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Original Article

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Comparison of Periodontal Status among Obese, Overweight, and Normal-Weight Diabetic Patients

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Abstract

Background: Periodontal disease and diabetes are two prevalent chronic conditions that have shown significant bidirectional relationships. The current study investigated the periodontal indices of diabetic patients, comparing those with normal weight to those with overweight or obesity.

Method: This cross-sectional study was conducted on 48 patients with Type 2 Diabetes (T2D). Data of age, gender, Body Mass Index (BMI), and Waist-to-Hip Ratio (WHR) of the patients were recorded. All individuals underwent periodontal examinations and data of Plaque Index (PI), Bleeding on Probing (BOP), Probing Pocket Depth (PPD), and Clinical Attachment Loss (CAL). The data were analyzed using SPSS version 24 with a significant level <0.05.

Results: The mean age of participants was 40.5 years and most participants were over 40, with about 50% classified as overweight or obese. Most patients had low (35.4%) to moderate (37.5%) PI levels. The mean BMI was 26.47±4.78 kg/m^2, and the mean WHR was 0.95±0.11 *cm*. Obese participants had significantly higher mean BOP, PPD, and CAL compared to those with normal weight (p=0.001). Significant associations were found between BMI and PI levels, with higher PI observed in overweight and obese individuals, and between WHR and PI, of which high WHR correlated with more severe PI levels (p=0.001).

Conclusion: The findings showed that overweight and obese individuals with diabetes had poorer periodontal health, with higher plaque levels and worse PPD and CAL, compared to those with normal weight. Both BMI and WHR were significantly associated with increased plaque accumulation.

Keywords: Body mass index, Waist to hip ratio, Periodontal diseases, Oral health

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Introduction

Periodontal disease, a complex and multifactorial condition affecting the supporting structures of the teeth, has emerged as one of the top six chronic Noncommunicable Diseases (NCDs) globally, characterized by the progressive destruction of the gums, periodontal ligament, and alveolar bone; this disease leads to tooth loss if left untreated (1,2) The burden of periodontal disease is particularly pronounced in low- and middle-income countries, where access to oral healthcare is often limited (3). The global prevalence of periodontal disease is increasingly recognized not only as a localized oral health issue but as a systemic concern, given its associations with other serious NCDs (4,5). The chronic inflammation such as obesity and diabetes inherent to periodontal disease can exacerbate these systemic conditions, creating a bidirectional relationship that further complicates management and outcomes (6,7). On the other hand, oral microbial dysbiosis may directly induce systemic inflammation, either by increasing inflammation by firsthand toxin release or by the transport of microbial products into the bloodstream (8).

Diabetes, a multifactorial disease characterized by impaired insulin production or function, leading to elevated blood glucose levels caused by mutations and/or environmental factors, results in various complications that affect the patient's quality of life (9-12). Type 1 Diabetes (T1D), caused by autoimmune destruction of insulin-producing β-cells, primarily affects children and young adults, requiring insulin therapy. While, Type 2 Diabetes (T2D), the most common form, results from insulin resistance and impaired secretion, often linked to obesity and typically managed with diet or oral medications (13,14).

The association between diabetes and obesity is particularly alarming, given that obesity is a major risk factor for the development of T2D. The prevalence of overweight and obesity among diabetic patients is concerning in both developed and developing countries (15,16). Evidence indicated that individuals with abnormal anthropometric parameters including Body Mass Index (BMI) ≥25 *kg/m²* (overweight or obese) and a Waist-to-Hip Ratio (WHR) >0.9 in men or >0.85 in women, which indicates central obesity and increased metabolic and inflammatory risks, often exhibit worse periodontal health. The coexistence of underlying diseases such as dyslipidemia, diabetes, cardiovascular diseases, and liver diseases usually worsens the circumstances (7,17,18).

A higher BMI and WHR worsen periodontal health by increasing systemic inflammation, releasing proinflammatory cytokines from adipose tissue, and altering the oral microbiome, all of which contribute to gum tissue inflammation and greater susceptibility to periodontal disease (1). Obesity is believed to create a systemic pro-inflammatory state in the body, affecting metabolism and immune function. Through this mechanism, obesity may increase the risk of developing periodontal disease (19,20). On the other hand, evidence suggests that inflammation of the periodontium, by causing metabolic disturbances, may increase the likelihood of obesity (21). Due to the correlation between abnormal anthropometric parameters in diabetic patients and poorer periodontal indices, the current study aimed to investigate the status of periodontal parameters and anthropometric indices (age, gender, BMI, and WHR) among diabetic patients.

Materials and Methods

Study design and sample size

This cross-sectional study was conducted on 48 patients with T2D aged 21 to 60 referred to Razi Hospital and Dental Clinic of the Guilan University of the Medical Sciences, Rasht, Iran. The participants were selected through the convenience sampling method. The sample size was calculated based on a 95% confidence level and 90% power, following the Chapper *et al* study (22). To improve the reporting data, the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist (23) was applied. All authors consented to participate in the study. The study was approved by the ethical committee of the Guilan University of Medical Sciences, Rasht, Iran [IR.GUMS.REC.1399.396].

Diabetes was previously confirmed by a specialist based on Fasting Blood Sugar (FBS) levels ≥126 *mg/dL*, glycated hemoglobin (HbA1c) levels ≥6.5%, or the use of antidiabetic medications. Demographical data and anthropometric characteristics of the patients were obtained from patients' archives, including age,

gender, BMI, and WHR. Patients with viral infection, autoimmune diseases, malignancy, and underlying diseases or using medications (except for antidiabetic drugs), pregnancy, history of smoking, and alcohol consumption were excluded from the study.

Anthropometric parameters were assessed by an expert technician. BMI <18.5 kg/m^2 was considered low weight, 18.5–24.99 kg/m^2 as normal weight, 25–29.9 kg/m^2 as overweight, and ≥30 kg/m^2 as obese. WHR was calculated by dividing waist circumference by hip circumference, and the normal level of WHR was evaluated as 0.9 or less in men and 0.85 or less in women (18). According to the BMI and WHR, 24 individuals were categorized as a normal-weigh group, and 24 individuals were considered an overweight/obese group' and the Plaque Index (PI) score was provided for all patients (Figure 1).

Periodontal clinical parameters

All periodontal examinations were conducted by a single experienced dentist with over five years of clinical experience in periodontology to ensure consistency and minimize inter-examiner variability. The periodontal clinical parameters, including PI, Bleeding on Probing (BOP), Clinical Attachment Loss (CAL), and Probing Pocket Depth (PPD), were

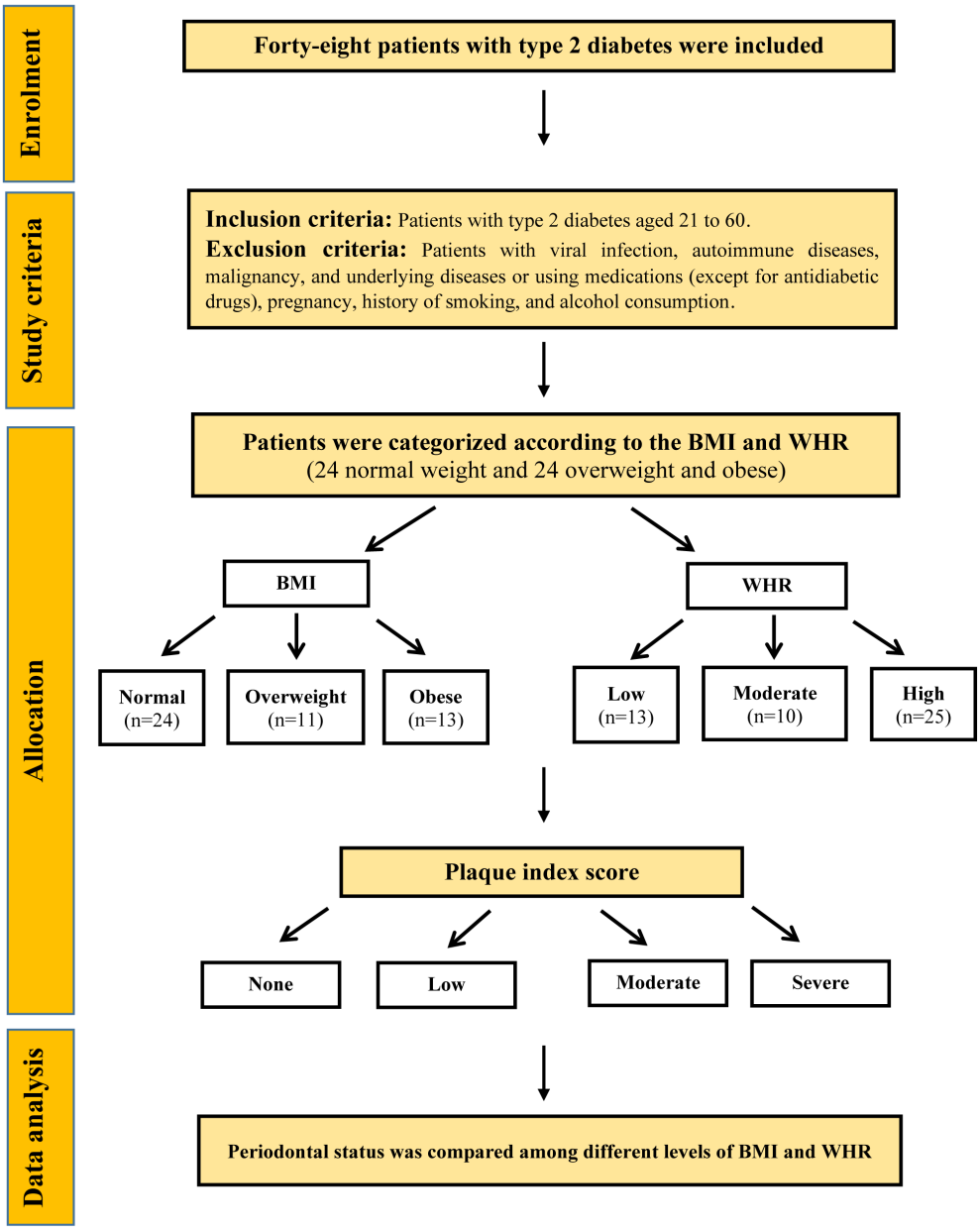

Figure 1. Study flow chart.

assessed *via* probing each tooth at six sites; the distal, middle, and mesial thirds of both the buccal and oral surfaces of the dental crown. The Community Periodontal Index (CPI), which evaluated periodontal disease status, divided the dental arch into six sextants for assessment. The CPI was scored on a scale from 0 to 4: 0 indicates healthy periodontium:

1. Indicates bleeding on probing without pockets; 2. Indicates supra- or sub-gingival calculus with gingival bleeding; 3. Indicates periodontal pockets 4–5 *mm* deep; and 4. Indicates periodontal pockets deeper than 6 *mm* (24). A score of zero was given if no bleeding occurred, and a score of 1 was given if bleeding was observed. The Silness & Löe PI scores were as follows: 0 indicates no plaque, 1 denotes a thin plaque layer at the gingival margin detectable only by scraping with a probe, 2 represents a moderate plaque accumulation within the gingival pocket visible to the naked eye, and 3 indicates abundant plaque along the gingival margin and in interdental spaces (25,26).

Statistical analysis

Statistical data was reported as numbers (percentages) and mean±Standard Deviation (SD). Following normality assessment, ANOVA and Monte Carlo tests were used to evaluate the differences in categorical variables and association between variables. All data was analyzed using SPSS version 24, and the significant level was set at 0.05.

Results

The mean age of participants was 40.5 years and the distribution of gender was equal among participants, of which about 50% were overweight and obese (high BMI and WHR). Most patients had mild or moderate PI (72.9%) (Table 1). The mean BMI and WHR were 26.47±4.78 kg/m^2 (19.03-38.06 kg/m^2) and 0.95±0.11 *cm* (0.78-1.22 *cm*), respectively. The mean BOP, PPD, and CAL were 0.64±0.32 (0.05-1), 2.22±1.16 *mm* (1-5 *mm*), and 2.09±2.25 (0-7), respectively. Among 24 individuals with overweight and obese, 11 were overweight (grade b/stage 2) and 13 were obese (grade c/stage 3).

The obese group showed higher mean values for BOP (0.87±0.16), CAL (3.98±1.66), and PPD (3.15±0.87) compared to the normal weight group (0.41±0.26, 0.21±0.37, 1.29±0.46, respectively). Results showed that mean BOP, CAL, and PPD differed significantly across BMI and WHR groups (all $p<0.001$). Pairwise comparisons indicated that patients with normal BMI had significantly lower BOP, CAL, and PPD than overweight or obese patients ($p<0.001$), with no significant differences between overweight and obese groups for BOP and PPD. Similarly, higher WHR levels were associated with significantly higher BOP, CAL, and PPD compared to low and moderate WHR levels ($p<0.001$), while differences between low and moderate WHR were not significant (Table 2).

A significant association was found between BMI categories and PI levels ($p<0.05$). Most individuals with normal weight (70.8%) had low PI, while none had severe PI. In contrast, overweight and obese individuals tended to have moderate to severe PI levels. Similarly, WHR significantly correlated with PI levels ($p<0.05$). Participants with low and moderate WHR predominantly had low PI levels,

Table 1. Frequency of demographical, anthropometric, and dental data of participants

Variables		Frequency n (%)
Age (year)	21-30	7(14.6)
	31-40	13(27.2)
	41-50	14(29.1)
	51-60	14(29.1)
Gender	Male	24(50.0)
	Female	24(50.0)
BMI	Low	0(0.0)
	Normal	24(50.0)
	Overweight	11(22.9)
	Obese	13(27.1)
WHR	Low	13(27.1)
	Moderate	10(20.8)
	High	25(52.1)
Plaque index	None	3(6.2)
	Mild	17(35.4)
	Moderate	18(37.5)
	Severe	10(20.8)

Body Mass Index (BMI) <18.5 kg/m^2 was considered low weight, 18.5-24.99 kg/m^2 as normal weight, 25-29.9 kg/m^2 as overweight, and ≥30 kg/m^2 as obese. Waist-to-Hip Ratio (WHR) was calculated by dividing waist circumference by hip circumference, and the normal level of WHR was evaluated as 0.9 or less in men and 0.85 or less in women.

Table 2. Comparison of periodontal parameters between normal, over-weight weight, and obese group using ANOVA test

Outcome	Factor	Pairwise comparison (I *vs.* J)	Mean difference (I-J)	p-value
BOP	BMI	Normal *vs.* overweight	-0.41	0.001
		Normal *vs.* obese	-0.52	0.001
		Overweight *vs.* obese	-0.11	0.43
	WHR	Low *vs.* moderate	-0.006	0.99
		Low *vs.* high	-0.46	0.001
		Moderate *vs.* high	-0.45	0.001
CAL	BMI	Normal *vs.* overweight	-3.25	0.001
		Normal *vs.* obese	-4.21	0.001
		Overweight *vs.* obese	-0.97	0.12
	WHR	Low *vs.* moderate	-0.005	1.00
		Low *vs.* high	-3.60	0.001
		Moderate *vs.* high	-3.60	0.001
PPD	BMI	Normal *vs.* overweight	-1.44	0.001
		Normal *vs.* obese	-2.21	0.001
		Overweight *vs.* obese	-0.77	0.14
	WHR	Low *vs.* moderate	0.008	1.00
		Low *vs.* high	-1.75	0.001
		Moderate *vs.* high	-1.76	0.001

According to the Body Mass Index (BMI) and Waist-to-Hip Ratio (WHR), 24 individuals were considered as a normal-weigh group, and 24 individuals were considered as an overweight/obese group.
Standard Deviation (SD); Bleeding on Probing (BOP); Clinical Attachment Loss (CAL); and Probing Pocket Depth (PPD).
Significant level <0.05.

while those with high WHR were more likely to have moderate to severe PI levels (Table 3).

Discussion

While numerous studies have examined the relationships between diabetes and periodontal disease and between obesity and periodontal disease separately (27,28), fewer investigations have focused on the combined effects of diabetes and obesity on periodontal health. The results of the present study indicated that the mean BOP, PPD, and CAL were significantly lower in T2D individuals with normal weight compared to those who were overweight or obese, which suggested a notable impact of higher BMI and WHR on the periodontal status of patients.

A study by Trullenque-Eriksson *et al* demonstrated that periodontitis was more prevalent among individuals with T1D and T2D compared to non-T1D and non-T2D individuals, respectively, with the disparity being more pronounced in younger age groups and exacerbated by poor glycemic control. Notably, periodontitis was associated with a higher incidence of diabetes-related complications in both T1D and T2D populations, which underscored the critical role of glycemic control in mitigating periodontal and systemic complications in diabetic

Table 3. The frequency of diabetic patients based on plaque score in different categories of BMI and WHR using Monte Carlo test

Anthropometric parameters		PI n (%)				df	p-value *
		None	Low	Moderate	Severe		
BMI	Normal	3(12.5)	17(70.8)	4(16.7)	0(0.0)	6	0.001
	Overweight	0(0.0)	0(0.0)	8(72.7)	3(27.3)		
	Obese	0(0.0)	0(0.0)	6(46.2)	7(53.8)		
WHR	Low	3(23.1)	8(61.5)	2(15.4)	0(0.0)	6	0.001
	Moderate	0(0.0)	8(80.0)	2(20.0)	0(0.0)		
	High	0(0.0)	1(4.0)	14(56.0)	10(40.0)		

Body Mass Index (BMI)<18.5 *kg/m²* was considered as low weight, 18.5-24.99 *kg/m²* as normal weight, 25-29.9 *kg/m²* as overweight, and ≥30 *kg/m²* as obese. Waist-to-Hip Ratio (WHR) was calculated by dividing waist circumference by hip circumference, and the normal level of WHR was evaluated as 0.9 or less in men and 0.85 or less in women.
Degree of freedom (df); Plaque Index (PI); Bleeding on Probing (BOP); Clinical Attachment Loss (CAL); and Probing Pocket Depth (PPD).
*Monte Carlo.
Significant level <0.05.

individuals (29). Diabetes and periodontitis have a bidirectional relationship, with each condition potentially exacerbating the other. Poorly controlled diabetes can lead to increased susceptibility to infections, including periodontal disease, due to impaired immune function and elevated blood sugar levels, which promote bacterial growth. Conversely, periodontitis can worsen blood glucose control by increasing systemic inflammation and contributing to insulin resistance (30,31).

A study by Abdolsamadi *et al* showed higher BOP among individuals with higher BMI. They stated that while the periodontal health of overweight and obese individuals was significantly poorer compared to those with normal weight, their overall dental health was not influenced by BMI. They highlighted the positive, strong association of periodontal health status with obesity (32). Chang *et al* reported a lower prevalence of periodontitis in individuals with lower BMI compared with obese individuals (33). Li *et al* reported that obesity was significantly associated with visible PI, BOP, and PPD (34). Some studies illustrated that PI, BOP, and PPD were notably elevated in obese children compared to the normal weight; however, the difference in CAL between the two groups was not statistically significant (35,36). The relationship between obesity and periodontitis is mediated by adipokines, hormones, and cytokines derived from adipose tissue. Evidence has shown a significant correlation between obesity and periodontal diseases, with adipokines directly affecting periodontal tissues (37). Increasing inflammatory cytokines from manure adipose tissue occurs when adipocytes engage with macrophages activated by periodontitis, particularly in individuals with mild obesity and diabetes, including those from Asian and American populations with a BMI around 25 *kg/m²* and diabetes (38). Moreover, the excessive adipose tissue in obese individuals releases these adipokines, including Tumor Necrosis Factor-alpha (TNF-α), adiponectin, resistin, and Interleukin-6 (IL-6), which collectively exacerbate chronic inflammation (20,39). Resistin has been implicated in enhancing pro-inflammatory cytokine production, thereby intensifying periodontal tissue destruction (40). Similarly, IL-6 is a key mediator of inflammation and has been linked to the upregulation of osteoclast activity, contributing to alveolar bone loss in periodontitis (41).

The current study revealed that the mean PI was significantly lower in the normal-weight group compared to overweight and obese individuals, suggesting that the severe periodontal problems observed in the obese group might be attributed to higher plaque levels rather than obesity itself. Suvan *et al* reported that higher BMI could be an independent predictor of poor response to non-surgical periodontal therapy (42) due to the negative effect of obesity on wound-healing processes (43).

Ayan and Dayi found the possible adverse effect of obesity on PI and gingival index values (44). Another study demonstrated that those with the highest systemic insulin resistance levels had significantly more sites with BOP and higher PPD, suggesting that endogenous insulin may help prevent periodontitis, in contrast, systemic insulin resistance could contribute to its progression (45).

The findings of this study underscored the complex relationship between obesity, diabetes, and periodontal health, highlighting the importance of considering multiple factors in better clinical management of periodontal disease in diabetic patients. To address potential bias from confounding factors, this study included only individuals who reported brushing and flossing at least once daily. This criterion was applied to minimize variability in basic oral hygiene practices, thereby strengthening internal validity and ensuring that observed differences in periodontal parameters are more likely attributable to anthropometric factors such as BMI and WHR rather than variations in self-care habits. Excluding participants with inconsistent oral hygiene behaviors reduces the impact of confounders like plaque accumulation unrelated to obesity or diabetes, providing a more controlled assessment of how obesity and central adiposity affect periodontal status in diabetic patients. This approach also underscores the relevance of maintaining regular oral hygiene routines to manage periodontal disease risk in high-risk populations. Nevertheless, the current study had some limitations, including its cross-sectional design, small sample size, lack of data about the duration of disease, oral habits, dietary patterns, and absence of non-diabetic control groups, which have been suggested to be considered in future studies.

Conclusion

The results of the current study demonstrated that overweight and obese individuals exhibited significantly worse periodontal health compared to those with normal weight, and both BMI and WHR were significantly associated with PI levels, of which higher BMI and WHR correlated with more severe plaque accumulation. These findings suggested that managing weight and waist-to-hip ratio could be important in improving periodontal health.

Ethics approval and consent to participate

All authors consented to participate in the study. The study was approved by the ethical committee of the Guilan University of Medical Sciences, Rasht, Iran [IR.GUMS.REC.1399.396]. All methods were carried out in accordance with relevant guidelines and regulations that is Declaration of Helsinki.

Declaration of generative AI in scientific writing

While preparing this work, AI was used to improve the manuscript's language and grammar. The author reviewed and edited the content as needed.

Conflict of Interest

The authors declared no competing interests.

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