Research Article

The effect of sweet and salty taste sensitivity on gingival health in relation to salivary serotonin among type1 diabetic patients aged 12-14 years

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Received date: 2-1-2022
Accepted date: 10-2-2022
Published date: 15-9-2022

https://doi.org/10.26477/jbcd.v34i3.3213

Abstract: Background: This study was conducted among diabetic persons to assess the sweet and salty taste sensitivity with its effect on gingival health in relation to salivary serotonin levels. Materials and methods: A cross-sectional comparative study design was used. All patients with diabetes aged 12-14 years that attend the Paediatric hospital at Baghdad medical city with specific inclusion criteria were involved in the sample of the present study (patients group 50 patients) compared with non-diabetic persons matched in age and gender of the study sample (control group 70 patients) who were attending dental unit in the college of dentistry/university of Baghdad. A two-alternative forced choice question including each component presented at five different quantities was used to evaluate the threshold sensitivity of salt and sweet taste, sub-sample of 44 subjects was recruited from each group and matched in age and gender for salivary analysis and serotonin measurement and gingival health status was measured by using the gingival index. Results: Data analysis of this study revealed that the occurrence of the highest sweet threshold was found among diabetic persons with no significant difference. The data revealed no significant difference in the mean gingival index while salivary serotonin value was lower in diabetic subjects with a significant difference; meanwhile, it showed no significant relation with both taste thresholds. Conclusions: Within the limitation of this study, it was observed, that diabetes did not affect salty and sweet taste thresholds in addition to gingival health. Whereas salivary serotonin had a role among the diabetic patients by which it was lower among diabetic subjects.

Keywords: Taste thresholds, Serotonin, Diabetes

Introduction

Diabetes mellitus is a category of metabolic disorders characterized by hyperglycemia in the absence of treatment caused by defects in insulin secretion, insulin action, or both [(1)]. The destruction of the ß-cells in the pancreas causes type 1 Diabetes mellitus (T1DM). When the pancreas stops producing insulin i.e. autoimmune impact, the result will be absolute insulin deficiency [(2)]. Taste impairment can be induced by a systemic metabolic abnormality that affects the taste senses, such as diabetes [(3)]. It has been linked to taste disorders such as ageusia, hypogeusia, and dysgeusia [(4)]. Sweetness refers to the sweet taste associated with various sugars and sweeteners. It plays a function in human nutrition by guiding feeding behavior toward meals that provide both energy and important nutrients [(5)]. Diabetic individuals have shown to have impairment for the sweet taste thresholds when compared to other taste modalities [(6)]. Many species appear to like the taste of salt. Even when there is no physiological necessity for salt,

humans like foods that contain it [7]. A person's capacity to perceive and discriminate between salty and bitter solutions can be reduced by diabetes and age [8].

Because various individual characteristics can play a role in the development of diabetes, many studies had theorized a relationship between diabetes and taste sensitivity [9,10]. Previously Jorgensen and Buch[11] found that there was no difference in taste detection between diabetics and non-diabetic persons. In addition, Dye and Koziatek[12] reported that diabetic patients did not differ significantly in the threshold for sweet from non-diabetic subjects, while later on Khera and Saigal[13] found that patients with diabetes demonstrate a high threshold for sweet, salt and sour taste. Also, Wasalathanthri et al[10] found a significant increase in the detected threshold of sucrose was observed among diabetics compared to non-diabetic persons. Concerning salt taste, Schelling et al[14] reported that an altered threshold for sweet taste was found only and not for salt. While Khobragade et al[6] found a significant increase in taste threshold for salt, sweet, sour and bitter among type 1 diabetics.

Serotonin is a neurotransmitter in the brain that can also be discovered outside the central nervous system, such as in the pancreas [15]. It is thought to be a key regulator of both ß-cell proliferation and insulin secretion. [16]. Taste problems are linked to changed serotonin levels, such as during anxiety or depression, showing the role of these transmitters in the detection of taste thresholds in health and sickness [17]. Gingivitis is a site-specific inflammatory disorder caused by the formation of dental biofilm [18]. Many of the conditions related to taste abnormalities include inflammation as a common cause. Taste abnormalities are common in patients with infectious disorders, such as oral cavity infections, [19]. The current study hypothesized that sweet and salt taste sensitivity has no effect on salivary serotonin levels in relation to gingival health. The goal of this study was to investigate sweet and salt taste sensitivity among diabetics, as well as its impact on gingival health in relation to salivary serotonin levels.

Materials and Methods

The present study was a cross-sectional comparative study approved by the Scientific Committee in the College of Dentistry/University of Baghdad (number: 319). Before data collection, official permissions were achieved from the relevant authority; a specific consent form was produced and given to the parents to acquire permission for their children to participate in the study and their full cooperation. The study sample includes all the diagnosed cases of type 1 diabetic patients aged (12-14) years old with glycated haemoglobin ≥ 7 and without any other systemic diseases who attended the Paediatric Teaching Hospital compared with a control group that include healthy persons , attending dental unit in the college of dentistry/university of Baghdad without any systemic disease. The sample of this study consisted of 50 diabetic subjects and 70 non-diabetic subjects, a sub-sample of 44 subjects was recruited from each group that matched in age and gender for salivary analysis and serotonin measurement. A special case sheet was used for writing all the information and data that including: age, gender, gingival index and taste measurements. An unstimulated saliva sample was collected in the morning for assessing salivary serotonin by spitting method [20]. The concentration of salivary serotonin was detected by an enzyme-linked immune-sorbent assay (ELISA) using a serotonin ELISA-Kit[21]. A two-alternative forced choice question was used to determine taste threshold sensitivity [22]. The test included ten solutions, five sodium chloride solutions (0.09, 0.18,0.37,0.75, 1.5 g/L) and five sucrose solutions (0.5, 1, 2, 4, 8 g/L). Each solution was given to the participants in a disposable plastic cup. Subjects were instructed to evaluate the taste of each solution before expectorating. When the subject made the correct answer, the same concentration was given again. When the subject made a wrong answer, the next trial was held at the next

highest level. After two accurate answers in a row, the test ended [23]. Gingival inflammation was evaluated using the gingival index (GI) by Loe and Sillness [24].

Statistical analysis used includes: descriptive statistics for quantitative data are mean, standard error while frequency and percentage for qualitative ones. Inferential statistics were student T-test, fisher exact, spearman correlation and probability of error (p-value).

Results

The sample of the present study included 50 diabetic patients and 70 non-diabetic patients in the age range of 12-14 years old. The distribution of the sample according to age and gender was presented in Table 1. It was clear that the occurrence of diabetes was highest for patients aged 12 years old and decreased with age. Concerning gender distribution at the same Table, it was found that diabetes occurred more among females than males. However, the statistical analyses showed no significant association between age, gender and diabetic status.

Table (1): *Distribution of the sample according to age and gender*

Variables		Groups				P value
		Diabetic group		Non-Diabetic group		
		N.	%	N.	%	
Age (years)	12	22	44.00	30	42.86	0.869 NS
	13	16	32.00	20	28.57	
	14	12	24.00	20	28.57	
Gender	male	16	32.00	33	47.14	0.096 NS
	female	34	68.00	37	52.86	

NS not significant (Chi-square test was used)

The distribution of the sample according to sweet taste threshold concentrations was shown in Table 2. This Table showed that 40% of diabetic children detected the sweet taste at a concentration of 8 gm/l, while only 37% of the non-diabetic group detect the same concentration. However, 54% of the diabetic and 45.71% of the non-diabetic group could not detect the highest concentration. However, the statistical analyses showed no significant association between diabetic status and sweet taste threshold detection.

Table (2): *Distribution of the sample according to sweet taste threshold*

Sweet taste threshold conc.gm/l	Groups				Fisher exact
	Diabetic group		Non-Diabetic group		
	N.	%	N.	%	
Group1(1gm)	1	2.00	2	2.86	0.460 NS
Group 2(2gm)	0	0.00	3	4.29	
Group 3(4gm)	2	4.00	7	10.00	
Group 4(8gm)	20	40.00	26	37.14	
Group5(> 8 gm/l)	27	54.00	32	45.71	

NS not significant

The distribution of the sample according to salt taste threshold concentrations was shown in Table 3. This table showed that diabetics people who detected salt at a concentration of 0.75gm/l constitute only 16% which was higher than the non-diabetic group which constitutes 12.86%. However, the oppo-

site result was found with increasing the concentration as the non-diabetic persons who detected the 1.5gm/l were higher (45.71%) than the diabetic persons (32.0%). On the other hand, the diabetic persons who could not detect the salt taste at the highest concentration formed a higher percentage (50.0%) than the non-diabetic group (41.43%), however, the statistical analyses showed that there was no significant association between the diabetic condition and the salt taste.

Table (3): *Distribution of the sample with different salt taste thresholds among diabetic and non-diabetic groups*

Salt taste threshold conc. g/l	Groups				
	Diabetic group		Non-Diabetic group		
	N.	%	N.	%	Fisher exact
Group1 (0.37gm)	1	2.00	0	0.00	
Group2 (0.75gm)	8	16.00	9	12.86	
Group 3(1.5gm)	16	32.00	32	45.71	
Group4 (> 1.5 g/l)	25	50.00	29	41.43	0.309 NS

NS not significant

The concentration of serotonin in saliva that compared the diabetic and the non-diabetic groups were shown in Table 4. This table showed that the mean value of salivary serotonin was higher among the non-diabetic group than in the diabetic group.

Table (4): *The concentration of salivary serotonin in saliva (ng/ml) in both diabetic and non-diabetic groups*

Groups	Salivary serotonin (ng/ml)						
	N	Mean	±SE	T-test	df	P value	Effect size
Diabetic group	44	16.39	2.21	1.96	86	0.05	0.5 medium
Non-Diabetic group	44	23.37	2.78				

Table 5 shows the correlation between salivary serotonin with sweet and salt taste thresholds among diabetic and non-diabetic groups. The data showed that the correlation between taste thresholds and serotonin value in both groups was in a positive direction. However, statistical analyses showed that there was no statistically significant difference (p>0.05.)

Table (5): *The Correlation between salivary serotonin and sweet and salt taste thresholds among diabetic and non-diabetic groups*

Groups		Salivary serotonin (ng/ml)	
		Salt	Sweet
Diabetic group	rsp	0.094	0.212
	p-value	0.542	0.168
Non-Diabetic group	rsp	0.175	-0.065
	p-value	0.257	0.673

*rsp: spearman correlation used

Table 6 illustrated the mean value of the gingival index among the diabetic and the non-diabetic groups. Data analysis showed that the mean value of the gingival index was higher among the diabetic group. However, the results showed that the difference was not significant.

Table (6): *Mean value of gingival index among diabetic and non-diabetic groups.*

	Groups								
	Diabetic group			Non-Diabetic group					
	N	Mean	±SE	N	Mean	±SE	T-test	Df	P value
Gingival index	50	1.034	0.017	70	1.013	0.019	0.763	118	0.447 NS

NS not significant (student t-test used)

Table 7 illustrated the correlation coefficient between sweet and salt taste thresholds with gingival index among diabetic and non-diabetic groups. The table showed that the correlations between taste thresholds and gingival index in both groups were in a positive direction. However, the relations were not statistically significant (p>0.05.)

Table (7): *The correlation coefficient between sweet and salt taste thresholds with gingival index among diabetic and non-diabetic groups*

Groups	Gingival index			
	Salt taste		Sweet taste	
	rsp	p-value	rsp	p-value
Diabetic group	0.065	0.653	0.100	0.489
Non-Diabetic group	0.114	0.347	-0.142	0.240

NS not significant * rsp: spearman correlation used

Discussion

Taste has been demonstrated to be an essential tool in the regulation of nutrient ingestion, digestive process monitoring, and the release of hunger and satiety neuroendocrine hormones. Few studies had examined how taste sensitivity changes in normal and pathological situations, and how this affects oral health [(25)]. The perception of sweet and salt tastes in T1DM patients was assessed in this study, which took into account gender, age and the concentration of the taste. Age and gender were not considered confounding variables as there was no significant difference between groups. The present study was conducted and mainly aimed at comparing the taste detection thresholds among T1DM and controls and to detect whether taste impairment occurred among type 1 diabetes. The result of the current study found that the distribution according to sweet taste thresholds revealed that the groups who detected the higher sucrose concentrations formed the higher percentage in both diabetic and control groups and yet there was no significant difference in the detection thresholds, this agreed with previous studies conducted by Jorgensen and Buch[(11)], Dye and Koziatek[(12)], while disagreed with studies by Khera and Saigal[(13)] ,Wasalathanthri et al[(10)], some of them may detect it as a bitter taste, which might be due to the receptors for the sweet taste, located in the type II cells of the taste buds that are the sweet and bitter sensing and transducing cells[(26)].

Another result concerning the frequency distribution of salt taste threshold revealed that groups that detect higher salt concentrations formed the higher percentage in both groups, and there was no significant difference in detection thresholds between groups, which goes in accordance with the previous study by Schelling et al[14]. These results concerning sweet and salt taste are not supported by khobragade et al [6] study.

Serotonin was successfully detected in the saliva, although the mean value of salivary serotonin was higher in the non-diabetic group than diabetic group, this could be explained neuro-pathologically, that depletion of brain monoaminergic activity, especially the serotonin system, due to a persistent chronic diabetic condition can cause mood and behavioral problems, and that persistent hyperglycemia can cause neurotransmitter activity to be lowered [27]. Also, it may be explained that, because pancreatic *b*-cells produce serotonin [28] and because type 1diabetes patients had destructed *b*-cells, so there is decrease in serotonin levels in the diabetic group.

Another result found that the correlation of serotonin with taste thresholds in both groups was in a positive direction. At the level of the taste bud, the strongest evidence for serotonin's participation in taste signaling exists. Serotonin is used as a neurotransmitter in the taste bud to modulate cellular responses to taste stimuli even before it is sent to the main afferent gustatory neurons. [29] . However, statistical analysis showed that it was not significant statistically and this disagrees with Heath et al [17] study that showed Serotonin and noradrenaline had a role in determining the taste thresholds, and the human taste was plastic in healthy people. Alteration of these neurotransmitters affects various taste modalities in different ways. In contrast to Larson et al [30] study, which found that taste buds activation triggers serotonin release, Serotonin is released directly by type III taste cells in reaction to acidic (sour) stimuli and indirectly in response to sweet and bitter taste stimulation. Concerning gingival health status, the results showed that the mean value of the gingival index was higher among the diabetic group. It may be that the diabetes oral complications can affect the primary periodontium as early as age 6 years old, possibly earlier. These findings highlighted the importance of emphasizing good oral hygiene to prevent future periodontal complications among diabetic patients[31], even though the difference was not significant, which could be due to the limited sample size, these results were in accordance with a study by Ismail et al[32] and with previous Iraqi study by Sarmamy et al [33] that found when diabetes children compared to healthy persons, no statistically significant difference in the gingival index was found between the two groups.

Researchers in dentistry had suggested that oral diseases should be included among the complications of diabetes [34,35]. The current result revealed that the correlations between taste thresholds and gingival index in both groups were in a positive direction; this could be explained as that gingivitis is a site-specific inflammatory condition. Inflammation is triggered when Toll-like receptors are activated by inflammatory stimuli derived from pathogens or damaged tissues, or stress [36] Toll-like receptors, type I and II interferon receptors are located in taste tissue [37]. The immune response to viral and bacterial pathogens is mediated by cytokines. Interferons are one of the main categories of cytokines critical in fighting these invaders [38]. The strong association between inflammation and taste impairment suggested that inflammation might affect the pathogenesis of taste dysfunction [37]. However, the difference was not

statically significant, this agreed with Ohnuki et al, which found that taste hyposensitivity had little association with oral health status, such as dental plaque and gingival status [39].

Conclusion

Diabetes mellitus is a devastating chronic condition that is becoming a global epidemic. The findings of the present study showed that diabetes and oral health were related, with no effect on taste detection thresholds and the effect of serotonin level was less in the diabetic group. Hence, there was a need for appropriate health education as good oral health is important for diabetic individuals.

Conflict of interest: None.

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العنوان: تأثير حساسية الطعم الحلو والمالح على صحة اللثة وعلاقتها بالسيرروتونين اللعابي لدى مرضى السكرالنوع الاول اللذين تتراوح اعمارهم بين 12-14 عاما

الباحثون: تبارك عادل رسول 1 بان صاحب دياب 2

المستخلص:

الهدف من الدراسة :أجريت هذه الدراسة على مرضى السكري من النوع الأول بهدف تقييم حساسية الطعم الحلو والمالح وتأثيره على صحة اللثة وعلاقته بمستوى السيروتونين اللعابي

المواد وطرق العمل : تم اعتماد تصميم دراسة مقارنة شارك فيه الأشخاص الذين تم تشخيص إصابتهم بمرض السكري و تتراوح أعمارهم بين 12 و 14 عامًا والذين حضروا مستشفى الاطفال التعليمي بمعايير محددة في عينة الدراسة الحالية (مجموعة المرضى 50 شخصًا) وتم مقارنتهم باشخاص غير مصابين بالسكري (المجموعة الضابطة 70 شخصًا) الذين حضرو وحدة طب الأسنان في المستشفى الطبي في مدينة بغداد / العراق.

تم استخدام(two-alternative forced choice question) والذي يتضمن ان يقدم كل مكون في خمسة تركيزات مختلفة لتقييم حساسية الطعم المالح والذوق الحلو ، وتم اختيار عينة فرعية من 44 شخصًا من كل مجموعة ومطابقتها في العمر والجنس لتحليل اللعاب و قياس السيروتونين. تم قياس حالة اللثة باستخدام موشر اللثة.

النتائج :كشف تحليل بيانات هذه الدراسة أنه لم يتم العثور على ارتباط كبير بين حالة مرض السكري وحساسية الطعم و التذوق. أظهرت البيانات عدم وجود فرق أحصائي في متوسط مؤشر اللثة بينما كانت قيمة السيروتونين اللعابية أقل في مرضى السكري مع اختلاف مهم و لم تظهر أي علاقة احصائية مع حساسية الذوق. .

الاستنتاج :ضمن حدود هذه الدراسة. تم الوصول الى أن مرض السكري ليس له أي تأثير على حساسية الطعم المالح والحلو وعلى صحة الفم واللثة. في حين أن مستوى السيروتونين اللعابي كان له دور وكان أقل بين مرضى السكري.