

Evaluation of the Sensory Perception of Sweet Taste in People with Diabetes Mellitus Type 1 in Indian Population: A Comparative Study

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Background: Taste perception is an integral part of a person's life. This perception gets altered due to many factors, one of which is diabetes mellitus. There is limited data on the taste alteration for sweet in Type 1 diabetics.

Objective: To evaluate the sweet taste perception in subjects with type 1 diabetes by the mouth threshold index test.

Methods: A cross-sectional study with 200 subjects inclusive of both sexes. The subjects were grouped into 2:100 control, composed of non-diabetics, and 100 tests, with Type 1 diabetic patients were recruited from Endocrinology Out patient department at Osmania General Hospital, Hyderabad to take part in this study. Sensitivity test in determining threshold index for sensory perception was analyzed. The tests were conducted on 5 sections containing different concentrations of glucose.

Statistical analysis: The two groups were statistically analyzed using Chi square test with P value < 0.05 was considered statistically significant.

Results: Among the study population, majority of participants had 0.25M (51 (51%) in non-diabetic and 28 (28%) in diabetic), 0.50M (26 (26%) in non-diabetic and 37 (37%) in diabetic) and 1M (11 (11%) in non-diabetic and 23 (23%) in diabetic) as concentration at which sweet taste was perceived. Type diabetics showed less sensitive to sweet stimuli compared to controls.

Conclusion: Type 1 diabetes patients showed greater threshold index for sweet taste perception, this finding could further result in increased sweet intake leading increased blood sugar levels in these patients.

Key words: Diabetes Mellitus, Type 1, Sensitivity, Sweet taste, Perception, sensory, threshold index

Diabetes, a condition which is most prevalent globally is the foremost public health concerns especially in Asian countries which harbours more than 60% of the world's diabetic population. A greater risk is observed among the population with undiagnosed cases of diabetes among the diagnosed cases of diabetics further leading to greater estimates than the actual. (Chandalia, 2013) Type 1 Diabetes accounts for about 5 – 10 % of all the cases of diabetes. Its incidence continues to increase worldwide & it has serious short term & long-term implications. In a plethora of complications of diabetes, taste perception and olfactory function in association with diabetes is least studied.

The physiology of taste perseverance involves induction of taste receptors by tastant stimuli on threshold stimulates gustatory nerve endings of taste receptors causing a taste feeling (Gutierrez and Simon 2011) The taste threshold can be altered in several conditions along with genetic factors (Keskitalo *et al.*, 2007), age (Seiberling and Conley 2004), body weight (Yanina Pepino *et al.*, 2010), consumption of alcohol (Kampov-Polevoy *et al.*, 2001), smoking (Pepino and Mennella 2007), acute and chronic diseases (Bloomfield *et al.*, 1999) and surgical interventions (Mori *et al.*, 2019).

Taste impairment is not considered a serious handicap and diabetic patients are not systemically screened for taste disorders. Taste disorders can lead to modify food intake & can influence the metabolic control. Decrease in sweet taste sensitivity can lead to greater consumption of sugar which might be a factor driving already diabetic patients to overt Diabetes (De Carli *et al.*, 2018). Hence, it is important to research the taste sensitivity among diabetic population.

An increased state of taste threshold is related to increased blood glucose levels (Wasalathanthri *et al.*, 2014) leading to a dampened response to sweet in type 2 diabetics (Gondivkar *et al.*, 2009).

Till date, there have been numerous studies done on the sweet taste sensitivity in Type 2 diabetes mellitus patients (Kumari and Kumar, 2020), (Pugnloni *et al.*, 2020), (Tjahajawati *et al.*, 2020), (Takai and Shigemura, 2020) No studies have been conducted on the taste impairment on Type 1 diabetic patients. Hence, our

study aimed to compare the taste threshold of type 1 diabetics with non-diabetics and also to assess whether sensitivity for sweet taste is altered in type 1 diabetics when compared with non-diabetics.

MATERIALS AND METHODS

Subjects:

The study design was cross-sectional with a convenience sample conducted in the Endocrinology Outpatient department at Osmania General Hospital, Hyderabad. This study consisted of 200 subjects involving both males and females, aged 20 to 45 years old, grouped into 2: control and test. The control group consisted of 100 non-diabetic individuals and the test group had 100 patients diagnosed with type 1 Diabetes Mellitus, who were willing to participate in the study. Exclusion criteria included subjects who consumed alcohol in last 24hrs, older patients and smoking, pregnant and lactating females and type 2 diabetes. Data collection was conducted from November 2014 to October 2016. Our study was conducted after an approval from ethics review committee from the university. All the subjects were included only after a written informed consent from them

Preparation of different concentrations of glucose solutions:

1M is 180g of glucose in 1litre. 100ml glucose solutions were prepared at six different concentrations and were collected in a container having a dropper. Every time fresh solutions were prepared on the testing day. (Table 1)

Procedure:

All the participants were informed to arrive at the study site at around 8am to 8:30 am on the day of test. The subjects were instructed not to take anything orally except water before one hour of the testing. The investigator distributed questionnaire to receive an information about the demographic details of subjects, food intake (sugar consumption), previous medical history and medication history. The patients were assessed for height and weight. The entire procedure of the test was explained to the subjects before starting the test. The test for taste perception was completed before 11am in a complete a fragrance -free room and was

completed Testing started with minimum concentration of glucose solution. Two to three drops of solution were given at the middle of the dorsum of the tongue approximately 1.5 cm from the tip.

Subjects were asked whether he/she was able to feel any taste sensation and was asked to indicate taste quality. If the subjects could not feel the taste sensation then a solution of next higher concentration was tested. In between the different concentrations distilled water was used for rinsing. Whenever the subject felt the sweet taste that concentration was noted.

Statistical methods:

Concentration at which sweet taste is perceived was considered as Primary outcome variable.

Study group (Diabetic v/s Non-Diabetic) was considered as primary explanatory variable.

Age and Gender were considered as other explanatory variables. The data was analyzed for normal distribution in each group of variables and was analysed by histograms and Q-Q plots. for normal distributed data Shapiro- Wilk test was applied. Chi square test was

used to analyze categorical outcomes. P value < 0.05 was considered statistically significant. IBM SPSS version 22 was used for statistical analysis. (Owen *et al.*, 2016)

RESULTS

A total of 200 subjects considered into final analysis. Among the study population, 100 (50%) participants belonged to Diabetic Group and 100 (50%) participants belonged to Non- Diabetic Group. (Table 2)

Comparison of demographic parameters between study groups (N=200) was done and there was no statistically significant difference between two groups in baseline parameters like age (P value 0.086) and gender (P value 0.154). (Table 3)

Among the study population, majority of participants had 0.25M (51 (51%) in non-diabetic and 28 (28%) in diabetic), 0.50M (26 (26%) in non-diabetic and 37 (37%) in diabetic) and 1M (11 (11%) in non-diabetic and 23 (23%) in diabetic) as concentration at which sweet taste is perceived. (Table 4)

Table 1: Amount of glucose at different molar concentrations

Concentrations	Amount of glucose in 100ml of distilled water
0.0625M	1.125g
0.125M	2.25g
0.25M	4.5g
0.5M	9g
1M	18g
2M	36g

Table 2: Descriptive analysis of Study Groups in study population (N=200):

Study Group	Frequency	Percentage
Diabetic	100	50%
Non-Diabetic	100	50%

Table 3: Comparison of demographic parameters between study groups (N=200):

Parameter	Study Group		Chi-Square	P-Value
	Diabetic (N=100)	Non-Diabetic (N=100)		
Age groups				
<=30	36 (36%)	48 (48%)	2.956	0.086
>30	64 (64%)	52 (52%)		
Gender				
Male	61 (61%)	51 (51%)	2.029	0.154
Female	39 (39%)	49 (49%)		

Table 4: Comparison of Concentration at which sweet taste is perceived between study groups (N=200):

Concentration at which sweet taste is perceived	Study Group		Chi-Square	P-Value
	Diabetic (N=100)	Non-Diabetic (N=100)		
0.0625M	0 (0%)	6 (6%)	*	*
0.125M	4 (4%)	6 (6%)		
0.25M	28 (28%)	51 (51%)		
0.50M	37 (37%)	26 (26%)		
1M	23 (23%)	11 (11%)		
2M	8 (8%)	0 (0%)		

*No statistical test was applied due to 0 value in one of the cells.

DISCUSSION

Diabetes is a major health care problem in India with an estimated 66.8 million people suffering from the condition, who represent the largest number of any country in the world (Joshi 2015). A vast majority of the individuals are unaware/undiagnosed of their ailment status are left untreated and pose complications at end stage of the disease. Hence, it is very necessary to detect this category of undiagnosed individuals early and provide necessary treatment (Mohan *et al.*, 2007).

Very few studies have studied the taste perception in type 1 diabetes in comparison to normal individuals. Hence, we aimed to access and compare the taste threshold in type 1 diabetics with normoglycemic individuals.

Here, the mouth threshold index technique was effective in assessing the taste sensitivity in Type 1 diabetic patients as our study found lower thresholds to perceive the taste of sweet in controls compared to type 1 diabetics. These results substantiated with the only study that recorded the taste threshold in Indian population which was conducted by Khobragade *et al.* (2012) where threshold of sucrose was used, as compared to our study where glucose was used.

Baseline characteristics of the subjects in the two groups are shown in Table 2. The con-founders on taste thresholders was presumed to be small as both the groups were adjusted for gender, age and other co-founders. For nearly 4 decades the impact of type 2 diabetes mellitus on taste sensitivity is well known.(De Carli *et al.*, 2018, Wasalathanthri, *et al.*, 2014,

Gondivkar *et al.*, 2009, Tepper *et al.*, 1996) The exact mechanism behind this is still obscure. However, it is presumed that a complication of diabetes, neuropathy interrupts the nerve signals with microangiopathy of taste buds causes low taste perception. (Bhandare *et al.*, 2014) the other reason was said to be the increase in the sweet taste receptors (STRs) T1R2 transcript receptors found in the intestine after glucose infusion. (Young *et al.*, 2013)

In these present one-of-a-kind studies, a substantial increase in the mean threshold for glucose was observed in Type 1 diabetics as compared to normal individuals. This result was in line with a study wherein, they used a serial of diluted glucose solutions to analyze the threshold in type 1 diabetic population (70 in test and 70 in controls). The diabetic study population showed a significant increase for sweet threshold and other tastes. (Tepper *et al.*, 1996) From the previous study findings this study too found a dampened taste perseverance in diabetics. Further to add, a study by Ribeiro Dias *et al.* (2016), also found increased thresholds to detect sweet taste perception in diabetics. Interestingly a study by Wasalathanthri *et al.* (2014) found decreased sweet taste perception in prediabetics compared to controls. In a previous research it was shown that diabetics desire for high carbohydrate foods especially when they are in poor glycemic control (Yu *et al.*, 2013). But, according to our knowledge there is no reported data to confirm whether this desire actually drives the diabetics to use more sugar to improve the taste of their food. Studies need to be conducted on this aspect of the disease process.

Altered taste was present only during certain time and not throughout the day as confirmed by a study by Nikhil Bhandare *et al.* (2014) Rather than being an indicator of duration or complications of disease, it could be an indicator of fluctuations in blood sugar levels. Hence, this study was conducted at a specified time of 8am to 10am for all the patients so as to avoid the time variation in taste perception. Hence the threshold for taste increases in diabetics. So, individuals sensing an increased threshold for glucose can use this sign as an alarm for a suspected diagnosis of diabetes mellitus.

CONCLUSION

From this cross-sectional study, it is evident that individuals with Type I diabetes mellitus have a higher threshold index value for the sweet taste. This implies that Type 1 diabetics need higher glucose concentrations to recognize the sweetness of foods. This may contribute to an increase in sugar consumption and further worsening of the disease.

LIMITATIONS AND RECOMMENDATIONS

There were few unavoidable limitations in this study. Some being; a small sample size. The severity of the diabetics was not considered in this study through blood glucose levels and HbA1c levels. Medications (hypoglycemics or anti-hypertensives) also can cause taste perception alterations, which was not recorded in this study. Further investigations and better study designs including the above-mentioned limitations can be incorporated in future studies on this aspect of Type 1 diabetes.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

REFERENCES

- Bhandare NN, Keny MS, Nevrekar RP, Bhandare PN. (2014). Diabetic tongue-Could it be a diagnostic criterion? *J Family Med Prim Care*. **3(3)**: 290.
- Bloomfield RS, Graham BG, Schiffman SS, Killenberg PG. (1999). Alterations of chemosensory function in end-stage liver disease. *Physiol Behav*. **66(2)**: 203-207.
- Chandalia HB. (2013) International Journal of Diabetes in Developing Countries. *Int J Diabetes Dev Ctries*. **33(1)**: 1-4.
- De Carli L, Gambino R, Lubrano C, Rosato R, Bongiovanni D, Lanfranco F, et al. (2018). Impaired taste sensation in type 2 diabetic patients without chronic complications: a case-

- control study. *J Endocrinol Invest.* **41(7)**: 765-72.
- Dias V R, Jamille M B, Juliane A, Camile S, Maria P M. (2016) Evaluation of the sensory perception of sweet taste in people with Diabetes Mellitus type 2. *Rev Rene.* **17(4)**: 483-489.
- Gutierrez R, Simon SA. (2011) Chemosensory processing in the taste-reward pathway. *Flavour Fragr J.* **26(4)**: 231-238.
- Gondivkar SM, Indurkar A, Degwekar S, Bhowate R. (2009). Evaluation of gustatory function in patients with diabetes mellitus type 2. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* **108(6)**: 876-880.
- Joshi SR. (2015). Diabetes care in India. *Ann Glob Health.* **81(6)**: 830-838.
- Keskitalo K, Knaapila A, Kallela M, Palotie A, Wessman M, Sammalisto S, et al. (2007) Sweet taste preferences are partly genetically determined: identification of a trait locus on chromosome 16. *Am J Clin Nutr.* **86(1)**: 55-63.
- Kampov-Polevoy A, Tsoi M, Zvartau E, Neznanov N, Khalitov E. (2001). Sweet liking and family history of alcoholism in hospitalized alcoholic and non-alcoholic patients. *Alcohol Alcohol.* **36(2)**: 165-170.
- Kumari BG, Kumar ZN. (2020) Evaluation of sweet taste sensitivity in type-II Diabetes Mellitus patients. *Int J Biomed Res.* **6(3)**: 10-12.
- Khobragade RS, Wakode SL, Kale AH. (2012). Physiological taste threshold in type 1 diabetes mellitus. *Indian J Physiol Pharmacol.* **56(1)**: 42-47.
- Mohan V, Sandeep S, Deepa R, Shah B, Varghese C. (2007). Epidemiology of type 2 diabetes: Indian scenario. *Indian J Med Res.* **125(3)**: 217-230.
- Mori M, Angraal S, Chaudhry SI, Suter LG, Geirsson A, Wallach JD, et al. (2019). Characterizing Patient-Centered Postoperative Recovery After Adult Cardiac Surgery: A Systematic Review. *J Am Heart Assoc.* **8(21)**: e013546.
- Pepino MY, Finkbeiner S, Beauchamp GK, Mennella JA. (2010). Obese women have lower monosodium glutamate taste sensitivity and prefer higher concentrations than do normal-weight women. *Obesity.* **18(5)**: 959-965.
- Pepino MY, Mennella JA. (2007) Effects of cigarette smoking and family history of alcoholism on sweet taste perception and food cravings in women. *Alcohol Clin Exp Res.* **31(11)**: 1891-1899.
- Pugnaroni S, Alia S, Mancini M, Santoro V, Di Paolo A, Rabini RA, et al. (2020). A Study on the Relationship between Type 2 Diabetes and Taste Function in Patients with Good Glycemic Control. *Nutrients.* **12(4)**: 1112.
- Seiberling KA, Conley DB. (2004) Aging and olfactory and taste function. *Otolaryngol Clin North Am.* **37(6)**: 1209-1228.
- Tjahajawati S, Rafisa A, Murniati N, Zubaedah C. (2020). Correlation between Taste Threshold Sensitivity and MMP-9, Salivary Secretion, Blood Pressure, and Blood Glucose Levels in Smoking and Nonsmoking Women. *Int J Dent.* **2020**: 4178674.
- Takai S, Shigemura N. (2020). Insulin Function in Peripheral Taste Organ Homeostasis. *Current Oral Health Reports,* **7**, 168-173.
- Owen MJ, Sawa A, Mortensen PB. (2016). Schizophrenia. *Lancet.* **388(10039)**: 86-97.
- Tepper BJ, Hartfiel LM, Schneider SH. (1996). Sweet taste and diet in type II diabetes. *Physiol Behav.* **60(1)**: 13-18.
- Wasalathanthri S, Hettiarachchi P, Prathapan S. (2014). Sweet taste sensitivity in pre-diabetics, diabetics and normoglycemic controls: a comparative cross sectional study. *BMC Endocr Disord.* **14(1)**: 1-7.
- Young RL, Chia B, Isaacs NJ, Ma J, Khoo J, Wu T, et al. (2013). Disordered control of intestinal sweet taste receptor expression and glucose absorption in type 2 diabetes. *Diabetes.* **62(10)**: 3532-3541.
- Yu JH, Shin M, Kim D, Lee J, Yoon SY, Kim S, et al. (2013). Enhanced carbohydrate craving in patients with poorly controlled Type 2 diabetes mellitus. *Diabet Med.* **30(9)**: 1080-1086.