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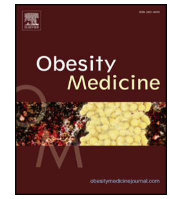

The relationship between metabolic factors and anthropometric indices with periodontal status in type 2 diabetes mellitus patients with chronic periodontitis

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ABSTRACT

Aims: The aim of this study was to evaluate the relationship between metabolic factors and anthropometric indices with periodontal status in type 2 diabetes mellitus (T2DM) patients with periodontal disease (PD).
Methods: In this case-control study, 100 T2DM patients with chronic periodontitis (CP) and 100 healthy people were selected using convenient sampling method. Demographic, anthropometric indices such as weight, body mass index (BMI), waist and hip circumference (WC, HC) and periodontal parameters including bleeding on probing (BoP), pocket depth (PD), clinical attachment level (CAL) and plaque index, systolic and diastolic blood pressure (SBP, DBP), physical activity, serum levels of fasting blood glucose (FBG), glycosylated hemoglobin levels (HbA1c), triglyceride) TG(, total cholesterol (CHOL), high-density (HDL), and low-density lipoprotein (LDL) cholesterol, BUN, creatinine, urinary albumin and eGFR were measured.
Results: The results of the study showed that there is a significant inverse correlation between physical activity and weight, BMI, WC, HC, FBS, HbA1c, Albuminuria, SBP, BoP, Plaque,pocket depth , and CAL ($p < 0.05$). It was also shown that pocket depth and CAL are positively correlated with weight, BMI, WC, HC, FBS, HbA1c, BUN, creatinine, Albuminuria, SBP and DBP ($p < 0.01$). Anthropometric indices were also found to be positively correlated with FBS, HbA1c, creatinine, Albuminuria, SBP and DBP ($p < 0.05$). In addition, it was shown that as HDL increases, WC, HC, CAL, and PD drop significantly ($p < 0.01$).
Conclusions: The results of the current study suggest that reduction of metabolic and anthropometric parameters can improve periodontal status in T2DM patients with PD.

1. Introduction

Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder characterized by an increase in blood glucose and owing to defects in secretion/function of insulin (Mu et al., 2019). T2DM can increase the risk of periodontal disease (PD) (Teeuw et al., 2017). Patient with T2DM are 2.4 times more likely to develop teeth alveolar destruction complications (Promsudthi et al., 2005). PD caused by the proliferation of pathogenic bacteria and extensive inflammatory response, leads to loss of bone alveoli (Chapple and Matthews, 2007). Its prevalence in European and American studies has been reported to be between 31% and 76% (Eke et al., 2015). PD is now recognized as the sixth complication of diabetes, and it can also affect other complications of diabetes, including retinopathy and coronary artery diseases (Casanova et al., 2014). Studies have considered weak glycemic control and high level of HbA1c as a risk factor for exacerbation of PD (Bandyopadhyay et al., 2010). New studies also suggest that periodontitis treatment can improve glycemic control through infection removal (Costa et al., 2017a). Studies have shown that the risk of periodontitis increases as BMI and WC increase (Gorman et al., 2012). In addition it has been shown that higher levels of serum CHOL, LDL, and TG are associated with increased risk of PD (Sayar et al., 2016). A significant inverse corelation has been observed between normal serum creatinine level and PD (Chhokra et al., 2013). A study on postmenopausal women

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showed a positive relationship between clinical adhesion level and the number of missing teeth with high blood pressure (Gordon et al., 2018). A significant relationship was observed between PD and high blood pressure among Japanese students (Kawabata et al., 2016). A study showed that poor oral hygiene and inflammation of the mouth were associated with hypertension (Darnaud et al., 2015). While in a study on non-diabetic non-smokers, no relationship was observed between hypertension and gingival bleeding and pocket (Ollikainen et al., 2014). Reducing inactive time and increasing physical activity as an intervention can improve renal function in diabetic patients (Guo et al., 2016). Physical activity through weight management, has beneficial effects on controlling blood glucose in diabetic patients (Association, 2003).

However, the link between physical activity and PD is unknown. The purpose of this study was to evaluate the relationship between metabolic factors, physical activity and anthropometric indices with periodontal status in T2DM patients with PD.

2. Materials and methods

2.1. Subjects and study design

In this study, 100 patients with at least 5 years' history of diabetes and also with PD, who had referred to the diabetes clinic of Golestan Hospital (Ahvaz, Iran), were selected. 100 healthy individuals were also selected as the control group. Inclusion criteria included age range of 30–60 years, a minimum of 20 teeth in mouth, without any history of other systemic diseases. The exclusion criteria were: pregnant, lactating, smoking, receiving insulin, immunosuppressive medications, antibiotics, any antioxidants and anti-inflammatory agents. Subjects of the control group were matched according to age and gender with subjects in the case group.

2.2. Anthropometric, blood pressure and physical activity

The body weight and height were measured using seca scale with a precision of 0.5 kg and 0.1 cm, respectively. Circumference (HC) and waist circumference (WC) were measured by the protocol of a previous study (Khader et al., 2009). Body mass index (BMI) was calculated as weight/height^2 $_{(kg/m2)}$. Blood pressure was measured using an armhole barometer after 10 min of rest. Physical activity questionnaire (IPAQ) was used to find out each subject's amount of physical activity Craig, 2003 .

2.3. Biochemical measurements

Venous blood (7 cc) samples were collected after an overnight fast. HbA1c was then measured using HPLC and DSS methods, CHOL, TG, HDL-C, FBS, BUN and Cr were measured by enzymatic method. LDL was calculated using Friedewald formula.

LDL-c (mg/dL) = TC (mg/dL) − HDL-c (mg/dL) − TG (mg/dL)/5 (VLDL)

VLDL = TG (mg/dl) / 5

The 24-h urine was also collected and 24-h urine albumin more than 30 mg was considered as an abnormal albumin excretion. The amount of eGFR was calculated using serum creatinine concentration.

EGFR $(mL/\min \text{ per } 1.73\,m^2) = 186 \times (S_{Cr})^{-1.154} \times (Age)^{-0.203} \times (0.742 \text{ if female}) \times (1.210 \text{ if African-American})$. * S_{Cr} is serum creatinine

2.4. Evaluation of periodontal status

The periodontal parameters including BOP, plaque, PD and CAL. BOP (Bleeding in 30–60 s after the probe; bleeding that is induced by gentle manipulation of the tissue at the depth of the gingival sulcus, or interface between the gingiva and a tooth where 0 means no bleeding, and 1 means bleeding), plaque (the amount of plaque on the tooth surface that was defined as 0 absent and 1 pesent).

PD and CAL were measured by a dentist at six sites of a tooth (mesiobuccal, midbuccal, distobuccal, mesiolingual, midlingual, and distolingual). The PD was measured by a UNC-15 (University of North Carolina No. 15) manual periodontal probe at 6 sites per tooth: mesiobuccal, midbuccal, distobuccal, mesiolingual, midlingual and distolingual sites. Then the selected sites were randomly selected from at least 3 of the quadrants (i.e. the term that dentists use for the division of mouth and teeth. The mouth has 4 quadrants: upper right, upper left, lower right and lower left) for the clinical measurements. The CAL (at 6 sites per tooth: mesiobuccal, midbuccal, distobuccal, mesiolingual, midlingual and distolingual sites) was evaluated by a full – mouth periodontal examination and determined by measuring the distance from the cement – enamel junction to the bottom of the gingival crevice. Then the selected sites were randomly selected from at least 3 of the quadrants.

2.5. Statistical analysis

The data was analyzed and then reported as mean ± SD using SPSS (Ver 19.0). Independent *t*-test and chi-square were used to compare variables in both groups. Pearson test and linear regression were used to investigate the relationship between variables. P-values less than 0.05 were considered as significant.

3. Results

The case group consisted of 100 patients with T2DM and PD and the control group consisted of 100 healthy subjects. The mean age was 51.11 ± 5.67 and 50.77 ± 5.37 years in case and control groups respectively. The mean of baseline variables is presented in Table 1. The weight, BMI, WC and HC were significantly higher among the diabetic subjects than the healthy subjects ($P < 0.001$) (Fig. 1). The healthy subjects had significantly more physical activity than patients with diabetes ($p < 0.001$). As expected, FBG and HbA1c levels were significantly higher in patients with T2DM compared to healthy subjects ($p < 0.001$). HDL-C levels were significantly higher in healthy subjects ($P = 0.001$) while LDL/HDL ($p = 0.04$), creatinine excretion ($p = 0.01$) and albumin excretion ($p < 0.001$) were significantly higher in patients with diabetes. Case group significantly had higher SBP ($p < 0.001$) and DBP ($p = 0.001$) than the healthy subjects. Periodontal indices including BOP, CAL, PD and plaque index were also significantly higher in the patients with diabetes ($p < 0.001$) (Table 1).

After performing the analysis, a significant and inverse relationship was found between physical activity with anthropometric parameters, FBG, HbA1c, periodontal indices and albumin excretion in 24-h urine ($P < 0.001$). With an increase in physical activity, SBP significantly dropped ($P = 0.04$ and $r = -0.14$) (Table 2). Also, llinear regression analysis showed that even after the effect of glucose-lowering drugs was removed, there was a marginal trend toward significant correlation between physical activity and FBG ($P = 0.05$). But this correlation was not significant for HbA1c ($P = 0.18$) (Table 3).

In the present study, a significant relationship was observed between periodontal quantitative indices including CAL and PD and anthropometric parameters, glycemic control indices and albumin excretion ($P < 0.001$). CAL was inversely and significantly correlated with HDL levels ($P = 0.005$). This inverse and significant correlation was also observed between the pocket depth (PD) and HDL levels ($P < 0.001$). A significant direct relationship was found between LDL/HDL, pocket depth ($p = 0.004$) and clinical adhesion level ($P = 0.03$).

A significant positive correlation was found between the pocket depth and the level of BUN and creatinine ($P = 0.01$), SBP and DBP

Table 1
Baseline characteristics of the subjects.

Variable	Control group (n = 100)	Diabetes Mellitus group (n = 100)	*P-value**
Age (y)	50.77 ± 5.37	51.11 ± 5.67	0.66
Gender			
Female (N)	67	69	0.76**
Male (N)	33	31	
Physical Activity (met-min/week)	957.43 ± 549.22	293.98 ± 159.29	< 0.001
FBG (mg/dL)	87.83 ± 7.78	165.06 ± 3.46	< 0.001
HbA1c %	4.83 ± 0.46	8.34 ± 1.3	< 0.001
TG (mg/dL)	157.82 ± 62.23	147.99 ± 39.89	0.18
Chol (mg/dl)	166.91 ± 64.23	159.06 ± 34.9	0.28
HDL (mg/dl)	48 ± 10.26	42.97 ± 10.53	0.001
LDL (mg/dl)	90.15 ± 39.22	96 ± 39.81	0.29
LDL/HDL ratio	2.03 ± 1.08	2.37 ± 1.29	0.04
eGFR (mL/min/1.73m^2)	81.15 ± 16.6	79.44 ± 17.6	0.48
BUN (mg/dL)	12.69 ± 2.22	13.23 ± 2.99	0.14
Cr (mg/dL)	0.8 ± 0.15	0.85 ± 0.15	0.01
Albuminuria (mg/24 h)	5.64 ± 2.07	10.85 ± 4.35	< 0.001
SBP (mmHg)	118.10 ± 10.01	125.10 ± 13.29	< 0.001
DBP (mmHg)	73 ± 7.45	76.60 ± 7.81	0.001
BOP (+) (n)	12	100	< 0.001**
plaque (+) (n)	69	100	< 0.001**
CAL (mm)	0.34 ± 0.07	3.19 ± 0.69	< 0.001
PD (mm)	2.2 ± 0.43	4.39 ± 0.85	< 0.001

*. *P < 0.05* was considered as significant using Independent T-test between the two groups at baseline.
**. *P < 0.05* was considered as significant using chi-square test.
SBP; Systolic blood pressure, DBP; Diastolic blood pressure, FBG; fasting blood glucose, HbA1C; glycosylated hemoglobin, TG; *Triglyceride*, CHOL; total cholesterol, HDL; high-density lipoprotein, LDL; low-density lipoprotein cholesterol, VLDL; very low-density lipoprotein, eGFR; estimated glomerular filtration rate, BUN; blood urea nitrogen, Cr; creatinine, BOP; bleeding on probing, PD; pocket depth, CAL; clinical attachment level. Values are expressed as means ± SD. *P < 0.05* was considered as significant.

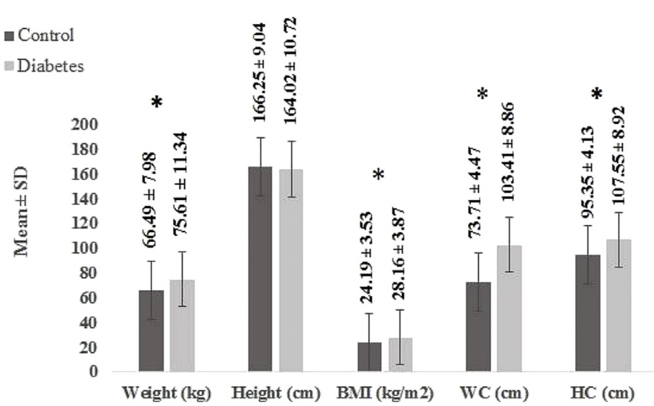

Fig. 1. *P < 0.001 was considered as significant using Independent T-test (for anthropometric indices) between the two groups at baseline.
T2DM; type 2 diabetes mellitus, BMI; body mass index, WC; Waist circumference, HC; Hip circumference.

(p = 0.001). Also, a significant positive correlation was observed between clinical adhesion level and creatinine (p = 0.005), albuminuria (p < 0.001), SBP (P = 0.001) and DBP (P = 0.002) (Table 4). Furthermore, a significant relationship was observed between anthropometric parameters (weight, WC, HC and BMI) and FBG, HbA1c level, albumin excretion (mg/24 h) (P < 0.001), creatinine level, and blood pressure (Table 5).

Table 2
The relationship between physical activity with anthropometric indices, glycemic control, lipid profile, renal indices, blood pressure and periodontal status.

Variable	Physical activity	
	Correlation coefficient	P-value[a]
Weight (kg)	- 0.25	< 0.001
BMI (kg/m2)	- 0.25	< 0.001
WC (cm)	- 0.6	< 0.001
HC (cm)	- 0.47	< 0.001
FBG (mg/dL)	- 0.55	< 0.001
HbA1c %	- 0.56	< 0.001
TG (mg/dL)	0.11	0.11
Chol (mg/dl)	0.09	0.17
HDL (mg/dl)	0.04	0.49
LDL (mg/dl)	- 0.02	0.7
LDL.HDL	- 0.04	0.54
eGFR (mL/min/1.73m^2)	0.001	0.99
BUN (mg/dL)	- 0.05	0.48
Cr (mg/dL)	- 0.08	0.25
Albuminuria (mg/24 h)	- 0.36	< 0.001
SBP (mmHg)	- 0.14	0.04
DBP (mmHg)	- 0.1	0.13
CAL (mm)	- 0.61	< 0.001
PD (mm)	- 0.55	< 0.001

P < 0.05 was considered as significant.
[a] Correlation and significant with Pearson-test.

Table 3
The relationship between physical activity with FBG and HbA1c (dependent variables).

Model 1	B	R Square	(95% CI)	P-value[a]
FBG (mg/dL)	−0.34	0.03	(-0.073, 0.005)	0.08
HbA1c %	−0.001	0.016	(-0.003, 0.001)	0.21
Model 2				
FBG (mg/dL)	−0.038	0.047	(-0.078, 0.001)	0.05
HbA1c %	−0.001	0.036	(-0.003, 0.001)	0.19
Model 3				
FBG (mg/dL)	−0.36	0.051	(-0.078, 0.006)	0.09
HbA1c %	−0.001	0.085	(-0.003, 0.000)	0.097

[a] P < 0.05 statistically significant by linear regression. Model 1: unadjusted, Model 2: adjusted for glucose-lowering drugs (mg/dL), Model 3: adjusted for glucose-lowering drugs (mg/dL) and weight, WC, HC, BMI.

4. Discussion

In the present study, a significant inverse relationship was observed between physical activity and weight, BMI, WC, HC, FBS, HbA1c, albuminuria, SBP and periodontal indices. The results of this study also showed a significant relationship between periodontal quantitative indices including CAL and PD, and anthropometric parameters (weight, WC, HC and BMI), glycemic control indices, HDL level, LDL/HDL, creatinine, SBP and excretion of albumin. In addition, a significant direct relationship was found between anthropometric parameters (weight, WC, HC and BMI), FBS, HbA1c, albuminuria, creatinine and blood pressure.

4.1. Physical activity and other variables

Havingphysical activity indirectly reduces the risk of T2DM through reducing body weight or improving body fat distribution (Blair, 1993). The mechanism through which physical activity improves insulin sensitivity can be a result of increased insulin delivery with improving blood flow to the muscles, increasing levels and replacing the muscles' glucose transporter (GLUT-4), and increasing the activity of glycogen synthase enzyme, which causes increased synthesis of glycogen and glucose disposition (Mayer-Davis et al., 1998). In addition, physical activity improves insulin sensitivity by reducing adipose tissue mass

Table 4
The relationship between periodontal status with anthropometric indices, glycemic control, lipid profile, renal indices and blood pressure.

Variable	CAL		PD	
	Correlation coefficient	P-value[a]	Correlation coefficient	P-value[a]
Weight (kg)	0.35	< 0.001	0.34	< 0.001
BMI (kg/m2)	0.44	< 0.001	0.41	< 0.001
WC (cm)	0.84	< 0.001	0.78	< 0.001
HC (cm)	0.65	< 0.001	0.53	< 0.001
FBG (mg/dL)	0.8	< 0.001	0.71	< 0.001
HbA1c %	0.81	< 0.001	0.74	< 0.001
TG (mg/dL)	- 0.09	0.16	- 0.11	0.12
Chol (mg/dl)	- 0.08	0.24	- 0.06	0.38
HDL (mg/dl)	- 0.2	0.005	- 0.28	< 0.001
LDL (mg/dl)	0.1	0.13	0.11	0.1
LDL.HDL	0.15	0.03	0.2	0.004
eGFR (mL/min/1.73m^2)	- 0.06	0.38	- 0.1	0.13
BUN (mg/dL)	0.08	0.22	0.17	0.01
Cr (mg/dL)	0.19	0.005	0.17	0.01
Albuminuria (mg/24 h)	0.55	< 0.001	0.47	< 0.001
SBP (mmHg)	0.24	0.001	0.23	0.001
DBP (mmHg)	0.21	0.002	0.23	0.001

P < 0.05 was considered as significant.
[a] Correlation and significant with pearson-test.

(Blair, 1993). In the present study, a significant inverse correlation was found between physical activity and albuminuria. A study reported that albuminuria increased by 11% in subjects who had low physical activity at baseline and during a 5-year review, but increased by 5% in those who had little physical activity at the beginning of the study but increased it during the follow-up. In patients with diabetes, an increase in physical activity was significantly associated with a decrease in albuminuria (Robinson et al., 2010), which was consistent with the results of our study. But this relationship has not been observed in non-diabetic patients (Finkelstein et al., 2006). A possible mechanism for the effectiveness of physical activity on reducing albuminuria may be its effect on vascular endothelial through nitric oxide mediating. Renal endothelial damage is associated with increased urinary excretion of albumin (Ochodnicky et al., 2006). Nitric oxide is a vasorelaxant. Inhibition of nitric oxide synthase in rats caused albuminuria (Erdely et al., 2007). In the present study, a significant and inverse correlation was observed between the level of physical activity and SBP. Alessandra Teixeira Neto Zucatti et al. also found that in subjects with T2DM, a lower level of physical activity was associated with higher systolic blood pressure, although no difference was observed in DBP (Neto Zucatti et al., 2017). The results of the studies regarding the relationship between physical activity and periodontitis are contradictory. In Alzahrani study, a significant relationship was observed between the increase in physical activity and lower prevalence of periodontitis among non-smokers and former smokers (Al-Zahrani et al., 2005). Merchant et al. also reported a relationship between the high level of physical activity and reduced risk of PD (Merchant et al., 2003). While in two cross-sectional studies in Japan and Finland, no relationship was observed between the level of physical activity and periodontal disease. It is worth mentioning that both of these studies had small sample sizes. In addition, physical activity questionnaire used in these studies seemed limited and had not covered all aspects of physical activity (Sakki et al., 1995; Shizukuishi et al., 1998).

4.2. Periodontal status and other variables

In the present study, a significant relationship was observed between periodontal status and anthropometric parameters (weight, WC, HC and BMI) ($p < 0.001$). In a study by Khader et al., those with BMI > 30 kg/m^2 showed periodontitis three times more than those with normal weight (Khader et al., 2009). A study by Al-Zahrani also showed that subjects with BMI > 30 kg/m^2 had significantly increased risks for periodontitis (Al-Zahrani et al., 2003). Our study is consistent with the findings of these studies. In a study by Khader et al. (Saito et al., 2001), the mean CAL was significantly higher in obese and overweight subjects, which was similar to the results Saito (Saito et al., 2001) and Wood (Wood et al., 2003) reported in their studies. Reeves showed that every 1 cm increase in WC was associated with a 5% increase in the risk of periodontitis (Reeves et al., 2007). The relationship between increased risk of periodontitis and increased WC has also been proven by AL-Zahrani (Al-Zahrani et al., 2003) and Khader (Khader et al., 2009). There is still now effective biological mechanism to explain the relationship between obesity and periodontitis, although cytokines and lipid-derived hormones may play a key role (Kershaw and Flier, 2004). Obesity can affect the host's immune system, and this effect can lead to increasing the thickness of the periodontal intima and thereby reducing the blood flow of the periodontal tissues (Tanaka et al., 1993). Inflammatory mediators, especially IL-6 and TNF-α, which are released from periodontal tissues in response to bacteria and inflammation, enter the bloodstream and finally reduce insulin sensitivity by binding to insulin receptors. Acute bacterial infection increases insulin resistance by 33% and infection removal reduces it by 28% (Southerland et al., 2005). In the present study, a significant relationship was observed between serum FBS level, HbA1c percentage, CAL and PD ($P = 0.001$). Contrary to our findings, in a study conducted on

Table 5
The relationship between anthropometric indices with glycemic control, lipid profile, renal indices and blood pressure.

Variable	Weight		BMI		WC		HC	
	Correlation coefficient	P-value[a]	Correlation coefficient	P-value[a]	Correlation coefficient	P-value[a]	Correlation coefficient	P-value[a]
FBG (mg/dL)	0.39	< 0.001	0.41	< 0.001	0.79	< 0.001	0.6	< 0.001
HbA1c %	0.34	< 0.001	0.37	< 0.001	0.76	< 0.001	0.54	< 0.001
TG (mg/dL)	0.05	0.4	0.003	0.97	- 0.07	0.32	- 0.07	0.28
Chol (mg/dl)	0.08	0.24	0.06	0.37	- 0.04	0.51	- 0.06	0.39
HDL (mg/dl)	- 0.12	0.08	- 0.17	0.01	- 0.23	0.001	- 0.05	0.41
LDL (mg/dl)	0.17	0.01	0.19	0.006	0.12	0.07	0.11	0.11
LDL.HDL	0.15	0.02	0.2	0.004	0.19	0.005	0.11	0.12
eGFR (mL/min/1.73m^2)	- 0.17	0.01	- 0.11	0.1	- 0.08	0.24	- 0.02	0.73
BUN (mg/dL)	0.02	0.71	0.1	0.13	0.13	0.057	0.01	0.89
Cr (mg/dL)	0.16	0.02	0.14	0.04	0.19	0.006	0.17	0.01
Albuminuria (mg/24 h)	0.27	< 0.001	0.3	< 0.001	0.53	< 0.001	0.46	< 0.001
SBP (mmHg)	0.09	0.19	0.16	0.02	0.25	< 0.001	0.24	0.001
DBP (mmHg)	0.12	0.08	0.15	0.03	0.22	0.001	0.23	0.001

P < 0.05 was considered as significant.
[a] Correlation and significant with pearson-test.

Indonesian population, no relationship was observed between periodontitis variables and HbA1C in patients with diabetes (Susanto et al., 2012), which could be due to the effect of oral hypoglycemic agents used by patients. Katia L. Costa et al. showed that the progression of periodontitis was associated with an increase in HbA1c in patients with diabetes (Costa et al., 2017b). Khanuja et al. also found that T2DM patients with healthy periodontal status had lower levels of HbA1c than those with PD (Khanuja et al., 2017). The results of the present study were consistent with these studies. In the present study, a significant inverse relationship was observed between periodontal status and HDL levels. In the study by Bittu Saira Koshy, those with chronic periodontitis showed an increase in serum cholesterol and LDL levels (Koshy and Mahendra, 2017), while in our study, no significant relationship was found between periodontal status, total cholesterol and LDL levels. Lui Wuy (Liu et al., 2010) and Pussion (Pussinen and Mattila, 2004), reported that chronic periodontitis was associated with a reduction in HDL concentration. The present study results were consistent with the results of this sutdy. These findings can be attributed to the effects of lipid metabolism, applied by liposaccharide and pro-inflammatory cytokines release induced by periodontal inflammation (Sandi et al., 2014). In the present study, no significant relationship was found between TG levels and periodontal status. While in Bittu Saira Koshy study, TG levels were significantly higher in subjects with chronic periodontitis (Koshy and Mahendra, 2017). Increased levels of TG in subjects with periodontitis have been reported in a meta-analysis (Nepomuceno et al., 2017). In this study, LDL/HDL ratio was significantly associated with periodontal status. However, the results of Korhonen et al. study, contrary to our findings, showed that there was no correlation between periodontal status and LDL/HDL ratio (Korhonen et al., 2011). This difference could be due to differences in the studied groups. Korhonen's study population consisted of healthy subjects with normal weight or overweight. While the participants of the present study were patients with diabetes, and a complex relationship was found between diabetes and dyslipidemia. CAL represents the history of periodontitis, while PD represents the current inflammatory state of the periodontal tissue (Kushiyama et al., 2009). In our study, a significant relationship was observed between BUN level, creatinine, excreted albumin in the urine and periodontal status (PD, CAL). The study by Li-Ping Chen et al. showed that severe periodontitis is associated with poor nutritional status, such as low levels of serum albumin, transferrin, BUN, and creatinine (Chen et al., 2006). In the present study, a significant relationship was observed between periodontal status and SBP and DBP ($p = 0.001$). Consistent with our study, Zeigler et al. concluded that adults with PD ≥ 4 mm had significantly higher DBP ($p = 0.008$) (Zeigler et al., 2015). According to the results from another study, high blood pressure was significantly associated with pocket depth in subjects with metabolic syndrome (Kushiyama et al., 2009).

4.3. Anthropometric indices and other variables

In the present study, a positive significant relationship was found between weight, WC, HC, BMI, FBS and HbA1c. A meta-analysis showed that a 5% weight loss has beneficial effects on HbA1c (Franz et al., 2015). Also, a significant relationship was found between weight, WC, HC, BMI, creatinine and albuminuria levels. Abdominal obesity has been shown to be a risk factor for the initial increase of albuminuria, independent of blood glucose, blood pressure and kidney function (Shaw et al., 2007). A prospective study showed that increasing WC independent of other risk factors could cause an increase in albuminuria (Al-Zahrani et al., 2005). In a study that followed up patients with T2DM for one year, it was shown that every 5 cm increase in WC at baseline and each unit increase in BMI during the follow-up period, increased the risk of ACR progression (urine albumin/creatinine) by 7% and 17%, respectively (Merchant et al., 2003). In the present study, a significant relationship was observed between WC, HC, BMI and SBP and DBP, but no significant relationship was shown with weight. These results were consistent with Taing KY study in which the relationship between central obesity (mainly WC and WC/height ratio) and hypertension was slightly stronger than the relationship between BMI and high blood pressure (Taing et al., 2016). Ehud Chorin et al. found that in adults, BMI was significantly associated with SBP and DBP in both genders and in normal and overweight subjects (Chorin et al., 2015). The results of the present study were similar to the results of these studies.

5. Conclusion

The results of the present study suggest that reducing metabolical and anthropometric parameters can improve the risk of periodontal status in T2DM patients with PD.

Conflicts of interest

The authors have declared that there is no conflict of interest.

Declarations of interest

None.

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