Urinary sodium and potassium in a sample of healthy adults in Sydney, Australia

L. Notowidjojo* and A.S. Truswell

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Australia has had an official guideline for the last ten years, that people should aim to consume less than 100 mmol sodium per day (equivalent to 6.0 g NaCl). The only practical way of estimating sodium intake is from the 24-h urinary sodium excretion. Between 1970 and 1980 average sodium excretions in different Australian surveys ranged from 130 to 200 mmol/day (middle number 165 mmol/d). These surveys involved small numbers of subjects (n=11 to 259). To see how Australians are responding to the guidelines and taking advantage of a range of reduced salt food products now in the supermarkets, we measured urinary sodium and potassium in 117 healthy adults, mostly in the university community. In group N (nutrition personnel) sodium excretion averaged 128 mmol/d in females and 137 mmol/d in males. In group W (eating a western, traditional Australian diet, no special knowledge of nutrition) urinary sodium averaged 133 mmol/d female and 159 mmol/d male. In group A (eating an Asian diet) sodium averaged 140 mmol/d female and 195 mmol/d (male). Potassium excretions were 73, 81, 72, 76, 53, and 65 mmol/day respectively in the six subgroups. We conclude these results possibly reflect a small downward trend in Australian sodium intake and that sodium intake is lower in mainland Australian diets than Asian diets. Only a minority of subjects' urinary sodium were within the recommended 40 to 100 mmol/d. Women excreted consistently smaller amounts of sodium than men; the guidelines for sodium should perhaps be expressed separately by gender. In six subjects who provided seven days' urine collections the coefficient of variation for sodium excretion was between 20 and 35%.

Introduction

'Reduce salt intake' is one of the dietary guidelines of the Australian federal Department of Health first published in 1979. The report of the National Health and Medical Research Council's (NH&MRC) working party on sodium in the Australian diet (1984) recommended that adult sodium intakes should be under 100 mmol/day with greater restrictions for individuals at risk; sodium intake above 100 mmol/d could increase the risk of hypertension. At about the same time the NH&MRC's working party on recommended dietary intakes published new recommended dietary intakes for sodium of 40 to 100 mmol/d for all adults. The 2nd edition (1992) of the Australian dietary guidelines confirm the recommended upper limit of 100 mmol/d in adults and the guideline about lower salt intake has been moved up from eighth position to seventh.

However, a review of sodium intake data for Australian adults in the NH&MRC sodium working party (1984) report showed the average to be around 165 mmol/d. Bullock summarized these different studies in Australia, almost all based on 24-h urine sodium excretions between 1968 and 1980. The average sodium intake for adults in the different studies was between 130 and 200 mmol/d. Since then, there appear to have been no published studies of sodium excretion (reflecting intake) until recently, Beard et al. in Tasmania reported a small but presumably random sample of 22 men and 22 women: the mean 24-h urine sodium were 160 mmol for men and 124 mmol for women. These figures suggest some decrease may be occurring in sodium intake, since Bullock's review, but it is still well above the range recommended by NH&MRC.

Alongside the confirmation and strengthening of official advice to restrict sodium intake a considerable number of reduced and low salt products have appeared in Australian supermarkets in the late 80s and early 90s. The Better Health Commission set national targets for sodium intake of 130 mmol/d by 1995 and 100 mmol/d by the year 2000. The WHO study group and the US National Research Council's Committee on Nutrition and Health, both also advise that healthy adults should eat less than 100 mmol Na or 6.0 g NaCl per day. Thus, it was thought it was time to sample urinary sodium excretions in healthy residents in Sydney to see whether there has been any tendency to reduction in sodium intake from previous studies.

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Methods

Study design

The study was carried out from March to November 1992 in different groups of people in Sydney. A total of 127 volunteers, 63 men and 64 women over 19 years of age, answered our invitation to contribute 24-hr urines. The participants had a wide range of nutritional knowledge and lifestyles, and volunteers were given a consent form before joining the study. Anyone with major medical illnesses and under certain treatments (anti-hypertensive agents, diuretics, other renal drugs and steroids) was not accepted. None of the female subjects were pregnant or lactating. Another important piece of information was the ethnic background of the subjects. People from overseas, especially from Asia, may eat more salty foods compared with those who eat a more traditional western diet, hence dietary salt intake may be underestimated. To counter this, the participants were asked about dietary salt intake which may also be more established in Australia than in some Asian countries.

The participants were given the explanation form to read, followed by detailed verbal instructions on how to collect an exact 24-hr urine collection. They were told that the collection was a survey of nutrients in urine. During the briefing the words, salt or sodium were not mentioned, so that subjects would not be influenced to change their salt intakes. Subjects’ body weight and height without shoes and heavy outer clothing were recorded.

A two-litre plastic bottle containing 30 g of borax as preservative was given to each subject, together with two spare 500 ml plastic containers, one funnel and one safety pin (to attach to underclothes as a reminder) all in a convenient, discrete black plastic bag. ‘Do Not Discard’ was written on all the bottles to prevent an accidental discard when the subject left the containers anywhere. Borax was chosen as preservative as it is not dangerous, if it should be spill and come in contact with the skin, and sodium and potassium are stable in urine.

From one to seven 24-hr urine collections were procured by different subjects. When subjects brought in their 24-hr urine collection, they were personally interviewed and carefully questioned about completeness of the urine collection, unusual dietary intake, any medical conditions or tablets taken at least two days before the collection and strenuous exercise taken during the collection period. After participants had finished all the collections, questions were asked about changes in their usual way of eating: whether they were attempting a low salt diet; whether they added salt when cooking or eating; preference in buying food products and the history of their general dietary intake, particularly high salt foods.

The completed urine sample was brought directly to the laboratory for refrigerator storage. Estimation of the completeness of urine collection in this study was done primarily by carefully questioning the subject. Urinary creatinine were measured, but only urine volumes were used as the reference values. Answers to the questionnaire and at the interview. Because of variability of creatinine excretion between and within healthy individuals, recent workers consider that attention questioning of the participant is more useful for checking the completeness of urine collection.13,12 All the subjects in this study were volunteers and appeared keen to cooperate and were carefully instructed before starting their urine collections.

Urine analyses

On receipt, the volume of the 24-hr urine specimen was measured, and the sample thoroughly mixed. A sample of approximately 400 ml was then removed and mixed again using a magnetic stirrer. Glucose, ketones, blood, pH, proteins, nitrites and estrogens were estimated qualitatively with Ames multistix® (Miles, Australia Pty, Limited, Mulgrave, Victoria) and any result that might need medical attention was reported to the participants.

Creatinine was analysed as soon as possible with a MA-kit Roche®Creatinine (F. Hoffmann-La Roche Co. Ltd, Duggan, Australia) based on the Jaffe reaction. Sodium and potassium were analysed using a Model 430 Flame photometer (Corning-Cel with diluter, Evans Electro Selenium Limited, Halstead, Essex CO9 2DX, England). All measurements were conducted in duplicate.

Statistical methods

Data were stored in a personal computer and processed using the statistical package, StatView-R Software v1.0. Subjects were categorized according to their gender, then into three groups: ‘N’ students or staff members from the university’s Human Nutrition Unit, ‘W’ group members eating predominantly a western, traditional Australian diet and ‘A’ group members eating an Asian type of diet. The groups were further divided into sub-groups based on their salt intake (see below), and Asian sub-group members were further distinguished on the basis of their Chinese or Thai origin.

Compliance with the original instructions was good; of the original 127 subjects only 13 subjects required repeat collections. Of these 13, eight were not prepared to give another collection, subgroups therefore were excluded from analysis. In addition two subjects had some abnormality on multistix analysis and were also excluded.

Sodium and potassium excretion

The average sodium and potassium excretions Table 1) had a similar pattern between female and male participants across the three groups. The lowest result for 24-hr sodium excretion was in group N, nutrition workers (female: 127.9 mmol; male: 136.9 mmol), next lowest was group W: modern diet (female: 152.7 mmol; male: 159.4 mmol) and the highest was in group A: Asian diet (female: 139.7 mmol; male: 194.5 mmol). Potassium excretions were in the opposite order. The lowest average potassium excretion was in group A, then group W and the highest was in group N. The ratio of sodium to potassium (Na/K) excretions showed a similar pattern across the groups to the sodium excretions. Creatinine excretions averaged 10.55 and 14.98 mmol per 24-h for female and male subjects, respectively.

A correlation was applied to look for the significance of the above data. Mean excretion of sodium of male subjects in group A was significantly higher than in groups N and W. As a result the sodium to potassium ratio was also higher in the other groups. Similarly, mean potassium excretion of female subjects in group A was significantly (P<0.05) lower than group N and group W. The sodium to potassium ratio was also significantly higher than in group N.

Distribution of individual’s excretions in each of these groups compared with the Australian Recommended Dietary Intakes (RDI’s) for sodium and potassium is shown in Figs. 1, 2 and 3 for groups N, W and A, respectively. These show overall, subjects in group N were close to the recommendation that the other groups, but fewer subjects were within the box for the sodium and potassium recommendation than group W. This is possibly caused by the smaller sample size in group N. The third Figure shows that in group A more subjects were far from the recommended values, particularly the males.

Sodium and potassium excretion and awareness of salt

In group N, female subjects who said they were trying to follow a moderately low salt diet had a lower sodium and potassium excretion than the other subjects (Table 2), but the sodium to potassium ratio was not different between the subgroups. In groups W and A, however, females aware of dietary salt did not excrete less sodium, but Na/K ratios were lower for the low salt diet subjects in both groups W and group A. After correction for sources of sodium in food and salt intake, mentioned above except for females in group A. Sodium excretion in this group was then higher in females who did not follow a low salt diet. None of this was significant in sodium and potassium excretion in paired t-tests.

Results for male subjects had a different pattern. In groups N and W and as a result the sodium to potassium ratio was also higher in the other groups. Similarly, mean potassium excretion of female subjects in group A was significantly (P<0.05) lower than group N and group W. The sodium to potassium ratio was also significantly higher than in group N.
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The study was carried out from March to November 1992 in different groups of people in Sydney. A total of 127 volunteers, 63 men and 64 women over 19 years of age, answered our invitation to contribute 24-h urine. The participants had a wide range of nutritional knowledge and lifestyle. Participants were given a consent form before joining the study. Anyone with major medical illnesses and under certain treatments (anti-hypertensive agents, diuretics, other renal drugs and steroids) was not accepted. None of the female subjects were pregnant or lactating. Another important piece of information was the ethnic background of the subject. People from overseas, especially from Asia, may eat more salty foods compared with those who eat a more traditional western diet, hence duration and education of the participants. Promotion and education about dietary salt may also be more established in Australia than in some Asian countries.

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A two-litre plastic container containing 30 g of boracic acid as preservative was given to each subject, together with two spare 500 ml plastic containers, one funnel and one safety pin (to attach to underclothes as a reminder) all in a convenient, discrete black plastic bag. 'Do Not Discard' was written on all labels to prevent an accidental discard when the subject left the containers anywhere. Boracic acid was chosen as preservative as it is not toxic, if it should be spilt and come in contact with the skin, and sodium and potassium are stable in urine.

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The completed urine sample was brought directly to the laboratory for collection and drying. Estimation of the completeness of urine collection in this study was done primarily by carefully questioning the subject. Urinary creatinine were measured, but only empirically judging the answers in the questionnaire and at the interview. Because of variability of creatinine excretion between and within healthy individuals, recent workers consider that attenuation of the participant is more useful for checking the completeness of urine collection. All the subjects in this study were volunteers and appeared keen to cooperate and were carefully instructed before starting their urine collections.

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Creatinine was analysed as soon as possible with a MA-kit 10 <Roche> Creatinine (F. Hoffmann-La Roche & Co. Ltd, Dugi, Switzerland) that was checked on site. Faro (Roche Diagnostic) autoanalyzer based on the Jaffe reaction. Sodium and potassium were analysed using a Model 430 Flame photometer (Corning-Ed with diluter, Evans Electro Selenium Limited, Halstead, Essex CO9 2DX, England). All measurements were conducted in duplicate.

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Results

Population sample
Results were obtained from 117 subjects: 56 males and 61 females. The age range was 20 to 64 years. The average body mass index (BMI: weight [kilograms] / height [meters] squared) was 21.5 and 23.9 for female and male subjects, respectively. Sixty nine percent of the participants’ BMIs were in the ideal range (20 to 25), 18% were less than 20, and 13% were more than 25.

In their backgrounds subjects were either human nutrition students or staff (as group N) or from the university community, but without training in nutrition. They were either following a western (group W) or Asian dietary pattern (group A). It was assumed that nutrition personnel would have more knowledge of sodium in food and not about the food they ate on a daily basis. In group W, female n=20, male n=19, 19 subjects were born in Australia, eight subjects had lived in Australia more than 20 years and the others were more recent immigrants. In group A, almost all the subjects (female n=21, male n=29) were students from overseas, only five females and six males were employed but they still followed an Asian lifestyle. Subjects in group A came from Indonesia (n=23), Malaysia (n=13), Bangladesh (n=2), China (n=2), Philippines (n=2), Taiwan (n=2), Cambodia (n=1), Japan (n=1), Laos (n=1) and Thailand (n=1).

Compliance with the original instructions was good; of the original 127 subjects only 13 subjects required repeat collections. Of these 13, eight were not prepared to give another collection, subjects whose creatinine were excluded from analysis. In addition two subjects had some abnormality on multistix analysis and were also excluded.

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Although this was apparent to look for the significance of the above data. Mean excretion of sodium of male subjects in group A was significantly higher than in groups N and W. As a result the sodium to potassium ratio was also higher in the other groups. Similarly, mean potassium excretion of female subjects in group A was significantly (P<0.05) lower than group N and group W. The mean sodium to potassium ratio was also significantly higher in group N.

Distribution of individual's excretions in each of these groups compared with the Australian Recommended Dietary Intakes (RDI's) for sodium and potassium is shown in Figs. 1, 2 and 3 for groups N, W and, A respectively. These show overall, subjects in group N were closer to the recommendation than the other groups, but fewer subjects were within the box for the sodium and potassium recommendation than group W. This is possibly caused by the smaller sample size in group N. The third Figure shows that in group A more subjects, were far from the recommended values, particularly the males.

Sodium and potassium excretion and awareness of salt
In group N, female subjects who said they were trying to follow a moderately low salt diet had a lower sodium and potassium excretion than the other subjects (Table 2), but the sodium to potassium ratio was not different between the subgroups. In groups W and A, however, females aware of dietary salt did not excrete less sodium, but Na/K ratios were lower for the low salt diet subjects in both groups W and group A. After correction for sources in food between overseas, mentioned above except for females in group A. Sodium excretion in this group was then higher in females who did not follow a low salt diet. Potassium did not have significance in sodium and potassium excretion in unpaired t tests.

Results for male subjects had a different pattern. In
was higher in males who said they were salt conscious, and their Na/K ratio was lower. In group A, sodium and potassium excretions were both higher in salt conscious males on the diet, yet the Na/K ratio was less in males who did not say they tried to avoid high salt foods. Correction with creatinine did not change these results. As with the females, sodium and potassium excretions were not significantly different between subjects who were salt conscious or not in three groups. It should be noted that none of the subjects were following a prescribed therapeutic low salt diet.

Seven-day collections
Six motivated participants gave 24-h collections for seven days (Table 3) and the patterns of each individual’s sodium and potassium excretions are shown in Fig. 4. Regardless of the days they started collection, the horizontal axis shows days of the week; day 1 for Monday and day 7 for Sunday, is weekend days at the right-hand end of all curves. From these Tables and Figures, it can be seen that sodium has a higher coefficient of variation than potassium, except for one subject (No. 25). On the fifth day in this subject, all measured excretions dropped, but the percent difference was less for sodium than for potassium excretion in the urine. Urinary creatinines averaged 11.1 mmol/24h in the three female subjects (individual coefficients of variation: 10.2, 17.3 and 3.2 respectively) and 14.1 mmol/24h in the three men (coefficients of variation 6.7, 15.8 and 16.4 respectively).

Discussion
Completeness of collection
Precision of urine collection in this study relied primarily on working with motivated, mostly tertiary education volunteers who were carefully briefed, given written instructions and questioned when they brought their urine in to the laboratory. We measured creatinines in all urines and they were available as a back-up, but the pattern of results was not changed by adjusting sodium and potassium excretions for creatinines. Six subjects passed under 8 mmol creatinine/day. All were female; three were this BMI<19, two of the dietarians. Three subjects gave multiple urine collections and the results were similar; the others were carefully questioned and appear to have collected their urine as instructed. Creatinine excretion is related to muscle mass and increased by meat consumption. It is not constant from day to day. In our subjects who provided 7 days’ collections the within-person coefficient of variation averaged 11.6%, within the range reported by others.

We did not give PABA to our subjects because this substance has given a foreign substance to healthy volunteers, and because there is no guarantee that subjects will take all the 3 capsules at the required times and because urinary PABA cannot show over-collection.

Sodium and potassium excretion in 24-hour urine across three groups
In the present study it was found that the mean sodium excretion in the urine of the groups in both men and women was, in descending order, groups: A, W and N. The groups’ descending order of potassium excretion was the other way round: N, W and A. These results might be expected. Group N consisted of people with more knowledge and concern about their diet. Group W were eating mainly (western) Australian diets and had been potentially exposed to promotion of lower salt intakes. Group A were mostly students who had recently come from an Asian country.

Overall, female subjects excreted substantially lower amounts of sodium (P<0.05) than male subjects but their potassium excretions were not significantly lower. This sodium result is in line with almost all studies that recruited both sexes[@12,13]. It is probably related to total food intake and more food and with it more salt than females. The National Heart Foundation of Australia survey in 1989 also reported that females were less likely to add salt to their food compared with male subjects.

Significantly higher sodium excretions were found in males in group A (Asian diet) in comparison with the other groups and potassium intakes were significantly lower in group A females. By analysis of variance, the Na/K ratio showed greater differences than sodium and potassium excretions themselves. This may be because the ratio is not affected by the size of the subjects. However, groups N and W showed no significant differences in urinary sodium and potassium within the female and male groups. Records of the minority of subjects with excretions within the Australian RDI for sodium and potassium were examined for their answers about dietary habits. Group N, three females and one male were within the RDI box for sodium and potassium (Fig. 1). From these four, one female agreed that she was trying to eat low amounts of salt, while the others considered that it was part of their normal diet. One female claimed that she sometimes used salt at table, and the other female said that she always used salt in cooking. Three of them had low consumption of meat. In group W, five females and one male subject were within the box of the RDI’s (Fig. 2). Four subjects said that they were trying to eat a low salt diet and one female and one male claimed that they achieved a low salt excretion without trying. Two females said that they sometimes used salt at table and the male said that he always used salt at table. Two females were vegetarian.

A question about meat consumption was one of the general questions about usual diet on the questionnaire. The meat eating habit might merely reflect concern about dietary intake and not be necessarily related to the sodium intake. People eating little or no meat are likely

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**Table 2. Comparison of subjects who aimed to moderate salt intake (‘mod salt’) and those not concerned about salt (‘not’) 24-hour urine sodium, potassium and creatinine excretions, and BMI in female and male subjects.**

<table>
<thead>
<tr>
<th>Group</th>
<th>No. of subjects</th>
<th>Sodium mmol/24h</th>
<th>Potassium mmol/24h</th>
<th>Na/K Ratio</th>
<th>Creatinine mmol/24h</th>
<th>BMI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not <em>mod salt</em></td>
<td>Not <em>mod salt</em></td>
<td>Not <em>mod salt</em></td>
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<tr>
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<td>25</td>
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</tr>
<tr>
<td>Average</td>
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<td>162.0</td>
<td>73.4</td>
<td>70.1</td>
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<td>2.15</td>
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**Table 3. 24-hour sodium and potassium excretions of seven collections.**

<table>
<thead>
<tr>
<th>Subject No.*</th>
<th>BMI</th>
<th>Mean Na</th>
<th>Coef. var</th>
<th>Mean K</th>
<th>Coef. var</th>
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<tbody>
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<td>108.0</td>
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<td>97</td>
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</tr>
<tr>
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<td>24.2</td>
<td>147.1</td>
<td>24.3</td>
<td>65.7</td>
<td>25.1</td>
</tr>
</tbody>
</table>

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*Subjects 1, 28, 66, 98 were Nutrition workers (group N)
was higher in males than in females. The Na/K ratio was lower in group A. Sodium and potassium excursions were both higher in sodium conscious males on the diet, yet the Na/K ratio was less in males who did not say they tried to avoid high salt foods. Correction with creatinine did not change these results. As with the females, sodium and potassium excursions were not significantly different between subjects who were salt conscious or not in three groups. It should be noted that none of the subjects were following a prescribed therapeutic low salt diet.

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We did not give PABA to our subjects because this might have involved giving a foreign substance to healthy volunteers, and because there is no guarantee that subjects will take all 3 capsules at the required times and because urinary PABA cannot show over-collection.

Sodium and potassium excretion in 24-hour urine across three groups

In the present study it was found that the mean sodium excretion in the urine of the groups in both men and women was, in descending order, groups: A, W and N. The groups’ descending order of potassium excretion was the other way round: N, W and A. These results might be expected. Group N consisted of people with more knowledge and concern about their diet. Group W were eating mainly (western) Australian diets and had been potentially exposed to promotion of lower salt intakes. Group A were mostly students who had recently come from an Asian country.

Overall, female subjects excreted substantially lower amounts of sodium (P<0.05) than male subjects but their potassium excursions were not significantly lower. This sodium result is in line with almost all studies that recruited both sexes. It is probably related to total food intake and does not mean that it was more salt than females. The National Heart Foundation of Australia survey in 1989 also reported that females were less likely to add salt to their food compared with male subjects.

Significantly higher sodium excursions were found in males in group A (Asian diet) in comparison with the other groups, and potassium taken were significantly lower in group A females. By analysis of variance, the Na/K ratio showed greater differences than sodium and potassium excursions themselves. This may be because the ratio is not affected by the size of the subjects. However, groups N and W showed no significant differences in urinary sodium and potassium within the female and male groups.

Records of the minority of subjects with excresions within the Australian RDI for sodium and potassium were examined for their answers about dietary habits. Group N, three females and one male were within the RDI box for sodium and potassium (Fig. 1). From these four, one female agreed that she was trying to eat less amounts of salt, while the other considered that it was part of their normal diet. One female claimed that she sometimes used salt at table, and the other female said that she always used salt in cooking. Three of them had low consumption of meat. In group W, five females and one male subject were within the box of the RDI’s (Fig. 2). Four subjects said that they were trying to eat a low salt diet and one female and one male considered that they achieved a low salt excretion without trying. Two females said that they sometimes used salt at table and the male said that he always used salt at table. Two females were vegetarian.

A question about meat consumption was one of the general questions about usual diet on the questionnaire. The meat eating habit might merely reflect concern about dietary intake and not be necessarily related to the sodium intake. People eating little or no meat are likely...
to eat more vegetables and fruits which usually have lower sodium content than meat dishes. But in a West Australian study Armstrong et al. reported no significant difference in sodium excretion between vegetarians (mainly Seventh-Day Adventists) and non-vegetarians.

In group A, only one male was just within the RDI range. He was not deliberately eating a low salt diet; he sometimes put salt in his cooking and ate a small amount of meat.

**Sodium and potassium excretion in 24-hour urine and moderately low salt diet**

There were no significant differences in sodium and potassium excretions or the Na/K ratio between subjects who said they had moderately low salt diets and subjects who did not, regardless of gender. Despite the small number in the sample, all the subjects were volunteers, mainly from in and around the University of Sydney. Therefore there is a possibility of narrow variation of salt intake within the subjects.

Although not significantly different, the data from groups N and W indicated (Table 2) that male participants were more successful than female subjects on moderately low salt diets, in reducing their sodium intake. Sodium and potassium are associated with energy-dense foods. Male subjects have higher total calorie intake, so it may be easier for them to reduce sodium intake by cutting down on, for example, some processed foods. The body mass index of salt conscious male subjects was lower than the other male subjects.

**24 hour sodium and potassium urinary excretions in seven-day collections**

Three females and three males provided seven days of urine collections. All the females and one of the males were from the Human Nutrition Unit. Excretion of sodium in females was lower than in the male subjects but the potassium excretion was not much different between the men and women. The coefficient of variation was higher for sodium than for potassium excretions, except in one male (subject 25). The higher coefficient of variation is presumably because the range of sodium concentrations in foods is wider than that of potassium.

**Conclusion**

Our study was with volunteers in a defined area of Sydney in 1992. The advantage of this was that cooperation and compliance of the mostly tertiary educated subjects in urine collection appeared to be excellent. On the other hand, we cannot generalize from our sample about results that might be found in a random sample, representing the sodium excretion of the population of Australia. However such a survey would be much more difficult to achieve and has never been mounted in Australia.

To compare our results with previous small surveys in Australia, reviewed by Bullock and incorporated in the NH&MRC's sodium report, our group W is the most representative of the majority of Australians. Their mean sodium excretion in men and women combined was 146 mmol/day, which is a little lower than the previous median value of 165 (between the range of 130 and 200) mmol/day in the 1984 review. Values in our survey for group W (n=39) of 159 mmol/day in men and 133 mmol/day in women and 146 mmol for the sexes combined are very similar to those in Beard's study in Tasmania (n=54) of 160 mmol in men, 134 mmol in women, or 142 mmol/day in men and women combined.

These two 1990's results suggest that there has possibly been a small downward trend in Australian sodium intake and it is also noteworthy that there were very few subjects in group W excreting more than 200 mmol/day. For the year 1995 we hope that a larger and more random survey can be organized to see if Australians are near to the target of average 130 mmol/day by that year.

Examination of the groups in our study leads to four further conclusions. Firstly, sodium excretions were consistently lower in women. Recommendations and targets should be written separately for men and women (as for energy, protein etc.). Secondly, people in our sample eating Asian diets had obviously higher sodium intakes. Except in Singapore, there appears to be less emphasis on reducing salt in public health nutrition in the region. Thirdly, professionals and trainees in nutrition and dietetics had slightly higher sodium excretions than in group W, but only a minority were within the target level of 100 mmol/day. It is hard, even for professionals, to control their sodium intake with mostly processed foods. Fourthly, potassium excretions (in molar units) averaged less than half the sodium excretions, expressed by Na/K ratio mostly above 2.0. This is a lower ratio than considered ideal.

Our results support the need for further promotion of lower salt intake, by eating more fresh food, avoiding addition of salt in the home and encouraging production and consumption of salt-reduced processed foods. At present it is very difficult for people to understand the numbers on food labels that provide sodium content. Further study is also required to up-date the sources of sodium and potassium in Australian foods, since fewer analyses have been done in recent times.

**Acknowledgements**

We would like to thank Mr Zia Ahmad and Mr Bill Lowe for advice and help with the laboratory work and Mrs Ida Hopwood for helping prepare the manuscript.

**References**

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to eat more vegetables and fruits which usually have lower sodium content than meat dishes. But in a West Australian study Armstrong et al.\(^6\) reported no significant difference in sodium excretion between vegetarians (mainly Seventh-Day Adventists) and non-vegetarians.

In group A, only one male was just within the RD1 range. He was not deliberately eating a low salt diet; he sometimes put salt in his cooking and ate a small amount of meat.

**Sodium and potassium excretion in 24-hour urine and moderately low salt diet**

There were no significant differences in sodium and potassium excretions or the Na/K ratio between subjects who said they had moderately low salt diets and subjects who did not, regardless of gender. Despite the small number in the sample, all the subjects were volunteers, mainly from in and around the University of Sydney. Therefore there is a possibility of narrow variation of salt intake within the subjects.

Although not significantly different, the data from groups N and W indicated (Table 2) that male participants were more successful than female subjects on moderately low salt diets, in reducing their sodium intake. Sodium and potassium are associated with energy-dense food.\(^{19,20}\). Male subjects have higher total calorie intake, so it may be easier for them to reduce sodium intake by cutting down on, for example, some processed foods. The body mass index of salt conscious male subjects was lower than the other male subjects.

**24 hour sodium and potassium urinary excretions in seven-day collections**

Three females and three males provided seven days of urine collections. All the females and one of the males were from the Human Nutrition Unit. Excretion of sodium in females was lower than in the male subjects but the potassium excretion was not much different between the men and women. The coefficient of variation was higher for sodium than for potassium excretions, except in one male (subject 25). The higher coefficient of variation is presumably because the range of sodium concentrations in foods is wider than that of potassium.

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To compare our results with previous small surveys in Australia, reviewed by Bullock\(^7\) and incorporated in the NH&MRC’s sodium report,\(^2\) our group W is the most representative of the majority of Australians. Their mean sodium excretion in men and women combined was 146 mmol/d, which is a little lower than the previous median value of 165 (between the range of 130 and 200) mmol/d in the 1984 review. Values in our survey for group W (n=39) of 159 mmol/d in men and 133 mmol/d in women and 146 mmol for the sexes combined are very similar to those in Beard’s study in Tasmania\(^6\) (n=54) of 160 mmol in men, 134 mmol in women, or 142 mmol/d in men and women combined.

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Our results support the need for further promotion of lower salt intake, by eating more fresh food, avoiding addition of salt in the home and encouraging production and consumption of salt-reduced processed foods. At present it is very difficult for people to understand the numbers on food labels that provide sodium content. Further study is also required to up-date the sources of sodium and potassium in Australian foods, since fewer analyses have been done in recent times.

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**References**

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Fig. 4. 24 hour urinary sodium (—O—) and potassium (—•—) excretion in six subjects who provided seven days collections. Day 2 = Tuesday, day 4 = Thursday, and day 6 = Saturday, for all subjects.
Urinary sodium and potassium in a sample of healthy adults in Sydney, Australia

L. Notowidjjo and A.S. Truswell


Urinary sodium and potassium in a sample of healthy adults in Sydney, Australia

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Sejak sepuluh tahun yang lalu, Australia mencanangkan pedoman kebutuhan gizi dalam di termasuk kebutuhan elemen sodium dengan target konsumsi kurang dari 100 mmol sodium per hari (sama dengan 6.0 g garam dapur). Cara termudah untuk memperkirakan konsumsi garam adalah dengan mengukur ekskresi sodium dalam urin selama 24 jam. Beberapa survei di Australia dari tahun 1970 sampai 1980, ekskresi sodium per hari rata-rata dalam urin adalah antara 130 sampai 200 mmol (rata-rata 165 mmol). Survei-survei ini mencakup sejumlah kecil subjek (n=11 sampai 259).

Kami mengukur kadar sodium dan potasium dalam urin dari 117 orang dewasa sehat, hampir semua dari lingkungan universitas, untuk melihat tingkat masyarakat Australia terhadap pedoman kebutuhan sodium dan pengurang dari banyaknya produk makanan dengan rendah kadar garam yang tersedia di pasar swayalan saat ini.

Rata-rata ekskresi sodium per hari pada grup N (staf atau pelajar dari bagian unit gizi) adalah perempuan: 128 mmol dan laki-laki: 137 mmol. Pada grup W (dengan kebiasaan diet makanan Australia, tanpa pengetahuan tentang gizi) ekskresi sodium per hari dalam urin kira-kira 133 mmol untuk perempuan dan 199 mmol untuk laki-laki. Pada grup A (dengan kebiasaan diet makanan Asia) ekskresi sodium per hari rata-rata 140 mmol untuk perempuan dan 195 mmol untuk laki-laki. Sedangkan ekskresi potasium per hari dalam urin pada kumam group diatas (berurut): 73, 81, 72, 53 dan 65 mmol. Kesimpulan, hasil penelitian ini menunjukkan kemungkinan penurunan konsumsi sodium pada masyarakat Australia dan konsumsi sodium lebih rendah pada orang dengan kebiasaan diet makanan Australia dibandingkan dengan kebiasaan di makanan Asia. Tetapi, secara keseluruhan hanya beberapa subjek yang mencapai range pedoman diet sodium yang dicantumkan, yaitu 40 sampai 100 mmol per hari. Subjek perempuan tampaknya mengonsumsi sodium lebih rendah dari pada laki-laki, maka pedoman tentang elemen ini sebaiknya dipisahkan antara perempuan dan laki-laki. Pada enam subjek yang memberikan pengumpulan urin tujuh hari yang berbeda, kofeina variasi ekskresi sodium adalah 20 sampai 35%.
Urinary sodium and potassium in a sample of healthy adults in Sydney, Australia

L. Notowidjiojo and A.S. Truswell


Sejak sepuluh tahun yang lalu, Australia mencanangkan pedoman kebutuhan gizi dalam di mana termasuk kebutuhan eleven sodium dengan target konsumsi kurang dari 100 mmol sodium per hari (sama dengan 6,9 g garam dapur). Cara termudah untuk memperkirakan konsumsi garam adalah dengan mengukur ekssesi sodium dalam urin selama 24 jam. Beberapa survei di Australia dari tahun 1970 sampai 1980, ekssesi sodium per hari rata-rata dalam urin adalah antara 130 sampai 200 mmol (rata-rata 165 mmol). Survei-survei ini mencapai sejumlah kecil subjek (n=11 sampai 259).

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Diet does not predict incidence or prevalence of non-insulin-dependent diabetes in Nauruans

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Cross-sectional and longitudinal relationships between diet and non-insulin-dependent diabetes (NIDDM) were assessed in Nauruan adults to determine if a particular component of the diet contributed to the high prevalence of NIDDM in this population. In 1982, 24-h dietary recall data were collected from 430 Nauruans over the age of 20, who were participating in a non-communicable disease (NCD) survey. In 1987 a follow-up survey was performed which included 350 of the subjects from whom dietary data was obtained. Neither cross-sectional nor longitudinal analyses showed any statistically significant associations between any of the specific dietary components studied and NIDDM prevalence or incidence. However, when nutrient intakes were adjusted for energy intake it appeared that the age- and body-mass-index (BMI)-corrected mean intakes of total fat, total carbohydrates, alcohol, sugar and monounsaturated fat were slightly higher in the seven incident cases than in those who remained healthy, while intakes of protein, fibre and cholesterer were lower. Despite the inability to demonstrate an association between NIDDM risk and nutrient intake at the individual level, Nauruans as a population have total energy intakes 115-135% greater than recommended for maintenance of healthy weight, protein intakes about 250% of that required, sugar intakes about twice the recommended, fibre intakes only about 30% of current recommended levels and in men a mean alcohol intake more than three times the recommended level. This adverse diet undoubtedly contributes to the high prevalence of obesity in the population and hence, even if there are no direct dietary effects, to the risk of NIDDM and other diet-related diseases.

Introduction

Diet in general and specific dietary components, notably fat and sugar, have long been suspected of having a role in causing NIDDM1. Studies in animals2,3 have shown high fat diets to be related to insulin resistance but the results of epidemiologic studies in humans have generally been inconclusive1. However, several recent studies have suggested that an increased intake of fat, especially saturated fat, is associated with an increased risk of NIDDM or impaired glucose tolerance6,7. Less directly, Raheja et al6 found that the diet of a high NIDDM risk group of urban Indians contained more fat and refined carbohydrate than a lower risk group from a rural area.

Fat intake is generally inversely correlated with carbohydrate intake and it is not clear which is more important in relation to the aetiology of NIDDM. Marshall et al6 found that the odds ratio (OR) associated with a 40 g increase in fat intake was higher than for an energy equivalent 90 g fall in carbohydrate intake. In contrast, Fejeskens et al7 have found a positive association between carbohydrate intake and incidence of glucose intolerance in a four-year study. The type of carbohydrate was important, the positive relationship only being evident with refined carbohydrate from pastries, and not with carbohydrate from legumes. In a study with 25 years follow-up there was no relationship between diet and NIDDM incidence7.

Many formerly traditional populations subject to rapid modernization, such as Australian Aborigines11, Pacific Islanders12,13, Asian Indians14,15, and American Indians16,17, have been subject to rapid increases in the frequency of NIDDM. The prevalence of NIDDM and obesity are known to be high in the Pacific island population of Nauru. This has been related to rapid acculturization, characterized by a change to a predomi- nantly imported food diet and mechanised transport reducing physical activity18. Even in 1957, Kirk18 found little use of local food, while rice, bread, tinned meat and milk constituted the bulk of the diet.

In this study we have examined cross-sectional and longitudinal relationships between diet and diabetes in Nauruans, relating 1982 diet to the incidence of diabetes between 1982 and 1987 in subjects who had normal glucose tolerance at baseline.

Materials and methods

Data for this study were collected during surveys performed on population-based samples of adults on the Pacific island of Nauru. Nauru is a small isolated island just south of the Equator with an indigenous population of Micronesian ancestry. In 1982 a survey of all Nauruans...