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Original Article

Salt taste threshold and its relation to blood pressure in normotensive offspring of hypertensive parents amongst indian adolescents

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Abstract

To study Salt Taste Threshold (STT) and its relation to Blood pressure (BP) in normotensive adolescents, age and BMI matched 60 subjects of 18-20 years were segregated on basis of family history of hypertension, documented risk factor for development of hypertension. Student's unpaired t- test showed that STT and BP values were significantly higher in Hypertensive offspring group than Control. Pearson Chi Square test with 60 mM Nacl as cut-off point showed highly significant association of STT in hypertensive offspring group. A significant positive correlation was found between STT and BP by Pearson correlation analysis. Family history of hypertension is strongly linked to reduced salt taste sensitivity. This reinforces rationale that both conditions may be genetically linked though causal relation cannot be established. STT can be used as significant marker to screen 'salt sensible' subjects that eventually will develop hypertension and can be advised healthy habits early or prophylactically treated.

Introduction

Hypertension is a major public health problem due to its high prevalence worldwide. Hypertension or high blood pressure (BP) is a chronic medical condition in which the blood pressure in the arteries is elevated. This disease is known to have many deleterious effects on the body and is considered one of the most important modifiable risk factor for cardiovascular diseases (1).

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There is still much uncertainty about the pathophysiology of hypertension. A small number of patients (2-5%) have an underlying renal or adrenal disease as the cause for their raised blood pressure. In the remainder (95%) however no clear single identifiable cause is found and their condition is labelled 'essential hypertension' (2, 3). Primary mechanism involved in the development of essential hypertension remains unclear, in part due to its multi-factorial origin.

Probably many interrelated factors contribute to the raised blood pressure in hypertensive patients, and their relative roles may differ between individuals. Among the factors that have been most intensively considered are genetic profiles and high salt intake (3). High BP values have been observed in populations with high salt intakes (4) and treatment strategies based on lowering salt ingestion have demonstrated its effectiveness in lowering BP levels (5).

Salt intake is a nutritional behaviour influenced by a multitude of factors. Cultural and socioeconomic factor in conjunction to intrinsic characteristic plays an important role in the hedonistic enjoyment of eating (6). This influence can be intermediated by the salt taste sensitivity, resulting in the modulation of the amount of salt intake.

A number of investigators have reported that individuals with hypertension tend to have reduced salt taste sensitivity as measured by salt (sodium chloride) taste recognition threshold in comparison to normotensive individuals (7, 8, 9). However, it is not entirely clear whether this relationship is causal. The variability in salt taste sensitivity could be related to BP either as a causal factor, as an accompanying variable to BP, or even as a consequence of raised BP. Moreover, the relationship between Salt Taste Threshold (STT) and BP in normotensive individuals has been studied by several authors, with different findings. Some have found a positive correlation between STT and BP while others have not (10, 11). It is possible that the association between STT and BP may differ between normotensive and hypertensive subjects. Incidentally, some studies in paediatric population have demonstrated that children with reduced salt taste sensitivity (higher STT) tend to have higher BP readings (12), thus suggesting that the alteration in taste function could exist prior to the development of hypertension or high BP.

Considering STT as a reliable indicator of salt taste sensitivity and keeping in view the conflicting reports about relation of STT with BP, with a lacunae present in literature in respect to relation of STT to BP in normotensive offspring of hypertensive parents amongst adolescent age group, the present study is proposed. In the present study, normotensive adolescent subjects were segregated on the basis of a family history of hypertension, which is a documented risk factor for the development of hypertension (13, 14). STT and BP readings measured in the hypertensive parent offsprings were compared with the normotensive parent offsprings.

Materials and Methods

The study was carried out in the premises of tertiary hospital in Nerul, Navi Mumbai with prior approval from the Dean, Head of Physiology department and Ethics committee for research on human subjects of the Institute.

Subjects (n=60) were healthy individuals of both sexes with age between 18-20 years (MBBS students) and normotensives with blood pressure readings persistently below 130/85 mm Hg as per British Hypertension Society (BHS) guidelines on three different occasions at monthly intervals (15). Subjects were divided into two study groups on the basis of family history of hypertension viz. Hypertensive offspring group and Control group. Hypertensive offspring group consisted of 30 healthy subjects of both sexes (15 males and 15 females) with a family history of long-standing hypertension - diastolic BP more than 90 mm Hg and systolic BP more than 140 mm Hg, history of taking anti-hypertensive medications or complications of hypertension e.g. stroke in at least one parent. Control group consisted of age and Body Mass Index (BMI) matched 30 healthy subjects of both sexes (15 males and 15 females) with no family history of hypertension in the parents. Subjects fulfilling the inclusion criteria were selected in each study group by purposive sampling technique.

Subjects with history of any major illness altering the taste sensation like facial nerve palsy, diabetes mellitus, stomatitis, addiction to alcohol, smoking and tobacco chewing, long duration intake of drugs like captopril, metronidazole were excluded.

Subjects meeting the above inclusion and exclusion criteria were approached to voluntarily participate in the study with clarification of no difference in the internal assessment marks of the students. After a detailed explanation of the procedure involved, safety and innocuous nature of solutions used in the study were also explained to the participants. Thereafter, written informed consent for the study was taken from each subject.

Through detailed history taking and clinical examination of the subjects, exclusion criteria factors altering taste sensation were ruled out. Age (years), sex and anthropometric parameters; height (metres) and weight (kg) were noted for each subject. Height of the subject was measured using a measuring scale with least count of 0.1 cm. Height of each subject was converted in unit of metres. Weight was measured using weighing machine whose least count was 0.5 kg with subjects lightly clothed and without shoes. BMI of each subject was calculated using Quetelet's index: BMI = weight (kg)/height^2 (m).

Systolic and Diastolic Blood pressure was recorded for each subject in sitting position with mercury sphygmomanometer using standard procedure. Mean arterial blood pressure (MABP) was calculated using the formula: MABP = DBP + pulse pressure (SBPDBP) ÷ 3, where DBP means diastolic blood pressure and SBP means systolic blood pressure.

Determination of salt taste threshold (STT)

In this study for the measurement of salt (Nacl) taste recognition threshold solutions of different NaCl concentrations were used, as per Harris and Kalmus method (16, 17). The salt solution used was prepared in the laboratory of Biochemistry Department of the Institute. The substance used for salt taste was sodium chloride with molecular weight of 58.44. A mole is the gram-molecular weight of a substance and 1 millimole (mmol) is 1/1000 of a mole (mol). Thus 1 mol of Nacl= 23+35.5g =58.5 g and 1 mmol= 58.5 mg. Thus on dissolving 58.5g of NaCl in a final volume of 1litre, we will get a1M NaCl solution. For this study following concentrations of Nacl solution were prepared by titrating 1 M Nacl stock solution: 15, 30, 45, 60, 75, 90, 120 and 180 mM. Solutions were stored at 4ˆc in coded airtight 100ml plastic container, each having separate pipette dropper. Fresh solutions were prepared and utilised on weekly basis throughout the period of data collection.

The tests were preferably carried out in the morning time. Subjects were asked not to eat or drink anything except water for at least one hour before the threshold measurement.

Subjects were blinded from knowing the identity and strength of preparation. Essentially, subjects were informed that the test solutions were of various tastes, e.g., distilled water, sucrose, urea (bitter), and sour but not salty, in order to avoid speculation. Assistance was taken to test the taste sensation using different concentration solutions on the anterior two-third portion of the tongue. Subjects were instructed to indicate the taste perceived using placard method by pointing to the card on which different taste sensations were written.

Subjects were given solution of lowest Nacl concentration to taste first followed by successively higher concentration of solutions until a definite salty taste was obtained. The tongue was rinsed with distilled water after each concentration test. After correct identification of Nacl solution, the procedure was continued until next higher concentration of Nacl. Subjects who were able to recognize that the NaCl solution is at a higher concentration, i.e. stronger in taste, the threshold value were recorded as the preceding NaCl concentration.

Statistical analysis of data

In the present study, all data collected were analyzed using SPSS (Statistical Package for Social Sciences) version 17. Mean was calculated for different parameters in each study group. Mean is a measure of central tendency and is one value around which other values are dispersed. Standard Deviation (S.D) which denotes the measure of variability or dispersion from the mean value was calculated. The recorded values were expressed as Mean±SD.

Statistical analysis of the data was done using student's unpaired t- test. In addition, Pearson Chi Square test was used to assess the distribution of STT variable in both study groups with a cut-off point of 60 mM Nacl concentration. To apply Chi Square test, expected value in four cells must be more than 5. If the expected value in any cell is less than 5, using Chi Square test gives over estimate. The gender difference in distribution of STT variable in both study groups were analysed using Fisher's Exact test as the expected value in four cells was less than 5. Karl-Pearson Correlation Coefficient analysis test was used to correlate STT with BP. Statistical significance of difference was determined. The P value gives the probability of any observed difference having happened by chance. P value of 0.05 means that the probability of the difference having happened by chance is 0.05 in 1 i.e 1 in 20. P value below 0.05 was considered to be statistically significant and P value below 0.01 was considered to be highly significant.

Results

Table I depicts Mean and standard deviation values of different parameters- Age, Body Mass Index (BMI), Systolic blood pressure (SBP), Diastolic blood pressure (DBP), Mean blood pressure (MBP) and Salt Taste Threshold (STT) for both study groups, with the inter-group comparison of significance using student's unpaired t- test. As shown in Table I, parameters like Age and BMI were not significantly different between two groups. SBP, DBP, MBP and STT values were significantly higher in Hypertensive offspring group than in Control group (P<0.01).

Table II shows highly significant association of STT variable in Hypertensive offspring group than Control group by Pearson Chi Square test. This test is used as a test of homogeneity to assess the distribution of STT values in two study groups with 60 mM Nacl concentration as a cut-off point. 53.33% of hypertensive offspring group had higher threshold values i.e STT value of 60 mM and greater, compared to only about 7% of control. This difference was found to be highly significant ($X^2 = 18.468$, P = 0.000).

TABLE II : Association of STT variable in both study groups.

STT with cut-off point of 60 mM	*Hypertensive offspring*	*Control*	*Total*
<60 mM	14	29	43
> or = 60mM	16	1	17
Total	30	30	60

mM - millimole, analysis done using Pearson Chi Square test.

On further gender distribution of subjects in both study groups as shown in Table III and IV, female subjects showed highly significant association with STT variable (P =0.002) as compared to male subjects (P=0.014) by Fisher's Exact test.

TABLE III : Association of STT in males subjects of both study groups.

STT with cut-off point of 60 mM	*Hypertensive offspring*	*Control*	*Total*
<60 mM	7	14	21
> or = 60 mM	8	1	9
Total	15	15	30

mM - millimole, analysis done using Fisher's Exact test.

TABLE IV : Association of STT in female subjects in both study groups.

STT with cut-off point of 60 mM	*Hypertensive offspring*	*Control*	*Total*
<60 mM	7	15	22
> or = 60 mM	8	0	8
Total	15	15	30

mM - millimole, analysis done using Fisher's Exact test.

Table V shows that on correlation of STT with blood pressure readings (SBP, DBP and MBP) in both study groups by Karl- Pearson correlation coefficient

TABLE I : Comparative data of Age, BMI, blood pressure (SBP, DBP, MBP) and Salt Taste Threshold (STT) of both study groups.

Parameters	*Hypertensive offspring (n=30)*	*Control (n=30)*	*t-value*	*P-value*
AGE (years)	18.67±0.66	18.37±0.56	1.902	0.062
BMI (kg/m^2)	21.30±2.54	20.05±2.33	1.984	0.052
SBP (mm Hg)	116.53±6.64	110.40±7.92	3.250**	0.002
DBP (mm Hg)	76.93±5.91	70.13±7.45	3.917**	0.000
MBP (mm Hg)	90.55±5.74	83.54±7.60	4.036**	0.000
STT (m M)	54.00±14.33	36.00±9.32	5.712**	0.000

Values are expressed as Mean±SD; Data was analysed using Student's unpaired t- test. **P<0.01 – statistically highly significant.

TABLE V : Correlation of STT with blood pressure readings (SBP, DBP and MBP) in both study groups.

Parameters	*Hypertensive offspring (n=30)*		*Control (n=30)*	
	r-value	*P-value*	*r-value*	*P-value*
SBP (mm Hg)	0.956**	0.000	0.877**	0.000
DBP (mm Hg)	0.947**	0.000	0.868**	0.000
MBP (mm Hg)	0.915**	0.000	0.872**	0.000

**P<0.01 - statistically highly significant.

analysis test, there was statistically highly significant positive correlation between STT and blood pressure (P<0.01).

Discussion

In the present study, age and BMI variables of the two study groups were matched, as these factors can contribute in the alteration of STT (18, 19). There was no statistical difference of age and BMI among the two groups. There was highly significant association of STT variable with Hypertensive offspring group which showed significantly higher STT values as compared to the Control group.

One persistent finding of literature is higher STT i.e reduced salt (Nacl) taste sensitivity in hypertensive subjects in comparison with normotensive subjects, but whether this relationship is causal is not entirely clear. The coexistence of reduced salt taste sensitivity and genetically determined conditions such as hypertension and diabetes (20, 21), has fostered the hypothesis of genetic predetermination of salt taste sensitivity.

The finding of the present study shows that STT were significantly higher in normotensive adolescents with a family history of hypertension than in those without such history, which is a documented risk factor for the development of hypertension. This finding is consistent with the observation of other workers (12, 22).

The overlap observed in the pattern of reduced salt taste sensitivity in normotensive adolescents with a genetic predisposition to hypertension in the present study, reinforces the prevailing rationale that both the conditions may be genetically linked. Moreover with improvement in the effectiveness and techniques of genetic testing, it is found that individuals with haptoglobin 1-1 phenotype are more likely to have sodium sensitivity than people with haptoglobin 2-1 or 2-2 phenotypes. Thus we can conclude that family history of hypertension is strongly linked with the occurrence of reduced salt taste sensitivity in normotensive adolescents while a causal relationship between two variables cannot be established.

On gender distribution of subjects in both study groups, female subjects showed highly significant association with STT variable as compared to male subjects. Studies have showed that females during pregnancy or otherwise throughout their menstrual cycle often have a higher tendency to have taste alterations and greater salt ingestion. Eating habits like Pica characterized by an appetite for non-nutritive substances like chalk, clay, soap etc. are also more common in women. A deficiency of a certain type of ingredient in the body e.g sodium loss could drive person to crave for food rich in those ingredients as a compensatory mechanism (23). Female sex hormones and metabolism differences most probably account for differences between males and females for the salt taste quality.

In the present study, BP readings were significantly higher in Hypertensive offspring group with higher STT in comparison to Control group in whom the STT was low. There was a highly significant positive correlation found between STT and SBP, DBP and MBP readings in both study groups. This finding is consistent with the observation of some but in contrary to observation of others (10, 11). Present study finding indicates that the salt taste sensitivity (STT) plays a greater role in the determination of blood pressure levels. In one of the community-based study involving adolescents, on examining any possible link between salt taste sensitivity and BP, it has been observed that about 14% of the variations in SBP were due to differences in the sensitivity to salt taste (16).

This can be explained on the basis that impaired salt taste sensitivity i.e higher STT is linked to involuntary excess salt consumption. It is obvious that the amount of salt ingested by any subject should be related in some way to his/her conscious or unconscious ability to recognize it. Reduced sensitivity would drive individuals to consume more salt until reach the salt concentration identified as pleasant. Furthermore, it is supposed that high salt intake gradually decreases salt taste perception and consequently increases the sodium concentration needed to trigger the STT (24). STT is a simple and reliable index to verify salt intake in clinic and thus can be used to evaluate an inherited characteristic of salt preference and sensitivity.

Epidemiological research during the last decades has reported dietary sodium as an important contributor to the pathogenesis of hypertension (25). When too much salt is ingested while kidneys react to excrete excess sodium and chloride in the body; water retention causes BP to increase inside blood vessel walls. It has been suggested that higher intakes of salt would trigger complex interrelated neurohormonal and volume changes contributing to increase of BP (19, 26).

In salt sensitive individuals, fluctuations in BP in response to increased or decreased sodium are more dramatic than normal fluctuations. In most studies, sodium sensitivity is defined as the change in mean blood pressure corresponding to a decrease or increase of sodium intake. Thus a diet high in sodium increases the risk of hypertension in people with sodium sensitivity, corresponding to an increase in health risks associated with hypertensions including cardiovascular disease (27). Hence it is important to be aware of this element not only in hypertensive subjects as it can have profound effects on their treatment plan but also in general population to help subjects change their salt intake behaviour as preventive therapy in controlling cardiovascular diseases. Thus we can conclude that STT can be used as a significant marker or tracking tool to screen 'salt sensible' subjects that eventually will develop hypertension and can be advised healthy habits early on or prophylactically treated.

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