Blood pressure and plasma sodium and potassium

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Summary

1. Two thousand, three hundred and twenty-eight men and 1496 women between the ages of 35 and 64 years were screened for hypertension and their plasma sodium and potassium concentrations measured. Those on antihypertensive or diuretic treatment were excluded from further analysis.

2. After adjusting for age, body mass index and other variables, plasma potassium was negatively associated with both systolic and diastolic pressure in men and women. A decrease in plasma potassium of 1 mmol/l was associated with an increase in systolic pressure in women of 7 mmHg (P < 0.001) and diastolic pressure of 4 mmHg (P < 0.001). In men the corresponding increases were 4 mmHg (P < 0.01) and 2 mmHg (P < 0.05).

3. After adjusting for the other variables as above, plasma sodium was positively related to systolic blood pressure but not to diastolic pressure. An increase in plasma sodium of 1 mmol/l was associated with an increase in systolic pressure of 1 mmHg in both men (P < 0.01) and women (P < 0.05).

Key words: potassium, sodium.

Introduction

There is considerable interest in the hypothesis that sodium chloride produces hypertension in genetically susceptible individuals [1, 2]. Conversely, blood pressure may be lowered by increasing potassium intake [3]. The present report indicates that blood pressure is positively related to plasma sodium and negatively to plasma potassium.

Subjects and methods

Of London civil servants aged 35–64 years involved in a health screening programme, 15,339 men and 8,795 women completed a questionnaire. On the basis of the replies 17% of men were called for a medical examination; of these 2,577 men 14% had the single complaint of possible angina pectoris; 22% had reported severe pain across the chest lasting for more than half an hour; 14% had a possible peptic ulcer; a small group of 4% had either a relatively high alcohol intake or symptoms suggestive of intermittent claudication or chronic bronchitis; 24% had more than one of these conditions and 22% did not have any of these problems but were selected at random or requested an examination on their own initiative. Twenty-two per cent of women were recalled; of these 1,895 women 15% had possible angina pectoris, 7% pain across the chest, 2% with either possible intermittent claudication or chronic bronchitis, 11% with possible peptic ulcer and 17% with more than one of these conditions. In addition 20% were recalled because of a putative high risk of breast cancer and 3% with a similar risk of cervical cancer; 25% were recalled who had none of the above abnormalities. The examination of the above individuals included measurements of blood pressure after lying for 10 min (the point of disappearance of sound was taken as the diastolic blood pressure) and the estimation of plasma electrolytes by flame photometry; 2,328 men and 1,496 women had both measurements. Five per cent of men (112) and 9% of women (134) were excluded from the analysis as they were receiving antihypertensive or diuretic medication.

Results

The men had an average blood pressure of 134 ± 21 mmHg systolic and 80 ± 13 mmHg...
diastolic. Average age was 48.2 years, plasma sodium 142 ± 1.8 mmol/l and plasma potassium 4.2 ± 0.4 mmol/l. The blood pressure in women averaged 132 ± 21 mmHg systolic and 79 ± 13 mmHg diastolic. Average age was 49.3 years, plasma sodium 142 ± 1.9 mmol/l and plasma potassium 4.3 ± 0.4 mmol/l.

Fig. 1 gives the mean systolic and diastolic blood pressures for both sexes for five approximately equal 'quintiles' of plasma sodium and plasma potassium. Also given are the first-order correlation coefficients (r) between pressure and the plasma electrolytes for 2216 men and 1362 women. In women there was a significant positive correlation between systolic pressure and plasma sodium (r = +0.14, P < 0.001) and negative correlation with plasma potassium (r = −0.07, P < 0.01). Diastolic pressure was negatively but not significantly correlated with plasma potassium (r = −0.04). There were no significant first-order correlations in men. In females the highest ‘quintile’ of plasma sodium was associated with a systolic/diastolic excess of 9/1 mmHg over the lowest ‘quintile’. The ‘quintiles’ of plasma potassium in women revealed a 6/2 mmHg excess pressure for the lowest quintile compared with the highest quintile.

Adjusting for statistically significant variables by multiple regression [age, body mass index (weight/square of height), serum proteins, glucose and calcium, blood haemoglobin, mean corpuscular volume and, in men, alcohol intake] revealed significant negative relationships between both systolic and diastolic pressures and serum potassium in men and women. These associations were independent of the above variables and plasma sodium. In women the partial regression coefficients were significant at the 0.1% level and revealed that a fall in plasma potassium of 1 mmol/l was associated with an increase in systolic/diastolic pressure of 7/4 mmHg. In men a fall of 1 mmol/l was associated with an increase in systolic pressure of 4 mmHg (P < 0.01) and an increase in diastolic pressure of 2 mmHg (P < 0.05). Adjusting for the significant variables (including potassium) confirmed the lack of association between plasma sodium and diastolic pressure but supported a positive association between plasma sodium and systolic pressure in men and women. A 1 mmol/l increase in plasma sodium appeared to be associated with a 1 mmHg rise in systolic pressure (P < 0.01 and P < 0.05 for men and women respectively). The full equations are available from the authors on request.

Six hundred and sixteen individuals (407 men and 209 women) were randomly selected for examination. These subjects were free of an obvious selection bias. The regression coefficients for the males and females combined were similar.
to those of the whole group. A rise in plasma sodium of 1 mmol/l was associated with a 1 mmHg increase in systolic pressure \((P < 0.05)\) and a rise in plasma potassium of 1 mmol/l with a decrease in systolic pressure of 4 mmHg \((P < 0.05)\).

**Discussion**

Blood pressure was weakly but significantly and positively related to plasma sodium and negatively to plasma potassium. Among possible explanations three suggest themselves. Firstly, elevated blood pressure may lead to an increase in aldosterone and a fall in plasma potassium \([4, 5]\). However, although secondary hyperaldosteronism may explain the negative relationship between blood pressure and plasma potassium, this theory is not compatible with a positive association between blood pressure and plasma sodium.

Secondly, an abnormality in mineralocorticoid excretion may elevate blood pressure, for example by a reduced metabolic clearance of aldosterone \([6]\). Thirdly, constant sodium loading or a deficiency of potassium in the diet may produce an elevated blood pressure, dietary excess or deficiency being reflected in the plasma levels of electrolytes. Serum potassium can be influenced by diet. In a recent trial of weight loss in obese patients a 120 mmol of sodium/day, low calorie diet was accompanied by an increase in serum potassium of 0·2 mmol/l and a 40 mmol of sodium/day diet by an increase of 0·5 mmol/l \([7]\).

The results lend some support to the hypothesis that increased sodium intake may raise blood pressure in some individuals. When considering diastolic pressure, however, it was apparent that a negative association could be demonstrated between plasma potassium and blood pressure, without any association with plasma sodium. Dietary potassium should also be considered in the genesis of hypertension.

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**References**