)	51 (12.6)
	p-value	**0.034***		0.364*		0.616*	
BMI categories	**Low/Normal – n (%)**	135 (32.8)	240 (33.3)	191 (32.5)	184 (33.7)	233 (32.0)	142 (35.0)
	Overweight – n (%)	191 (46.4)	306 (42.4)	264 (45.0)	233 (42.7)	332 (45.7)	165 (40.6)
	Obese – n (%)	86 (20.9)	175 (24.3)	132 (22.5)	129 (23.6)	162 (22.3)	99 (24.4)
	p-value	0.324*		0.735*		0.263*	
C-reactive protein (in mg/L)	**Mean±SD**	2.31±2.76	2.71±4.27	2.40±3.34	2.76±4.23	2.52±3.75	2.66±3.88
	p-value	0.481#		0.360#		0.251#	
Serum interleukin-6 (in pg/ml)	**Mean±SD**	2.24±1.73	2.40±2.10	2.33±1.93	2.36±2.02	2.35±1.95	2.33±2.01
	p-value	0.766#		0.932#		0.851#	
Sleep duration	**≤5h/day – n (%)**	51 (12.6)	79 (11.1)	70 (12.1)	60 (11.2)	85 (11.9)	45 (11.3)
	>5h/day – n (%)	355 (87.4)	630 (88.9)	509 (87.9)	476 (88.8)	631 (88.1)	354 (88.7)
	p-value	0.477*		0.641*		0.767*	
Sleep duration	**≤6h/day – n (%)**	154 (37.9)	154 (37.9)	219 (37.8)	192 (35.8)	266 (37.2)	145 (36.3)
	>6h/day – n (%)	252 (62.1)	252 (62.1)	360 (62.2)	344 (64.2)	450 (62.8)	254 (63.7)
	p-value	0.575*		0.489*		0.788*	
Sleep duration	**≤7h/day – n (%)**	273 (67.2)	448 (63.2)	396 (68.4)	325 (60.6)	481 (67.2)	240 (60.2)
	>7h/day – n (%)	133 (32.8)	261 (36.8)	183 (31.6)	211 (39.4)	235 (32.8)	159 (39.8)
	p-value	0.173*		**0.007***		**0.019***	

Table 4. (continuation) Demographical, medical, dental characteristics of the participants, classified according to different criteria of probing depth.

Variables		CAL ≥ 3 mm in >20% of the sites		CAL ≥ 3 mm in >30% of the sites		CAL ≥ 3 mm in >40% of the sites	
		≤20% of the sites (n=412; 36.4%)	>20% of the sites (n=721; 63.6%)	≤30% of the sites (n=587; 51.8%)	>30% of the sites (n=546; 48.2%)	≤40% of the sites (n=727; 64.2%)	>40% of the sites (n=406; 35.8%)
Tooth brushing frequency	**<2 times/day – n (%)**	114 (27.7)	237 (33.1)	160 (27.3)	191 (35.2)	206 (28.4)	145 (35.9)
	≥2 times/day – n (%)	298 (72.3)	480 (66.9)	426 (72.7)	352 (64.8)	519 (71.6)	259 (64.1)
	p-value	0.060*		**0.004***		**0.009***	
Daily use of dental floss	**No – n (%)**	98 (23.8)	267 (37.3)	148 (25.3)	217 (40.0)	194 (26.8)	171 (42.4)
	Yes – n (%)	313 (76.2)	448 (62.7)	436 (74.7)	325 (60.0)	529 (73.2)	232 (57.6)
	p-value	**<0.001***		**<0.001***		**<0.001***	
Visit to the dentist	**≥2 times/year – n (%)**	278 (67.5)	369 (51.7)	385 (65.7)	262 (48.5)	468 (64.6)	179 (44.6)
	Once a year – n (%)	58 (14.1)	131 (18.3)	86 (14.7)	103 (19.1)	108 (14.9)	81 (20.2)
	Less than once a year – n (%)	76 (18.4)	214 (30.0)	115 (19.6)	175 (32.4)	149 (20.6)	141 (35.2)
	p-value	**<0.001***		**<0.001***		**<0.001***	

*Chi-square; # Mann-Whitney. Bold p-values represent statistical significance (p<0.05).

Table 5. Crude prevalence ratio (PR) according to different criteria of CAL. Analyses were performed with Poisson regression with robust variance.

Variables		CAL≥ 3mm in >20% of the sites PR (95%CI)	p-value	CAL≥ 3mm in >30% of the sites PR (95%CI)	p-value	CAL≥ 3mm in >40% of the sites PR (95%CI)	p-value
Plaque score		1.32 (1.23 – 1.41)	**<0.001**	1.56 (1.43 – 1.70)	**<0.001**	1.69 (1.51 – 1.89)	**<0.001**
Gingival Index		1.40 (1.32 – 1.48)	**<0.001**	1.64 (1.52 – 1.77)	**<0.001**	1.80 (1.63 – 1.99)	**<0.001**
Sex	**Male**	Ref.	**<0.001**	Ref.	**<0.001**	Ref	**<0.001**
	Female	0.84 (0.77 – 0.92)		0.76 (0.67 – 0.86)		0.72 (0.62 – 0.85)	
Age		1.02 (1.01 – 1.04)	**0.016**	1.01 (0.99 – 1.04)	0.231	1.00 (0.97 – 1.03)	0.906
Race	**White**	Ref.	**<0.001**	Ref.	**<0.001**	Ref.	**<0.001**
	Non-white	1.20 (1.10 – 1.31)		1.28 (1.14 – 1.45)		1.41 (1.21 – 1.64)	
Marital status	**Single**	Ref.		Ref.		Ref.	
	Married	1.14 (0.90 – 1.43)	0.279	1.13 (0.83 – 1.53)	0.451	1.12 (0.75 – 1.67)	0.587
	Widow	1.15 (0.91 – 1.46)	0.246	1.20 (0.88 – 1.65)	0.250	1.34 (0.89 – 2.02)	0.157
	Divorced	1.11 (0.84 – 1.46)	0.462	1.16 (0.81 – 1.66)	0.418	1.26 (0.80 – 2.00)	0.324
Schooling	**Up to Grade 8**	Ref.		Ref.		Ref.	
	Grade 9 to 12	0.90 (0.78 – 1.04)	0.149	0.85 (0.70 – 1.03)	0.102	0.87 (0.67 – 1.14)	0.310
	Higher	0.77 (0.70 – 0.89)	**<0.001**	0.68 (0.56 – 0.83)	**<0.001**	0.67 (0.51 – 0.87)	**0.003**
Tobacco smoking	**Never**	Ref.		Ref.		Ref.	
	Current	1.39 (1.24 – 1.57)	**<0.001**	1.67 (1.42 – 1.98)	**<0.001**	1.83 (1.46 – 2.29)	**<0.001**
	Former	1.10 (0.99 – 1.21)	0.052	1.23 (1.08 – 1.40)	**0.002**	1.28 (1.08 – 1.52)	**0.004**
Diabetes	**No**	Ref.	**0.019**	Ref.	0.350	Ref.	0.611
	Yes	1.15 (1.02 – 1.29)		1.09 (0.91 – 1.30)		1.06 (0.84 – 1.34)	
BMI categories	**Low/Normal**	Ref.		Ref.		Ref.	
	Overweight	0.96 (0.87 – 1.07)	0.461	0.96 (0.83 – 1.10)	0.521	0.88 (0.73 – 1.05)	0.152
	Obese	1.05 (0.94 – 1.17)	0.423	1.01 (0.86 – 1.18)	0.929	1.00 (0.82 – 1.23)	0.987
C-reactive protein		1.01 (1.01 – 1.02)	**0.013**	1.01 (0.99 – 1.02)	0.067	1.01 (0.99 – 1.02)	0.514
Serum interleukin-6		1.02 (0.99 – 1.04)	0.146	1.00 (0.97 – 1.04)	0.806	1.00 (0.96 – 1.04)	0.910

Table 5. (Continuation) Crude prevalence ratio (PR) according to different criteria of CAL. Analyses were performed with Poisson regression with robust variance.

Variables		CAL≥ 3mm in >20% of the sites PR (95%CI)	p-value	CAL≥ 3mm in >30% of the sites PR (95%CI)	p-value	CAL≥ 3mm in >40% of the sites PR (95%CI)	p-value
Sleep duration	**≤5h/day**	Ref.	0.492	Ref.	0.578	Ref.	0.166
	>5h/day	1.05 (0.91 – 1.22)		1.03 (0.94 – 1.13)		1.07 (0.97 – 1.17)	
Sleep duration	**≤6h/day**	Ref.	0.647	Ref.	0.491	Ref.	**0.006**
	>6h/day	1.05 (0.86 – 1.27)		1.05 (0.92 – 1.19)		1.19 (1.05 – 1.34)	
Sleep duration	**≤7h/day**	Ref.	0.769	Ref.	0.788	Ref.	**0.017**
	>7h/day	1.04 (0.81 – 1.33)		1.02 (0.87 – 1.21)		1.21 (1.04 – 1.42)	
Tooth brushing frequency	**<2 times/day**	Ref.	0.053	Ref.	**0.003**	Ref.	**0.008**
	≥2 times/day	0.91 (0.83 – 1.00)		0.83 (0.74 – 0.94)		0.81 (0.69 – 0.95)	
Daily use of dental floss	**No**	Ref.	**<0.001**	Ref.	**<0.001**	Ref.	**<0.001**
	Yes	0.81 (0.74 – 0.88)		0.72 (0.64 – 0.81)		0.65 (0.56 – 0.76)	
Visit to the dentist	**≥2 times/year**	Ref.		Ref.		Ref.	
	Once a year	1.22 (1.08 – 1.37)	**0.001**	1.35 (1.15 – 1.58)	**<0.001**	1.55 (1.26 – 1.90)	**<0.001**
	Less than once a year	1.29 (1.18 – 1.42)	**<0.001**	1.49 (1.31 – 1.70)	**<0.001**	1.76 (1.48 – 2.09)	**<0.001**

Bold p-values represent statistical significance (p<0.05).

Table 6. Multivariate prevalence ratio (PR), according to different cutoff point of CAL ≥3 mm and sleep duration. Analyses were performed with Poisson regression with robust variance.

Sleep duration	CAL≥ 3 mm in 20% of the sites[1] PR (95%CI)	p-value	CAL≥ 3 mm in 30% of the sites[2] PR (95%CI)	p-value	CAL≥ 3 mm in 40% of the sites[3] PR (95%CI)	p-value
	PR (95%CI)		**PR (95%CI)**		**PR (95%CI)**	
≤5h/day	Ref.	0.223	Ref.	0.294	Ref.	0.318
>5h/day	1.10 (0.95 – 1.27)		1.11 (0.91 – 1.36)		1.14 (0.88 – 1.48)	
≤6h/day	Ref.	0.285	Ref.	0.397	Ref.	0.694
>6h/day	1.05 (0.96 – 1.16)		1.06 (0.93 – 1.20)		1.03 (0.88 – 1.22)	
≤7h/day	Ref.	0.378	Ref.	**0.024**	Ref.	0.055
>7h/day	1.04 (0.95 – 1.14)		1.15 (1.02 – 1.29)		1.17 (0.99 – 1.36)	

Bold p-values represent statistical significance (p<0.05).
Adjusted for: [1] Mean gingival index, age, sex, race, level of education, C-reactive protein, serum interleukin-6, smoking exposure, and use of dental floss. [2] Mean gingival index, sex, race, level of education, C-reactive protein, smoking exposure, use of dental floss, and visit to the dentist. [3] Mean gingival index, sex, race, level of education, marital status, body mass index, smoking exposure, use of dental floss, and visit to the dentist.

Discussion

Prior evidence suggests that sleep duration can lead to changes in the immune system (Patel *et al*., 2012) that can potentially increase susceptibility to periodontal disease, promoting interactions of bacterial, host and environmental factors (Seymour *et al*., 2015). The present study evaluated the association between sleep duration and periodontal parameters in a large sample of older adults, and found no association between sleep duration and PPD defined using a range of severity cut-points. The only significant association observed was between long sleep duration (>7h/day) and a higher likelihood of CAL defined as ≥3mm in >30% of sites evaluated (Table 6). These results do not support an association between periodontitis and sleep duration, in contrast to previous studies (Romandini *et al*., 2017; Han *et al*., 2018). It is important to consider that only older individuals were included in the present study. Readers must be aware that higher rates of tooth loss, mainly due to the cumulative burden of oral diseases, may be expected among those individuals (Wu *et al*., 2014). In addition, poorer oral hygiene might be observed with increased age, which must be considered when interpreting the current results (Albandar and Kingman, 1999). Similarly, this burden may be observed in other health-related outcomes, including poor quality of sleep (Walsleben *et al*., 2004).

Sleep is essential for maintained health and general well-being, which includes cognitive performance, emotion regulation, physical development and homeostatic system maintenance (Leproult and Van Cauter, 2010). Adequate sleep is required by all individuals regardless of age, sex or ethnicity (Hirshkowitz *et al*., 2015). Nevertheless, the prevalence of sleep disturbance increases with advancing age (Prinz, 1995). Difficulties in falling asleep, frequent and long-lasting night-time awakenings that interrupt sleep, waking up too early in the morning, and daytime sleepiness occur with increasing frequency and are associated with sleep dissatisfaction and sleep complaints in older adults (Foley *et al*., 1995). However, since the prevalence of sleep dissatisfaction among older adults is lower among healthy older adults, poor sleep may not be due to the aging process *per se*, but secondary to age-associated health problems (Vitiello *et al*., 2004; Zilli *et al*., 2009).

A recent cross-sectional study assessed the relationships between periodontitis, hours of sleep and inflammatory biomarkers, and reported that few hours of sleep (<7h per day) was associated with 19% higher odds of having periodontitis (Beydoun *et al*., 2020). Another case-control study showed a significant association between poor sleep quality and chronic periodontitis in a Malaysian population (Singh *et al*., 2019). The present study in contrast, did not observe an association between shorter sleep duration and periodontal parameters. It is important to note that both of the above-mentioned studies included much younger participants, ≥21 (Beydoun, *et al*. 2020) and ≥30 (Singh *et al*., 2019) years old.

The inclusion of only older, but generally healthy adults should be highlighted when interpreting the results, and may partly explain the absence of an association between sleep duration and PPD. The low number of present teeth also must be considered (mean: 17.42±9.43), as only 4.5% (n=259) participants had at least 28 teeth. Medical and psychiatric illness, as well as overall poor self-rated health and depression, have been emphasized as contributing to geriatric complaints of poor sleep (Ohayon *et al*., 2001; Vitiello *et al*., 2002; Jacobs *et al*., 2006). However, the lack of reports about drug therapies adopted by the participating individuals, which may interfere with the presented outcomes, must be considered.

These factors may be associated with the fact that less than half of the sample evaluated in the present study reported ≥7 hours of sleep per day (35.3%). Therefore, insufficient sleep may be a potential contributor to the clinical development of insulin resistance, increased accrual of adipocytes, resulting in elevated inflammatory mediators (Mullington *et al*., 2009; Silva-Costa *et al*., 2015; Itani *et al*., 2017). Moreover, several studies report that short and long sleep durations are positively associated with chronic diseases, such as obesity, type 2 diabetes, hypertension and cardiovascular disease (Reis *et al*., 2018; Buxton and Marcelli, 2010). These conditions, when present, could interfere with the evaluated periodontal parameters.

Another important factor to be considered is the method of assessing sleep duration. Some tools that assess sleep quality, widely described in the literature, include sleep duration (Romandini *et al*., 2017). The Pittsburgh Sleep Quality Index questionnaire has seven domains, with sleep duration in the domain covering indication of sleep quality (Buysse *et al*., 1989). Therefore, the number of hours slept is not the focus of this tool.

Literature reports that individuals with periodontitis present higher levels of IL-6 and CRP (Kc *et al*., 2020; Machado *et al*., 2021). In addition, sleep disturbance is also associated with levels of both of these biomarkers (Irwin *et al*., 2016). As both periodontitis and poor quality of sleep promote systemic inflammation, these biomarkers may act as confounders for the association between periodontitis and number of hours of sleep.

Finally, this study used data from a complete periodontal examination, using six sites per tooth, which is a good point to highlight, because a detailed examination can give much stronger evidence. However, its cross-sectional design, as periodontal data were collected only in the second year of follow-up, does not allow temporality, and should be considered a limitation. Further studies, using longitudinal data, and providing a more comprehensive periodontal examination and sleep quality parameters must be conducted. It should be highlighted that a case definition of periodontitis was not possible with the available data, and this must be faced as another limitation of the present study. Conversely, higher cutoff points of PPD may indicate higher complexity of need for periodontal treatment, as suggested by the Community Periodontal Index of Treatment Needs (CPITN), an index highly used in periodontal epidemiology. Higher extent of CAL may indicate a higher burden of periodontal diseases, which may justify the exploratory strategy used in the present study. In addition, the present study assessed sleep duration as reported by the older adults, but literature shows that self-reported sleep duration is overestimated by approximately 1 hour (Jackson *et al*., 2018).

Conclusions

It can be concluded that sleep duration is not associated with periodontal parameters, such as PPD and CAL, among older adults.

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