Sodium and potassium excretion in a sample of normotensive and hypertensive persons in eastern Finland

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SUMMARY A 24-hour urine collection was carried out during a cardiovascular survey in eastern Finland. The study population comprised 148 hypertensive subjects in a random sample of the middle-aged population and 86 normotensive controls. The mean sodium excretion was 199 mmol/24h in both normotensive and hypertensive men, 179 mmol/24h in normotensive women and 174 mmol/24h in hypertensive women. There were no significant differences in potassium excretion rate or in sodium: potassium molar ratio between the normotensive and the hypertensive among either men or women. There was no statistically significant correlation between blood pressure level and sodium or potassium excretion or sodium: potassium molar ratio. One in four of the subjects reported that they usually added salt to their food before tasting it. The results of this study show that the average level of salt intake in a Finnish population is high, and so is the sodium: potassium molar ratio. Although there was no correlation between sodium excretion and blood pressure levels, it is known that in this population the average blood pressure level is high and cardiovascular disease extremely frequent.

A high intake of sodium and a low intake of potassium have been increasingly implicated in the aetiology and pathogenesis of arterial hypertension.^{1,2} Moderate restriction of salt (sodium) intake produced a definite antihypertensive effect in hypertensive patients.^{3–5} During a community-wide multifactor risk reduction campaign, a decrease in urinary sodium:potassium molar ratio was the strongest predictor of the lowering of systolic blood pressure.⁶ Therefore a decrease in sodium intake or an increase in potassium intake, or both, might be effective for the prevention or even the treatment of hypertension.

In North Karelia in eastern Finland cardiovascular disease morbidity and mortality among men is higher than that reported for any other non-institutionalised population in the world.^{7–11} Arterial hypertension is known to predispose to other cardiovascular diseases, such as stroke and coronary heart disease.¹² Little attention has been paid to the levels of sodium and potassium intake in North Karelia or in Finland generally. Only one study, on a small group of elderly men, suggested that the intake of sodium might be high in North Karelia.¹³ The aim of the present pilot study was to obtain a preliminary idea of the levels of sodium and potassium intake in middle-aged

Table 1 The study material

	MEN				WOMEN				TOTAL	
	Normotensive No.	%	Hypertensive No.	%	Normotensive No.	%	Hypertensive No.	%	No.	%
Subjects invited to participate	41	100	66	100	45	100	82	100	234	100
Non-attendant during survey	5	12	4	6	2	4	2	2	13	5
Excluded due to inadequate collection of urine	5	12	6	9	12	27	18	22	41	18
Total excluded	10	24	10	15	14	31	20	24	54	23
Total	31	76	56	85	31	69	62	76	180	77

normotensive and hypertensive people in North Karelia.

Material and methods

This study was part of a large epidemiological survey for which the material consisted of a 6.6% random sample of the population aged 25–64 in the county of North Karelia. The total number of persons studied was 4123, with a participation rate of 89%. The examination was carried out in February–April 1977.¹⁴ The respondents in two small towns in North Karelia were selected for the sub-study. In this pilot study approximately 200 subjects took part (Table 1).

The study population was selected as follows:

(1) Subjects were defined as hypertensive if, after two consecutive measurements, they were found to have 160 mmHg systolic or 95 mmHg diastolic blood pressure, or both; or if they had higher levels than these. People receiving treatment with antihypertensive drugs were also defined as hypertensive. This group of 148 persons was made up of 66 men and 82 women. During the preceding year, raised blood pressure had been recorded by a doctor in 52% of the hypertensive men and 53% of the hypertensive women. Thirty-eight per cent of the hypertensive men and 45% of the hypertensive women were receiving drug treatment for the condition; (2) When a hypertensive person was found, the next subject of the same sex and 10-year age group, with blood pressure levels lower than those specified for the definition of hypertensives, and without treatment, was taken into the normotensive control group. This group of 86 persons was made up of 41 men and 45 women. During the preceding year raised blood pressure had been recorded by a doctor in 3% of the normotensive men and of the women.

Casual blood pressure was measured in the sitting position according to the standardised technique in which the fifth phase of the Korotkoff sounds was taken as the diastolic blood pressure.¹⁵ The details of the blood pressure measurement procedure have been described elsewhere.¹⁶

After the measurement of blood pressure, a 24-hour urine sample was collected approximately two weeks after the subject's first visit to the clinic. The urine volume was measured and a sample of mixed urine was taken and put into the freezer. Urine sodium and potassium were determined by routine flame photometry, and creatinine by the Jaffe method (Technicon®).

The creatinine content of the 24-hour urine sample was used to exclude inadequate urine collections. If the sample of a man contained less than 6.7 mmol and that of a woman less than 5.7 mmol creatinine, the collection was considered unsatisfactory and was therefore excluded from the final analysis. On this basis 31 samples obtained from women and 10 from men were excluded.

Height and weight were measured without shoes and with light clothing. The body-mass index was calculated as weight/height^2 (kg/m^2).

A family history of hypertension and cardiovascular diseases was considered positive if the questionnaire data showed that mother or father had suffered from hypertension, myocardial infarction or stroke before the age of 60.

Subjective estimation of salt consumption was measured using structured questions: 'Do you usually add salt to your food before tasting it?'; 'How often do you reckon to use salt and salty food items compared with other people?'; and 'How salty do you consider meals outside compared with your home food?'

Results

The average blood pressure values of the normotensive men were 141 mmHg systolic and 85 mmHg diastolic and those of the hypertensive men were 165 and 102 mmHg respectively. The corresponding values for women were 145 and 85 mmHg and 170 and 97 mmHg.

The average body mass index (BMI) of the hypertensive men was about 14% greater than that of the normotensive men. The average BMI was approximately similar in normotensive and hypertensive women. The prevalence of overweight

was markedly greater in hypertensive than in normotensive men so that the BMI exceeded 30.0 in 45% of the hypertensive and in only 6% of the normotensive men. In normotensive women the prevalence of overweight (BMI >30.0) was almost as common (39%) as in hypertensive women (45%) (Table 2).

Table 2 Some variables of the material by sex and by blood pressure levels

Variable	Hypertensive		Normotensive	
	Men %	Women %	Men %	Women %
Age (years): mean±SD	50.1±11.3	53.8±7.4	50.1±10.4	52.2±7.4
Body mass index mean±SD (kg/m ²)	28.9±4.8	28.5±4.3	25.4±2.4	27.9±3.7
Body mass index > 30	45	45	6	39
No. of retired persons	36	26	16	26
Family income per year > 32 000 Fmk	30	13	42	10
High blood pressure detected in preceding year	52	53	3	3
Antihypertensive drug treatment	38	45	—	—
Mean values of blood pressure ($\bar{x}$ ±SD)				
Systolic	165±18.3	170±18.8	141±14.4	145±10.3
Diastolic	102±9.0	97±8.9	85±9.3	85±7.5

The mean sodium excretion was 197 mmol/24h in both normotensive and hypertensive men. The mean 24-hour excretion of sodium was 179 mmol in normotensive women and 174 mmol in hypertensive women. In both men and women sodium excretion values were lower among persons over 55 compared with those in the younger age groups (Table 3). In the 24-hour excretion of potassium there were no statistically significant differences between the normotensives and the hypertensives among either men or women (Table 4). Nor did the average Na/K value differ significantly between the groups. The excretion of creatinine was smaller in women than in men but there was no difference between the normotensive and hypertensive groups.

Among men, those with a positive family history of cardiovascular diseases had significantly higher

Table 3 Mean values of 24-hour urinary sodium excretion by age and sex

Age group (years)	MEN				WOMEN			
	Normotensive X	Hypertensive SD	Normotensive X	Hypertensive SD	Normotensive X	Hypertensive SD	Normotensive X	Hypertensive SD
25-44	208	77	199	94	172	11	174	30
45-54	269	51	221	65	189	69	183	52
55-64	163	60	178	61	168	42	167	60
Total	197	75	197	74	179	56	174	54

Table 4 Mean values (±SD) of mmol of creatinine, sodium, and potassium excretion, and ratio Na:K, in 24-hour sample of urine

	MEN		WOMEN	
	Normotensive	Hypertensive	Normotensive	Hypertensive
Creatinine	12.0±3.3	11.8±3.3	8.4±1.6	8.6±2.1
Sodium	197.4±74.6	197.0±74.0	178.6±55.6	174.0±54.0
Potassium	70.4±26.7	63.6±20.0	62.5±17.1	61.5±17.1
Na:K ratio	2.9±0.8	3.2±1.3	3.0±0.9	2.9±0.9

diastolic blood pressure ($P < 0.05$) than those with a negative family history. Systolic blood pressure, 24-hour urinary Na-excretion, and Na:K ratio were also slightly higher among men with a positive family history but the differences were not statistically significant. Among women, there were no significant differences between those with a positive and a negative family history with regard to these variables (Table 5). There was no correlation between sodium excretion and blood pressure level among persons with either a positive or a negative family history.

Table 5 Sodium and potassium excretion, Na:K ratio, and blood pressure by family history of cardiovascular diseases and sex

	Na/24h (mmol)	K/24h (mmol)	Na:K (ratio)	Systolic blood pressure (mmHg)	Diastolic blood pressure (mmHg)
Men's family history					
Negative	194	67	3.0	155	94
Positive	200 (NS)	65 (NS)	3.2 (NS)	157 (NS)	97*
Women's family history					
Negative	176	62	2.9	158	91
Positive	175 (NS)	61 (NS)	3.0 (NS)	164 (NS)	95 (NS)

* $P < 0.05$

A larger proportion of hypertensive than of normotensive men considered meals outside the home less salty than home food but there was no such difference between the normotensive and hypertensive women.

The proportion of persons who reported that they usually added salt to their food before tasting it was about 25% in all four groups. Information on subjective estimation of salt consumption derived from the questionnaire correlated well with 24-hour urinary sodium excretion (Table 6).

Discussion

High salt intake^{1 17 18} or a high ratio of sodium to potassium in the diet^{2 6 19} may be important causative

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factors in arterial hypertension and thus also in several other cardiovascular diseases. Therefore it seemed important to estimate the levels of sodium and potassium intake in eastern Finland, an area with exceptionally high death rates from cardiovascular diseases.⁸⁻¹¹ The measurement of 24-hour urinary excretion of sodium and potassium was performed for a group of people because it gives a reasonable estimate of the intake levels of these cations.²⁰⁻²² The results in the random population sample of people aged 25-64 indicate that both the average intake of salt and the sodium to potassium ratio in eastern Finland greatly exceed dietary recommendations.^{1,2,23,24} So far the importance of inappropriate intakes of sodium and potassium as potential causative factors in the high cardiovascular morbidity and mortality in this area has been largely neglected. In Finland the excretion of sodium and potassium has been measured in only one previous epidemiologic study on men over 55.¹³ The results of the present study agree well with that report.

Only one 24-hour urine sample was collected from each individual in the present study. Six to 14 measurements of 24-hour urinary excretion of sodium and potassium may be required to categorise the level of an individual's long-term intake. It is therefore useless to try to find any correlation between casual sodium excretion or sodium to potassium ratio on the one hand and blood pressure on the other. As in some other studies,²⁵ there was no difference in the average level of sodium excretion between the normotensive and hypertensive groups. This is not surprising because the level of salt use is mainly determined by the culture and dietary habits of the community.¹ However, the lack of a difference in sodium excretion between the normotensive and hypertensive groups by no means indicates that sodium is not involved in hypertension. Animal experiments have clearly demonstrated that sensitivity to the hypertensive effect of sodium is genetically determined.¹⁷ At the same level of intake, sodium induces mild or severe hypertension in some animals but no hypertension in others.¹⁷ There is some evidence to suggest that sensitivity to the hypertensive effect of sodium may be genetically

determined in man also.²¹ If this is true it could be expected that at the high intakes found in eastern Finland and in most, if not all, industrialised countries, salt contributes to the development of hypertension in part of the population. This assumption is supported by the findings that hypertension is absent or rare in populations with low intakes of salt.^{1,18} Pietinen *et al*²¹ demonstrated that in their sample a positive correlation between sodium excretion and blood pressure was found in subjects with a positive family history of hypertension. This hypothesis was not confirmed in our study, but among men in our material there was a tendency for those with a positive family history to have slightly higher blood pressure and sodium intake. The study population of Pietinen *et al* was much younger and within a rather narrow age range, whereas ours was much more heterogenous. Because our study was not designed to find such a correlation there might be some weakness in the selection of the population and the methods in this respect.

Furthermore, even a moderate restriction of dietary salt produces an antihypertensive effect,⁵ and the antihypertensive effect of thiazide diuretics is obviously due to the loss of sodium and extracellular fluid.¹⁸ Accordingly, although there is no conclusive direct evidence that the present levels of salt intake in eastern Finland contribute to the high prevalence of hypertension and other cardiovascular diseases, there is plenty of indirect evidence to suggest that this might be the case. In future, therefore, greater emphasis should be placed on the high intake of salt and the high ratio of sodium to potassium in the diet^{2,6,19,26} as modifiable, potential causative factors in cardiovascular diseases in eastern Finland.

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Table 6 Subjective estimation of salt consumption compared with urinary sodium excretion (mmol/24h): men and women combined

Salt added to food before tasting			Estimation of salt consumption compared with other people's			Consideration of salt content of meals outside home		
	No.	Sodium excretion		No.	Sodium excretion		No.	Sodium excretion
Never	(45)	171	Less	(137)	164	More salty	(28)	158
Sometimes	(110)	186	Same	(34)	176	Same	(125)	177
Always	(23)	196	More	(6)	189	Less salty	(21)	185

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