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The association between periodontal disease and obesity among adults in Jordan

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Abstract

Aim: To determine the relationship between periodontitis and overweight/obesity among Jordanians.

Material and Methods: A systematic random sample of 340 persons aged between 18 and 70 years was selected from those who accompanied patients during their visit to the outpatient clinics in the medical centre of Jordan University of Science and Technology in north of Jordan. All participants underwent periodontal examination, had anthropometric measurements, and completed the questionnaire. Periodontitis was defined as presence of four or more teeth with one or more sites with probing pocket depth $\geqslant$4 mm and clinical attachment loss $\geqslant$3 mm.

Results: Only 14% of normal weight participants had periodontal disease whereas 29.6% of overweight and 51.9% of obese participants had periodontal disease. Periodontitis was more prevalent among subjects with high waist circumference (WC) and among subjects with high waist-to-hip ratio. After adjusting for important variables, only body mass index (BMI)-defined obesity [odds ratio (OR) = 2.9, 95% confidence interval (CI): 1.3, 6.1], high WC (OR = 2.1, 95%CI: 1.2, 3.7), and high fat per cent (OR = 1.8, 95% CI: 1.03, 3.3) remained significantly associated with increased odds of periodontitis.

Conclusion: BMI-defined obesity, high WC, and high fat per cent were significantly associated with increased odds of having periodontitis.

Key words: body mass index; obesity; periodontal disease; waist circumference

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Obesity is the fastest growing health-related problem in the world (Haenle et al. 2006). The age-standardized prevalence of obesity in north of Jordan was 28.1% [95% confidence interval (CI): 23.4, 2.8] for men and 53.1% (95% CI: 49.3, 57.0) for women (Khader 2006). Obesity, a common metabolic and nutritional disorder, is a complex multifactorial chronic disease that develops from an interaction of genotype and the environment (Dennison et al. 2007). Overweight and obese adults are considered to be at high risk of hypertension (Redon & Lurbe 2007), type 2 diabetes (National Heart Lung and Blood Institute 1998), high blood cholesterol (Dennison et al. 2007), coronary heart disease (Curioni et al. 2006), and other life-threatening diseases (Calle 2007, Reeves et al. 2007).

Recent studies documented the important role of nutritional status in periodontal disease (Boyd & Madden 2003, Ritchie & Kinane, 2003, Schifferle 2005) and showed that obesity could be a potential risk factor for periodontal disease (Chapper et al. 2005, Saito et al. 2005). Through its impact on metabolic and immune parameters, obesity may increase the host's susceptibility to periodontal disease (Nishimura & Murayama 2001, Genco et al. 2005).

Despite the fact that many recent studies attempted to examine the relationship between obesity and periodontitis, the majority of them were primarily based on analyses of Japanese populations and US data from the Third National Health and Nutrition Examination Survey (NHANES III). Furthermore, the majority of studies used body mass index (BMI) as an indicator of obesity and only limited number of studies used combined indicators of overweight and obesity. The accuracy of the BMI for setting obesity standards

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is controversial because it does not take into account frame size and whether the weight is fat or muscle. Determining waist circumference (WC) eliminates the inconsistencies of the BMI. Recent large studies have indicated that measurement of WC or waist–hip ratio (WHR) may be a better disease risk predictor than BMI (Yusuf et al. 2005), and there is still intensive research ongoing as to whether BMI, WC, or both should be used to assess disease risk. In this study, we aimed to determine the relationship between periodontitis and overweight/obesity among Jordanians using different indicators including BMI, WC, WHR, and body subcutaneous fat per cent.

Material and Methods

Participants

A systematic random sample of 340 persons aged between 18 and 70 years was selected from those who accompanied patients during their visit to the outpatient clinics in the medical centre of Jordan University of Science and Technology in the north of Jordan. Each day, for the whole study period, every 10th escort aged 18 years or above was selected after a random starting point. Selection of every 10th person allowed participants to be interviewed and examined without delay. Participants were informed about the objective of the study. Based on their approval, participants were asked to read carefully and sign a consent form. One person diagnosed with cancer and three persons diagnosed with osteoporosis were excluded. Pregnant women and those who required antibiotic prophylaxis for dental examination were excluded.

Questionnaire

The questionnaire was completed through a structured interview by a trained interviewer. Socio-demographic characteristics including age, gender, marital status, income, and years of education were collected. Participants' history of chronic diseases including history of diabetes, hypertension, and dyslipidaemia were collected. Participants were asked whether they were ever diagnosed and told by the physician that they have one of the previously mentioned diseases. They were also asked whether they were on regular medication at the time of data collection. Smoking was defined as current smoker, past smoker, or non-smoker.

Anthropometric measurements

Anthropometric measurements including weight, height, hip (HC) and waist circumferences (WC) were measured with the subjects wearing light clothing and no shoes by professional nutritionist. Height was measured using measuring rod and body weight was measured using mechanical flat scale. WC and HC were measured using circumference-measuring tape. The body fat percentage was measured using the Omron body fat monitor (BF306, Omron Healthcare Co. Ltd., Yamanouchi Yamanoshita-cho, Ukyoku, Kyoto, Japan) (Martin Moreno et al. 2001). WC was measured to the nearest centimetre at the narrowest point between the umbilicus and the rib cage and HC was measured at the widest part of the body below the waist. WHR was calculated as the ratio of WC to HC. BMI was calculated as the ratio of weight (kilograms) to the square of height (metres). According to WHO guidelines, obesity for men and women was defined as BMI $\geqslant 30\,kg/m^2$ and overweight was defined as BMI between 25 and $29.9\,kg/m^2$ (WHO 1998) Obesity, based on WC, was defined as WC > 102 cm (40 in.) in men and > 88 cm (35 in.) in women. Obesity, based on WHR, was defined as a WHR > 0.90 for men and > 0.85 for women (Alberti & Zimmet 1998).

Clinical Examination

All participants underwent a clinical periodontal examination that was carried out by a professional dental hygienist. The oral hygiene of six selected teeth and the periodontal status of all teeth, excluding third molars, were assessed using plaque index (PlI) of Silness & Loe (1964), gingival index (GI) of Loe & Silness (1963), probing pocket depth (PPD), and clinical attachment loss (CAL). The six teeth chosen were the Ramfjord teeth: The maxillary right first molar, the maxillary left central incisor, the maxillary left first premolar, the mandibular left first molar, the mandibular right central incisor, and the mandibular right first premolar. Sterile dental mirrors and explorers were used to assess plaque accumulation and gingival status while standardized Michigan 0 periodontal probes with Williams's markings (Diatech, Swisstzland) were used to measure PPD and CAL. Six representative teeth and four surfaces (mesio-facial, mid-facial, disto-facial, and mid-lingual) of each studied tooth were assessed and scored for PlI. PPD and CAL were measured at six sites (mesio-facial, mid-facial, disto-facial, mesio-lingual, mid-lingual, and disto-lingual) per tooth for all teeth, excluding third molars. The number of decayed teeth (DT), number of filled teeth (FT), and number of missing teeth (MT) for each participant were recorded. The means PlI, GI, PPD, and CAL over all examined surfaces or sites as well as percentages of sites with CAL of $\geqslant 3$, CAL $\geqslant 4$ mm, PPD $\geqslant 3$ mm, and PPD $\geqslant 4$ mm were calculated for each participant. Disease extent was defined by the percentage of periodontal sites. The percentage of sites meeting the severity criteria for PPD and CAL was calculated within each mouth by dividing the number of sites meeting the criteria by the total number of sites measured. Periodontitis was defined as presence of four or more teeth with one site or more with PPD $\geqslant 4$ mm and CAL $\geqslant 3$ mm.

Statistical analysis

The Statistical Package for Social Sciences software (SPSS Inc., version 11.5, Chicago, IL, USA) was used for data processing and data analysis. Characteristics of subjects' variables were described using frequency distribution for categorical variables and mean and standard deviation for continuous variables. χ^2 test was used to assess the association between categorical variables. The multivariate analysis of the association between obesity indicators and periodontal parameters (average PPD, average CAL, and percentage of surfaces with PPD $\geqslant 3$, PPD $\geqslant 4$, CAL $\geqslant 3$, and CAL $\geqslant 4$) was conducted using the General Linear Model Multivariate procedure. This procedure provided regression analysis and analysis of variance for multiple dependent variables (periodontal parameters) by explanatory variables and covariates including one obesity indicator each time. Multivariate binary logistic regression was conducted to determine the association between each anthropometric measurement and the prevalence of periodontal disease after adjusting for important variables. All variables that were significantly associated with periodontal disease constituted the best

regression model. The association between BMI, WC, WHR, and fat per cent and periodontal disease was tested, in separate models, for each obesity indicator after adding that indicator to the best model. The statistical significance of the two-way interactions between independent variables was assessed with the use of forward stepwise regression. The two-way interaction terms, one at a time, were added in the model containing all the main effects and were assessed for their significance using the likelihood ratio test. Crude and adjusted odds ratios (ORs) and their 95%CI were calculated. A p-value of <0.05 was considered statistically significant.

Results

This study included a total of 340 participants (168 males and 172 females) aged between 18 and 70 years with a mean (standard deviation) of 36.4 (14.9). Table 1 shows their socio-demographic, anthropometric, clinical, and relevant characteristics. According to BMI, 33.8% were overweight and 30.5% were obese. About 42.5% had high WC and 45.0% had high WHR. Of the total 340 subjects examined, 30.9% had periodontal disease.

The prevalence of periodontal disease according to socio-demographic, oral health parameters, clinical, and relevant characteristics are shown in Table 2.

Table 3 shows the dental and periodontal parameters according to BMI. Compared with people with BMI $<25\,kg/m^2$ values, those with a BMI $\geqslant 30\,kg/m^2$ had a significantly higher average of PlI, GI, number of MT, PPD, CAL, per cent of sites with CAL $\geqslant 3$ mm, and per cent of cites with CAL $\geqslant 4$ mm. People with BMI between 25 and 29.9 had a significantly higher average of number of MT, CAL, per cent of sites with CAL $\geqslant 3$ mm, and per cent of sites with CAL $\geqslant 4$ mm when compared with those with BMI <25. Compared with overweight people, obese had a significantly higher average of per cent of sites with CAL $\geqslant 3$ mm and per cent of sites with CAL $\geqslant 4$ mm. Only 14% of normal weight participants had periodontal disease whereas 29.6% of overweight and 51.9% of obese participants had periodontal disease.

Table 4 shows the dental and periodontal parameters according to WC and WHR. The average PlI, GI, PPD, CAL, number of MT, average of per cent of sites with CAL $\geqslant 3$ mm, and per cent of sites with CAL $\geqslant 4$ mm were significantly higher among subjects with high WC. The number of MT, the average of PPD, CAL, per cent of sites with CAL $\geqslant 3$ mm, and per cent of sites with CAL $\geqslant 4$ mm were significantly higher in participants with high WHR when compared with those of normal WHR. Periodontitis was more prevalent among subjects with high WC (46.5%) compared with those with normal WC (19.5%) and among subjects with high WHR (38.2%) compared with those with normal WHR (24.7%).

In the univariate analysis, all studied anthropometric measures were significantly associated with increased odds of having periodontitis (Table 5). After adjusting for important variables including age, PlI, and number of MT, only BMI-defined obesity (OR = 2.9, 95%CI: 1.3, 6.1), high WC (OR = 2.1, 95%CI, 1.2, 3.7), and high fat per cent (OR = 1.8, 95% CI: 1.03, 3.3) remained significantly associated with increased odds of periodontitis. There were no significant interactions between anthropometric measurements and other independent variables.

Table 1. Socio-demographic, clinical, anthropometric, and relevant characteristics of participants

Variable	*n* (%)
Gender	
Male	168 (49.4)
Female	172 (50.6)
Age (year)	
$\leqslant 25$	127 (37.4)
26–45	113 (33.2)
46–77	100 (29.4)
Years of education	
$\leqslant 12$	133 (39.1)
>12	207 (60.9)
Income (JD)*	
$\leqslant 400$	187 (55.2)
>400	152 (44.8)
Smoking	
Current	69 (20.3)
Past	29 (8.5)
No	242 (71.2)
Brushing	
Regular	223 (65.6)
Irregular	89 (26.2
No	28 (8.2))
Body Mass Index (BMI)†	
Underweight	13 (3.8)
Normal	108 (31.8)
Overweight	115 (33.8)
Obesity	104 (30.5)
High waist circumference‡	144 (42.5)
High waist-to-hip ratio§	152 (45.0)
Diabetes mellitus	61 (17.9)
Elevated cholesterol level	37 (10.9)
Hypertension	46 (13.5)

*The Jordanian Dinar (JD) = $1.41

†Underweight (BMI $<18.5\,kg/m^2$), normal weight ($18.6<$ BMI $<24.9\,kg/m^2$), overweight ($25<$ BMI $<30\,kg/m^2$), and obesity (BMI $\geqslant 30\,kg/m^2$).

‡High waist circumference: >102 cm in males and >88 cm in females.

§High waist-to-hip ratio: >0.9 in. males and >0.8 in. females.

Discussion

In this study, a total of 105 (30.9%) participants had periodontitis (32% among males and 29.7% among females). A strong association was found between BMI and periodontal disease. After adjusting for age, PlI, and number of MT, the odds of periodontitis were not significantly different between overweight and normal weight participants. People with BMI $>30\,kg/m^2$ were three times more likely to have periodontitis compared with those of normal weight. The same finding was documented by Nishida et al. (2005). The association between periodontitis and obesity but not overweight was also confirmed by Dalla Vecchia et al. (2005). A study conducted by Al-Zahrani et al. (2003) showed that participants with a BMI $>30\,kg/m^2$ had significantly increased risk of periodontitis. However, the relatively small sample size may be a possible cause for the lack of significance difference in the odds of periodontitis between overweight and normal weight participants.

In our study the average PPD was significantly higher in obese subjects ($p = 0.002$) when compared with that among participants with BMI $<25\,kg/m^2$. Researchers in Hisayama study (Saito et al. 2005) showed that the participants with the highest quartile of BMI had a significantly higher OR for the highest quintile of mean PPD in multivariate analyses. In our study the average CAL was significantly higher ($p<0.0005$) in both overweight and obese participants when compared with that in normal weight participants (Saito et al. 2001). This finding was consistent with the findings of the study conducted by Wood et al. (2003) who reported that CAL and PPD, as indicators of periodontal disease, were correlated with increased BMI. Anthropometric measurements were significantly associated with the extent of periodontal disease when measured by CAL but not when

Table 2. Prevalence of periodontal disease according to socio-demographic, oral health parameters, clinical, and relevant characteristics

Variable	Periodontal disease		Total	*p*-value
	no *n* (%)	yes *n* (%)		
Gender				0.619
Male	114 (67.9)	54 (32.1)	168	
Female	121 (70.3)	51 (29.7)	172	
Age (years)				<0.0005
⩽25	117 (92.1)	10 (7.9)	127	
26–45	64 (56.6)	49 (43.4)	113	
46–77	54 (54)	46 (46)	100	
Marital status				<0.0005
Single	131 (84.5)	24 (15.5)	155	
Married	104 (56.2)	81 (43.8)	185	
Income (JD)				0.467
⩽400	126 (67.9)	61 (32.6)	187	
>400	108 (71.1)	44 (28.9)	152	
Years of education				<0.0005
⩽12	75 (56.4)	58 (43.6)	133	
>12	160 (77.3)	47 (22.7)	207	
Brushing				0.809
Regular	154 (69.1)	69 (30.9)	223	
Irregular	63 (70.8)	26 (29.2)	89	
No	18 (64.3)	10 (35.7)	28	
Average plaque index				<0.0005
⩽1	83 (84.7)	15 (15.3)	98	
1–2	119 (63.3)	69 (36.7)	188	
>2	19 (47.5)	21 (52.5)	40	
Diabetes mellitus				0.013
Yes	34 (55.7)	27 (44.3)	61	
No	201 (72.0)	78 (28.0)	279	
Elevated cholesterol level				0.332
Yes	23 (62.2)	14 (37.8)	37	
No	212 (70)	91 (30)	303	
Hypertension				0.134
Yes	28 (60.9)	18 (39.1)	46	
No	207 (70.6)	86 (29.4)	293	
Smoking				0.346
Current	46 (66.7)	23 (33.3)	69	
Past	17 (58.6)	12 (41.4)	29	
No	172 (71.1)	70 (28.9)	242	

JD, Jordanian Dinar.

measured by PPD. This finding may be explained by that attachment loss may correlate more with periodontal disease and is more precise measure of alveolar bone loss when compared with PPD.

Periodontitis was significantly associated with WC-defined obesity but not with WHR-defined obesity. Our findings confirm previous findings of higher odds of periodontitis (OR = 2.1) with increased WC even after adjusting for age, PlI, and number of MT.

Al-Zahrani et al. (2003) examined the relation between WC and periodontitis. They found that WC was significantly associated with prevalence of periodontal disease (adjusted OR = 2.27). Reeves et al. (2006) documented that each 1 cm increase in WC was associated with 5% increase in risk of periodontitis. Saito et al. (2001) used WHR as an indicator of abdominal obesity instead of WC. They reported that participants with lower WHR values had less risk of periodontitis. In another study by Saito et al. (2005) the highest quintile of mean PPD was significantly associated with WHR in a multivariate analysis, whereas CAL did not reach statistical significant when correlated to WHR. In our study the average CAL and PPD were significantly higher in participants with higher WHR. Our results were in concordance with that documented by Wood et al. (2003).

Fat per cent was also associated with increased odds of periodontitis. After adjusting for age, PlI and number of MT, the OR of having periodontitis was 1.8 for persons who had fat per cent >30% when compared with persons with fat per cent ⩽30%. This finding was consistent with what was found in the Hisayama study (Saito et al. 2005). Their study showed that the proportion of subjects with the highest quintile of mean PPD increased significantly in a linear trend with body fat. Saito et al. (2001) assured that deeper pockets were noticed in those with higher body fat. Wood et al. (2003) declared that adjusted mean PPD was correlated significantly with subcutaneous fat.

The underlying biological mechanisms for the association of obesity with periodontitis are not well-known; however, adipose-tissue-derived cytokines and hormones may play a key role. Fat tissue produces a vast amount of cytokines and hormones, collectively called adipokines or adipocytokines which in turn may modulate periodontitis (Kershaw & Flier 2004). Obesity increases the host's susceptibility by modulating the host's immune and inflammatory system, leaving the patient with greater risk of periodontitis. Plasminogen-activating system has been shown to play an important role in gingival inflammation. Plasminogen-activator inhibitor-1 (PAI-1) has an increased expression in visceral fat and induces agglutination of blood increasing the risk of ischaemic vascular disease. Thus, PAI-1 may also decrease the blood flow to the gingiva in obese people that encourage periodontitis progression (Wood et al. 2003). These are possibilities and studies are not yet conducted to reveal disease mechanisms.

It is important to mention that the association between obesity indicators and prevalence of periodontal disease was assessed in the multivariate analysis without adjusting for the effect of smoking. The association between smoking and the prevalence of periodontal disease was not statistically significant. Furthermore, there was no significant interaction between smoking and other variables on the occurrence of periodontal disease. This finding of the lack of association contradicts the findings of previous epidemiological, clinical, and in vitro studies that have provided irrefutable evidence that smoking negatively impacts periodontal health (Albandar et al. 2000). This finding may be due to that current smokers had a significantly lower average PlI when compared with non-smokers ($p = 0.008$). Another possible explanation

Table 3. Oral health, dental, gingival, and periodontal status according to body mass index (BMI) categories*

	Normal BMI < 24.9 kg/m^2 $N = 121$ (mean ± SD)	Overweight 25 < BMI < 30 kg/m^2 $N = 115$ (mean ± SD)	Obesity BMI ⩾ 30 kg/m^2 $N = 104$ (mean ± SD)	*p*-value
Average pocket depth (PPD)	1.95 ± 0.23	2.00 ± 0.30	2.08 ± 0.26*	0.002
Average clinical attachment loss (CAL)	2.27 ± 0.77	2.57 ± 0.98*	3.03 ± 1.14*	<0.0005
Per cent of surfaces with				
PPD ⩾ 3	25.41 ± 0.10	27.00 ± 0.11	28.51 ± 0.13	0.136
PPD ⩾ 4	0.21 ± 0.01	0.40 ± 0.03	0.49 ± 0.02	0.518
CAL ⩾ 3	9.41 ± 0.18	16.61 ± 0.21*	26.60 ± 0.24*,†	<0.005
CAL ⩾ 4	9.41 ± 0.18	16.61 ± 0.21*	26.60 ± 0.24*,†	<0.005
Prevalence of periodontal disease, *n* (%)	17 (14.0)	34 (29.6)	54 (51.9)	<0.005
Average plaque index	1.32 ± 0.60	1.43 ± 0.56	1.59 ± 0.52*	0.002
Average gingival index	1.44 ± 0.56	1.57 ± 0.58	1.72 ± 0.45*	0.001
Number of				
Missing teeth	0.59 ± 1.52	1.68 ± 3.51*	2.32 ± 3.21*	<0.005
Filled teeth	2.03 ± 2.58	2.05 ± 2.67	2.01 ± 2.46	0.995
Decayed teeth	2.21 ± 2.67	1.95 ± 2.21	2.21 ± 2.88	0.708

The differences between BMI categories in the average PPD, average CAL, and percentage of surfaces with PPD ⩾ 3, PPD ⩾ 4, CAL ⩾ 3, and CAL ⩾ 4 were adjusted for gender, age, years of education, income, average plaque index, number of missing teeth, smoking, brushing of teeth, diabetes mellitus, elevated cholesterol level, and hypertension.

*Significantly different from normal.

†Significantly different from overweight.

SD, standard deviation.

Table 4. Oral health, dental, gingival, and periodontal status according to waist circumference and waist-to-hip ratio*

	Waist circumference			Waist-to-hip ratio		
	normal $N = 195$ (mean ± SD)	high $N = 144$ (mean ± SD)	*p*-value	normal $N = 186$ (mean ± SD)	high $N = 152$ (mean ± SD)	*p*-value
Average pocket depth (PPD)	1.96 ± 0.27	2.07 ± 0.25	0.001	1.97 ± 0.26	2.04 ± 0.27	0.030
Average clinical attachment loss (CAL)	2.36 ± 0.87	2.94 ± 1.09	<0.005	2.48 ± 1.00	2.73 ± 1.00	0.026
Per cent of surfaces with						
PPD ⩾ 3	25.99 ± 0.10	28.19 ± 0.13	0.089	26.17 ± 0.11	27.56 ± 0.12	0.272
PPD ⩾ 4	0.33 ± 0.02	0.40 ± 0.01	0.741	0.38 ± 0.02	0.33 ± 0.01	0.837
CAL ⩾ 3	11.59 ± 0.19	24.73 ± 0.24	<0.005	14.43 ± 0.22	19.95 ± 0.22	0.024
CAL ⩾ 4	11.59 ± 0.19	24.73 ± 0.24	<0.005	14.43 ± 0.22	19.95 ± 0.22	0.024
Prevalence of periodontal disease, *n* (%)	38 (19.5)	67 (46.5)	<0.005	46 (24.7)	58 (38.2)	0.008
Average plaque index	1.37 ± 0.58	1.55 ± 0.54	0.005	1.44 ± 0.60	1.44 ± 0.53	0.977
Average gingival index	1.47 ± 0.56	1.71 ± 0.49	<0.005	1.54 ± 0.55	1.61 ± 0.54	0.242
Number of						
Missing teeth	0.84 ± 2.29	2.37 ± 3.45	<0.005	1.00 ± 2.38	2.07 ± 3.40	0.001
Filled teeth	2.07 ± 2.69	1.99 ± 2.39	0.774	2.00 ± 2.80	2.08 ± 2.26	0.772
Decayed teeth	2.12 ± 2.59	2.15 ± 2.59	0.904	2.16 ± 2.60	2.11 ± 2.59	0.881

The differences between waist circumference categories and between waist-to-hip ratio categories in the average PPD, average CAL, and percentage of surfaces with PPD ⩾ 3, PPD ⩾ 4, CAL ⩾ 3, and CAL ⩾ 4 were adjusted for gender, age, years of education, income, average plaque index, number of missing teeth, smoking, brushing of teeth, diabetes mellitus, elevated cholesterol level, and hypertension.

*High waist circumference: > 102 cm in males and > 88 cm in females. High waist-to-hip ratio: > 0.9 in. males and > 0.8 in. females.

SD, standard deviation.

for the lack of this association is the relatively small number of current and past smokers.

Although that this study indicated an association between obesity and periodontal disease, the design of this study limits interpretability about temporal relationships. Because anthropometry and periodontal status were assessed simultaneously, it is unclear whether obesity truly precedes periodontitis. Prospective cohort studies may circumvent this problem. It is possible that the presence of residual confounding might be responsible for some of the putative associations. This association could be, at least in part, due to common lifestyle characteristics that make subjects more prone to both. Furthermore, one should consider that it might be impossible to adjust the influence of age because of its high variability in the sample.

In conclusion, obesity was significantly associated with increased prevalence, severity, and extent of periodontal disease. Maintaining a normal body weight, eating a well-balanced diet, and indulging in physical activity have been shown to reduce the severity of periodontitis.

Table 5. Multivariate association between periodontitis and obesity indicators*

	Univariate analysis		Multivariate analysis†	
	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
Body mass index (BMI)‡				
Normal	1		1	
Overweight	2.6 (1.3, 4.9)	0.004	1.4 (0.7, 3.0)	0.330
Obesity	6.6 (3. 5, 12.5)	<0.005	2.9 (1.3, 6.1)	0.006
Waist circumference§				
Normal	1		1	
High	3.6 (2.2, 5.8)	<0.005	2.1 (1.2, 3.7)	0.009
Waist-to-hip ratio¶				
Normal	1		1	
High	1.9 (1.2, 3.0)	0.008	1.4 (0.8, 2.4)	0.221
Fat per cent				
<30	1		1	
>30	2.0 (1.2, 3.3)	0.006	1.8 (1.03, 3.3)	0.039

*Obesity indicators were tested separately in different multivariate logistic regression models.
†Adjusted for age, plaque index, and number of missing teeth.
‡Normal weight (BMI < 25 kg/m^2), overweight (25 < BMI < 30 kg/m^2), obesity (BMI ⩾ 30 kg/m^2).
§High waist circumference: > 102 cm in males and > 88 cm in females.
¶High waist-to-hip ratio: > 0.9 in males and > 0.8 in females.
CI, confidence interval; OR, odds ratio.

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Clinical Relevance

Scientific rationale for the study: Most studies that examined the relation between obesity and periodontitis used BMI to define obesity. The accuracy of the BMI for setting obesity standards is controversial because it does not take into account frame size and whether the weight is fat or muscle. Determining the WC eliminates the inconsistencies of the BMI. Recent large studies have indicated that measurement of WC or WHR may be a better disease risk predictor than BMI.

Principal findings: BMI-defined obesity, high WC, and high fat per cent were significantly associated with increased severity, extent, and odds of periodontal disease.

Practical implications: Dentists can provide an important service to their patients with obesity by educating them about the risk of periodontal disease and the importance of proper oral hygiene.