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**DIFFERENCES IN SALIVARY VOLUME, PH, AND ORAL CONDITIONS OF
 DIABETES MELLITUS AND NON-DIABETES MELLITUS PATIENTS**

Dahlia Salsa Farhani¹⁾, Sri Tjahajawati^{2)*}, Anggun Rafisa²⁾

¹⁾ Faculty of Dentistry, Padjadjaran University, Sumedang, Indonesia

²⁾ Department of Oral Biology, Faculty of Dentistry, Padjadjaran University, Sumedang, Indonesia

ABSTRACT

Background: The Prevalence of diabetes mellitus (DM) has been increasing over the past decades. DM is a chronic metabolic disease characterized by persistent hyperglycemia, which impacts various body systems, including the oral cavity. It affects salivary volume, salivary pH, and oral health, leading to conditions such as xerostomia, gingivitis, dental caries, and ulceration. **Purpose:** This study aimed to determine the differences in salivary volume, salivary pH, and oral conditions in DM patients and non-DM. **Methods:** This study was an analytic comparative using secondary data from the result of Unpad Lecturer Competency Research (RKDU) by a consecutive sampling of 22 DM women and 22 non-DM women. The numerical data were analyzed using t test or Mann-Whitney test and the categorical data were analyzed using z proportion test with a significance level of $p < 0,05$. **Results:** The results showed that there were significant differences in salivary volume ($p = 0,0001$), salivary pH ($p = 2,54E-05$), xerostomia ($p = 0,01$), and dental caries ($p = 0,007$), and there were no significant differences in gingivitis ($p = 0,216$) and ulceration ($p = 0,154$) in DM group and non-DM group. **Conclusion:** There are differences in salivary volume, salivary pH, and the conditions of xerostomia and dental caries, but there are no differences in the conditions of gingivitis and ulceration in DM patients and non-DM. The differences in saliva and oral conditions are caused by autonomy neuropathy, dehydration, alteration in vascularization and immune response, increasing salivary glucose level, and drug consumption.

Keywords : Diabetes mellitus, Oral conditions, Salivary pH, Salivary volume, Women

***Correspondence:** Sri Tjahajawati; Department of Oral Biology, Padjadjaran University, Jl. Raya Bandung Sumedang KM.21, Hegarmanah, Kec. Jatinangor, Kabupaten Sumedang, Jawa Barat, 45363, Indonesia; E-mail sri.tjahajawati@fkg.unpad.ac.id

INTRODUCTION

Diabetes mellitus (DM) is one of the four priority non-communicable diseases whose prevalence has been continuously increasing over the past few decades, especially among adults.^{1,2} The Basic Health Research (Riskesdas) reported an increase in the prevalence of diabetes in Indonesia for individuals aged 15 and above, by 0.5%, from 1.5% in 2013 to 2% in 2018.³ One of the factors driving the change in diabetes prevalence in many countries today is the significant shift towards a sedentary lifestyle, which increases the risk of overweight or obesity and leads to insulin resistance.^{1,2,4} According to gender, diabetes is more commonly experienced by women than men. Riskesdas reported an increase in the prevalence of diabetes in women from 2013 to 2018, while the prevalence of diabetes in men showed a decrease.³ DM is characterized by elevated blood sugar levels above the normal threshold (hyperglycemia).^{1,4} Chronic hyperglycemia causes complications in various parts of the body, including the oral cavity. The severity of the complications typically depends on the degree and duration of hyperglycemia. Oral manifestations among individuals with DM are notably high. The pathogenesis that leads to microvascular complications in DM patients also appears to play a role in oral complications.^{5,6}

Salivary dysfunction, commonly found in individuals with DM, leads to hyposalivation and xerostomia, causing dry mouth, taste disturbances, burning sensations, and halitosis.^{5,7,8,9} Reduced saliva flow also lowers saliva pH, creating an acidic environment that increases the risk of dental caries and periodontal disease.^{8,10} Furthermore, DM patients experience weakened antimicrobial protection and slower wound healing due to impaired immunity and vascularization, making them more susceptible to oral infections.^{5,8,11}

Previous studies have reviewed differences in saliva and oral conditions between DM and non-DM patients, but none have simultaneously examined saliva volume, saliva pH, and overall oral health. This study aims to identify potential differences in these factors to detect early changes leading to oral complications. The findings are expected to contribute to dental literature and support public education on oral health in DM patients.

METHODS

This study is a comparative analytical research using secondary data from the 2018-2019 Lecturer Competency Research (RKDU) at Unpad. The population consists of women with diabetes mellitus (DM) and women without DM from the Jatinangor and Sekeloa areas in Bandung, based on secondary data. The sampling technique used is consecutive sampling. The inclusion criteria for the DM group are women with type 2 DM who have an HbA1c value of $\geq 6.5\%$ and are aged between 20 and 79 years. The inclusion criteria for the non-DM group are women without DM who have an HbA1c value of $\leq 5.6\%$ and are aged between 20 and 79 years. The exclusion criteria for this study include subjects with incomplete data, smokers, and those who consume alcohol. A total of 22 women with DM and 22 women without DM were included in the study.

Primary data collection for saliva volume in the RKDU study was conducted by the spitting method. Saliva pH was measured by placing a test paper in the subject's mouth for two minutes. Oral conditions were assessed through a direct examination by the research team. This examination was conducted with limited contact to minimize direct interaction during the COVID-19 transition period. All secondary data collected were processed and analyzed statistically to identify differences between individuals with diabetes mellitus (DM) and those without DM. Numerical data were first tested for normality using the Liliefors test. Normally distributed numerical data were analyzed using a t-test, while data that were not normally distributed were analyzed using the Mann-Whitney test. Categorical data were analyzed using a z-proportion test. The significance level used was a p-value with a 95% confidence interval. If $p < 0.05$, a difference was considered significant; if $p > 0.05$, no difference was found. The research was conducted from February to June 2022 in Bandung City. This study received approval from the Ethical Research Committee (KEP) of Universitas Padjadjaran with the approval number 342/UN6.KEP/EC/2022, dated April 7, 2022.

RESULTS

Table 1. Age and systemic conditions of DM and non-DM patients

	DM (n = 22)	Non-DM (n = 22)	Statistic test	p-Value
	Mean $\pm$ SD	Mean $\pm$ SD		
Age (year)	54,27 $\pm$ 9,61	27,09 $\pm$ 6,12	t = - 11,190	3,52E- 14*
Systemic Conditions				
Blood Glucose (mg/dl)	240,36 $\pm$ 73,10	98,32 $\pm$ 18,48	t = -8,960	5,82E- 09*
Systol (mmHg)	143,18 $\pm$ 33,19	102,59 $\pm$ 11,01	t = -5,445	1,18E- 05*
Diastol (mmHg)	85,77 $\pm$ 15,07	71,18 $\pm$ 8,23	z = -3,588	0,0003*

*Significance (p-Value = $p < 0,05$)

SD: standar deviation

Table 1 shows the results of statistical analysis using the t-test (age, random blood glucose, systolic blood pressure) and the Mann-Whitney test (diastolic blood pressure) for individuals with diabetes mellitus (DM) and without DM. The analysis results indicate a significant difference in age and systemic conditions, including random blood glucose, systolic blood pressure, and diastolic blood pressure, between DM and non-DM individuals, as evidenced by a p-value < 0.05 .

Table 2. Saliva volume and pH in DM and non-DM patients

	DM (n = 22)	Non-DM (n = 22)	Statistic test	p- Value
	Mean ± SD	Mean ± SD		
Volume (mL / 5 minutes)	1,04 ± 0,43	2,1 ± 0,97	t = 4,692	0,000 1*
pH	5,89 ± 0,51	6,68 ± 0,48	z = 4,211	2,54E- 05*

*Significance (p-Value = p<0,05)

SD: standar deviation

Table 2 shows the results of statistical analysis using the t-test (saliva volume) and the Mann-Whitney test (saliva pH) for individuals with diabetes mellitus (DM) and without DM. The analysis results indicate a significant difference in saliva volume and pH between DM and non-DM individuals, as evidenced by a p-value < 0.05.

Table 3. Oral conditions of DM and non-DM patients.

	Xerostomi a	Gingivitis	Caries	Ulcerati on
DM				
n	22	22	22	22
x	11	5	16	4
%	50%	23%	73%	18%
P(x)	0,50	0,23	0,73	0,18
Non-DM				
n	22	22	22	22
x	3	2	7	1
%	14%	9%	32%	5%
P(x)	0,14	0,09	0,32	0,05
P(x) gab	0,32	0,16	0,52	0,11
z-test	-2,589	-1,237	-2,716	-1,425
p-Value	0,01*	0,216	0,007 *	0,154

*Significance (p-Value = p<0,05)

Table 3 shows the results of statistical analysis using the z-proportion test for oral conditions, including xerostomia, gingivitis, dental caries, and ulceration in DM and non-DM patients. The analysis results indicate a significant difference in the conditions of xerostomia and dental caries between DM and non-DM patients, as evidenced by a p-value < 0.05. However, no significant difference was found in the conditions of gingivitis and ulceration between DM and non-DM patients, as indicated by a p-value > 0.05.

DISCUSSION

Women with diabetes mellitus (DM) in this study had an average age of 54.273 ± 9.612 . In this age range, women experience menopause that occurs due to a decrease in ovarian hormone secretion, specifically estrogen and progesterone.¹² Estrogen and progesterone play roles in influencing the body's cellular response to insulin and in enhancing insulin sensitivity. After menopause, hormonal changes in the body lead to decreased insulin levels, which in turn raises blood glucose levels.^{12,13} Age is an important risk factor in the development of diabetes mellitus. Seventy-five percent of diabetes cases in developing countries occur in individuals aged 45 and older. This indicates that the older a person is, the higher the risk of developing diabetes.^{3,14} Hyperglycemia in older adults occurs due to insulin secretion deficiency caused by a reduced sensitivity of pancreatic β -cells to incretins, leading to lower insulin production and weakened suppression of glucagon.¹⁵

Diabetes Mellitus (DM) can be diagnosed through random blood glucose (RBG) measurement.^{1,4} The average RBG value for the DM group in this study was 240.36 ± 73.10 . This value is consistent with

the diagnostic criteria for DM based on RBG levels according to the American Diabetes Association (ADA) and the Consensus on Management and Prevention of Type 2 DM in Indonesia, which is ≥ 200 mg/dL.^{3,4}

The DM group in this study had significantly higher systolic and diastolic blood pressure compared to the non-DM group ($p = 1.18E-05^*$; 0.003^*). Hypertension is a complication that occurs in 50% to 80% of patients with type 2 DM.¹⁶ Hyperinsulinemia associated with insulin resistance stimulates the production of the vasoconstrictor endothelin-1 (ET-1), which contributes to vascular insulin resistance, excessive arterial stiffening, and ultimately raises blood pressure.^{16,17} High blood glucose concentrations form Advanced Glycation End-products (AGEs) and trigger inflammatory reactions, which cause leukocytes and platelets to aggregate into clots, resulting in blockages that raise blood pressure.¹⁸

Saliva Volume

The analysis of saliva volume showed a significant difference between the DM and non-DM groups ($p = 0.0001^*$). Research by Verhulst et al. indicates that dry mouth is one of the most common complaints among DM patients.⁵ A study by López-Pintor showed that the prevalence of hyposalivation in DM patients is much higher compared to non-DM individuals.¹⁹ This can occur due to disrupted oral homeostasis caused by imbalances in water and electrolyte regulation, leading to increased diuresis and reduced extracellular fluid volume, which can affect saliva production.^{8,11,20}

The reduction in saliva volume is also related to factors like angiopathy and neuropathy.¹⁸ Saliva secretion is regulated by the autonomic nervous system, so autonomic neuropathy will affect the function of autonomic nerves, which in turn affects the performance of salivary glands and leads to decreased saliva secretion.^{7,8,21}

Saliva pH

The analysis of saliva pH in both groups showed a significant difference ($p = 2.54E-05^*$), with the saliva pH of the DM group (5.886 ± 0.510) being lower compared to the non-DM group (6.682 ± 0.477). This finding aligns with research by Seethalakshmi et al., which showed that the saliva pH in DM patients is lower than in non-DM individuals.¹⁰ DM patients with high HbA1c levels have a greater risk of developing angiopathy, which can lead to decreased saliva secretion and lower saliva pH.^{8,22} The decrease in saliva pH in DM patients can also be caused by metabolic acidosis in all body fluids, including saliva, due to a reduction in bicarbonate levels.¹⁰

Xerostomia

The analysis of xerostomia conditions showed a significant difference between the two groups ($p = 0.01^*$), with the percentage of the DM group (50%) being higher compared to the non-DM group (14%). This is consistent with research by Hoseini et al., which showed that xerostomia is more prevalent in DM patients compared to healthy individuals.²³ Xerostomia in DM patients can be caused by changes in saliva composition (high levels of protein, potassium, and glucose), autonomic neuropathy, dehydration, or long-term medication use such as metformin.^{21,24-26} Xerostomia leads to a range of physical, psychological, and social problems, negatively impacting the quality of life of affected individuals.^{5,8}

Gingivitis

The analysis of gingivitis conditions showed no significant difference ($p = 0.216$) between the DM group (23%) and the non-DM group (9%). This contradicts the study by Seethalakshmi et al., which showed that DM patients had a higher incidence of gingivitis compared to the non-DM group.¹⁰ DM patients with poor metabolic control and a longer disease duration are at higher risk and greater severity of periodontal disease.^{11,27}

Chronic hyperglycemia increases the production of Advanced Glycation End-products (AGEs) in the periodontal tissues, triggering the release of pro-inflammatory cytokines, resulting in collagen degradation and periodontal tissue damage, which can lead to mobility and tooth loss in DM patients.^{8-11,27} Neutrophil dysfunction and hyposalivation exacerbate plaque bacterial accumulation, increasing the risk of periodontal disease, especially in patients with poor glycemic control.^{5,8,10,11} Some studies suggest that periodontal treatment can reduce HbA1c and inflammatory biomarkers, thus helping improve glycemic control in DM patients.^{9,11}

Tooth Decay (Caries)

The analysis of tooth decay (caries) in both groups showed a significant difference ($p = 0.007^*$), with the DM group (73%) having a higher percentage compared to the non-DM group (32%). This finding is consistent with research by Malvania et al., which showed that the prevalence of tooth decay is higher in the DM group compared to the non-DM group.²⁸

Xerostomia in DM patients reduces the self-cleansing action of saliva, leading to plaque accumulation and an acidic environment that promotes the proliferation of cariogenic bacteria, such as *Streptococcus mutans* and *Lactobacillus acidophilus*, thereby increasing the risk of tooth decay.^{8,10,29,30} The reduced antimicrobial effects of saliva, due to decreased lactoferrin and lysozyme, exacerbate this condition

along with high glucose levels in saliva that accelerate carbohydrate fermentation by oral bacteria.^{10,11,28} The prevalence of caries is higher in DM patients with poor metabolic control, so effective diabetes management through a high-fiber, low-simple carbohydrate diet can help inhibit the growth of cariogenic bacteria and plaque production.^{28,30}

Ulceration

The analysis of ulceration showed no significant difference ($p = 0.154$) between the DM group (18%) and the non-DM group (5%). This contrasts with the study by González-Serrano et al., which showed that the prevalence of oral mucosal disorders in DM patients is statistically higher than in non-DM individuals.³¹ Research by Silva et al. showed a high prevalence of oral mucosal lesions in DM patients, with ulceration being the most commonly found lesion.³² Recurrent Aphthous Stomatitis (RAS) is commonly found in DM patients and may be linked to changes in immune response, increased glucose levels in saliva, and xerostomia, which hinders wound healing.^{5,31,32} DM can also be a risk factor for the development of Necrotizing Ulcerative Gingivitis (NUG) or Necrotizing Ulcerative Periodontitis (NUP) due to impaired neutrophil function in controlling infections.⁷

Hormonal changes in women, particularly during menopause, can affect the condition of the oral cavity. Estrogen and progesterone hormones influence blood supply to the gingival tissues and the body's response to toxins from dental plaque, thus modulating the periodontal tissue's response to microbes and contributing to the development of periodontal disease.³³ Postmenopausal women also experience hormonal changes and physiological aging, leading to salivary gland hypofunction, which results in decreased saliva volume and pH.³⁴

The condition of saliva and the oral cavity in the DM and non-DM groups is influenced by various factors such as economic status, education, and individual environmental factors. These factors may explain why the study did not show a significant difference in gingivitis and ulceration conditions between the two groups. Limitations of this study include the lack of demographic data collection (occupation, educational history, and knowledge level) and the use of secondary data, which prevented direct examination of the subjects' oral cavity.

Future research could explore other aspects of saliva and oral cavity conditions in DM patients using primary data, such as saliva samples and direct examinations, while also incorporating demographic data. Healthcare professionals, particularly dentists, are encouraged to take preventive and curative actions against oral complications in DM patients and provide education about the risks and the importance of regular check-ups. DM patients are advised to maintain oral hygiene, follow a healthy diet, and regularly visit the dentist to improve oral health and quality of life.

Based on the study, it can be concluded that there are differences in saliva volume and pH, as well as conditions of xerostomia and tooth decay, but no significant differences were found in gingivitis and ulceration conditions between DM and non-DM patients. These changes in saliva and oral conditions are caused by autonomic neuropathy, changes in vascularization and immune response, increased glucose levels in saliva, and medication use.

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