Sodium and potassium intakes and blood pressure in Chinese adults in Hong Kong: A comparison with southern China

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The ranges of sodium and potassium intake and their relationship to blood pressure were studied in 126 healthy Chinese subjects (42 men, 84 women) aged between 20 and 65 years living in Hong Kong. An average of three blood pressure measurements and one to three 24-hour urinary sodium and potassium outputs were used to characterize an individual's blood pressure, and sodium and potassium intake, respectively. The average sodium and potassium intakes were 145 and 40 mmol/day in men and 135 and 41 mmol/day in women. When compared with subjects of similar age in southern China, Chinese in Hong Kong excreted 20% less sodium but 40% more potassium and had a lower systolic blood pressure (113 vs 118 mmHg in men, 106 vs 112 mmHg in women). It should be remembered that the Hong Kong subjects were heavier and were under more urban stress, both of which would be expected to be associated with higher blood pressure. The findings from this pilot study are compatible with a positive association between sodium intake and blood pressure and/or an inverse association between potassium intake and blood pressure.

Key words: sodium intake, potassium intake, urinary outputs, blood pressure, Chinese, Hong Kong, China.

Introduction

A positive association between sodium intake and blood pressure (BP) has been demonstrated in Asian populations.[1–5] Population studies have also shown an inverse relationship between BP and urinary potassium excretion in both Asian and Western populations.[1,5–7] In China, a regional difference in BP in relation to sodium intake is seen.[5]

Chinese populations in Hong Kong and in southern China may have similar genetic backgrounds; both have typical Chinese diets rich in carbohydrate (rice) and low in fat, animal protein, and alcohol.[5,8] Comparative studies of sodium and potassium intakes and BP between these two populations are of great interest because Hong Kong has a lifestyle which, compared with southern China, is more influenced by the West.

We report the relationship between sodium and potassium intakes and BP in Chinese adults in Hong Kong and compare our results to the published data from Fuchow in southern China.[5]

Subjects and methods

Between October 1989 and May 1991, a community group and a women's association in Shatin and staff/student representatives of the Prince of Wales Hospital were asked to invite healthy Chinese subjects aged between 20 and 65 years to participate in a study of the relationship between sodium intake and BP. Informed consent was obtained. Of the 126 subjects (42 men, 84 women) who had participated in the study, 107 (85%) were recruited between January 1990 and May 1990.

The 126 subjects were mostly housewives (45%), medical personnel or medical students (15%). The participants in Kesteloot's study in southern China[5] were recruited between November 1984 and January 1985 and were mostly industrial workers (34%), army officers (31%), farmers (28%), students (18%), medical personnel (14%) and housewives (18% of females).

The subjects had their seated (after 5 min) systolic and diastolic (phase V) BP measured on three mornings as outpatients by a trained nurse using a Hawksley random-zero sphygmomanometer. In Kesteloot *et al.*'s study, supine systolic and diastolic (phase IV) was measured at the subject's work place three times at 3-minute intervals by trained nurses using a standard mercury sphygmomanometer.[5] In both studies, an average of the three readings were taken as the subject's BP.

In our study, the sodium and potassium intakes in each individual were assessed by measuring the 24-hour urinary

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output. All participants were asked to provide up to three collections and an average of the three values was taken as the subject's sodium and potassium intakes. If a subject could only provide one or two collections, or if one or more of the collections had to be excluded because of under (creatinine output < 5.3 mmol in women and < 7.1 mmol in men) or over correction (creatinine output > 15.9 mmol in women and > 17.7 mmol in men), the 1 day value or the mean of the 2 day values would be used for analysis. Twenty-one men and 41 women managed the three collections and five men and 17 women managed two collections. In Kesteloot *et al.*'s study, only one 24-hour specimen was collected.[5]

Urinary sodium and potassium were measured by indirect ion-selective electrodes in our study and by emission flame photometry in Kesteloot *et al.*'s study.[5] Creatinine was measured using the Jaffe reaction in both studies.

Our results were subjected to univariate and multivariate analysis. Comparisons with Kesteloot *et al.*'s study for BP and urinary sodium and potassium excretion were performed using unpaired Student's *t*-test.[5] Probability of < 0.05 were taken as statistically significant.

Results

Group 24-hour urinary sodium and potassium outputs and urinary sodium/potassium ratio in our subjects living in Hong Kong are shown in Table l. The average 24-hour urinary sodium excretion was higher in men but the average 24-hour urinary potassium excretion was similar in both groups, giving rise to a higher Na/K ratio in men compared with women. The standard deviation of the average, which gives a rough estimate of the interindividual variability in sodium excretion, was 48.7 mmol in men and 45.8 mmol in women.

Simple regression analysis did not reveal a significant relationship between systolic BP and 24-hour urinary sodium ($r = 0.16$), potassium ($r = 0.12$) or Na/K ratio ($r = 0.11$) among our subjects. Diastolic BP related significantly with 24-hour urinary sodium ($r = 0.21$, $P < 0.01$) but not with potassium ($r = 0.13$) or Na/K ratio ($r = 0.13$).

Among our subjects, age, sex and body mass index were significantly ($P < 0.0001$) associated with systolic BP (R = 0.60) and diastolic BP (R = 0.56), where R is the multiple correlation coefficient. After adjusting for age, sex and body mass index, there was no relationship between systolic or diastolic BP and 24-hour urinary sodium, potassium or Na/K ratio.

As can be seen in Table 2, the two groups of subjects were comparable in terms of age, height and weight. However, the subjects in southern China not only excreted about 20% more sodium and 40% less potassium but also had a higher systolic BP. Diastolic BP was not compared because phase IV rather than phase V was used in Kesteloot *et al.*'s study.[5]

Discussion

In this study, we have determined the ranges of sodium and potassium intakes in a group of healthy Chinese subjects in Hong Kong. The average sodium intake was 145 mmol/day in men and 135 mmol/day in women and the overall average of 139 mmol/day was considerably lower than those reported in many Asian and Western populations.[6,7] The average potassium intake of 41 mmol/day was low compared with most Western populations.[6,7]

Unlike the previous studies in Asian populations,[1–5] we were unable to demonstrate a significant relationship between BP and urinary excretion of sodium and potassium. In a similar study of 1513 Chinese employees of a public utility company and non-medical personnel of the Prince of Wales Hospital in Hong Kong using a fasting 20 mL specimen of urine and an ordinary mercury sphygmomanometer,[9] no association between sitting systolic and diastolic (phase V) BP and urinary sodium and potassium concentrations was shown. Instead, age, body mass index, and urinary sodium/potassium ratio were positively associated with systolic and diastolic BP, while urinary potassium/creatinine ratio was inversely related to BP. Multivariate analysis revealed that only age and body mass index were independently associated with BP.

The Hawksley random-zero sphygmomanometer was originally chosen for our study with the view of reducing the bias of multiple readings per person.[10] This device is now known to underestimate systolic readings by an average of 2.5–3.3[10] to 2.0–3.7 mmHg,[11] compared with the standard

Table 1 Twenty-four-hour urinary excretion of sodium (Na), potassium (K) and the Na/K ratio in 126 healthy Chinese subjects living in Hong Kong

	Men ($n = 42$)		Women ($n = 84$)	
	No.	Mean ± SD (range)	No.	Mean ± SD (range)
Na (mmol)				
Day 1	35	149.7 ± 60.0 (36.0–315.1)	65	138.3 ± 55.4 (33.6–275.4)
Day 2	34	157.5 ± 52.1 (51.8–287.8)	64	148.7 ± 66.0 (39.2–354.6)
Day 3	32	137.4 ± 62.3 (33.9–270.0)	66	132.7 ± 49.3 (43.7–315.7)
Mean ± SD*	42	145.2 ± 48.7 (44.8–254.6)	84	135.3 ± 45.8 (42.7–262.0)
K (mmol)				
Day 1	35	40.8 ± 16.4 (16.6–74.8)	65	44.6 ± 18.3 (10.1–110.3)
Day 2	34	43.2 ± 17.7 (17.9–86.5)	64	44.9 ± 17.7 (17.2–110.0)
Day 3	32	36.9 ± 16.2 (11.6–90.9)	66	37.8 ± 12.7 (17.9–78.0)
Mean ± SD*	42	40.4 ± 15.1 (17.2–76.3)	84	41.3 ± 14.3 (16.3–110.0)
Na/K ratio				
Day 1	35	3.6 ± 1.5	65	3.3 ± 1.4
Day 2	34	4.3 ± 2.8	64	3.6 ± 1.6
Day 3	32	4.1 ± 2.1	66	3.7 ± 1.5
Mean ± SD*	42	4.0 ± 1.7	84	3.5 ± 1.2

*Mean and standard deviation of the averaged values over the number of collections for each individual.

Table 2 Anthropometric data, blood pressure and 24-hour urinary cations and creatinine values in Hong Kong as compared with the People's Republic of China

	Men		Women	
	Hong Kong (n = 42)	Southern China (n = 504)	Hong Kong (n = 84)	Southern China (n = 501)
Age (years)	41.8 ± 16.4	40.4 ± 14.4	41.6 ± 10.9	40.5 ± 14.3
Height (m)	1.66 ± 0.05*	1.68 ± 0.06	1.54 ± 0.06	1.57 ± 0.06
Weight (kg)	63.7 ± 9.3	60.9 ± 8.2	55.2 ± 8.6**	52.2 ± 7.6
Systolic blood pressure (mmHg)	113.4 ± 14.7	118.1 ± 12.6[a]	106.0 ± 16.4	112.3 ± 14.3[a]
Diastolic blood pressure (mmHg)	74.4 ± 9.1	77.6 ± 9.8[a]	69.1 ± 9.9	75.0 ± 10.2[a]
Sodium (mmol/24 h)	145.2 ± 48.7***	179.4 ± 72.9	135.3 ± 45.8***	172.4 ± 70.6
Potassium (mmol/24 h)	40.4 ± 15.1***	28.8 ± 13.0	41.3 ± 14.3***	29.7 ± 11.6
Sodium/potassium ratio	4.0 ± 1.7***	6.7 ± 2.4	3.5 ± 1.4***	6.2 ± 2.3
Creatinine (mmol/24 h)	11.3 ± 2.4	11.7 ± 3.2	7.7 ± 1.3	7.9 ± 2.1

Data from China is from Kesteloot *et al.*[5]
[a]Supine systolic blood pressure and diastolic blood pressure, (phase IV) were used.
*P < 0.05, **P < 0.01, ***P < 0.001 compared with southern China.

mercury sphygmomanometer. However, the observed difference in mean systolic BP (4.7 mmHg in men, 6.3 mmHg in women) between Hong Kong and southern China subjects cannot entirely be accounted for by the variation in the methods to measure BP. It should also be remembered that Hong Kong subjects were heavier and were under more urban stress, both of which would be expected to be associated with higher BP. Moreover, if we had measured systolic BP in the supine position, as was done in Kestleloot *et al.*'s study,[5] instead of in the sitting position, the mean readings in our subjects would be expected to be lower by about 1 mmHg.[12] When these three factors are taken into consideration, the difference in systolic BP between the two Chinese populations becomes more significant.

It is also obvious from Table 2 that our subjects consumed 20% less sodium but excreted 40% more potassium than their counterparts in China. The findings from this pilot study suggest that the observed difference in systolic BP between Chinese adults in Hong Kong and southern China could be related, at least in part, to the difference in sodium and potassium intakes. The relative importance of alcohol intake or habitual exercise as a confounder needs to be addressed in future studies.

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香港華人鈉、鉀進食與血壓的關係，與南中國發表的數據相比較

摘　要

作者在香港選擇了 126 位（男 42 位，女 84 位） 20 — 65 歲的健康華人爲對象，研究了他們的鈉、鉀進食水平與血壓的關係，他們分別用三次血壓測定的平均數和 1—3 次 24 小時尿液鈉、鉀排量作爲對象血壓，和鈉、鉀進食量的評估，結果發現男性平均鈉、鉀進食量爲每日 145 和 40 毫克分子量，而女性爲 135 和 41 毫克分子量。當與南中國相同年齡的對象比較，香港華人排鈉少 20%，但排鉀多 40%,且收縮壓較低(男性爲 113 對 118mmHg ,女性爲 106 對 112mmHg)。應該提醒的是，香港華人體重較大，面對城市壓力較多，該二者與高血壓有關。從該研究發現，鈉進食與血壓成正相關和鉀進食與血壓成負相關相一致。

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