Comparative Analysis of Salt Taste Perception among Diabetics, Hypertensives and Diabetic Hypertensives

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Summary

Impaired salt taste perception has been described in patients with essential hypertension. Hypertension occurs more frequently in diabetics than the general population. We compared salt taste perception among patients with type 2 diabetes (n=59), hypertension (n=57) and concurrent hypertension and diabetes (n=56) using graded NaCl solution (0 - 400 mmol/L). Sixty age, sex and body mass index-matched healthy individuals served as controls. Main outcome measures included taste threshold for NaCl recognition, and salt taste insensitivity defined as taste threshold for NaCl recognition > 100 mmol/L. Diabetic hypertensives had insignificantly higher duration of diabetes than the diabetic normotensives (5.0 ± 4.1 versus 3.5 ± 2.6, P= 0.07). The prevalence of NaCl taste insensitivity did not differ significantly among hypertensives, diabetic hypertensives and diabetics normotensives (52.6% versus 46.4% versus 40.7%; P=0.3). Compared to the controls, normotensive diabetics were at higher risk of salt taste insensitivity (40.7% versus 18.3%, P=0.01; OR=3.1, 95% CI =1.2-7.7). In the diabetic normotensive group, NaCl taste recognition threshold correlated positively with systolic blood pressure (r=0.501, P=0.001), diastolic blood pressure (r=0.411, P=0.04) and duration of diagnosis of diabetes (r=0.402, P=0.02). These results suggest that salt taste acuity is impaired in type 2 diabetics and could be a contributory factor to the high prevalence of hypertension in the diabetic population.

Key words. *Salt taste perception, type 2 diabetes, hypertension.*

Introduction

Both epidemiologic and clinical trial data have shown that essential hypertension is strongly linked with salt intake and handling. Populations with high salt intake tend to have high incidence of hypertension. Salt restriction is, on the other hand, associated with blood pressure reduction (1, 2). Salt taste threshold, a measure of salt sensitivity, is also higher among hypertensives than the normal population (3, 4). It is established that the prevalence of hypertension is higher among diabetics compared to the general population (5). In Nigeria, for example, 2-4% and 15-20% of the population have diabetes and hypertension, respectively (6,7). Both conditions occur concurrently in 20-40% of diabetics (8, 9). Information on salt taste perception among diabetics is scanty. Such information may give insight into the mechanism underlying development of hypertension in the diabetic population. We compared salt taste thresholds among patients with type 2 diabetes, hypertension and concurrent hypertension and type 2 diabetes. Non-diabetic normotensive individuals served as controls.

Methods

The subjects consisted of type 2 diabetics (n=59), hypertensives (n=57) and type 2 diabetic hypertensive (n=56) patients who were consecutively recruited at the medical outpatient clinic of Usmanu Danfodiyo University Teaching Hospital, Sokoto, Nigeria. Sixty age, sex and body mass index-matched individuals made of randomly selected volunteers certified by clinical and/or biochemical evaluations to be neither hypertensive nor diabetic, served as controls. Left upper arm clinic blood pressure measurement was done in sitting position with mercury sphygmomanometer (Accoson), size 150 x 30 cm, using standard procedures (10). A subject with diastolic blood pressure of 90 mmHg and/or systolic blood pressure of 140 mmHg or taking antihypertensive medication was considered as having hypertension (10). Subjects with fasting blood glucose greater than 7.0 mmol/L on 1 and at least 2 occasions for those who were asymptomatic and symptomatic, respectively were diagnosed as having diabetes (11). Type 2 diabetes was diagnosed if a diabetic is managed with diabetic diet and/or oral hypoglycaemic drugs (11). Weight and height were measured with the subjects lightly clothed and without shoes. Body mass index (BMI) was calculated from the formula: BMI = Weight (Kg)/Height (m^2). Socioeconomic status was determined using the British Registrar General Scale (12). Informed consent to participate in the study was obtained after detailed explanation of the harmlessness of the solutions used.

Determination of salt taste threshold

The salt solution used was prepared in the Biochemistry Laboratory of Usamnu Danfodiyo University, Sokoto. Sodium chloride (29.25 gm) was

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dissolved in 100 mls of distilled deionised water and made up to 500 mls in a volumetric flask. Based on the results of the pilot study on salt taste perception, the following strengths of NaCl solutions were prepared by serial dilution: 0, 5, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 120, 140, 160, 180, 200, 240, 280, 320, 360 and 400 mmol/L. The solutions were stored at 4°C in coded airtight 100 ml plastic container, each having a separate pipette dropper. Fresh solutions were prepared and utilised on weekly basis throughout the period of data collection which covered November 2005 – June 2006. Subjects were blinded from knowing the identity and strength of the preparations. Four drops of distilled deionised water (NaCl solution of o mmol/L) were dropped on the anterior two third of the tongue using a pipette dropper. The subjects were instructed to describe the taste perceived. Further tests were carried out only on those who correctly described the 0 mmol/L strength of NaCl as water or tasteless. Different concentrations of salt were subsequently administered at sequentially incremental rate to determine

Table 1: General characteristics of the study population.

Characteristics	Diabetic normotensive N = 59	Hypertensive N = 57	Diabetic Hypertensive N = 56	Control N = 60
	N (%)	N (%)	N (%)	N (%)
Tribe: Hausa N (%)	49 (83.1)	39 (68.4)	42 (75)	46 (76.7)
Others N (%)	10 (16.9)	18 (21.6)	14 (25)	14 (23.3)
Economic class: Upper N (%)	4 (6.8)	6 (10.5)	6 (10.7)	8 (13.3)
Middle N (%)	35 (59.3)	23 (40.4)	37 (66.1)	38 (63.3)
Lower N (%)	20 (33.9)	18 (49.1)	13 (23.2)	14 (23.4)
Place of domicile: Rural N (%)	43 (72.9)	40 (70.2)	45 (80.4)	42 (70)
Urban N (%)	16 (27.1)	17 (29.8)	11 (19.6)	18 (30)
Sex: Male N (%)	33 (55.9)	34 (56.1)	32 (57.1)	35 (58.3)
Female N (%)	26 (44.1)	23 (43.9)	24 (42.9)	25 (41.7)
	Mean ± SD	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**
Age (years)	47.3 ± 12.5	51.9 ± 11.8	49.5 ± 13.2	50.6 ± 9.9
Duration of diabetes (years)	3.5 ± 2.6	—	5.0 ± 4.1	—
Duration of HBP (years)	—	4.5 ± 4.3	5.0 ± 4.1	—
Body mass index (Kg/m²)	30.1 ± 12.4	28.8 ± 9.6	28.3 ± 5.6	27.8 ± 6.9
Systolic blood pressure (mmHg)	122.7 ± 32.4	165.3 ± 26.3	175.9 ± 28.6	111.3 ± 10.6
Diastolic blood pressure (mmHg)	77.3 ± 11.0	99.6 ± 14.3	110.0 ± 17.5	70.7 ± 7.0
Fasting blood glucose (mmol/L)	14.3 ± 5.5	4.8 ± 0.9	12.7 ± 6.7	5.1 ± 0.6
Sodium (mmol/L)	136.4 ± 12.1	139.0 ± 8.5	139.0 ± 9.1	137.8 ± 8.3
Urea (mmol/L)	6.5 ± 3.6	5.5 ± 2.8	6.9 ± 3.0	4.0 ± 0.7
Creatinine (mmol/L)	1.4 ± 0.7	1.2 ± 0.6	1.3 ± 0.8	0.9 ± 0.2

Table 2: Comparison of salt taste threshold among diabetics, hypertensives and diabetic hypertensives.

Salt taste threshold	Diabetic normotensive N = 59	Hypertensive N = 57	Diabetic Hypertensive N = 56	Control N = 60	*P-value
Detection (mol)	50.4 ± 19.5	46.8 ± 19.5	48.1 ± 10.7	21.6 ± 14.1	<0.001
Recognition (mol)	107.4 ± 43.1	118.9 ± 42.4	112.1 ± 44.8	76.9 ± 32.6	0.01
Maximum tolerable concentration (mol/L)	229.6 ± 61.4	236.3 ± 59.2	256.6 ± 64.4	151.3 ± 31.8	<0.001

**P-value obtained from the groups (including controls) comparison using ANOVA*

Table 3: Comparison of salt taste sensitivity among diabetics, hypertensive and diabetic hypertensive.

Salt taste sensitivity	Diabetic normotensive N = 59	Hypertensive N = 57	Diabetic Hypertensive N = 56	Control N = 60
Salt taste sensitive N (%)	*35 (59.3)	*27 (47.4)	*30 (53.6)	49 (81.7)
Salt taste insensitive N (%)	*24 (40.7)	*30 (52.6)	*26 (46.4)	11 (18.3)
Total	*59 (100)	*57 (100)	*56 (100)	60 (100)

**P=0.3: Diabetic normotensive versus hypertensive versus diabetic hypertensive.*

the salt taste thresholds (3, 4, 13). The tongue was rinsed with distilled water after each test.

The first NaCl concentration recognised by the subject as tasting different from distilled deionised water was recorded as salt taste detection threshold. The concentration recognised by the subject as definitely salted was recorded as NaCl taste recognition threshold. Taste threshold to maximum tolerable NaCl concentration was defined as the salt concentration considered by the subjects as intolerable. Based on the derived normal range of salt taste threshold distribution in the control population, patients with taste threshold for salt recognition > 100 mmol/L were recorded as having salt taste insensitivity, while those with values ≤ 100 mmol/L were considered salt taste sensitive.

Statistical analysis

Data entry and analysis were done using statistical software package (SPSS). Continuous variables are presented as means ± standard deviation, while categorical variables are expressed as percentages. Mean taste threshold for salt detection, recognition and maximum tolerable concentration values were each compared between 2 groups using independent t–test (2-tailed) and among 3 or more groups using analysis of variance (ANOVA). Chi square test was used to compare proportions. Linear regression analysis was utilised in determining the correlation between salt taste threshold and continuous variables of interest including blood pressure and duration of diabetes.

Results

The general characteristics of the subjects and controls are shown in Table 1. Hypertension preceded diabetes by 0–16 years (mean: 5.5 ± 4.1 years) in the diabetic hypertensive group. Patients with diabetes, hypertension and concomitant diabetes and hypertension differed significantly from control with respect to taste threshold for salt detection (F=9.1, P<0.001), recognition (F=4.4, P=0.01) and maximum tolerable concentration (F=12.8, P<0.001) (Table 2). The distribution of salt taste sensitivity is shown in Table 3. Compared to the controls, normotensive diabetics were at higher risk of salt taste insensitivity (40.7% versus 18.3%, P = 0.01; odd ratio (OR) = 3.1, 95% confidence interval (CI) =1.2-7.7). However, the prevalence of salt taste insensitivity did not differ significantly among diabetic hypertensives, diabetic normotensives and hypertensives (46.4% versus 40.7% versus 52.6%, P=0.3). Furthermore, considering the whole study population including the controls, hypertensives were at higher risk of salt taste insensitivity than non-hypertensives (49.6% versus 29.4%, P=0.003; OR=2.4, 95% CI=1.3-4.2).

In the diabetic normotensive group, NaCl taste recognition threshold correlated positively with systolic blood pressure (r=0.501, P=0.001), diastolic blood pressure (r=0.411, P=0.04) and duration of diagnosis of diabetes (r=0.402, P=0.02). Age, gender, urban dwelling and socioeconomic status did not influence salt taste threshold.

Discussion

Several previous data showed that hypertensives have higher salt taste threshold than normotensives (3, 4). There are however only very few reports describing salt taste insensitivity in animal and human models of diabetes (14, 15). The current study demonstrates poor salt taste perception among diabetics, irrespective of blood pressure status. Patients with diabetes and/or hypertension did not differ significantly in salt taste thresholds. Salt taste threshold is probably genetically determined. This is suggested by the similarity in salt taste perception among patients with diabetes and hypertension, which are themselves genetically determined. Furthermore, the perception of salt taste appears to be unrelated to environmental factors including urban dwelling and socioeconomic status, at least, in the current report. Finally, the genetic component of salt taste perception was illustrated by the previously described higher prevalence of salt taste insensitivity among the relatives of people with family history of diabetes or hypertension compared to those without (4, 13). Both type 2 diabetes and hypertension have been linked to insulin resistance (16). Salt sensitive essential hypertensives are more insulin resistant than the salt resistant individuals (17). Insulin resistance may therefore be proposed as the common denominator underlying salt taste insensitivity among type 2 diabetics and hypertension.

High salt taste threshold is believed to lead to involuntary excess salt consumption which may in turn trigger complex and interrelated processes involving volume and humoral changes. These may culminate in sustained blood pressure elevation or essential hypertension, particularly in blacks with inherited inability to excrete salt efficiently (18, 19). We hypothesised that this mechanism is operational in type 2 diabetics. It probably explains the high prevalence of hypertension in this population. There is therefore the need to investigate the relationship between salt taste perception, salt handling and blood pressure in the diabetic population.

In conclusion, salt taste acuity is impaired in type 2 diabetes. This assertion needs to be confirmed using a larger sample size population. We admit the subjectivity involved in the determination of taste perception.

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