Correlation between Serum Sodium and Potassium Levels and Risk of Developing Hypertension

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ABSTRACT

Introduction: High blood pressure, also known as hypertension, is one of the most well-known major risk factors for cardiovascular disease (CVD) and stroke. Several studies have suggested that the sodium and potassium are important determinants of blood pressure. We in the present study tried to evaluate the correlation between the serum sodium and potassium levels and development of hypertension.

Material and Methods: This study was conducted in the Departments of General Medicine and Biochemistry SMBT Medical College and Hospital, Igatpuri, Nasik. The subjects were examined clinically and the physical examinations included measurement of height in cms, weight and blood pressure. Body mass index (BMI) was calculated as the weight in kilograms divided by the square of the height in meters. Blood Pressure was measured on the right arm using standard sphygmomanometer with participant seated quietly on a bench with back support after physical rest for 5 minutes. Overnight fasting venous blood samples were collected for the measurements of serum glucose, blood lipid, and electrolyte concentrations. Serum potassium and sodium levels were measured by the ion-selective electrode method.

Results: A total of 169 subjects were included in the study out of which 95 (56.21%) were male and 74 (43.79%) were females. Out of the total 169 subjects, 49.12% were in the overweight category 30.76 were in the normal weight category and obese people were 20.11%. By logistic regression analysis among all the variables the serum potassium levels having an odds ratio of 2.1 and p values were 0.04 found to be significant. Higher BMI categories 25 – 30 and > 30 had an odds ratio of 1.35 and 1.95 with p values less than 0.05 for both indicating that higher BMI is an important factor for the development of hypertension.

Conclusion: serum sodium levels and serum potassium were significantly associated with the risk of development of hypertension. Higher BMI also has been found to be associated with hypertension. Therefore changing lifestyles and making people aware of the adverse effects of an increase in BMI and electrolyte imbalance causing hypertension and its complications may go long way in preventing this development in the population.

Keywords: Serum sodium, Serum Potassium, Hypertension

INTRODUCTION

Hypertension is considered one of the major risk factors for the development of cardiovascular disease. The known risk factor for hypertension includes genetic predisposition and environmental factors like diet, physical activity, and tobacco or alcohol intake.[1,2] The involvements of major elements such as sodium and potassium have received attention in the last several years. The mechanisms underlying the origin and maintenance of hypertension are still relatively obscure. Studies on sodium and potassium seem to show an inverse relationship between blood pressure and Na^+/K^+ ratio.[3] The global prevalence of hypertension in adult aged 25 years and above was around 40% in 2008.[4] In India, the prevalence of hypertension was varying from 17 to 21% in all the states with marginal rural-urban differences. The overall pattern of prevalence was found increasing with age groups in all states.[5] Sodium has a critical role in extracellular volume regulation and is important for the cellular functions of all organs systems. It ensures adequate blood volume, arterial pressure, and ultimately organ perfusion.[6,7] Several studies have indicated the relation of salt intake to blood pressure.[8,9] Potassium ion is the most prevalent cation in the human body. The small extracellular potassium pool is controlled by exterior intake, internal redistribution, and excretion.[10] In normal persons approximately 90% of dietary potassium is absorbed and excreted via kidneys. Aburto NJ et al; in a meta-analysis from 22 randomized controlled trials concluded that increased potassium intake reduced systolic blood pressure by 3.49 mmHg and diastolic blood pressure by 1.96 mmHg in adults, this effect was only seen in people with hypertension but not without hypertension.[11] Study by Zhang et al; showed that higher sodium and lower potassium consumption were associated with hypertension.[12] Sharma et al;[13] in a cross-sectional study indicated that dietary potassium and sodium were not associated with elevated blood pressure in individuals with no prior history of hypertension. Therefore there are conflicting results obtained for different studies as far as an association of sodium and potassium levels is concerned.

MATERIAL AND METHODS

This study was conducted in the Departments of General Medicine and Biochemistry SMBT Medical College and

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Hospital, Igatpuri, Nasik. Institutional Ethical committee permission was obtained for the study. Written consent was obtained from all the participants involved in the study after explaining the nature of study in the local language. Only those participants voluntarily willing to participate were included in the study. Their physical examinations included measurement of height in cms, weight and blood pressure. Body mass index (BMI) was calculated as the weight in kilograms divided by the square of the height in meters. Blood Pressure was measured on the right arm using standard sphygmomanometer with participant seated quietly on a bench with back support after physical rest for 5 minutes. The mean value of three consecutive readings was used both at the baseline and the follow-up surveys. Hypertension was defined as a mean systolic blood pressure ≥140 mmHg, and/or a mean diastolic blood pressure ≥90 mmHg, and/or taking antihypertensive medication. Optimal blood pressure was defined as a mean systolic blood pressure < 120 mmHg and a mean diastolic blood pressure < 80 mmHg. Normal blood pressure was defined as a mean systolic blood pressure of 120–129 mmHg and a mean diastolic blood pressure of 80–84 mmHg. Pre-hypertension was defined as a mean systolic blood pressure of 130–139 mmHg and a mean diastolic blood pressure of 85–89 mmHg. Diabetes mellitus was defined as fasting blood glucose ≥ 126 mg/dl (7.0 mmol/L) or the use of anti-diabetic drugs. Overnight fasting venous blood samples were collected for the measurements of serum glucose, blood lipid, and electrolyte concentrations. Serum potassium and sodium levels were measured by the ion-selective electrode method.[14] Fasting blood glucose was measured by enzymatic methods. High-density lipoprotein and low-density lipoprotein were measured by the homogeneous assay.

Age Group (Yrs)	Male	Female	Total	Percentage
35 – 40	42	35	77	45.56
41 – 45	28	19	47	27.81
46 – 50	13	12	25	14.79
51 – 55	12	8	20	11.83
Total	95	74	169	100

Table-1: Showing age and sex wise distribution of the subjects included in the study

BMI category	Male	Female	Total	Percentage
< 25	30	22	52	30.76
25 – 30	45	38	83	49.12
> 30	20	14	34	20.11
Total	95	74	169	100

Table-2: Distribution of the subjects based on BMI categories

	BMI < 25	BMI 25 - 30	BMI >30	Total
< 120 / 80	35	27	5	67
129-129 / 80-84	12	33	11	56
130 -139 / 85 -89	5	23	18	46
Total	52	83	34	169

Table-3: Correlation between BMI and blood pressure recorded in the subjects

RESULTS

A total of 169 subjects were included in the study out of which 95 (56.21%) were male and 74 (43.79%) were females. The most common age group from 35 – 40 years constituted to about 45.56% of the patients. The next age group involved was 41 – 45 yrs having 27.81% of patients followed by 14.79% and 11.83% in 46 – 50 and 51 – 55 yrs age groups shown in table 1.

The subjects were categorized based on BMI readings those with < 25 were considered as normal weight those between 25 – 30 were considered as overweight and those with BMI >30 were considered as obese. Out of the total 169 subjects, 49.12% were in the overweight category 30.76 were in the normal weight category and obese people were 20.11% given in table 2.

The correlation between the BMI category and blood pressures were analyzed. The BMI category of < 25 had 35 (67.30%) out of total 52 in optimal blood pressures category were as those with BMI 25 - 30 in optimal BP category were

BP range	Male		Female	
	Serum Na^+ mmol/L	Serum K^+ mmol/L	Serum Na^+ mmol/L	Serum K^+ mmol/L
< 120 / 80	140.15 ± 35.5	4.15 ± 0.52	141.15 ± 10.5	4.14 ± 0.4
129-129 / 80-84	141.5 ± 40.5	4.14 ± 0.6	142.71 ± 35.8	4.12 ± 0.51
130 -139 / 85 -89	142.5 ± 32.5	4.05 ± 0.32	142.95 ± 39.5	4.01 ± 0.35

Table-4: Correlation of blood pressure with serum sodium and serum potassium levels

Parameter	BMI < 25	BMI 25 – 30	BMI > 30
Fasting blood glucose (mg/dl)	95.5 ± 20.5	116.8 ± 22.5	146.8 ± 35.2
HbA1c %	5.89 ± 1.16	6.1 ± 2.25	8.21 ± 3.05
Triglycerides (mg/dl)	180.45 ± 31.6	192.5 ± 25.2	210.2 ± 40.2
Cholesterol (mg/dl)	170.65 ± 38.9	178.05 ± 32.5	198.56 ± 30.6
HDL-C (mg/dl)	42.5± 7.5	40.15 ± 5.5	37.5 ± 6.5
LDL-C (mg/dl)	90.58 ± 16.8	99.5 ± 25.8	101.5 ± 30.6

Table-5: Showing the mean levels of glucose and lipid profile in subjects.

Variable	Odds ratio	Confidence Interval 95% [CI]	P value
Age	0.55	0.35 – 1.15	0.23
Gender	1.15	0.75 – 1.65	0.12
Tobacco	0.95	0.65 – 1.25	0.06
Alcohol	0.54	0.31 – 0.96	0.7
Serum Na^+	1.56	0.92 – 1.75	0.25
Serum K^+	2.1	1.85 – 2.25	< 0.04*
BMI categories			
< 25	0.56	0.29 – 0.79	0.69
25 – 30	1.35	0.76 – 1.65	<0.05*
> 30	1.95	1.66 – 2.15	<0.05*
* Significant			

Table-6: Risk of developing hypertension determined by logistic regression analysis

27 (32.53%) out of 83 subjects and those with BMI > 30, 5 (14.70) out of 34 subjects were in <120 / 80 mmHg BP category. Similarly BP rage of 129-129 / 80-84 mmHg the number of subjects in <25 BMI category was 12 (22.22%) and those with BMI 25 – 30 were 33 (39.67%) out of 83 and with BMI >30 11 (32.35%) of the 34 patients. The blood pressure range of 130 - 139 / 85 -89 mmHg in BMI < 25 were 5 (9.6%) out of 52 and in BMI 25 – 30 were 23 (27.71%) out of 83 and in BMI > 30 were 18 (52.94%) out of 34 (table-3). The patients were categorized based on the blood pressure readings those with the blood pressure of less than 120/80 were having Optimal blood pressure the mean serum Na^+ levels in the male with optimal BP was 140.15 ± 35.5 mmol/L and mean K^+ was 4.15 ± 0.52 mmol/L. Similarly, in females, the mean Na+ was 141.5 ± 10.5 mmol/L and K^+ were 4.14 ± 0.4 mmol/L. The Normal blood pressure was defined as a mean systolic blood pressure of 120–129 mmHg and a mean diastolic blood pressure of 80–84 mmHg the mean serum Na^+ in male and female respectively were 141.5 ± 40.5 mmol/L and 142.71 ± 35.8 mmol/L and mean K^+ levels were 4.14 ± 0.6 mmol/L and 4.12 ± 0.51 in male and female. The systolic blood pressure of 130–139 mmHg and a mean diastolic blood pressure of 85–89 mmHg were having the mean Na^+ and K^+ levels in males and females as 142.5 ± 32.5 mmol/L and 4.05 ± 0.32 mmol/L 142.95 ± 39.5 mmol/L and 4.01 ± 0.35 mmol/L given in table 4.

The glucose and lipid profiles of the subjects involved in the study were analyzed based on the BMI categories, the mean fasting blood glucose, HbAlc, Triglycerides, Cholesterol, HDL, and LDL were recorded for each group as shown in table 5.

To calculate the effect of variables on blood pressure we investigated the parameters with logistic regression analysis to determine the independent effect on risk of development of hypertension. Among all the variables the serum potassium levels having an odds ratio of 2.1 and 'p' values were 0.04 found to be significant. Higher BMI categories 25 – 30 and > 30 had an odds ratio of 1.35 and 1.95 with 'p' values less than 0.05 for both indicating that higher BMI is an important factor for the development of hypertension other parameters are as shown in table 6.

DISCUSSION

Hypertension is the cause of 50% of incidences of cardiovascular diseases worldwide.[15] There were several factors affecting the development of blood pressure which includes high salt intake, low K^+ intake, obesity, lack of exercise and excess alcohol intake. In this article, we studied the effect of serum Na^+ and K^+ on the development of hypertension. In the present study, we divided the subjects into three groups based on BMI < 25 (Normal), BMI 25 - 30 (Overweight) and BMI > 30 (Obese). Out of the 169 subjects, 30.76% were normal, 49.12% were found to be overweight and obese 20.11% when BMI was correlated with Blood pressure. Those with obese and overweight had the higher percentage of people with increased blood pressure. Several studies have shown the positive effect of increased BMI on blood pressure.[16,17] The correlation between serum sodium and serum potassium levels and BP ranges were studied in male and female subjects. The overall pictures show there was an increase in serum Na^+ levels with increasing blood pressure and the slight decrease in serum potassium levels with increasing blood pressure both in male and females. In a study by V Pandey et al;[18] found Na^+ was positively correlated with BP and K^+ had a negative correlation with SBP. They also found that there is a strong association of BMI with Na^+ and K^+ levels and BP agrees with the findings of the present study. We determined the risk factors for hypertension using logistic regression analysis. We found serum potassium having highest association with the odds ratio of 2.1 and [CI 95% 1.85 – 2.25] the other factor was the BMI 25 – 30 and > 30 having a higher odds ratio of 1.35, 1.95 respectively and 'p' values were found to be < 0.05. In a similar study by Lu XI et al;[19] found baseline potassium levels were positively associated with risk of incidence of hypertension (OR 1.75 95% CI: 1.01–3.04) they also found there was no significant association between baseline serum sodium level. The Framingham Heart Study found that adults with serum potassium ≥ 5.2 mEq/L had increased risk of hypertension, though the difference was not significant.[20] Hu, et al;[21] suggested that serum potassium level was lower in the hypertension group compared with the non-hypertension group. These findings were similar to the findings of our study. Syed et al; showed a more negative correlation of serum Na^+ and K^+ with BMI.[22] Several mechanisms exist by which sodium and potassium can influence blood pressure, and evidence indicates that the interaction between these ions plays an important role in the development of hypertension.[23] Some studies have indicated that the joint effects of low sodium and high potassium intakes on blood pressures, hypertension, and related factors may be larger than the effects of either sodium or potassium alone.[23,24] A study by Kesteloot et al; revealed that serum potassium and sodium levels were negatively related to blood pressure.[23] Increased dietary intake of potassium and sodium may subsequently increase potassium and sodium levels in the blood.[26,27] Some studies have suggested that the ratio of sodium to potassium is more important than either electrolyte alone, however,

other studies have found a positive correlation between sodium-potassium ratio and blood pressure.[28-32] In the study we found an increased risk of hypertension individuals with baseline potassium < 4.2 mmol/L, the Framingham heart study[20] found potassium levels < 4.0 mEq/L or > 5.2 mEq/L with hypertension in partial agreement of the results of this study. In the INTERSALT study, the data collected from standardized 52 centers the urinary sodium and blood pressure showed significant positive association in eight centers and a negative association in two centers.[33] there are suggestions that within populations, a high degree of intra-individual variability of sodium intake is present and it may obscure potential biological correlations.[34] Although it is difficult to generalize the results of this cross-sectional study on the whole population at the same time it does provides significant information regarding the characteristics of hypertension and their association with electrolyte levels in this group of the population.

CONCLUSION

Within the limitations of the present study, it was found that serum sodium levels and serum potassium were significantly associated with the risk of development of hypertension. Higher BMI also has been found to be associated with hypertension. Therefore changing lifestyles and making people aware of the adverse effects of an increase in BMI and electrolyte imbalance causing hypertension and its complications may go long way in preventing this development in the population.

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