original article

Body mass index and periodontal health status among young Saudi adults: a cross-sectional study

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BACKGROUND: Obesity has been suggested as a risk factor for periodontal disease. Despite the high prevalence of obesity and overweight among Saudi population, no study has assessed whether there is an association between periodontal health status and body mass index (BMI).

OBJECTIVES: Assess the association between BMI and other variables with periodontal health status among young Saudi adults.

DESIGN: Analytical, hospital-based cross-sectional study.

SETTING: University dental hospital, Riyadh.

PATIENTS AND METHODS: All dental students aged 21-35 years who met inclusion criteria were invited to participate in the study. Periodontal health status was assessed by the plaque index (PI), gingival index (GI) and community periodontal index (CPI) scores. Biometric measurements included weight, height and BMI. Multiple logistic regression was used to assess the association of independent variables with periodontal disease (CPI>2 vs CPI ≤2) and multiple linear regression models to assess associations with PI and GI.

MAIN OUTCOME MEASURES: Periodontal health by BMI and other variables.

SAMPLE SIZE: 308.

RESULTS: Of 700 participants invited, 380 participated for a response rate of 54.2%. Slightly more than half of the obese subjects 54 (52%) did not brush their teeth regularly. The mean (standard deviation) PI and GI scores were significantly higher among the obese (PI score: 1.54 [0.45]); GI score: 1.52 [0.51]) and overweight (PI score: 1.36 [0.47]) and (GI score: 1.42 [0.57]) subjects when compared with subjects with normal weight (PI score: 1.27 [0.51]); (GI score: 1.31 [0.48]); (P<.05). No significant differences were seen between BMI groups in CPI scores. There were also no significant differences in the mean number and percentage of sextants between different BMI groups. The only signficant factor for periodontal disease in the multivariable analysis was toothbrushing.

CONCLUSION: The present study shows a significant positive correlation between BMI and PI and GI scores. However, no statistically significant association was found between BMI and periodontal health status.

LIMITATION: Cross-sectional, so not possible to assess the association of oral health and BMI over time.

CONFLICT OF INTEREST: None.

Obesity is a major global health problem. Its prevalence has increased dramatically over the past few decades.[1] According to the WHO, the prevalence of obesity worldwide has tripled since 1975, and in 2016 around 1.9 billion of adults (aged 18 years and older) were reported overweight; of these, 650 million were obese.The main cause of obesity and overweight is an imbalance in calories consumed and calories expended. Obesity has fatal health consequences. It is a major risk factor for cardiovascular disorders especially heart disease and stroke, diabetes, osteoarthritis and cancers.[2]

Periodontal disease, a chronic inflammatory disease of periodontium, is a highly prevalent disease, and is the main cause of tooth loss in adults worldwide.[3] Periodontal disease is represented by the pocket depth (PD) which is the pathologically altered gingival sulcus, defined when the distance from the gingival margin to the base of the pocket is >3 mm. Several demographic and systemic factors are associated with increased risk and severity of periodontal diseases including, smoking, alcohol consumption, age, stress, osteoporosis and diabetes.[4,5] Recently, a correlation between body mass index and periodontal disease has been suggested.[6,7] Perlstein et al was the first to report a relationship between obesity and periodontal disease when he observed significant histopathologic changes in the periodontium of obese rats as compared with non-obese control rats.[8] The authors concluded that obesity significantly contributed to severity of periodontal disease.8 Since then, a number of studies have evaluated the association between obesity and periodontal disease in adult populations.[6,7,9-14] A 2011 systematic review and meta-analysis conducted on 33 independent studies from different countries found a significant association between periodontitis and the odds ratio for obesity [1.81 (1.42, 2.30)], overweight [1.27 (1.06, 1.51)] and obese and overweight combined [2.13 (1.40, 3.26)].[15] Moreover, a more recent systematic review concluded that obesity, overweight, weight gain and increased waist circumference might be risk factors for periodontal diseases.[16]

The mechanism by which obesity affects the periodontium is still poorly understood. However, it is suggested that obesity-related inflammation can promote periodontitis by secretion of inflammatory cytokines such as tumour necrosis factor alpha (TNF-α), interleukin-6 (IL-6), and interleukin-8 (IL-8) that may increase gingival inflammation and promote bacterial proliferation.[15,16]

In Saudi Arabia, obesity is a serious public health problem with a prevalence among the highest in the world.[17,18] In 2014, it was estimated that 34.7% of Saudi adults were obese and 69.6% were overweight.[18] Despite the high prevalence of obesity and overweight among the Saudi population, there is no published study that has explored the association between BMI and periodontal health status. Therefore, the purpose of this study was to investigate the association between periodontal health status and BMI among young Saudi adults.

PATIENTS AND METHODS

The present cross-sectional study, conducted between January and May 2017, included undergraduate dental students at Al-Farabi Dental College in Riyadh. The study protocol was approved by the Al-Farabi College Institutional Ethical Review Board, and written consent was obtained from the participants. The sample size calculated using a formula for 95% confidence level with an absolute precision of 5% and an expected prevalence rate of 50%, yielded a minimum sample size of 380. All clinical students (4th-6th year) enrolled in the academic year 2016-2017 were eligible and invited to participate. Inclusion criteria were that students by healthy males or females, 18 to 40 years old and have at least 20 natural teeth. Exclusion criteria included pregnancy, periodontal treatment within the past 4 months, a history of systemic diseases or medications known to affect periodontal health status (i.e. diabetes, topical or systemic corticosteroids use, and/or antibiotics intake).

Sociodemographic data such as age, gender, academic level, frequency of tooth brushing and smoking status were sought using a questionnaire (closed ended). Body mass index (BMI) was calculated as the body weight (kg) divided by the square of the height (m). Height was measured using a hard ruler installed vertically and secured with a stable base, while weight was assessed in kilograms using a mechanical scale (DETECTO, United States). Prior to weight measurement, participants were asked to remove heavy outer clothing (such as coats, and jackets), purses, and shoes. According to the BMI classification developed by the World Health Organization, subjects were categorized as underweight (BMI<18.5 kg/m^2), normal weight (BMI 18.5-24.9 kg/m^2), overweight (BMI 25-29.9 kg/m^2), and obese (BMI>30 kg/m^2). The clinical examinations for male and female students were conducted separately by two precalibrated periodontists (AD and DM, respectively) using the World Health Organization Community Periodontal Index (CPI) probe.[19] The two periodontists were calibrated prior to the clinical examination by examining 10 patients at the periodontology clinic, AlFarabi teaching hospital. The examinations were repeated until

an acceptable level of intra-examiner and inter-examiner reliability tests were achieved for all parameters (Kappa>0.8). Periodontal health status was recorded on six predetermined teeth (16, 17, 11, 26, 27, 31, 36, 37, 46, and 47) under five scores: score 0 (healthy), score 1 (bleeding), score 2 (calculus), score 3 (4- 5 mm periodontal pockets) and score 4 (pockets 6 mm or more). Index teeth in each sextant were evaluated and the individual CPI score was defined as the highest score among the examined sextants. Subjects were considered as having periodontitis if the CPI score was (3 or 4) and not having periodontitis if the CPI score was 0, 1, and 2. Additional assessments of periodontal health status included oral hygiene status and gingival health. Oral hygiene was assessed on the six predetermined teeth using the plaque index (PI) as described by Silness and Loe.[21] PI scores ranged from 0 to 3 as follows: 0-0.9, good oral hygiene; 1.0-1.9, fair; or 2.0-3.0, poor oral hygiene. The gingival health was assessed using the gingival index (GI) as described by Loe and Silness: 0, no gingival inflammation; 1, mild inflammation; 2, moderate inflammation; and 3, severe inflammation.[21]

Statistical analyses were performed using the IBM SPSS version 21.0 for Windows (IBM Corp., Armonk, NY) and jamovi version 1.0.8.0, *https://www.jamovi.org*. Descriptive statistics of the mean outcomes were calculated for the study sample; categorical data were presented as frequencies and percentages, while numerical data were presented as means and standard deviations (SD). Categorical outcomes were analyzed by the chi-square/Fisher exact tests while quantitative outcomes were analyzed by either t-test or ANOVA, as appropriate. A *P* value <.05 was considered statistically significant.

Multiple logistic regression was used to assess the association between periodontal disease and other variables, including BMI. The dependent variable for the multiple logistic regression was presence/absence of periodontitis (CPI 0-2= no periodontitis; CPI: >2=periodontitis). Variable selection was by backwards elimination using a criterion-based approach to modeling, the Akaike Information Criterion (AIC).[22] The variance inflation factor was used to check collinearity. Plaque index and gingival index were independent variables in multiple linear regressions. Independent variables included in the models were BMI (obese/overweight/normal), smoking (yes/no), duration of smoking (>10 years, 5-10 years, <1 year), age (continuous data), gender (male/female), brushing frequency either regular (at last twice daily) or irregular (less than twice daily), and floss use (yes/no).

RESULTS

Of 700 participants invited, 380 agreed to participate, giving a response rate of 54.2%. Of these, 72 students were excluded (40 did not meet the inclusion criteria, 25 students did not present for oral examinations and 7 students did not complete the questionnaires). Of the 308 subjects, half were males (**Table 1**). The mean (SD) age was 24.0 (3.1) years, with a range of 21-35 years. One hundred forty-nine subjects (48.4%) were of normal weight, 88 (28.6%) overweight, 46 (14.9%) obese and 25 (8.1%) were underweight. Two hundred ninety-nine (67.9%) reported regularly brushing their teeth (at least twice a day), and only 80 (26%) reported using dental floss. Seventy-three (23.7%) were smokers. **Table 2** shows the sociodemographic data, smoking status and oral hygiene practices by BMI. Overall, gender, age and smoking status were found significantly associated with BMI (*P*<.05). Twenty-two of the overweight sub-

Table 1. Sociodemographic data of the study subjects (n=308).

	N (%)
Gender	
Male	154 (50)
Female	154 (50)
Age (years)	
≤25 years	236 (76.6)
>25 years	72 (23.4)
BMI (kg/m²)	
<18.5	25 (8.1)
18.5-24.9	149 (48.4)
25-29.9	88 (28.6)
≥30	46 (14.9)
Smoking	
Yes	73 (23.7)
No	235 (76.3)
Tooth brushing	
At least twice	209 (67.9)
Once daily	79 (25.6)
Rarely	20 (6.5)
Floss use	
Yes	80 (26)
No	228 (74)

Data are number (%).

Table 2. Sociodemographic data by body mass index category (n=308).

Variables	Body mass index (kg/m²)			*P* value
	<25 (n=174)	25≤30 (n= 88)	≥30 (n=46)	
Gender				
Male	66 (37.9)	54 (61.4	34 (73.9)	**.001**
Female	108 (62.1)	34 (38.6)	12 (26.1)	
Age (years)	23.2 (2.4)	25.0 (3.5)	24.9 (3.7)	**<.001**[a]
Age category				
≤25 years	150 (86.2)	56 (63.6)	30 (65.2)	**<.001**
>25 years	24 (13.8)	32 (36.4)	16 (34.8)	
Smoking				
Yes	31 (17.8)	27 (30.7)	15 (32.6)	**.021**
No	143 (82.2)	61 (69.3)	31 (67.4)	
Tooth brushing				
≥2 times	133 (76.4)	54 (61.4)	22 (47.8)	**<.001**
Once/irregular	41 (23.6)	34 (38.6)	24 (52.2)	
Floss use				
Yes	48 (27.6)	22 (25)	10 (21.7)	.702
No	126 (72.4)	66 (75)	36 (78.3)	

Data are mean (standard deviation) or number (%). [a]ANOVA; other comparisons by chi-square test.

Table 3. Periodontal health status by body mass index.

	Body mass index (kg/m²)			Total (n=308)	*P* value
	Normal (n=174)	Overweight (n=88)	Obese (n=46)		
Plaque index scores	1.27 (0.51)	1.36 (0.47)	1.54 (0.45)	1.33 (0.49)	**.003**
Gingival index scores	1.31 (0.48)	1.42 (0.57)	1.52 (0.51)	1.37 (0.51)	**.018**
CPI scores					
Healthy (code 0)	5 (2.9)	1 (1.1)	0	6 (1.9)	.457[a]
Bleeding (code 1)	45 (25.9)	18 (20.5)	8 (17.4)	71 (23.1)	
Calculus (code 2)	109 (62.6)	63 (71.6)	34 (73.9)	206 (66.9)	
Shallow pocket (code 3)	15 (8.6)	6 (6.8)	4 (8.7)	25 (8.1)	
Deep pocket (code 4)	0	0	0	0	
Healthy sextants	0.51 (1.22)	0.40 (1.01)	0.33 (0.73)	0.45 (1.11)	.521
Bleeding sextants	3.27 (1.95)	3.09 (1.87)	3.17 (1.88)	3.20 (1.91)	.769
Calculus sextants	1.99 (1.91)	2.28 (1.96)	2.41 (2.01)	2.14 (1.94)	.305
Shallow pocket sextants	0.18 (0.70)	0.15 (0.57)	0.09 (0.28)	0.16 (0.62)	.670

Data are mean (standard deviation) or number (%). [a]Chi-square test, other comparisons ANOVA. CPI: Community Periodontal Index.

jects (38.6 %) and 54 of obese (52%) did not brush their teeth regularly.

The periodontal parameters (PI, GI, CPI) by BMI categories are presented in **Tables 3**. The Mean PI and GI scores were significantly higher among obese subjects when compared with subjects with normal weight (*P*<.001). CPI scores did not differ between BMI groups. Only 6 subjects (1.9%) had healthy periodontium as measured by CPI score, while 71 presented with bleeding (23.1%); 206 (66.9%) had calculus and 25 (8.1%) presented with a shallow pocket, with no significant differences between different BMI groups. There was no significant difference in the mean number of sextants with different levels of CPI scores among different BMI groups (**Table 3**). There was a statistically significant association between periodontal disease (CPI >2) and gender, age, smoking, frequency of tooth-brushing and floss use (**Table 4**). There was also a weak but significant positive correlation between BMI and both PI and GI (**Figures 1 and 2**).

In the multiple logistic regression model, brushing frequency and BMI were statistically significant after adding smoking duration, which substantially improved the model fit as measured by a change in AIC from 160 to less than 50 whereas smoking itself had minimal effect (**Table 5**). Use of BMI as a continuous variable also improved parameters over classification into groups. In the multiple linear regression for PI, significant independent variables were gender (*P*<.001), smoking (*P*=.025), and frequency of brushing (*P*<.001) (adjusted R-squared=0.386). For GI, the significant independent variables were gender (*P*<.001), frequency of brushing (*P*<.001), and age (*P*=.055) (adjusted R-squared 0.304).

DISCUSSION

Understanding the association among obesity and pocket depth (PD) is important as it not only contributes to increased morbidity of coronary heart disease and type 2 diabetes mellitus, but also can up date current preventive and therapeutic modalities. BMI can be effortlessly measured in clinical studies. Conversely, it may be an imprecise indicator of adiposity because the precision varies between women and men and between diverse populations compared to measurements of percentage of body fat.[23] The present study was conducted to assess the association between BMI and periodontal health status among young adults. To the best of our knowledge, this is the first study to explore such association among young adults in Saudi Arabia. Overall, the results of the present study showed that periodontal health status and oral hygiene practices are unsatisfactory, with only two thirds of the participants reported

Table 4. Univariable analysis of the association between periodontal parameters and demographic and clinical factors.

	CPI scores ≤2	CPI scores >2	*P* value
Overall	283 (91.9)	25 (8.1)	
BMI			
Normal	159 (91.4)	15 (8.6)	
Overweight	82 (93.2)	6 (6.8)	.870
Obese	42 (91.3)	4 (8.4)	
Gender			
Male	134 (87.0)	20 (13.0)	**.002**
Female	149 (96.8)	5 (3.2)	
Age (years)			
≤25 years	222 (94.1)	14 (5.9)	**.011**
>25 years	61 (84.7)	11 (15.3)	
Smoking			
Yes	60 (82.2)	13(17.8)	**.001**
No	233 (94.9)	12 (5.1)	
Tooth brushing			
≥2 times	197 (94.3)	12 (5.7)	**.027**
Once/irregular	86 (86.9)	13 (13.1)	
Floss use			
Yes	78 (97.5)	2 (2.5)	**.033**
No	205 (89.9)	23 (1.1)	

Data are number (%).

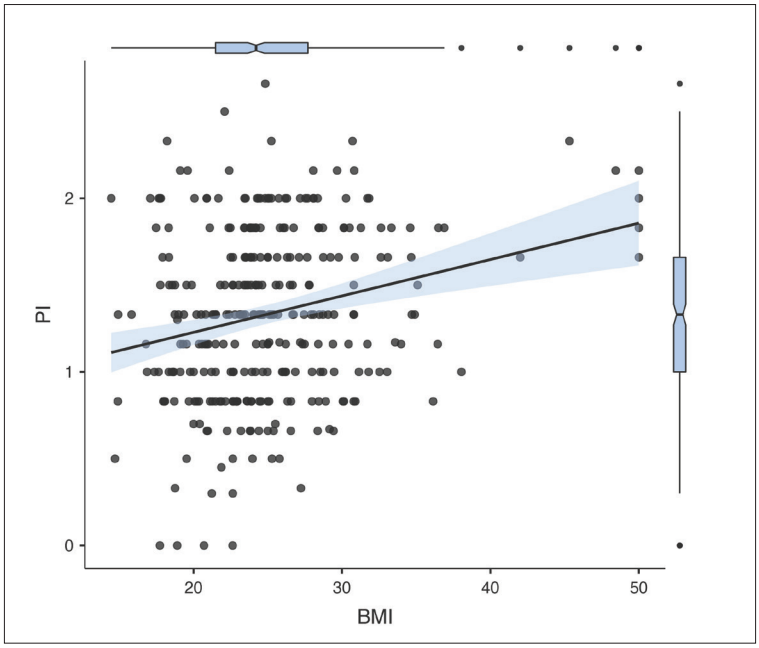

Figure 1. Correlation between body mass index and plaque index (r=0.241; *P*<.001)

Table 5. Multivariable logistic regression analysis of the association between CPI score category and variables that might affect periodontal disease, including body mass index (CPI scores: ≤2=no periodontitis; >2=periodontitis).

Variable	B	S.E.	Wald	*P* value	OR	95% CI	
						Lower	Upper
BMI					1		
Overweight	-0.510	0.557	0.837	.360	0.60	0.201	1.790
Obese	-0.953	0.695	1.879	.170	0.39	0.099	1.506
Age	0.005	0.074	0.005	.945	1.01	0.869	1.162
Gender	0.799	0.656	1.484	.223	2.22	0.615	8.043
Smoking	0.681	0.528	1.665	.197	1.97	0.702	5.560
Tooth-brushing	2.059	0.625	10.867	.001	7.84	2.305	26.680
Floss use	0.971	0.772	1.583	.208	2.64	0.582	11.996

Model fit parameters: Deviance 143.688; AIC 160, Nagelkerke R Square 0.214. Reference levels are normal weight for BMI, female for gender, no for smoking, yes for tooth-brushing and floss use

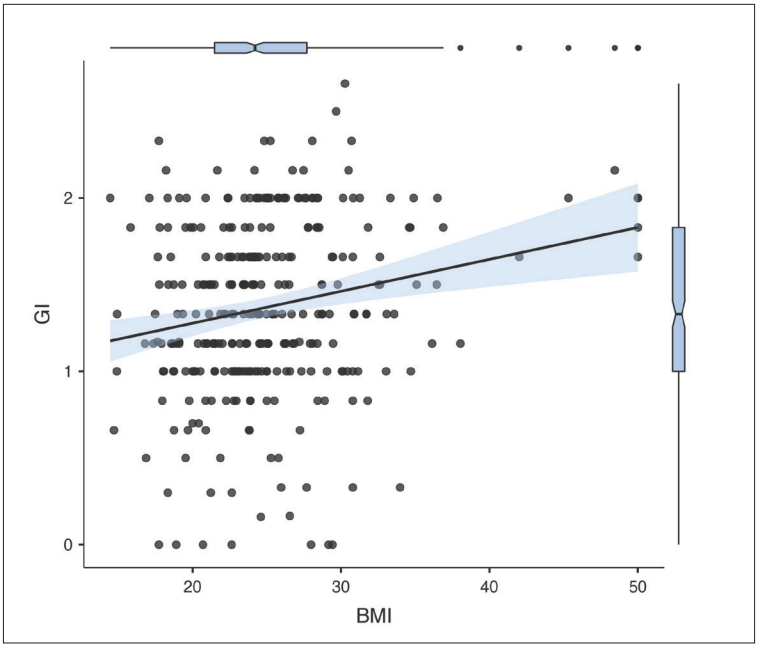

Figure 2. Correlation between body mass index and gingival index (r=0.204, *P*<.001)

regularly brushing their teeth and only one quarter of the subjects reported using dental floss. With reference to periodontal health, only six subjects showed healthy periodontium, while the majority presented with bleeding, calculus or shallow pockets. Moreover, the results of the present study showed significant associations between PI and GI scores and BMI. However, no statistically significant association was found between BMI and periodontal health status.

Body fat may stimulate an agitated inflammatory response in PD and obesity may impede host immunity and inflammatory processes, causing the patient to be at probable risk to the effects of microbial plaque.[24] The relationship between obesity and periodontitis may be restricted to the key inflammatory stage of periodontitis, which may explain the differing results observed in the current study.[25] One of the most significant features of this study was the exclusion of diabetic patients.

This study targeted young university students because the influence of obesity and PD in elderly patients might be confounded by age and other factors. The present study showed a statistically significant positive correlation between BMI and periodontal measurements of PI and GI scores, whereas the association between BMI and CPI scores was not statistically significant.

Our study is in agreement with De Castilhos et al findings where no association was reported between obesity (measured by waist circumference), and periodontitis (measured by periodontal pockets) in a group of 720 young individuals.[26] Moreover, the findings of the present study are in agreement with Kongstad et al, who reported that BMI was positively related to bleeding on probing but not to PD.[27]

In a Nigerian study, all subjects, who had Basic Periodontal Examination scores of 4 were obese although this was not statistically significant.[23] These results were also in accordance with a study done in Japanese women.[24] The lack of association between periodontitis and obesity cannot be attributed to the low prevalence of periodontitis, as we did not observe a linear trend according to nutritional status. This result is

similar to a previous report where the relationships between obesity and periodontal tissue loss did not reach statistical significance.[27]

A systematic review by Suvan and colleagues concluded that the association between body composition and periodontitis is uncertain. The possible association between obesity and periodontitis involves inflammatory pathways. Proinflammatory cytokines, such as interleukin-6 and tumor necrosis factor-alpha (TNF-α), are associated with periodontitis, which is supported by animal studies.[28] The presence of obesity might not be related to the incidence of periodontal pockets in young adults, substantiating preceding studies where obesity in young adults was not coupled with PD in later ages.[29]

Although the association between BMI and periodontitis was not statistically significant, the present study identified a positive clinically significant association between BMI and GI and PI scores. It is apparent that the epidemiology of oral disease is multifaceted, and these findings give us only a minor insight into how oral health is modeled. The present study showed that only 6 students had healthy periodontium. This finding is much lower than reported in a previous study among 20-24 year Saudi students, in which 10% had healthy periodontium.[30] Such differences could be attributed to the variability between the two studies with regards to the age and methods of assessment. It is disappointing to note that majority of students had calculus, a finding which suggests inadequate oral hygiene practices and other unhealthy behaviors among this young adult population. These results are consistent with other local and international studies, which reported calculus to be the most frequently encountered periodontal health condition.[5,30,31] The results of the present study also identified a significant association between frequency of oral hygiene practices (namely tooth brushing) and periodontitis. These results corroborate previous findings elsewhere.[5,30-32] Of note, most of obese and overweight students reported irregular oral hygiene practices compared to normal-weight students. This finding is probably related to psychological factors (e.g. low self-esteem or low perception of self-worth among the obese), that negatively affect their attitudes towards oral hygiene practices.[33-36] The association between toothbrushing and periodontal health has been established in the literature, and therefore adequate oral hygiene practices such as regular tooth brushing and dental floss use should be emphasized.[31-33]

This is the first study that explored the potential association between BMI and periodontal measurements among young adults in Saudi Arabia. However, the study has some limitations that should be taken into consideration. First, this is a single-center study targeting university students and hence the generalization of the results is questionable. Second, the periodontal status was assessed using the community periodontal index, which does not measure the attachment loss, which is considered one of the most important clinical indicators of periodontitis. A third limitation is related to the fact that the present study is cross-sectional, and hence provided no insight into the association of oral health and BMI over time. Additionally, the lack of a control group to test the hypothesis that BMI has an effect on periodontal health is an obvious limitation of the present study. Finally, the study did not obtain any information about the students' nutritional and behavioral habits that might have an effect on the periodontal health. Therefore, future multicenter studies studies with large sample sizes are required to confirm any association between BMI and PD.

In conclusion, the present study, which targeted young university students in Saudi Arabia, showed a significant positive correlation between gingival inflammation as well as poor oral hygiene and being overweight or obese, but no statistically significant relationship between obesity and periodontal status. Our results suggest that being at risk of overweight is an impending risk factor and a predictor of gingival disease.

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