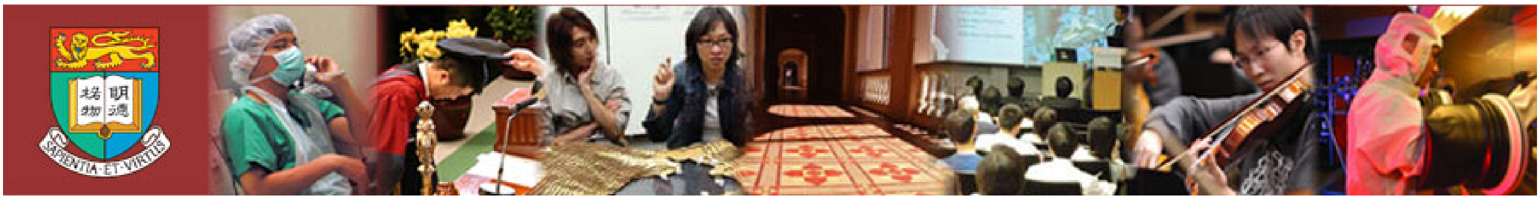

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Cost-effectiveness of low-salt diet for lowering blood pressure in the Hong Kong Chinese population

Key Messages

1. A low-salt diet lowers blood pressure, is cost-effective and well accepted by patients, so hypertensive patients should be encouraged to reduce their salt intake.
2. Most hypertensive patients are likely to need more than one antihypertensive drug in combination with a low-salt diet.
3. For the general population, the strategy should be to maintain an ideal body weight and recommended salt intake.

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Introduction

Hypertension affects one in 10 adults in Hong Kong[1] and is a risk factor for coronary heart disease and strokes. One of the environmental factors that may promote the development of hypertension is a high-salt intake. The Intersalt project[2] was a study of over 10 000 subjects from 52 centres in different countries and showed a relationship between sodium and blood pressure levels. In a dietary and nutritional survey of British adults, a difference in sodium intake of 100 mmol was associated with a blood pressure difference of 5 mm Hg/1 mm Hg in men and 7 mm Hg/4 mm Hg in women.[3] Many studies have failed to show a relationship between sodium intake and blood pressure because of regression dilution bias and short study durations. Studies that involved salt restriction for more than 4 weeks showed a blood pressure reduction as predicted.[4-6]

In Caucasians, the relationship between blood pressure and sodium intake is still questioned. The food industry prefers to ignore the evidence. Three quarters of dietary sodium in the western diet is hidden in processed food. A substantial reduction in sodium intake would require the purchase of expensive food items or a change in food industry practices. In Chinese, there is a clearer relationship between blood pressure and sodium intake.[2] Moreover, there is a steep rise in blood pressure with age, associated with a high-sodium intake. In Hong Kong, the prevalence of hypertension rises from below 1% in people under 35 years to 27% in men and 36% in women over 65.[1] Dietary salt intake in Hong Kong is high, the mean being 203 mmol Na/day.[1] Local studies show that blood pressure is related to sodium intake.[7] A high-salt intake may be a risk factor for stroke independent of blood pressure. The benefits are much larger if a significant reduction in blood pressure can be achieved. Reducing salt intake by several mm Hg may be sufficient to enable reduction or withdrawal of anti-hypertensive medications in patients with mild hypertension. Although a low-salt diet is safe and cheap, its cost-effectiveness needs to be established, as there is demand on dieticians' time and a change in spending on food. Our hypothesis was: because blood pressure levels are related to sodium intake, a low-salt diet might be efficacious and cost-effective in patients with borderline-to-mild hypertension.

Methods

This study was conducted from October 1998 to September 2000. The faculty ethics committee approved the protocol.

Relationship between sodium intake and blood pressure in normal adults

Adults between the ages of 18 and 75 years inclusive who were not current hospital patients were recruited. They were asked to come to the Queen Mary Hospital, were questioned about their medical and dietary histories and had their height, weight, waist-hip ratio, body fat, dietary patterns, exercise and alcohol habits, blood pressure, 24-hour urinary electrolytes, plasma electrolytes assessed. High-sodium food items regularly consumed by these subjects were identified.

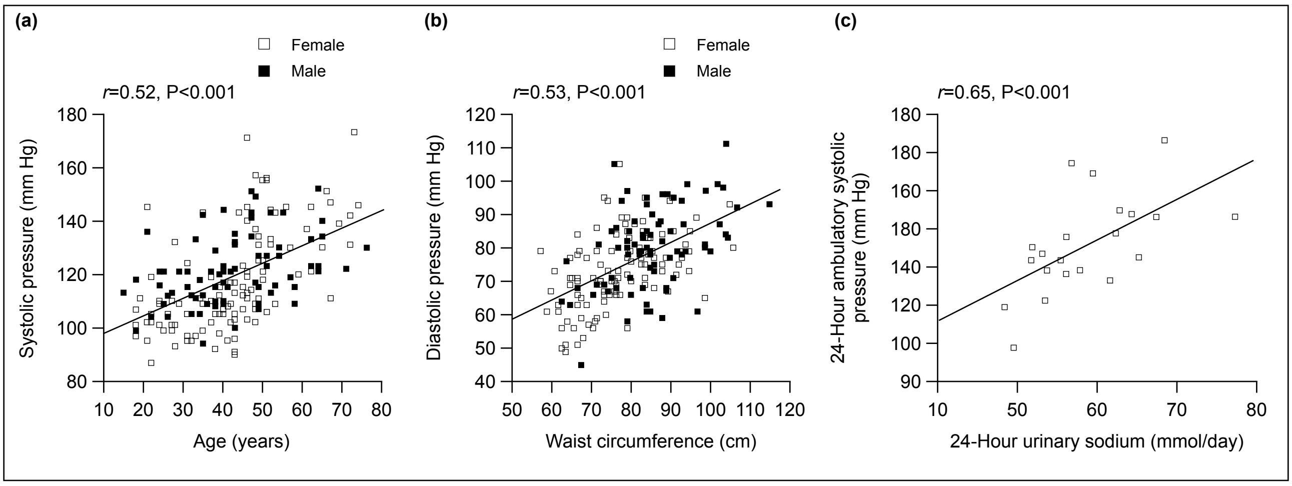

Fig 1. Relationship between sodium intake and blood pressure in normal adults

Randomised controlled trial of sodium restriction in the treatment of mild essential hypertension

A total of 93 patients with mild-to-moderate hypertension (pre-treatment diastolic blood pressure of 90-110 mm Hg) attending the hypertension out-patient clinic were recruited and gave informed consent. All patients underwent a 4-week placebo run-in phase; 74 patients were randomised to conventional treatment (hydrochlorothiazide 25 mg daily or metoprolol 100 mg daily) or a low-sodium (80 mmol/day) diet for 6 months. At baseline, 3 months, and 6 months, 3-day food diaries were completed. The patients were seen by a dietician and completed food frequency questionnaires. The data yielded by these were used in a nutrient analysis (Nutrient Analysis System, Nutritionist IV; N-Squared Computing, First DataBank Division, San Bruno [CA], US). Those allocated to conventional treatment received conventional lifestyle advice from a doctor and a nurse, and were given drugs needed to achieve a target seated diastolic blood pressure of <90 mm Hg. Those allocated to the low-sodium diet received special instructions from a dietician regarding a low-sodium (80 mmol/day) intake. They were then seen at monthly intervals, when their food diaries were reviewed to monitor their dietary intake and compliance, and the dietary advice reinforced. Blood pressure and 24-hour urine sodium measurements were performed at baseline, 3 months, and 6 months. If the blood pressure exceeded 160/90 mm Hg after 3 months of a low-sodium diet, antihypertensive medication was started. Patients on the low-sodium diet were asked to rate the diet and their quality-of-life was assessed by a questionnaire (WHOQOL-BREF [HK]).

Cost-effectiveness of salt reduction vs drug therapy

Cost-effectiveness ratios (cost per mm Hg fall in diastolic blood pressure) were calculated for the low-salt diet and conventional treatment. The costs included health service costs and patient costs. Health service costs included the dietician's and doctor's time, costs of drugs, and laboratory tests. Patient costs include changes in the cost of food, food supplements, and lifestyle, as well as the costs of extra visits to see the dietician. To test the robustness of the cost difference between diet and drugs, we performed a sensitivity analysis, varying the cost of drugs and food, the dietician's time, and the degree of blood pressure lowering.

Results

The relationship between sodium intake and blood pressure in normal adults

Altogether 190 adults were studied. Of these, 151 were normotensive and 39 were hypertensive. Systolic blood pressure correlated with age (*r*=0.52, P<0.001) [Fig 1a] and various indices of obesity, including body mass (*r*=0.24, P=0.001), body mass index (*r*=0.36, P<0.001), waist-hip ratio (*r*=0.49, P<0.001), and waist circumference (*r*=0.44, P<0.001). Diastolic blood pressure correlated with age (*r*=0.35, P<0.001), sex (*r*=0.27, P<0.001), and various indices of obesity, including body mass (*r*=0.39, P<0.001), body mass index (*r*=0.39, P<0.001), waist-hip ratio (*r*=0.53, P<0.001), and waist circumference (*r*=0.53, P<0.001) [Fig 1b]. The 24-hour urinary sodium excretion did not correlate significantly with the systolic and diastolic blood pressures but did correlate with the 24-hour ambulatory systolic blood pressure (*r*=0.65, P<0.001) in 23 subjects who underwent ambulatory blood pressure monitoring (Fig 1c).

Randomised controlled trial of sodium restriction in the treatment of mild essential hypertension

Thirty-six patients were randomised to drug treatment (with hydrochlorothiazide 25 mg daily [n=19], metoprolol 100 mg daily [n=15], or perindopril [n=2]) and 38 to a low-sodium diet. Their baseline characteristics (mean±SD) are shown in Table 1.

In the low-sodium diet group, there was a significant decrease in sodium intake (54±11 mmol/day), as assessed by the nutrient analysis (Table 2). Sodium intake assessed by the nutrient analysis correlated with 24-hour urinary

Table 1. Baseline characteristics of randomised subjects

Baseline characteristics	Mean±SD	
	Diet group	Drug group
No. of subjects	38	36
% of male	50	42
Age (years)	45±12	41±9
Weight (kg)	69.5±12.9	67.8±12.6
Body mass index (kg/m^2)	26.1±6.7	25.6±6.1
Waist circumference (cm)	89.4±10.9	85.2±11.2
24-h Na^+ (mmol/day)	194.6±84.7	192.7±73.8
Systolic blood pressure (mm Hg)	142±12	142±11
Diastolic blood pressure (mm Hg)	94±8	96±6
Heart rate (beats per minute)	70±8	72±9

Table 3. Commonly eaten foods that are high in sodium content

Food	Typical portion (g)	Sodium content (mmol)
Ham	40	23.1
Dim sum	100	26.7
Marinated spare ribs	80	23.1
Chinese barbecue pork	80	36.9
Instant noodles	100	49.6
Fish balls	60	17.4
Sausages	34	19.1
Fried rice	180	23.6
Preserved vegetables	40	37.7-140.6
Luncheon meat	28	16.2

Table 2. Sodium intake in the diet and drug groups

	Sodium intake (mmol/day) Mean±SD		
	Baseline	3 Months	6 Months
No. of subjects	74	63	62
Diet group	178.2±12.2	122.9±10.7*	124.6±10.0*
Drug group	168.3±8.7	158.1±9.5	153.9±9.0

* $P<0.05$ vs baseline and drug group

sodium excretion (r=0.3, P<0.001). Using dietary recall, foods with a high-sodium content were identified (Table 3). In the diet group, there was a significant decrease in body mass and body fat (2.1±0.4%; Table 4). After five visits, 14 patients in the diet group required drug treatment to control their blood pressure. Changes in blood pressure, heart rate, urinary sodium and potassium excretion, body mass, and left ventricular mass index are shown in Table 4.

There was a significant decrease in ambulatory systolic and diastolic blood pressure in the drug (16±3 mm Hg and 9±2 mm Hg) and diet group (9±2 mm Hg and 6±1 mm Hg). The decreases in ambulatory blood pressure were significantly larger in the drug group compared to the diet group. In the diet group, the decrease in sodium intake correlated with the decrease in diastolic blood pressure (r=0.44, P=0.02; Fig 2) but not with systolic blood pressure (r=0.35, P=0.1).

Cost-effectiveness of salt reduction vs drug therapy

The health service costs and the patient costs for diet and drug therapy are listed in Table 5. There were 32 subjects in the diet group and 29 in the drug group with economic data available for analysis.

The costs of medications were $30.4±9.3 and $157.7±28.1 in the diet and drug groups, respectively (P<0.001). Health service costs per subject were $764.5±13.9 in the diet group and $736.1±29.5 in the drug group. Total costs per subject were $591.6±163.4 in the diet group and $774.8±75.0 in the drug group. The cost-effectiveness ratios for diet and drug therapy were $103.1±56.7 and $69.6±39.6 per mm Hg decrease in diastolic blood pressure. These were not significantly different. A sensitivity analysis showed that the cost-effectiveness ratio depends on the blood pressure reduction and the food costs, but is insensitive to dietician's time and drug costs. Overall, there were no significant changes in quality of life in terms of WHOQOL-BREF (HK) scores associated with either form of therapy. In the diet group, 94% found the low-salt diet acceptable. Subjects in the diet group were willing to pay more for the diet ($479.0±118.1 vs 430.4±75.4), although this finding was not statistically significant.

Discussion

Our study of nearly 200 subjects recruited from the general

Table 4. Changes in measurements

Measurement	Diet group Mean±SE			Drug group Mean±SE		
	Baseline	3 Months	6 Months	Baseline	3 Months	6 Months
No. of subjects	38	33	31	36	31	31
Systolic blood pressure (mm Hg)	142±2.1	141±2.8	134±2.2*	141±2.0	129±2.5*†	124±2.5*†
Diastolic blood pressure (mm Hg)	95±1.3	91±1.6*	88±1.3*	95±1.0	86±1.7*†	84±1.8*†
Heart rate (beats per minute)	69±1.2	68±1.6	68±1.5	71±1.5	67±1.5	69±1.6
24-h Na^+ (mmol/day)	190.7±14.5	154.2±13.6*	201.2±15.9	200.4±13.6	164.0±11.1*	179.7±13.3
24-h K^+ (mmol/day)	46.5±3.0	47.9±3.0	55.7±3.9*	54.2±4.7	49.5±3.8	49.3±4.0
Body mass (kg)	67.5±2.1	66.0±2.0	65.6±2.0*	68.8±2.4	67.3±2.2	67.2±2.2
Left ventricular mass index (g/m^2)	128.7±4.8	-	124.9±4.3	129.3±5.6	-	123.6±4.8

* $P<0.05$ vs baseline
† $P<0.05$ diet vs drug groups

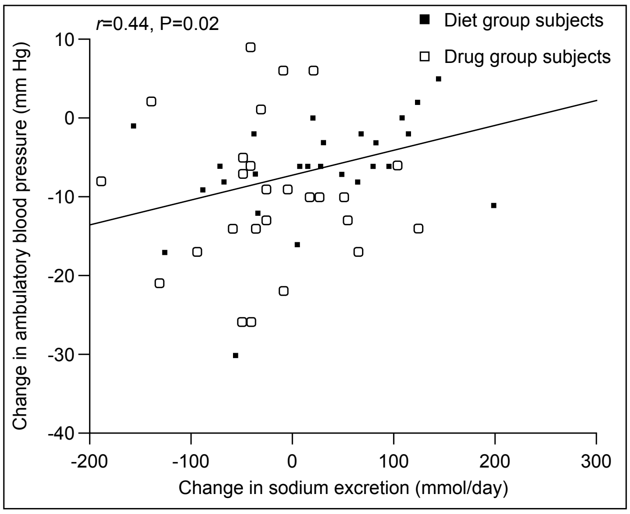

Fig 2. Correlation of ambulatory blood pressure and sodium intake

population showed that the correlation between sodium excretion and blood pressure is weak. This correlation is stronger among hypertensive subjects. This is an expected finding because not everyone in the general population who has a high-salt intake will develop hypertension. What clearly emerged from our study was the strong relationship between blood pressure and obesity, especially the waist circumference. This is consistent with clinical studies showing that weight control is by far the most effective non-pharmacological means of lowering blood pressure.

In our randomised controlled trial of a low-sodium diet, we showed that the diet achieved a reduced sodium intake and urinary sodium excretion and that there were significant reductions in both systolic and diastolic blood pressure. Moreover, the reduction in diastolic blood pressure correlated with the reduction in sodium intake. Nonetheless, although blood pressure levels decreased significantly in both groups, there was a much greater decrease in blood pressure levels in the group allocated to drug treatment. Most patients randomised to the low-sodium diet group eventually required drug treatment to bring their blood pressure down to the target level. Non-pharmacological treatment can still enhance the effects of drug therapy, resulting in a lighter drug regimen and fewer side-effects. A diet that is not only low in sodium but also rich in fruit and vegetables might be more effective. Moreover, the healthy diet and lifestyle approach addresses not only high blood pressure but also other cardiovascular risk factors such as obesity, glucose tolerance, and dyslipidaemia.

Our economic analysis found that the low-sodium diet and drug therapy were equally cost-effective. We used upper and lower 95% confidence limits to test the robustness of the cost-effectiveness ratios and found that they were mainly sensitive to the degree of blood pressure reduction and change in the cost of food. Due to the limited size of our study and the entry criteria for a clinical trial, our estimate of the effect size, ie the reduction in blood pressure, is subject to error. Caution must be exercised if extrapolating our findings to the community and generalising our conclusions. Nevertheless, our analysis of the costs of the low-sodium diet showed that savings in drug costs offset the cost of the dietician's time. It is sometimes argued that special diets are less affordable, but patients in the diet group reported a decrease in the costs of food. This suggests that for the Hong Kong Chinese population, a low-sodium diet does not cost more. Moreover, the dietary restrictions did not decrease quality of life and nearly all patients in the low-sodium diet group found the regimen acceptable.

Conclusions

As a reduction in blood pressure is related to a reduction in sodium intake, hypertensive patients able to reduce their sodium intake should be able to lower their blood pressure. A low-sodium diet reduces blood pressure to a lesser extent than antihypertensive drugs but this reduction may be sufficient for patients with mild hypertension. In patients with more severe hypertension, dietary sodium reduction is a safe, cost-effective complement to drug therapy. The low-sodium diet should be part of a calorie-controlled diet

Table 5. Cost-effectiveness of low-salt diet versus drug therapy

	Mean±SD		P value
	Low-salt diet	Drug therapy	
No. of subjects	32	29	-
Dietician's time (3 visits, $/subject)	146.3±8.3	-	-
Doctor's time (2 visits, $/subject)	107.8±6.3	98.4±6.3	-
Cost of drugs ($/subject)	30.4±9.3	157.7±28.1	<0.001
Cost of laboratory test (renal function test, $/subject)	480	480	-
Health service cost ($/subject)	764.5±13.9	736.1±29.5	0.39
Change in cost of food ($/subject)	-357.3±152.0	-137.4±97.5	-
Cost of food supplements ($/subject)	47.8±37.7	-	-
Cost of lifestyle changes ($/subject)	25.0±19.6	53.1±53.1	-
Travelling costs ($/subject)	111.7±11.8	123.0±15.0	-
Patients' costs ($/subject)	-172.8±162.8	38.7±85.4	0.26
Total cost ($/subject)	591.6±163.4	774.8±75.0	0.31
Fall in diastolic blood pressure (mm Hg)	7.4±1.4	11.1±1.9	0.12
Cost-effectiveness ratio ($/mm Hg fall in diastolic blood pressure)*	103.1±56.7	69.6±39.6	0.64

* Cost-effectiveness ratios were calculated for each individual

rich in fruits and vegetables. In terms of public health, a healthy diet and lifestyle may reduce the prevalence of hypertension.

Acknowledgements

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