Food Choices for Lowering Sodium Intake

AARON M. ALTSCHUL, PH.D., AND JANET K. GROMMET, PH.D.

SUMMARY Excessive intake of dietary sodium is one form of affluent or industrial society malnutrition. When combined with a genetic-based sodium sensitivity, this high sodium intake becomes a factor in the etiology of hypertension. Most dietary sodium comes from food, natural or processed. Indirect measures of discretionary sodium intake, that from the salt shaker in the kitchen or at the table, put it at a level of 25% to 50% in the United States. Direct measures on a small sample of subjects indicate that less than 10% of sodium intake is discretionary. Anyone who needs to reduce sodium intake must, therefore, make major changes in diet. This requires information on the sodium content of common foods, the availability of low sodium analogs of popular foods, and a variety of low sodium condiments to provide more choice for the individual.

(KEY WORDS) sodium sensitivity, discretionary sodium consumption, sodium consumption, consumer options

This paper focuses on epidemiology and what it shows about the interplay of genetics and environment; on strategies for control of sodium intake or other environmental factors as they may affect blood pressure; and on experience in intervention in diet and life style to affect the course of hypertension.

Nutritionists accept the proposition that nutritional parameters can modulate metabolic events. This is a different aspect of nutrition from that which deals with nutrient deficiency, although there is surely an overlap between the two. We consider the former an aspect of affluent or industrial society malnutrition. Sodium intake is a useful paradigm for this kind of a problem. In discussing sodium intake, we shall: 1) review some of our data that emphasize the need to include a genetic marker when seeking to relate environmental factors to blood pressure; 2) examine the choices available to an individual in the United States who wishes to moderate sodium intake; and 3) comment on the implications of problems of individual choice for society and the food industry. Our primary interest is to raise questions that could well be treated further.

Environment vs Heredity

Numerous personal and environmental characteristics interact in determining blood pressure. Among the personal characteristics are genetic factors that reflect directly on arterial pressure homeostasis and those that reflect on energy balance. Exercise pattern and response to stress are likewise involved. Hence, obesity becomes an important personal characteristic. Environmental factors include total dietary calories, sodium and linoleic acid intake, and, perhaps, calcium and sucrose intake. One ought to consider some marker of genetics before making statements about the role of any of the environmental variables. Of all these, the one that perhaps is more clearly inheritable, based on animal models, is the sensitivity to excess sodium.1

Our own introduction into this matter, reported earlier,2 confirmed to us that the relationship between sodium and blood pressure is inheritable, and this may as well be true of the relationship between the ratio of sodium to blood pressure and to potassium and blood pressure. Our data are shown in figures 1 and 2. Figure 1 shows a relationship in normotensive individuals between mean arterial pressure and 24-hour sodium excretion when there is a history of hypertension among first-degree relatives ($Y = 85.71 + 0.07X; r = 0.71, p < 0.001$). Figure 2 shows the same relationship for the ratio Na/K in the urine ($Y = 84.87 + 4.33X; r = 0.62, p < 0.01$).

We also have the suggestion illustrated in figure 3 that, among normal weight individuals, weight relates to blood pressure when there is a family history of hypertension ($Y = 74.50 + 0.13X; r = 0.83, p < 0.001$). Even though there is evidence that simple reduction in weight causes a reduction in blood pressure,3,4 there remains the possibility that for those who have the genetic sensitivity to sodium, this reduction would be even greater. Our marker for heritability was crude. As more sophisticated markers become avail-

From the Department of Community and Family Medicine, Georgetown University School of Medicine, Washington, D.C.
Address for reprints: Aaron M. Altschul, Ph.D., Georgetown University School of Medicine, Suite 535, 2233 Wisconsin Ave. N.W., Washington, D.C. 20007.
FIGURE 1. Relation of 24-hour urinary sodium output to mean blood pressure in normotensive individuals with and without a family history (FH) of hypertension among first degree relatives (see ref. 2).

FIGURE 2. Relation of ratio Na/K in 24-hour urine collection to mean blood pressure in same individuals as in figure 1 (see ref. 2).

FIGURE 3. Relation of weight to mean blood pressure in same individuals as in figure 1 (see ref. 2).
able for general application, it should be possible to factor such data into epidemiological studies. Then such studies could become more meaningful in dealing with the question of the relationship between genetics and environment.

Let us assume that a consensus is evolving that sodium is an important part of the environment affecting blood pressure and that sensitivity to sodium is heritable. What can an individual do who either believes that he or she is sensitive to sodium or is hypertensive and wishes to potentiate other treatments by lowering sodium intake?

Food Choices in the United States

To address this question, we must determine the extent of control an individual has over sodium intake in the existing food supply system. We can divide sodium intake into two categories: 1) discretionary, that amount of sodium intake controlled directly by the individual with a saltshaker either at the table or in the kitchen; and 2) nondiscretionary intake, that which comes from the food purchased for home use or in a restaurant. These are artificial distinctions because it might be argued that all sodium intake is discretionary since anyone can determine which foods to eat. But the decisions are more difficult. It is easier to decide to use or not to use the saltshaker than to decide to forego such popular foods as bread, cheese, processed meat, soup, or pickles.

Estimates of total sodium intake in the United States expressed as grams of sodium chloride (NaCl) per day are given in table 1. While the value of 17.1 g NaCl per day seems out of line with the other values, it represents salt intake associated with a high caloric intake, 3900 kcal/day. When recalculated as intake per 1000 kcal, this value becomes 4.4 g NaCl.

Discretionary Sodium Intake

Published values for discretionary sodium intake in the United States are given in table 2.13 The Select Committee on Generally-Recognized-as-Safe Substances (GRAS), based on its review of the literature,13 concluded that discretionary intake was 33% of the total (range of 25% to 50%). We undertook to measure discretionary NaCl directly on a small number of subjects.14 We estimated total sodium intake by measuring the rate of sodium output in overnight urines collected over 3 successive days. Previously, we had found that this method corresponds well with 24-hour urinary sodium output when both were taken over 3 consecutive days.15 In this way we obtained baseline values for all participants. Each subject was given two weighed saltshakers, one for the kitchen for cooking, the other for table use at home or when eating out. We indirectly determined total sodium intake by measuring sodium urine output and weighed the saltshakers weekly over a period of 6 weeks. We tested two kinds of salt preparations: ordinary table salt and sodium chloride diluted with an equal weight (50%) of a complex carbohydrate. The results are shown in table 3.

Contrary to what we have seen in the literature, we found that discretionary sodium use was less than 10% of the total sodium intake. A total sodium intake of 9 g/day is average and agrees with other data in the literature. Is it possible that the experiment itself could have affected the subjects' use of discretionary sodium and resulted in falsely low usage? That possibility must be tested by additional experiments. The experiment needs to be repeated on a larger and more representative population sample. If the results are confirmed, they raise questions about the options available to reduce individual sodium intake. In the light of these data, warnings to stop salting foods would be considered as ineffectual. It would seem that more options need to be created for those who are sodium-sensitive so that it would be possible for them to make drastic changes in sodium intake. These options would require actions either by government or by the food industry.16

The options facing an individual who needs to reduce sodium intake are listed in table 4. Such a person must first decide to reduce sodium intake. Then it becomes necessary to know the sodium content of the important foods consumed and to find acceptable alternatives.

### Table 1. Estimates of Total Sodium Intake in the United States

<table>
<thead>
<tr>
<th>NaCl (g)</th>
<th>Method</th>
<th>Reference</th>
</tr>
</thead>
</table>
| 11       | Urinary excretion | Coatney et al., 1958
| 10       | Urinary excretion | Dahl, 1961
| 11       | Urinary excretion | Altman and Dittmer, 1974
| 12       | Review of literature | Meneely and Battarbee, 1976
| 17.1     | FDA food survey | FDA, 1977
| 10.1     | Urinary excretion | Liu et al., 1979

### Table 2. Estimates of Discretionary Sodium Intake in the United States

<table>
<thead>
<tr>
<th>NaCl (g)</th>
<th>Method</th>
<th>Reference</th>
</tr>
</thead>
</table>
| 3.4      | Retail sales | Wood, 1970
| 4.4-6    | 1965 USDA survey | FDA, 1977
| 6.5      | Survey | Bowen et al., 1973

### Table 3. Experimental Determination of Discretionary Sodium Consumption (n = 72)

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Sodium consumption (g NaCl)</th>
<th>Discretionary</th>
<th>Nondiscretionary</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. NaCl</td>
<td>9.1</td>
<td>0.7 (8%)†</td>
<td>8.4 (92%)†</td>
</tr>
<tr>
<td>2. ½ NaCl</td>
<td>8.9</td>
<td>0.4 (4%)‡</td>
<td>8.5 (96%)‡</td>
</tr>
</tbody>
</table>

*Baseline sodium consumption was 8.0 g NaCl.
†By difference.
‡p < 0.001.
Table 4. Sodium Consumption: Options for the Individual, Society, and the Food Industry

<table>
<thead>
<tr>
<th>Option</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Individual:</strong></td>
<td></td>
</tr>
<tr>
<td>Decide on extent of</td>
<td>Determine if person is hypertensive</td>
</tr>
<tr>
<td>concern over level</td>
<td>Determine if family history of hypertension</td>
</tr>
<tr>
<td>of sodium consumption</td>
<td>Do genetic screening</td>
</tr>
<tr>
<td>Learn sodium content</td>
<td>Research</td>
</tr>
<tr>
<td>of favorite foods</td>
<td>Reduce consumption of high-sodium foods</td>
</tr>
<tr>
<td>Reduce sodium intake</td>
<td>Increase consumption of low-sodium analogs</td>
</tr>
<tr>
<td></td>
<td>Use low-sodium flavorings</td>
</tr>
<tr>
<td><strong>Society:</strong></td>
<td></td>
</tr>
<tr>
<td>Change standards</td>
<td>Reduce sodium content of processed foods</td>
</tr>
<tr>
<td></td>
<td>Require labeling of sodium content</td>
</tr>
<tr>
<td><strong>Food industry:</strong></td>
<td></td>
</tr>
<tr>
<td>Technology</td>
<td>Label sodium content</td>
</tr>
<tr>
<td></td>
<td>Reduce sodium content of existing foods</td>
</tr>
<tr>
<td></td>
<td>while maintaining flavor</td>
</tr>
<tr>
<td></td>
<td>Provide low-sodium food alternatives</td>
</tr>
<tr>
<td></td>
<td>Provide low-sodium flavorings for home consumption</td>
</tr>
</tbody>
</table>

Salt Use by the Food Supply System

One of the options for a society that desires to cope with the problem of salt intake (table 4) is general education on the known or suspected relationship between dietary sodium intake and blood pressure. This may also include changing the standards for certain foods to lower their sodium content. This was done in Belgium to lower the sodium chloride content of bread and other baked products from 3% to 2% (E.G. Rapp and C. Feldberg, personal communication).

One approach now being pursued by the Federal government is to provide information to consumers on the sodium content of foods by including this information on the label. A second action, consistent with the first, is to encourage the food industry either to lower the sodium content of all their foods or to provide low sodium options or analogs for foods containing high levels of sodium. The problem, of course, is that sodium chloride has been added to improve taste. There is a limit to the amount that can be removed without affecting taste and acceptability. But there is a feeling that salt levels can be reduced in many foods without appreciably influencing either taste or acceptability. There is the possibility of reducing salt content and encouraging more dependence on nonsodium sources of flavoring.

In considering the options facing the food industry (table 4), we sense an acceptance by the food industry of the need to furnish information on sodium content and expect that, sooner or later, even with voluntary labeling, the sodium content of common foods will become widely known to the consumer. There is also a trend toward providing foods lower in sodium with improved flavor; and we expect this trend to continue. When low sodium alternatives to popular foods become available, the marketplace can decide the direction that sodium content of food products must go. The food industry can either provide good-tasting low sodium analogs of certain foods or low sodium analogs of the present foods together with better flavoring mixtures that can replace the salt shaker in the home and kitchen. This can provide each individual with the opportunity to increase discretionary use of flavorings and consequitively reduce non-discretionary consumption of sodium.

Any number of combinations of strategies shown in table 4 could probably lower the average sodium intake by 20%. There is no experience from which to anticipate the public health consequences of such a change. Hunt's data\textsuperscript{17} on the effect of sodium intake on diuretic therapy offers some suggestion of possible outcome. He showed that those excreting more than 150 mEq sodium in their 24-hour urine had a far lower chance of becoming normotensive under antihypertensive therapy than those excreting 75 to 149 mEq sodium. He was comparing an intake, estimated by output in the urine, of over 8.7 g Na Cl per day to a range of 4.4 to 8.6 grams/day. His data suggest that moderate reduction of sodium intake could have a profound effect on the course of hypertensive disease.
References


Food choices for lowering sodium intake.
A M Altschul and J K Grommet

Hypertension. 1982;4:III116
doi: 10.1161/01.HYP.4.5_Pt_2.III116

Hypertension is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 1982 American Heart Association, Inc. All rights reserved.
Print ISSN: 0194-911X. Online ISSN: 1524-4563

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://hyper.ahajournals.org/content/4/5_Pt_2/III116

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Hypertension can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Hypertension is online at:
http://hyper.ahajournals.org/subscriptions/