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Development of hypertension due to inability of kidney to excrete excess sodium ions (Na^+) and water in salt-sensitive people: a population based study

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ABSTRACT

Background: The main aim of this study is to investigate the role of salt in the development of hypertension in people who are unable to excrete excess amount of salt and water through urine.
Materials and methods: We studied serum and urine samples and others parameters like blood pressure, weight, height, age, physical activity, waist, hip, sociodemographics etc. regarding hypertension from 114 selected people out of 2,453 members of households of study areas to find out the exact cause of salt-induced hypertension due to inability of kidneys within the studied people.
Results: Now-a-days, we take average 9-15g salt with diet that ultimately leads to the development of hypertension. The salt-induced hypertension is mainly due to inability of kidney to excrete excess sodium ions (Na^+) and water through urine. Some people does not show raised blood pressure although they take high amount of salt in their diet and it is possibly due to ability of their kidney to excrete high salt and fluid at normal level. Their blood pressure is increased when they take high (≥10.0g/day) amount of salt for a long time. Here salt-induced hypertensive group is said to be salt-sensitive. Whose blood pressure does not rise with salt intake is called salt-resistant group.
Conclusion: From this study it is found that more than 5.0g salt intake per day exerts harmful effects on kidneys and cardiovascular system in low kidney capacity people. The salt resistant people can tolerate medium salt (<10.0g/day) intake per day due to their high kidney capacity to excrete excess salt and water through urine, but long time high salt intake (>10.0g/day) leads to hypertension in this people.

Keywords: Hypertension, Scheduled Caste Community, Salt-sensitive and Salt-resistant people, Blood pressure, Excretion capacity.

Introduction

For several million years the evolutionary ancestors of humans ate a diet that contained <1g salt/day [1]. Approximately 40 nonacculturated tribes have been recorded which consumed <3g salt/day. Their blood pressure did not rise with age. They lived or still live, in Amazon Basin of South America [2], Africa [3], the South Pacific [4], and the highlands of Malaysia [5], the most extensive and most striking example are the Yanomamo Indians on the border between Venezuela and Brazil [6]. The salt consumption of these people was extremely low and the average sodium excretion in the urine was only 1mEq per day. Blood pressure did not rise with age and hypertension was completely absent among them. From the evolutionary view point, it is estimated that the Scheduled caste Community of the district Nadia, West Bengal, India, of this study ingest approximately 9-15g salt per day and it is 90-150 folds more than primitive societies because their salt intake was less than 0.1g per day [7]. The 24h urine volume and 24h urine sodium were increased with the high salt intake in human [8].

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Materials and methods

Population based survey

A cross sectional door-to-door community based survey work was conducted to investigate the prevalence of usual salt-related hypertension within the SC community of three selected villages (viz. Chowgachha, Bagula and Priyanagar) of the district Nadia, West Bengal, India. About 2,453 members of households of study areas were interviewed and detailed information (i.e., age, sex, weight and height for BMI, waist and hip for WHR, HR, blood pressure, physical activity, oil intake, salt intake etc.) regarding hypertension were recorded. Average age of the studied individuals is approximately 41.58±14.25

(range, 20-70 yrs). Data were collected from 10.00 am to 4.00 pm.

Blood pressure measurement

The blood pressure was measured by both authentic mercury and digital (HEM-7111 and HEM-4030, Omron healthcare, Kyoto, Japan) sphygmomanometer in supine position after at least 10 minutes rest.

Blood and urine biochemical analysis

The biochemical analysis of serum and urine was done in 114 people of the study areas. Out of 114 people, forty three (43) hypertensive and seventy one (71) were normotensive (NTN) people. The studied people took their usual diet and were instructed to collect 24-hour urine sample for the measurement of volume and electrolytes (Na^+, K^+ and Cl^-). Fasting blood sample was also collected for serum electrolytes (Na^+, K^+ and Cl^-) and other biochemical analysis like blood sugar, Hb% and lipid profile regarding hypertension. The biochemical analysis was done by a semi-automatic biochemistry analyzer (prietest-easy lab, Robonik India Pvt. Ltd., Mumbai, India). Here only salt or sodium-related hypertension was studied.

Definition criteria

According to VIIth report of American Joint National Committee (JNC), hypertension was diagnosed if the subjects had SBP/DBP ≥ 140/90 mmHg [9]. Depending on the excretion capacity of Uv (24h Urine volume) and Us (24h urine Na^+) of the kidney, the study individuals are categorized into two in each salt intake group, i.e., high and low excretion capacity of kidney.

Statistical analysis

All values were presented in the form of mean ± SEM. Data were analyzed using z-statistics at both 5% and 1% level of significance. Data and statistical analysis were performed using SPSS 12.0 software for windows.

Result

Salt and overall prevalence of hypertension in study people

The overall crude prevalence of hypertension is given in the Table No.-2 and Fig No.-2 and it is 15.85% in the study people (N=2,453). The prevalence of hypertension is 4.10%, 4.31%, 12.42%, 22.17% and 32.02% in <5g, 5-7.9g, 8-10.9, 11-13.9g and ≥14g salt intake groups. From z- statistics, it is observed that both SBP ($p<0.05$ in 8.0-10.9g salt/day and $p<0.01$ in ≥11g salt/day) and DBP ($p<0.01$ in ≥8.0g salt per day) are significantly increased with the amount of dietary salt in comparison to NTN group.

Salt and prevalence of hypertension in selected people

Prevalence and development of hypertension in relation to usual salt intake with diet and plasma and urine Na^+ concentration in one hundred fourteen (N=114) studied people is given in the Table no.-1 and Figure no.-1. Each salt intake group is compared with the normotensive (NTN) group. Prevalence rate of hypertension is also increased in low kidney capacity group with increased salt intake and it is 9.09%, 22.72%, 62.50% and 80.00% in <5g, 5-9.9g, 10-14.9g and ≥15g of salt intake groups respectively. On the other hand, prevalence rate of hypertension in high kidney capacity group are 0.00%, 7.40%, 20.00% and 25.00% in <5g, 5-9.9g, 10-14.9g and ≥15g of salt intake groups respectively. From this result it is observed that high kidney capacity group can tolerate high salt load than low kidney capacity group.

Salt and Us and Uv

In low and high kidney capacity group, Us and Uv excretion is not significantly changed in low salt intake group, but it is statistically significant in medium ($p<0.05$), high ($p<0.01$) and very high ($p<0.01$) salt intake groups compared to low and high kidney capacity group of NTN people respectively.

Salt and Ps

In low kidney capacity group, Ps level is not significantly changed in low salt intake group, but it is statistically significant in medium ($p<0.05$), high ($p<0.01$) and very high ($p<0.01$) salt intake groups compared to low kidney capacity group of NTN people. In high kidney capacity group, Ps level is not significantly changed in low and medium salt intake group, but it is statistically significant in high ($p<0.01$) and very high ($p<0.01$) salt intake groups compared to low kidney capacity group of NTN people.

Salt and blood pressure

In low kidney capacity group, SBP is not significantly changed in low salt intake group, but it is statistically significant in medium ($p<0.05$), high ($p<0.01$) and very high ($p<0.01$) salt intake groups compared to low kidney capacity group of NTN people. In high kidney capacity group, SBP is not significantly changed in low and medium salt intake group, but it is statistically significant in high ($p<0.05$) and very high ($p<0.01$) salt intake groups compared to low kidney capacity group of NTN people. In low kidney capacity group, DBP is not significantly changed in low salt intake group, but it is statistically significant in medium ($p<0.05$), high ($p<0.05$) and very high ($p<0.01$) salt intake groups compared to low kidney

capacity group of NTN people. In high kidney capacity group, DBP is not significantly changed in low and medium salt intake group, but it is statistically significant in high ($p<0.01$) and very high ($p<0.01$) salt intake groups compared to low kidney capacity group of NTN people.

Effect of salt on SR people

Hypertension is more significantly found in low kidney capacity group than high kidney capacity group. The group that can excrete more Uv (24h Urine volume) and Us (24h urine Na^+) to keep their blood pressure normal and is able to tolerate medium salt intake (<10.0g salt/day). Hypertension is rare in this group, hence they are known as 'Salt-resistant (SR)'. This group exhibits hypertension only when they take high (≥10.0 g salt per day) amount of salt with their diet for long time.

Effect of salt on SS people

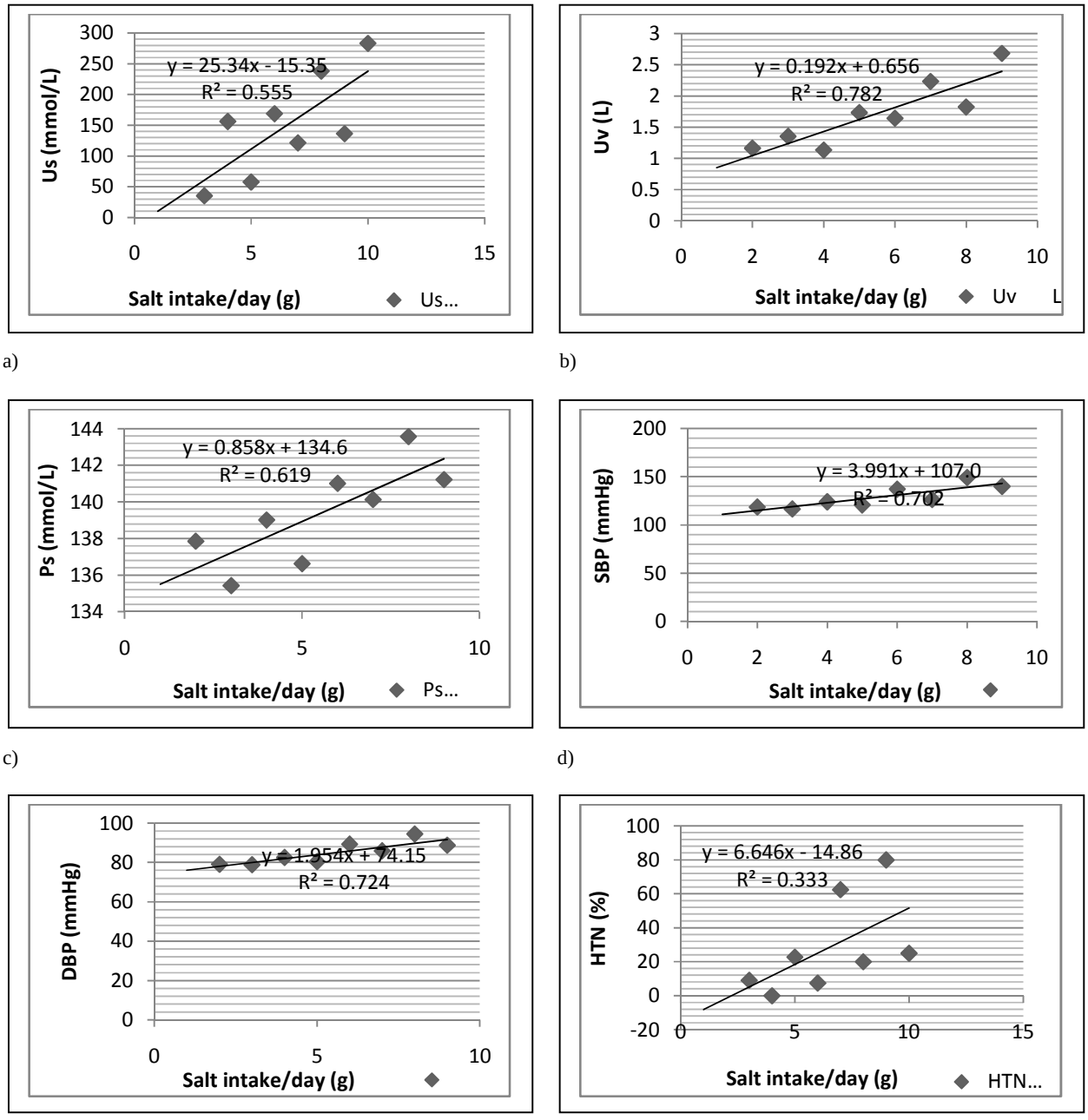
SS group of people is unable to excrete high Us and Uv and can't regulate their blood pressure. Hypertension is proportionally related with amount of dietary salt. This group shows high blood pressure above 5.0g of usual salt intake for long time, hence they are called 'Salt-sensitive (SS)'. To avoid hypertension this group should take salt less than 5.0 g per day.

Table 1: Prevalence of hypertension in relation to capacity of kidney to excrete Na^+ through urine in different salt intake groups

Salt intake /day	excretion capacity of kidney	No. 114	Us Avg±SEM mmol/L	Uv Avg±SEM L	Ps mmol/L	SBP mmHg Avge± SEM	DBP mmHg Avge±SEM	HTN (%)
NTN n=71	Low	55	43.06±7.05	1.04±0.05	138.02±0.20	119.13±1.84	80.15±0.68	0.00
	High	16	160.72±2.01	1.51±0.06	136.14±0.16	117.82±2.56	77.04±1.83	0.00
<5.0g Low	Low	11	35.07±5.85	1.16±0.07	137.85±0.19	118.54±2.02	79.09±0.65	9.09
	High	4	156.00±2.83	1.35±0.09	135.42±0.37	116.48±3.13	78.84±3.32	0.00
5-9.9g Medium	Low	22	57.54±7.08*	1.13±0.06	139.01±0.39*	123.92±2.21*	82.55±1.04*	22.72
	High	27	168.66±4.01*	1.73±0.11*	136.62±0.25	120.72±2.40	80.43±1.77	7.40
10-14.9g High	Low	8	121.17±18.05**	1.64±0.18**	141.01±0.28**	137.04±5.09**	89.28±4.52*	62.50
	High	25	237.74±12.41**	2.23±0.15**	140.13±0.25**	126.23±4.17*	85.90±2.57**	20.00
≥15.0g Very high	Low	5	136.05±17.83**	1.82±0.23**	143.57±0.47**	149.06±9.62**	94.42±4.60**	80.00
	High	12	283.06±22.71**	2.68±0.31**	141.22±0.41**	139.85±8.06**	88.71±4.50**	25.00

Table 2: Overall prevalence of HTN and change of blood pressure in relation to daily salt intake with diet

Salt intake /day	NO N=2,453	SBP mmHg	|z|-value	DBP mmHg	|z|-value	HTN (%)
NTN (N=425)	-	117.13±0.51	-	78.35±0.41	-	0.00
<5g	146	113.51±1.88	1.92	76.83±0.81	1.87	4.10
5-7.9g	255	116.73±0.31	1.29	77.072±0.72	1.77	4.31
8-10.9g	1006	123.33±2.48	2.50*	83.00±1.05	4.42**	12.42
11-13.9g	893	127.30±0.94	10.81**	90.46±0.70	17.30	22.17
≥14g	153	136.79±2.30	8.54**	88.36±0.42	23.83	32.02
*=p<0.05 and **=p<0.01						

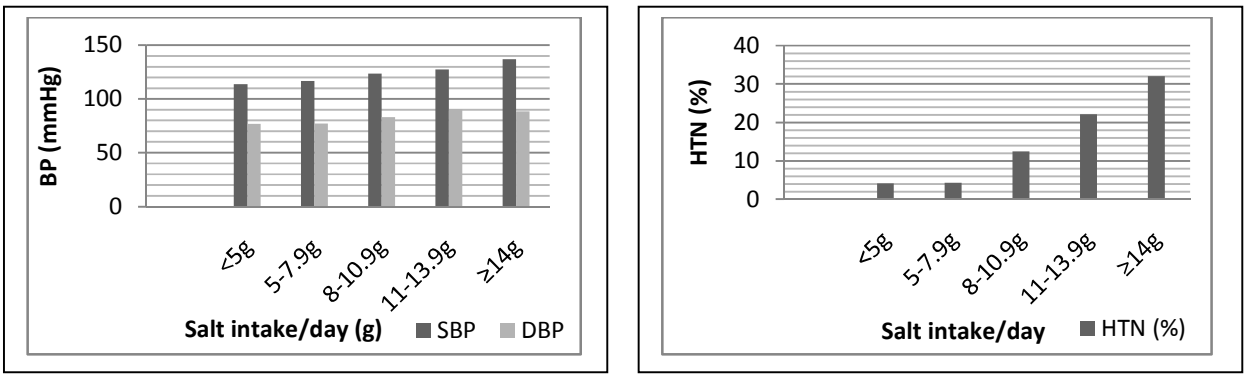


a) b)

c) d)

e) f)

Fig 1: The scatter diagrams a, b, c, d, e and f showing the linear relationship between daily salt intake and Us, Uv, Ps, SBP, DBP and hypertension respectively in studied people.



a) b)

Fig 2: Figures a and b showing daily salt intake wise change of blood pressure (both SBP and DBP) and prevalence of hypertension respectively in overall studied people (N=2,453).

Discussion

The prevalence rate of hypertension is gradually increased with dietary salt in low and high kidney capacity groups but it is found that salt is more effective for the development of hypertension in salt sensitive group than salt resistant group. This kind of salt related hypertension study was also reported by some other workers [8, 10, 11].Both the systolic and diastolic blood pressure is positively correlated with high salt intake. These kinds of works were also done by others [11-14]. High salt intake significantly increases renal excretion of water due to increased water intake. These compatible findings were also reported by some other workers [15-19]. The development of hypertension in some individuals of high salt intake group is mainly due to poor renal functional capacity to handle/excrete an excess renal volume (Uv) and renal salt or sodium (Us). These were also diagnosed by other researchers [7, 8]. High salt intake increases plasma sodium ions concentration mainly in low kidney capacity group and it is due to poor renal capacity to excrete excess sodium from blood [8, 20].

Conclusions

Compared to normotensive (NTN) group, the Us and Uv excretion, Ps (plasma Na^+), blood pressure and prevalence of hypertension are significantly increased with the high salt intake especially in low kidney capacity group than high kidney capacity group. As more than 5.0g salt ingestion per day exerts harmful effects on cardiovascular system and kidneys in low kidney capacity group, everyone under salt-sensitive group should take less salt (<5.0g) with their diet to protect their cardiovascular system as well as kidney functions. On the other hand, salt-resistant group tolerates medium salt intake (<10.0g/day), but it may exert harmful effects on their kidney and cardiovascular system if they take high salt for long time. From this study, it can be suggested that salt resistant group can ingest medium amount of salt (<10.0g/day) with their diet to avoid harmful effects on their physiological.

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