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Research Paper

Evaluation of the effect of physical exercise on the periodontal status of diabetics in a Nigerian Teaching Hospital.

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ABSTRACT

Introduction*- Periodontitis and Diabetes are bidirectionally related, and both are also globally prevalent. Studies reported that physical exercise lowers the effect of inflammatory mediators in both conditions.*

Objective*- To evaluate the effects of physical exercise on the periodontal status of diabetics in a Nigerian tertiary hospital.*

Methodology*: This was a cross-sectional study conducted in the Endocrinology unit of the Department of Medicine at the Lagos State University Teaching Hospital (LASUTH), Ikeja, Lagos, Nigeria.*

Data collection was conducted using a self-administered questionnaire. This was used to obtain the biodata and data on the participants' smoking habits, physical exercise, type of physical exercise, body mass index (BMI), Oral hygiene index (OHI) score and community periodontal index for treatment need (CPITN). Data analysis was carried out using SPSS version 24. Appropriate statistics were determined for the continuous and categorical variables. Pearson's chi-square analysis and ordinal logistic regression were used to assess the relationship between the covariates and the periodontal status of the participants. Statistical significance was determined at $p \leq 0.05$.

Results*- A total of 220 diabetics partook in this study; their mean age was 58.7±13.5, ranging from 13 to 90 years old. The mean HbA1c of the participants was 6.5±3.5. Physical exercise was significantly associated with the periodontal status of the participants (p = 0.005) OR 0.92, 95% CI .281-1.564. Participants who engage in regular physical exercise had a higher prevalence of healthy periodontium 11(7.9%), those who do not had a higher prevalence of mild to moderate 23(28.8%) and severe periodontitis 7(8.8%). The oral hygiene status of the participants had a significant association with their periodontal status. Good oral hygiene (p=0.005) OR-1.309, 95% CI -2.22- -.430, and fair oral hygiene (p=0.002) OR -1.203, 95% CI -1.950- -.455.*

Conclusion *- It is noteworthy from this study that physical exercise has a beneficial effect in lowering the prevalence and severity of periodontitis in diabetics. Diabetic patients should incorporate physical exercise into their daily routine, as this will improve their periodontal health and glycaemic control.*

Keywords: *Physical activity, Exercise, Diabetes, Diabetics, Periodontal status, Periodontitis.*

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I. INTRODUCTION

Periodontitis is an inflammatory disease characterized by the accumulation of dental biofilm on the tooth[1-4]. This initiates a host-mediated immune response that eventually leads to destruction of the periodontal tissues[1,2]. The inflammatory response involves interactions between virulence factors of bacteria and immune mechanisms of the host, resulting in connective tissue destruction, alveolar bone resorption, tooth mobility, tooth migration, and eventual tooth loss[1,2,3]. Periodontal disease is one of the most common chronic diseases worldwide, with periodontitis affecting more than 60% adults , and almost a quarter of these having a severe form. It is also the second most common oral disease[4]. Periodontitis is more than a localised infection of the periodontium; it also initiates a systemic inflammatory reaction. There is a higher titer of inflammatory markers such as tumour necrosis factor-α, interleukin-6 and C-reactive protein in individuals with periodontitis than in individuals without periodontitis[2,5,6].

Periodontitis and diabetes mellitus are both bidirectionally related and globally prevalent conditions, and periodontitis has been termed the 6th complication of Diabetes mellitus[7,8,9]. Individuals with uncontrolled Diabetes are 2-3 times more prone to having periodontitis, just as periodontitis can worsen glycemic control in diabetics[7,8]. The mechanisms behind this relationship involve inflammatory reactions, dysregulated immune functions, and microbial imbalance[9,10]. Cytokines, chemokines, and prostaglandins are important inflammatory mediators in the pathogenesis and progression of both diseases[9]. Altered immune responses in diabetes can heighten inflammation in periodontitis, resulting in enhanced soft-tissue and alveolar bone destruction[9,10,11]. Periodontal inflammation can exacerbate insulin resistance and impaired glycemic control in diabetic patients, whereas several studies have reported that periodontal treatments that reduce periodontal inflammation improve glycated haemoglobin levels[10,11].

While bacterial biofilm and host immune response are known key factors in periodontal pathogenesis, the impact of lifestyle factors such as diet and physical activity have received research attention, as studies suggest a relationship between physical activity and periodontal health[12-18]. Physical activity (PA) is defined as bodily motion mediated by skeletal muscles that requires an increase in energy expended when compared to levels at rest[12,13]. The World Health Organization (WHO) prescribed 150 min moderate exercise weekly to lower the prevalence of chronic diseases, including periodontitis[14,17]. The relationship between PA and inflammatory conditions, such as periodontitis, is thought to be mediated by the modulation of inflammation [12-15]. Studies suggest beneficial effects of physical activity in stress reduction, lowering systemic inflammation and fat tissues, improved blood circulation, insulin sensitivity and musculoskeletal health[15-17]. Adequate physical activity is known to lower levels of inflammatory mediators such as C-reactive protein levels, serum tumor necrosis factor-alpha, interleukin-6, and interleukin-8, reduce alveolar bone loss, and inhibit epithelial attachment loss, which supports periodontal health[12,13,18].

The global burden of periodontitis and the increased prevalence in diabetics demand a concerted effort in their management, including physical exercise. Therefore, this study is to assess the relationship between physical activity and periodontal disease among diabetics in a tertiary hospital in Lagos, Nigeria.

II. METHODOLOGY

The study was conducted in the Endocrinology unit of the Department of Medicine at the Lagos State University Teaching Hospital (LASUTH), Ikeja, Lagos, Nigeria. LASUTH is a public referral hospital and an institution established for the training of medical, dental and other allied medical specialities located in Lagos, Nigeria.

This was a cross-sectional study involving 220 diabetic patients; 73 were male, and 147 were female. Convenient sampling technique was employed for the sample selection. The inclusion criteria included consenting participants aged 10 years and above who were known diabetics and were compliant in their clinic appointments. Participants who were pregnant, on antibiotic medications or who had a nonsurgical periodontal therapy or any major periodontal procedure within the previous 3 months were excluded from the study.

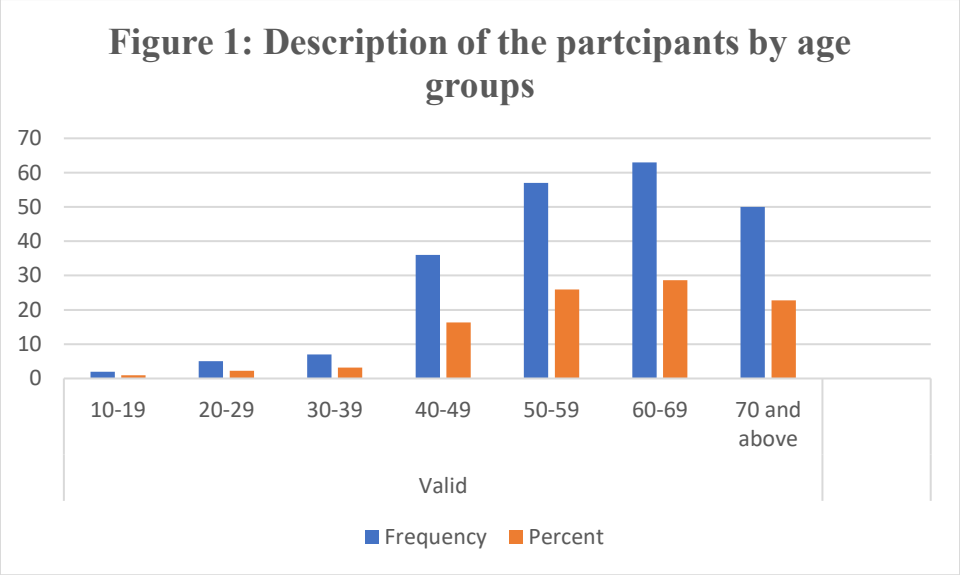
Data collection was conducted using a self-administered questionnaire, which comprised both open-ended and closed-ended questions. This was used to obtain the biodata such as age, sex, marital status, and educational status. It was also used to collect data on the participants' smoking habits, physical exercise, type of physical exercise, body mass index (BMI) and Oral hygiene index (OHI) score. The Oral hygiene index was graded as good when the score ranged from 0.1 to 1.2, fair when it ranged between 1.3 and 3.0, and poor when the score ranged between 3.1 and 6.0 Community periodontal index for treatment need (CPITN) index was used to assess the periodontal status of the participants with the use of the WHO probe. All the participants were examined by the primary researcher. A score of 0 was assessed as healthy periodontium, a score of 1 or 2 was assessed as gingivitis, a score of 3 was assessed as mild to moderate periodontitis and a score of 4 was assessed

as severe periodontitis. Written informed consent was obtained from the subjects before they participated in the study. Ethical approval for this research was obtained from the Health Research and Ethics Committee of Lagos State University Teaching Hospital (LASUTH).

Data analysis was carried out using SPSS version 24. For continuous descriptive variables, such as age, oral hygiene, body mass index and HbA1c the mean, measures of variability, minimum, and maximum were determined. While simple frequency and percentages were determined for categorical variables such as age groups, sex, marital and educational status, smoking habit, physical exercise, type of exercise, body mass index, oral hygiene index and CPITN. Pearson's chi-square analysis was carried out to determine the bivariate relationship of the covariates and the periodontal status of the participants (CPITN). Multivariate analysis was done using ordinal logistic regression to assess the relationship between the covariates and the periodontal status of the participants. Statistical significance was determined at $p \leq 0.05$.

III. RESULT

A total of 220 diabetics partook in this study; their mean age was 58.7±13.5, ranging from 13 to 90 years old. The majority were aged above 40 years, while the predominant age group was 60-69 years old, 63 (28.6%), followed by the 50-59 years old, 57(25.9%) (Figure 1). The mean HbA1c of the participants was 6.5±3.5. Table 1 shows that the male to female ratio was 1:2, most of the participants were married, 158(71.8%), followed by the widowed, 28(12.7%), and the least were the single, 16(73.%). The majority of the participants attained up to the tertiary level of education, 98(44.5%), 58(26.4%) attained up to secondary level of education, and those without formal education were the least, 12(5.5%). Fifteen (6.8%) reported that they smoke cigarettes. Most of the participants, 140(63.6%) participates in one form of physical exercise or another, with the majority, 92(41.8%), reportedly doing brisk walking regularly, followed by those involved in aerobics, 20(9.1%), and the least were those who carry out stretching exercises, 3(1.4%).



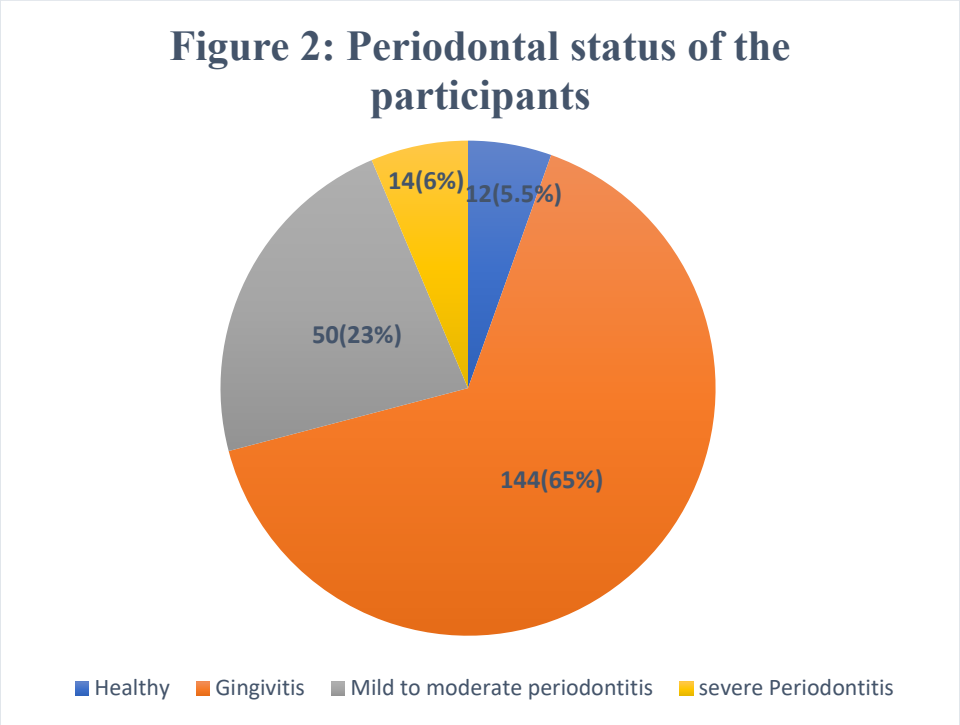


Table 1: Description of the variables.

Variable		Frequency (n)	Percentage (%)
Sex	Male	73	33.2
	Female	147	66.8
Marital status	Single	16	7.3
	Married	158	71.8
	Widowed	28	12.7
	Divorced	18	8.2
Education	Uneducated	12	5.5
	Primary	52	23.6
	Secondary	58	26.4
	Tertiary	98	44.5
Smoking	Yes	15	6.8
	No	205	93.2
Exercise	Yes	140	63.6
	No	80	36.4
Type of exercise	Stretching	3	1.4
	Walking	92	41.8
	Jogging	17	7.7
	Cycling	4	1.8
	Aerobics	20	9.1
	Dancing	4	1.8
Body mass Index (BMI)	Underweight	1	0.5
	Normal weight	69	31.4
	Overweight	91	41.4
	Obese	59	26.8
Oral hygiene Index (OHIS)	Good	50	22.7
	Fair	125	56.8
	Poor	45	20.5

The mean BMI of the participants was 27.5±5.1; the majority of them were overweight 91(41.4%), 59(26.8%) were obese, while 1(0.5%) was underweight. The mean OHI index score was 2.24±1.1; most of the participants had fair oral hygiene 125(56.8%), while 45(20.5%) had poor oral hygiene. Most of the participants, 144(65%), had CPITN of 2 (gingivitis), 50(23%) had CPITN of 3 (mild to moderate periodontitis) and 14(6.4%) had CPITN of 4 (severe periodontitis). Only 12(5.5%), presented with a healthy periodontium (Figure 2).

Table 2: Chi-square analysis of the variables and the periodontal status of the participants.

Variable		Healthy N (%)	Gingivitis N (%)	Mild to moderate periodontitis N (%)	Severe periodontitis N (%)	P value
Age(years)(n)	10-19 (2)	1(50)	1(50)	0	0	0.18
	20-29 (5)	0	5(100)	0	0	
	30-39 (7)	1(14.3)	5(71.3)	1(14.3)	0	
	40-49 (36)	1(2.7)	19(52.7)	14(38.9)	2(5.6)	
	50-59 (57)	2(3.5)	41(71.9)	10(17.4)	4(7)	
	60-69 (63)	6(9.5)	40(63.5)	12(19)	5(7.9)	
	≥70 (50)	1(2)	33(66)	13(26)	3(6)	
Sex	Male (73)	7(9.6)	47(64.4)	14(19.2)	5(6.9)	0.25
	Female (147)	5(3.4)	97(66)	36(24.5)	9(6.1)	
Marital status	Single (16)	1(6.3)	10(63)	5(31.3)	0	0.37
	Married (154)	10(6.5)	100(65)	30(19.5)	14(9.1)	
	Widowed (28)	1(3.6)	18(64.3)	9(32.1)	0	
	Divorced (20)	0	13(65)	7(35)	0	
Education	Uneducated (12)	2(16.7)	7(58.3)	3(25)	0	0.26
	Primary (52)	0	37(71.2)	10(19.2)	5(9.6)	
	Secondary (58)	2(3.5)	38(65.5)	16(27.6)	2(3.5)	
	Tertiary (98)	8(8.2)	62(63.3)	21(21.4)	7(7.1)	
Smoking	Yes (15)	0	8(53.3)	6(40)	1(6.7)	0.32
	No (205)	12(5.9)	136(67.3)	44(21.5)	13(15.1)	
Exercise	Yes (140)	11(7.9)	95(67.9)	27(19.3)	7(5)	**0.04***
	No (80)	1(1.3)	49(61.3)	23(28.8)	7(8.8)	
Type of exercise	Stretching (3)	0	3(100)	0	0	0.44
	Walking (92)	8(8.7)	61(66.3)	19(20.7)	4(4.4)	
	Jogging (17)	0	12(70.6)	3(17.7)	2(11.8)	
	Cycling (4)	0	3(75)	1(25)	0	
	Aerobics (20)	3(15)	14(70)	2(10)	1(5)	
	Dancing (4)	0	2(50)	2(50)	0	
Body mass index(BMI)	Underweight (1)	0	1(100)	0	0	0.88
	Normal weight (69)	4(5.8)	44(63.8)	14(20.3)	7(10.1)	
	Overweight (91)	5(5.5)	59(64.8)	24(26.4)	3(3.3)	
	Obese (59)	3(5.1)	40(67.8)	12(20.3)	4(6.8)	
Oral hygiene Index (OHIS)	Good (50)	4(8)	32(64)	11(22)	3(6)	**0.03***
	Fair (125)	7(5.6)	88(70.4)	26(20.8)	4(3.2)	
	Poor (45)	1(2.2)	24(53.3)	13(28.9)	7(15.6)	

Table 2 revealed that the association between age groups and periodontal status of the participants is not statistically significant (p>0.05). Though the prevalence of gingivitis was highest among the 50-59 years old, 41(71.9%), mild to moderate was highest among the 40-49 years old, 14(38.9%) and severe periodontitis was highest among the 60-69 years old, 5(7.9%). The females had a higher prevalence of gingivitis, 97(66%) and mild to moderate periodontitis, 36(24.5%), while the males had a higher prevalence of severe periodontitis, 5(6.9%). This was, however, not statistically significant (p>0.05). Prevalence of gingivitis was higher amongst the married 100(65%) and the divorced 13(65%); the divorced had the highest prevalence of mild to moderate periodontitis 7(35%). Marital status was not significantly associated with the periodontal status (p>0.05). The educational status of the participants was not statistically significant; those with a primary level of education had the highest prevalence of gingivitis, 37(71.2%), mild to moderate periodontitis was commonest among those with secondary level of education, 16(27.6%). None of the smokers had a healthy periodontium, while they also had a higher prevalence of mild to moderate periodontitis 6(40%), this association was not significant (p>0.05).

Physical exercise was significantly associated with the periodontal status of the participants (p=0.04). Participants who engage in regular physical exercise had a higher prevalence of healthy periodontium 11(7.9%) and gingivitis 95(67.9%), while those who do not participate in any physical exercise had a higher prevalence of mild to moderate periodontitis 23(28.8%) and severe periodontitis 7(8.8%). There was no statistically significant difference in exercise type or periodontal status (p>0.05), although gingivitis was least prevalent among those who dance regularly. There were no cases of severe periodontitis among those who engage in stretching, cycling, and dancing. Body mass index of the participants was not significantly associated with the periodontal status of the participants (p>0.05); those with normal weight had the highest prevalence of healthy periodontium, 4(5.8%), while those who were overweight had the highest prevalence of mild to moderate periodontitis, 24(26.4%). The oral hygiene status of the participants had a significant association with their periodontal status (p=0.03). The prevalence of healthy periodontium was highest among those with good oral hygiene, 4(8%), and least among those with poor oral hygiene, 1(2.2%). The prevalence of gingivitis was highest among those with fair oral

hygiene, mild to moderate periodontitis, and severe periodontitis was commonest among those with poor oral hygiene

Multivariate analysis of the relationship of the independent variable and the periodontal status of the participants showed that (Table 3), physical exercise has a significant association with periodontal inflammation. (p = 0.005) OR 0.92, 95% CI .281-1.564. The oral hygiene status of the participants also showed statistical significance with their periodontal status. Good oral hygiene (p=0.005) OR-1.309, 95% CI -2.22- **-.**430, and fair oral hygiene (p=0.002) OR -1.203, 95% CI -1.950- -.455. The other variables did not display statistical significance in relationship with the periodontal status of the participants.

Table 3: Multivariate analysis to assess the relationship of physical activity and periodontal status of the participants.

Variable		Estimate	Standard error	Wald	df	Significance	95% Confidence interval	
							Lower bound	Upper bound
Age (years)	**20-29**	-1.414	2.013	.494	1	0.482	-5.359	2.531
	30-39	-.220	1.275	.030	1	0.863	-2.719	2.279
	40-49	.587	.781	.565	1	0.323	-.944	2.118
	50-59	.178	.685	.067	1	0.452	-1.166	1.521
	60-69	-.080	.586	019	1	0.796	-1.229	1.068
	≥70	0			0	891		
Sex	**Male**	-371	.447	.710	1	.399	-1254	.500
	Female	0			0			
Marital status	**Single**	.503	1.106	.207	1	.649	-1.065	2.677
	Married	-.351	.728	.233	1	.629	-1.173	1.075
	Widowed	.566	.852	.442	1	.506	-1.103	2.235
	Divorced	0			0			
Exercise	**Yes**	0			0			
	No	.922	.327	7.942	1	**.005***	.281	1.564
Oral hygiene score	**Good**	-1.309	.464	7.963	1	**.005***	-2.218	-.430
	Fair	-1.203	.381	9.946	1	**.002***	-1.950	-.455
	Poor	0			0			
BMI	**Underweight**	.100	.412	.059	1	.809	-.708	.908
	Normal	.086	.086	.047	1	.828	-.690	.863
	Overweight	0			0			

IV. DISCUSSION

The participants in this study were predominantly older than 40 years; the predominant age group was 60-69 years, 63(28.6%). This explains why most of them have type 2 diabetes, which typically occurs in older individuals, often associated with insulin resistance 19, 20. The mean HbA1c of the participants was 6.5±3.5%, which indicates that most of the participants have their blood sugar under control. There were twice as many females as males; this is because Diabetes mellitus is more prevalent in females as reported by Yahaya and coworkers and Ubanu et al[21,22]. Studies have shown that females have better health-seeking behaviour than males[23]. The majority of the participants attained up to the tertiary level of education, 98(44.5%); those without any form of formal education were the least, 12(5.5%). Fifteen (6.8%) reported that they smoke cigarettes. A large proportion (63.6%) of the participants engage in a form of physical exercise, of which 41.8% does brisk walking regularly, followed by aerobics (9.1%), and the least was stretching exercises (1.4%). Studies have associated regular physical exercise with better outcomes in the management of the condition[24, 25]. The mean BMI of the participants was 27.5±5.1kg/m^2; the majority were overweight (41.4%), 26.8% were obese. Most of the participants had fair oral hygiene (56.8%), and about 20% had poor oral hygiene. Gingivitis had the highest prevalence among the participants (65%), Severe periodontitis had a prevalence of 6.4%, while only 5.5% presented with a healthy periodontium. Obesity and overweight are known risk factors for diabetes mellitus[19, 20].

While the age groups, sex of the participants, marital status, educational status, and smoking showed no significant difference with the periodontal status of the participants, physical activity was significantly associated. Participants who engaged in regular physical exercise had a higher prevalence of healthy periodontium and gingivitis, whereas those who did not engage in any physical exercise had a higher prevalence of mild-to-moderate and severe periodontitis. This is comparable to previous studies[12-15]. The anti-inflammatory effects of physical activity on inflammatory mediators have direct implications for the periodontium and, indirectly, through its

positive effect on blood glucose levels, which also impact periodontal health[16,18]. There was no statistical difference between the type of exercise and body mass index (BMI), and the periodontal status. The oral hygiene status of the participants had a significant association with their periodontal status. The prevalence of healthy periodontium was highest among those with good oral hygiene (8%), and least among those with poor oral hygiene (2.2%). This is because the primary aetiological factor of periodontitis is the bacterial biofilm on the tooth surface, which may spread subgingivally and involve the deeper periodontal structures, causing apical migration of the junctional epithelium and involving the alveolar bone and the periodontal ligaments[2-5]. The prevalence of gingivitis was highest among those with fair oral hygiene, mild to moderate periodontitis, and severe periodontitis was most prevalent among those with poor oral hygiene. The poorer the oral hygiene, the more severe the periodontitis.

Regression analysis showed that, compared with those who engage in physical exercise, diabetics who do not engage in regular exercise have 0.92 odds of presenting with periodontal inflammation OR 0.92, 95% CI .281-1.564. This further emphasizes the role of physical exercise in the management of diabetes and the periodontal complications. The oral hygiene status of the participants also showed statistical significance with their periodontal status. Good oral hygiene OR-1.309, 95% CI -2.22- **-.**430, and fair oral hygiene OR -1.203, 95% CI -1.950- -.455. The other variables did not display statistical significance in relationship with the periodontal status of the participants.

V. CONCLUSION

While both periodontitis and diabetes mellitus are globally prevalent and interrelated, there is an increased prevalence and severity of periodontitis in diabetics. Both conditions also have inflammatory mediators involved in their pathogenesis and progression. It is of note from this study, as other previous studies, that physical activity and exercise has beneficial effect in lowering the prevalence and severity of periodontitis profoundly in diabetics as in non-diabetics. It is important that diabetic patients are encouraged to include a regimen of physical exercise in their daily routine. This will not only help them to sustain an improved periodontal health status, it will also positively impact glycaemic control.

CONFLICT OF INTEREST- None

REFERENCES

[1]. Łasica A, Golec P, Laskus A, Zalewska M, Gędaj M and Popowska M. Periodontitis: etiology, conventional treatments, and emerging bacteriophage and predatory bacteria therapies. Front. Microbiol. 2024;15(1469414). doi: 10.3389/fmicb.2024.1469414.

[2]. Dubey P, Mittal N. . Periodontal diseases- A brief review. International Journal of Oral Health Dentistry. 2020;6(3):177-187. https://doi.org/10.18231/j.ijohd.2020.038

[3]. Bagde H, Mustilwar R, Mishra S, Upadhyay P, Bhavishyavani M, & Darade L.

a. Periodontitis and systemic diseases: A literature review. International Journal of Health

b. Sciences. 2022;6(S9):2765–2775. https://doi.org/10.53730/ijhs.v6nS9.13063

[4]. Bernabe E, Marcenes W, Abdulkader R et al.Trends in the global, regional, and national burden of oral conditions from 1990 to 2021: a systematic analysis for the Global Burden of Disease Study 2021.The Lancet. 2025;405:897-910.

[5]. Könönen E, Gursoy M, & Gursoy UK. Periodontitis: A Multifaceted Disease of Tooth-Supporting Tissues. Journal of Clinical Medicine. 2019;8(8):1135.

[6]. https://doi.org/10.3390/jcm8081135.

[7]. Mehrotra N, Singh S. Periodontitis. [Updated 2023 May 1]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2026 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK541126/

[8]. Yongqiang Yang, Xia Sun, Yucheng Yang, Yingchun Qie. Insight of the interrelationship and association mechanism between periodontitis and diabetes mellitus, Regenerative Therapy, 2024;26:1159-1167, ISSN 2352-3204. https://doi.org/10.1016/j.reth.2024.11.001.

[9]. Saini R, Saini S, Sugandha R. Periodontal disease: The sixth complication of diabetes. J Family Community Med. 2011;18(1):31. doi: 10.4103/1319-1683.78636. PMID: 21694958; PMCID: PMC3114608.

[10]. Păunică I, Giurgiu M, Dumitriu AS, Păunică S, Pantea Stoian, AM, & Martu, MA. The Bidirectional Relationship between Periodontal Disease and Diabetes Mellitus—A Review. Diagnostics. 2023;36(4);681. https://doi.org/10.3390/diagnostics13040681

[11]. Zhao Mingcan , Xie Yuandong , Gao Wenjia , Li Chunwang , Ye Qiang , Li Yi . Diabetes mellitus promotes susceptibility to periodontitis—novel insight into the molecular mechanisms. Frontiers in Endocrinology. 2023; 14 https://www.frontiersin.org/journals/endocrinology/articles/10.3389/fendo.2023.1192625. doi10.3389/fendo.2023.1192625ISSN=1664-2392.

[12]. Alwithanani N. Periodontal Diseases and Diabetes Mellitus: A Systematic Review. J Pharm Bioallied Sci. 2023;15(Suppl 1):S54-S63. doi: 10.4103/jpbs.jpbs_515_22. Epub 2023 Jul 5. PMID: 37654263; PMCID: PMC10466651.

[13]. Balice G, Paolantonio M, Murmura G. Serroni M, Di Gregorio S, Femminella B. The Influence of Diet and Physical Activity on Periodontal Health: A Narrative Review. Dent. J. 2025;13:200. https://doi.org/10.3390/dj13050200.

[14]. Ferreira RO, Corrêa MG, Magno MB, Almeida APCPSC, Fagundes NCF, and Rosing CK. Physical Activity Reduces the Prevalence of Periodontal Disease: Systematic Review and Meta-Analysis. Front. Physiol. 2019;10:234. doi: 10.3389/fphys.2019.00234.

[15]. Chan CCK, Chan AKY, Chu CH and Tsang YC. Physical activity as a modifiable risk factor for periodontal disease. Front. Oral. Health. 2023;4:1266462. doi: 10.3389/froh.2023.1266462.

[16]. Das A, Menon I, Kumar G, Singh A, Jha K. Impact of physical activity on oral health: A systematic review. J Family Med Prim Care 2025;14:1161-8.
[17]. Railson OF, Deborah RF, Maria K, Martins F, Marcela B, Nathália CF. Periodontal disease and sports performance: a systematic review and meta-analysis. Research in Sports Medicine. 2024;32(5):767-786. doi: 10.1080/15438627.2023.2235048.
[18]. Piaopiao Q, Bo D, Rongkai C, Junli H, Jiaao Y, Ruoqi Y. The Relationship Between Physical Activity Levels and Periodontal Health Status Among College Students: A Cross-Sectional Study. Risk Management and Healthcare Policy. 2025;18:131–141.
[19]. Şen DÖ, Yarkaç FU, Eroğlu ZT. et al. The relationship between periodontal status, physical activity, dietary practices, and dental caries. Sci Rep. 2024;14:29086 https://doi.org/10.1038/s41598-024-73690-4.
[20]. Sesti G, Antonelli IE, Bonora A, Consoli A, Giaccari S, Maggi G. et al. Management of diabetes in older adults, Nutrition, Metabolism and Cardiovascular Diseases. 2018;8(3) :206-218. ISSN 0939-4753, https://doi.org/10.1016/j.numecd.2017.11.007.
[21]. Bradley D, Hsueh W. Type 2 Diabetes in the Elderly: Challenges in a Unique Patient Population. J Geriatr Med Gerontol. 2016;2(2):14. doi: 10.23937/2469-5858/1510014. Epub 2016 Sep 8. PMID: 31692858; PMCID: PMC6831098.
[22]. Yahaya TO, Oladele EO, Mshelia MB. *et al.* Influence of ABO blood groups and demographic characteristics on the prevalence of type 2 diabetes in Lagos, southwest Nigeria. Bull Natl Res Cent. 2021;45:144. https://doi.org/10.1186/s42269-021-00603-0.
[23]. Ubani BC, Nkpozi MO, Ekrikpo UE, Ekuma I, Young EE, Unachukwu CN. Prevalence and risk factors of type 2 diabetes mellitus in a rural and an urban Nigerian community: Are the demographics changing? GJMEDPH. 2025;14(1)|OPENACCESS
[24]. Barua K, Gohar M, Mahajan H, Srivastava S. Reproductive healthcare seeking behaviour of women of the reproductive age group in an urban resettlement area of district Gautam Buddh Nagar in Uttar Pradesh, India. J Family Med Prim Care. 2024;13(2):758-763. doi: 10.4103/jfmpc.jfmpc_1382_23. Epub 2024 Mar 6. PMID: 38605795; PMCID: PMC11006087.
[25]. Zahalka SJ, Abushamat LA, Scalzo RL, et al. The Role of Exercise in Diabetes. [Updated 2025 Jul 6]. In: Feingold KR, Adler RA, Ahmed SF, et al., editors. Endotext [Internet]. South Dartmouth (MA): MDText.com, Inc.; 2000-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK549946/
[26]. Sheri R. Colberg, Ronald J. Sigal, Jane E. Yardley, Michael C. Riddell, David W. Dunstan, Paddy C. Dempsey, Edward S. Horton, Kristin Castorino, Deborah F. Tate; Physical Activity/Exercise and Diabetes: A Position Statement of the American Diabetes Association. *Diabetes Care* 1 November 2016; 39 (11): 2065–2079. https://doi.org/10.2337/dc16-1728