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ORIGINAL ARTICLE

Why and how to implement sodium, potassium, calcium, and magnesium changes in food items and diets?

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The present average sodium intakes, approximately 3000–4500 mg/day in various industrialised populations, are very high, that is, 2–3-fold in comparison with the current Dietary Reference Intake (DRI) of 1500 mg. The sodium intakes markedly exceed even the level of 2500 mg, which has been recently given as the maximum level of daily intake that is likely to pose no risk of adverse effects on blood pressure or otherwise. By contrast, the present average potassium, calcium, and magnesium intakes are remarkably lower than the recommended intake levels (DRI). In USA, for example, the average intake of these mineral nutrients is only 35–50% of the recommended intakes. There is convincing evidence, which indicates that this imbalance, that is, the high intake of sodium on one hand and the low intakes of potassium, calcium, and magnesium on the other hand, produce and maintain elevated blood pressure in a big proportion of the population. Decreased intakes of sodium alone, and increased intakes of potassium, calcium, and magnesium each alone decrease elevated blood pressure. A combination of all these factors, that is, decrease of sodium, and increase of potassium, calcium, and magnesium intakes, which are characteristic of the so-called Dietary Approaches to Stop Hypertension diets, has an excellent blood pressure lowering effect. For the prevention and basic treatment of elevated blood pressure, various methods to decrease the intake of sodium and to increase the intakes of potassium, calcium, and magnesium should be comprehensively applied in the communities. The so-called 'functional food/nutraceutical/food-ceutical' approach, which corrects the mineral nutrient composition of extensively used processed foods, is likely to be particularly effective in producing immediate beneficial effects. The European Union and various governments should promote the availability and use of such healthier food compositions by tax reductions and other policies, which make the healthier choices cheaper than the conventional ones. They should also introduce and promote the use of tempting nutrition and health claims on the packages of healthier food choices, which have an increased content of potassium, calcium, and/or magnesium and a lowered content of sodium. Such pricing and claim methods would help the consumers to choose healthier food alternatives, and make composition improvements tempting also for the food industry.
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Introduction

The objective of this paper is to review the role of dietary sodium, potassium, calcium, and magnesium in the pathogenesis, prevention, and treatment of elevated blood pressure (hypertension). This paper illustrates the reasons for the fact that the present average intakes of these mineral nutrients are remarkably different from the levels, which are encountered in 'Natural Diet', that is, in diets composed of unprocessed food (items). The evidence for or against the recent hypothesis that the genetic programs of man are best compatible with the intake levels, which are characteristic of diets composed of unprocessed foods ('Natural Diet'), is discussed. The current intakes of sodium, potassium, calcium, and magnesium are also compared with the levels, which are recommended by the US Department of Health and Human Services and the US Department of Agriculture.[1] On the basis of scientific evidence and current intake recommendations, it is proposed that, for the improvement of the control of hypertension in the community, the food manufacturers, governments, and other organizations should use different methods, which improve in a health-promoting manner the diets in general and the above-mentioned electrolytes in particular.

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Physiological basis for intimate connection of blood pressure with sodium, potassium, calcium, and magnesium

Among the dietary factors, which are connected to the present epidemic of high blood pressure, the mineral nutrients sodium, potassium, calcium, and magnesium are of particular interest. All of these mineral nutrients have important roles in both the control of cardiac output and peripheral vascular resistance, the main determinants of the blood pressure level.[2] On the other hand, the body uses the rise of blood pressure as the most powerful physiological mechanism in the maintenance of sodium balance to prevent sodium accumulation in the case of a high intake. By increasing the blood pressure level, the body is able to get rid of excess sodium by the pressure-natriuresis mechanism.[3,4] Interestingly, the sensitivity of the pressure-natriuresis mechanism and, hence, the excretion of excess sodium is markedly improved by increased intakes of potassium, calcium, and magnesium.[4,5] The development of sodium deficiency during very small intake or losses due to gastrointestinal causes, sweating, or blood loss can, in turn, be effectively prevented by decreasing the blood pressure. In fact, by lowering the blood pressure, the body is able to prevent renal sodium excretion completely.

Intakes of sodium, potassium, calcium, and magnesium: levels in natural diet, modern diet, and recommended diet

It has been suggested that the optimum dietary basis for good health is provided by a diet, which is in agreement with our genetic programmes. According to Eaton and Konner,[6] there is an optimum type and composition of food, which each species, including man, is genetically programmed to eat and metabolise.[6] For example, the lion is programmed to eat animal food only, while the antelope is programmed to eat plant food only. The nutrients provided by such foods are believed to provide optimum nutrition for the lion and antelope, respectively. In the case of wild animals, it is evident, *a priori*, that the genetic programming does not include any processing of food in the form of removal of, or enrichment with, any nutrient components. Human beings are believed to be programmed to eat and metabolise both plant and animal food.[6,7] It has also been suggested that the human genetic programme, which has remained essentially unchanged for at least the past 100 000 years, is best compatible with unprocessed mixed foods, that is, foods without removal of any nutrient components and without addition of any nutrients or other compounds.[6,7] According to this hypothesis, man-made changes in the composition of foods and diets would cause, or at least predispose to, a number of pathological conditions, including elevated blood pressure.

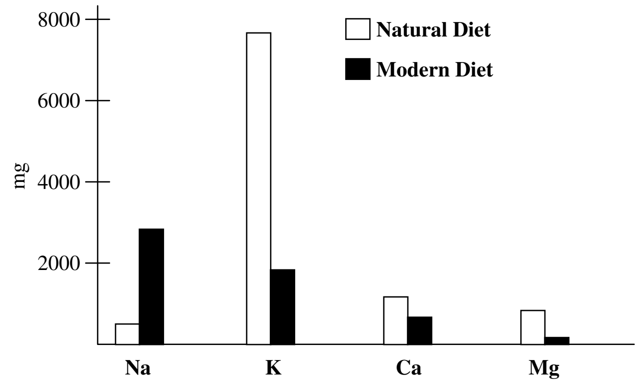

Figure 1 Sodium, potassium, calcium, and magnesium contents (calculated per 2100 kcal) in the Natural Diet and in the Modern Diet (average US diet, which served as the control diet in the DASH study; see below and Appel *et al*[8]). Data extrapolated from Eaton and Eaton III[7].

In view of the important connections of sodium, potassium, calcium, and magnesium with the physiological control of blood pressure and also many other body functions, it is interesting to compare the amounts of various mineral nutrients that are derived from the 'Natural Diet' with the amounts of nutrients that are obtained from current diets. It is also of considerable interest to evaluate the scientific data on the blood pressure effects of changes in the intakes of sodium, potassium, calcium, and magnesium away from the levels of the 'Natural Diet' on the one hand, and towards the levels encountered in the 'Natural Diet', on the other hand. Authoritative expert bodies have recently evaluated the scientific evidence on optimum intakes.[1] The levels derived from the Recommended Diet are given for comparison.

Natural diet

The levels of sodium, potassium, magnesium, and calcium in diets, which consist of unprocessed foods so that approximately two-thirds of the energy is derived from plant food and one-third from animal food, are illustrated in Figure 1 (data derived from Eaton and Konner[6] and Eaton and Eaton III[7]). If a daily energy need of 2100 kcal is satisfied by such a diet composition, the daily intake of sodium is approximately 500 mg, that of potassium about 7400 mg, that of calcium approximately 1100 mg, and that of magnesium about 800 mg.

Modern diet

The modern diets provide sodium, potassium, calcium, and magnesium in dramatically different amounts and ratios than the Natural Diet (Figure 1). In the average US diet, the energy-standardised intake (per 2100 kcal) of sodium was about 3000 mg a day, that is, approximately six-fold as compared with the genetically programmed diet.

By contrast, the potassium intake was as low as 1750 mg,[8] which is only 24% of the amount provided by the Natural Diet.

From the Modern Diet, the daily intake of calcium (about 440 mg;[8]) is remarkably lower than that from the Natural Diet, approximately 40% only.

The usual intake of magnesium (approximately 180 mg;[8]) is also very low (approximately 23% only) as compared with the amount provided by the Natural Diet.

Recommended diet

Recently, the recommended Dietary Reference Intakes (DRIs) have largely replaced the 1989 Recommended Dietary Allowances (RDAs; see US Department of Health and Human Services and US Department of Agriculture[1]).

The DRI for sodium is 1500 mg a day, while 2500 mg has been given as the maximum level of daily intake that is likely to pose no risk of adverse effects. Hence, the average current sodium intake of 3000–4500 mg a day in various westernised communities[9,10] exceeds clearly even the highest sodium intake level, which has been estimated to be safe.

The recommended intake of potassium for adolescents and adults is 4700 mg/day. Recommended intake of potassium for children 1–3 years of age is 3000 mg/day, for 4–8 years of age it is 3800 mg/day, and for 9–13 years of age it is 4500 mg/day.[1]

Hence, the current average potassium intake in USA is very low, only about 37% of the recommended level.

The DRIs for calcium are 1000–1300 mg per day. Therefore, the usual USA intakes are only 35–40% of the DRIs.

The magnesium intake recommendation is 420 mg for adult men.[1] No exact figures have been given for other groups, but the weight-based corresponding value for women would be approximately 300 mg a day. Therefore, the usual USA intake of 180 mg is only approximately 50% of the recommended level.

Pathophysiological basis for the hypertensive effect of current diets (Modern diet)

The average sodium intake is remarkably higher than the recommended or natural intake, which the body can handle without any difficulties and harms. Although suppression of the sodium-retaining renin–angiotensin–aldosterone system, together with other hormonal mechanisms, can improve the excretion of sodium to some extent, in the majority of individuals such mechanisms alone are not effective enough to increase the excretion of sodium enough to match the high intake.

Lifton *et al*[11] emphasised that, given the diversity of physiologic systems that can influence blood pressure, it is striking that all Mendelian forms of hypertension and hypotension solved to date converge on a final common pathway, altering blood pressure by changing net renal salt balance. Since most of the known Mendelian forms of high and low blood pressure have now been solved, the findings on the key role of salt in hypertension do not reflect an obvious selection bias.[11]

The elevated blood pressure levels, which are present in more than half of the population, contribute markedly to the output of sodium.[3] The estimated total number of adults with hypertension in 2000 was 972 million (957–987 million): 333 million (329–336 million) in economically developed countries and 639 million (625–654 million) in economically developing countries. The number of adults with hypertension in 2025 was predicted to increase by about 60% to a total of 1.56 billion (1.54–1.58 billion).[12]

The Intersalt study[9,10] as well as combined data from other studies[10] have shown that in the industrialised communities, the average intake of sodium is approximately 3000–4500 mg per day. The average blood pressure in various communities increases in a dose-related manner with increasing sodium intake. Moreover, weighted linear regression analyses have convincingly shown a correlation between the reduction in urinary sodium, an indicator of sodium intake, and the reduction in blood pressure.[13]

In addition to the high intake of sodium, the low intakes of potassium, calcium, and magnesium further increase the need for blood pressure rise in the maintenance of sufficient sodium output.[4,5]

Improvement of the intakes of sodium, potassium, calcium, and magnesium towards the natural levels lowers blood pressure

Effect of sodium reduction alone

In the second DASH study,[14] the rather vigorous sodium restriction alone, to approximately 40% of the usual level, during a control diet produced a fall of 6.7 mmHg in systolic blood pressure and 3.5 mmHg in diastolic blood pressure. A moderate sodium reduction to approximately 67% of the usual level produced a smaller fall in blood pressure. The average fall in systolic blood pressure was 2.1 mmHg and that in diastolic blood pressure, 1.1 mmHg.

Two recent meta-analyses[15,16] have revealed that an approximately 75 mmol a day (about 50%) reduction in the intake of sodium lowers blood pressure in both subjects with hypertension and normotensive individuals. In hypertensives, the fall in systolic blood pressure is about 5 mmHg and that in diastolic pressure, approximately 3 mmHg. In normotensives, the fall in systolic pressure is approximately 1.3–2 mmHg and that in diastolic pressure about 1 mmHg.

Effect of increased potassium intake alone

An increase of potassium intake by approximately 1.8–1.9 g a day has proved to lower the blood pressure of hypertensive subjects so that the average fall in systolic blood pressure is approximately 4 mmHg and that in diastolic pressure, about 2.5 mmHg[16,17] This increase in potassium intake is about 25% of the amount provided by a 2100 kcal Natural Diet, and not sufficient to raise the potassium intake in USA to the currently recommended level of 4.7 g per day.

Several mechanisms, such as increased natriuresis, reduced sympathetic nervous activity, and decreased pressor response to noradrenaline and angiotensin II, seem to be involved in the blood pressure lowering effect of potassium.[18]

Effect of increased calcium intake alone

Calcium supplementations, which have increased the total daily intake to more than 1000 mg a day, have produced an average fall of 1.4 mmHg in systolic and 0.8 mmHg in diastolic blood pressure.[19]

Improved sodium excretion, modulation of the function of the sympathetic nervous system, increased sensitivity to the vasodilatory action of nitric oxide, and decreased production of superoxide and vasoconstrictor prostanoids have been implicated in the antihypertensive effect of increased calcium intake.[18]

Effect of increased magnesium intake alone

According to a recent meta-analysis,[20] magnesium supplementation resulted in only a small overall reduction in blood pressure. The pooled net estimates of blood pressure change were −0.6 mmHg for systolic pressure and −0.8 mmHg for diastolic pressure. However, there was an apparent dose-dependent effect of magnesium, with reductions of 4.3 mmHg in systolic and of 2.3 mmHg in diastolic blood pressure for each 10 mmol/day increase in magnesium dose.

The antihypertensive effect of magnesium may be mainly due to its vasodilatatory effects.[21]

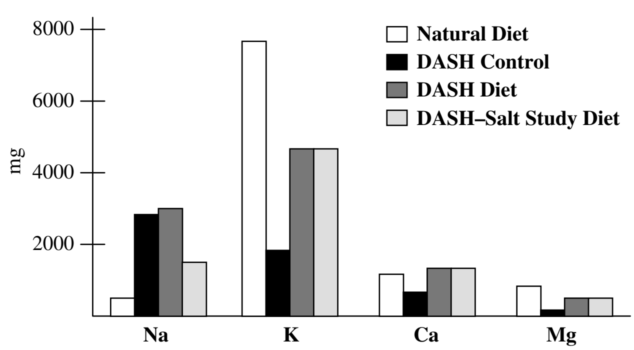

Figure 2 Sodium, potassium, calcium, and magnesium contents (calculated per 2100 kcal) in the DASH diets. For comparison, the contents in the Natural Diet and DASH control diet are also shown. Data adapted from Appel *et al*[8] and Sacks *et al.*[14]

Effect of multiple improvements

In view of the many and complex interactions between sodium, potassium, calcium, and magnesium in body physiology, one can easily realise that all deviations from the optimum levels should be simultaneously corrected for an optimum effect. However, in search for simple measures to combat high blood pressure, single-factor approaches aiming at sodium reduction only, or increase of one beneficial mineral nutrient only, have been used in most studies.

However, in the recent DASH studies,[8,14] the intakes of potassium, calcium, and magnesium increased simultaneously (Figure 2). These changes were produced through a change in the dietary pattern.

The term DASH is derived from studies called ‘the Dietary Approaches to Stop Hypertension’.[8,14] As compared with a typical diet in the US, the DASH diet contains more fruits, vegetables, low-fat dairy products, whole grains, poultry, fish, and nuts. It contains only small amounts of red meat, sweets, and sugar-containing beverages, and it contains decreased amounts of total and saturated fats and cholesterol. The DASH diet provides larger amounts of potassium, calcium, magnesium, dietary fibre, and protein than the typical diet. The Reduced Sodium DASH Diet, which has proved particularly effective for blood pressure reduction, also contains less sodium than the typical US diet.[14]

Although the diets in different populations may differ considerably from that used as the control diet in the DASH study, the essential features are similar in all industrialised populations. As compared with the Natural Diet, the sodium level is very high while the levels of potassium and magnesium are very low. In most populations, the level of calcium is also low, but Finland and some other ‘milk countries’ make an exception in this respect.

The DASH diet produced a nearly 6 mmHg average fall in systolic blood pressure, and an approximately 3 mmHg fall in diastolic blood pressure. Importantly, among the subjects with hypertension, the fall of blood pressure was even more impressive. The average fall in systolic blood pressure was 11.4 mmHg and that in diastolic blood pressure 5.5 mmHg.

When even sodium was reduced from approximately 150 mmol a day to about 60 mmol a day, the average systolic blood pressure was lowered by approximately 9 mmHg, and the fall in diastolic blood pressure was about 4.5 mmHg. The effect of sodium reduction was more pronounced during the control diet than during the DASH diet.

Increased levels of potassium, calcium, and magnesium, and decreased levels of sodium: effects beyond blood pressure

Potassium may protect against stroke and other cardiovascular diseases by mechanisms, which are not related to blood pressure.[18,22] The antiathero-sclerotic properties of potassium have recently created a lot of interest.[18]

The improvement of glucose tolerance appears to be one of the beneficial effects of potassium.[22,23]

Increased intake of calcium has an established place in the prevention of osteoporosis. There is evidence that calcium may also have beneficial effects on serum lipids (for a review, see Vaskonen[18]). Recently, it has been found that increased levels of dietary calcium and magnesium enhance the cholesterol lowering effect of plant sterols.[24,25] There is also increasing evidence that an increased intake of calcium may prevent and decrease obesity (for a review, see Vaskonen[18]).

Increased intake of magnesium appears to protect against ischaemic heart disease by several different mechanisms.[26]

Decreased intake of sodium decreases the urinary loss of calcium and, hence, protects against osteo-porosis.[27,28] Decreased sodium intake decreases the potentially dangerous left ventricular hypertrophy also by mechanisms that are not dependent on the lowering of blood pressure.[4,29–31]

Safety of diets with increased levels of potassium, calcium, and magnesium, and decreased levels of sodium

It would, *a priori*, appear logical that the Natural Diet[6,7] and the nutrients, which such a diet provides, are both useful and safe. In a recent evaluation of the safety of the nutrient amounts, which can be derived from the Natural Diet, it was also concluded that

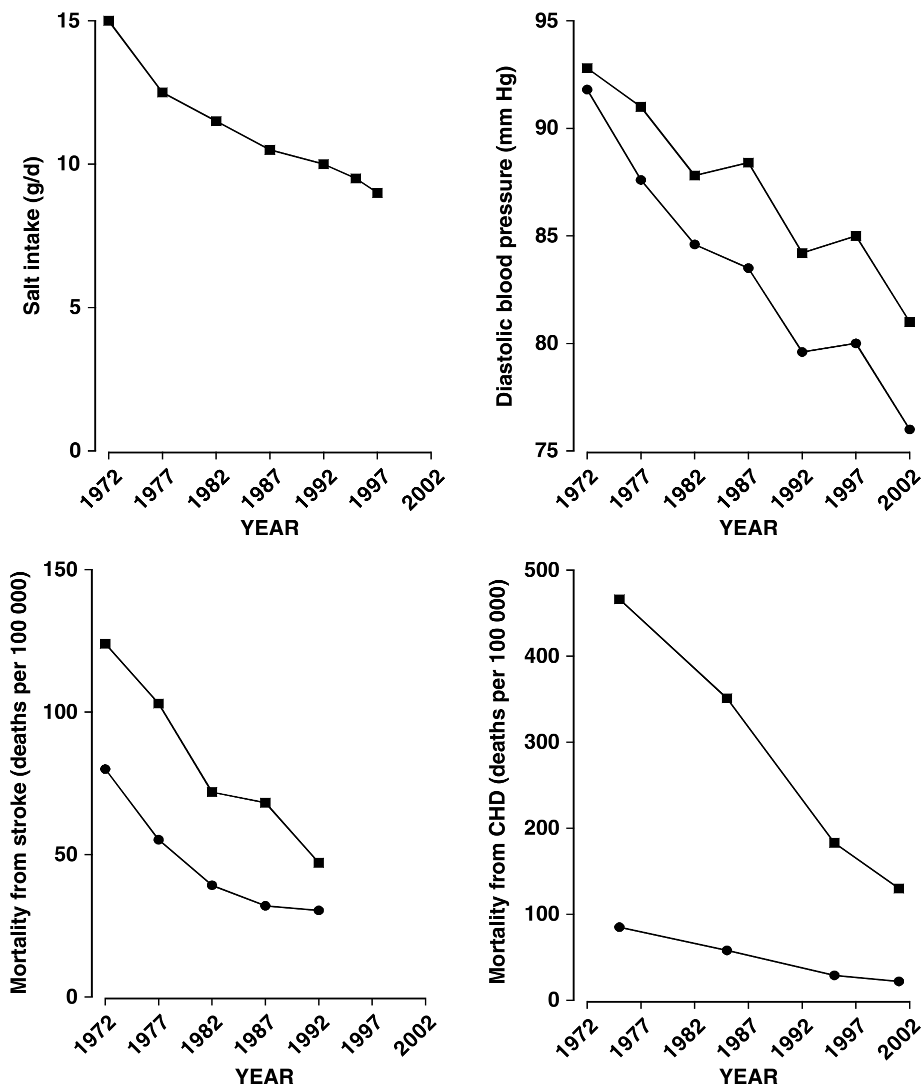

Figure 3 Decrease of salt intake, and lowering of the population blood pressure, and decrease of mortality from both stroke and ischaemic heart disease in Finland.

such amounts are safe, even though they are in some cases markedly different from the current average intakes.[32] Hence, moderate supplementation of the current diets with potassium, calcium, and magnesium can be considered safe for the population.

Unlike in most other countries, in Finland, a progressive and marked decrease in the average intake of salt has taken place during the past three decades (Figure 3).[33] During this period, there has been a remarkable 10 mmHg fall in the average diastolic blood pressure of the population. Moreover, in the middle-aged population, the death rate both from stroke and heart diseases has decreased by approximately 70% (Figure 3).[34-36] The age-adjusted overall mortality has also decreased remarkably so that the life expectancy has increased by several years both among women and men.[36]

The findings in Finland are consistent with an overall beneficial effect of a comprehensive population-wide sodium reduction.

Moreover, the conclusion of Tuomilehto *et al*[37] from a comprehensive prospective study in Finland was that high sodium intake predicted mortality and risk of coronary heart disease, independent of other cardiovascular risk factors, including blood pressure.

Magnitude of the effects on blood pressure makes improvements in the intakes of sodium, potassium, calcium, and magnesium warranted

The main thing, which determines the population impact of a blood pressure lowering factor, is the extent to which such a factor is implemented in the population. It should be noted that its importance greatly exceeds the importance of the effectiveness of a factor in an individual. The antihypertensive drugs can be used as an example to illustrate the fundamental difference between the effectiveness in individuals and the impact in preventing hypertension problems in the population. Antihypertensive drugs are the most effective agents in lowering blood pressure in the treated individuals. However, their role in the overall control of high blood pressure in the whole population is surprisingly small. The average long-term effect of antihypertensive drugs is an approximately 10 mmHg fall in the systolic blood pressure. A nationwide register kept by the Social Insurance Institution reveals that in Finland 8.5% of those aged 35–59 years were entitled to special reimbursement of antihypertensive medication at the end of 2004 (data kindly provided by professor Timo Klaukka, M.D., 2005). Since approximately nine individuals out of 10 do not receive the treatment, the average population effect of the present extensive use of antihypertensive drugs is one-tenth of 10 mmHg, that is, approximately 1 mmHg only. It is important to realise that any measure that can be implemented in all individuals, and has an average effect of 1 mmHg on systolic blood pressure, has a population impact which is equal to the effect of current antihypertensive drug therapy.

To take an example, potassium supplementation in moderate amounts lowers systolic blood pressure by 4.5 mmHg. If this is applied to the whole population, the population impact is more than four-fold as compared with the impact of blood pressure lowering drugs.

For many years, the high blood pressure guidelines have emphasised the need to decrease the sodium content of processed foods. So far, the food industries at large have failed to comply to any useful extent with this recommendation. Since up to 80% of the dietary sodium in many populations is obtained from processed, industry-produced foods, the average sodium intake shows no decreasing tendency in most populations. This shows that there are many big, unsolved problems, which are associated with the decrease in the use of salt.

One of the reasons for the reluctance of the food industries to reduce the amount of sodium, which is added in the course of the food processing, has been the opinion of some scientists. For example, Jurgens and Graudal[38] (24) stated in their recent report: 'The magnitude of the effect in Caucasians with normal blood pressure does not warrant general recommendation to reduce sodium intake.' The authors found that a reduced intake of sodium lowers systolic blood pressure by 1.27 mmHg in Caucasians with normal blood pressure. In individuals with elevated blood pressure, the fall in systolic blood pressure was remarkably greater, 4.18 mmHg. Since elevated blood pressure is present in approximately half of the population, the data of the authors indicate an average population effect, which is (1.27 mmHg + 4.18 mmHg)/2, that is, approximately 2.7 mmHg. This compares very favourably with the population impact of the antihypertensive drug treatment, which is less than half of the impact of a population-wide sodium reduction. Therefore, lack of effectiveness is not the real reason for the failure in the sodium reduction efforts.

Owing to taste habits, consumers may be reluctant to accept products with remarkably less salty taste. It is not tempting for the food industry to manufacture low-salt products, which are unacceptable for the consumers. The ions (sodium and chloride) also have good water binding and other useful technological effects on the structure of several food items. Owing to these factors, a decrease in the average intake of salt in a modern population is likely to be sluggish.

How to implement the potassium, calcium, magnesium and sodium changes in the population?

Due to the factors mentioned above, rather than focusing on salt (sodium) only, it may be wise to also

Table 1 Sodium (Na) and potassium (K) content of various food items

Food item	*Na per 100 g*	*Na per 1000 kcal*	*K per 100 g*	*K per 1000 kcal*
Tomato	2.5	139	290	16111
Tomato ketchup	1360	15111	400	4444
Sunflower seeds	3	5	690	1139
Vegetable margarine	760	1389	15	27
Milk	44	647	160	2353
Butter	650	889	18	25
Unprocessed meat	61	257	340	1435
Processed meat (ham)	920	7077	240	1846
Whole wheat flour	0.8	3	390	1322
Doughnut	210	457	120	261
Wheat flake cakes	270	740	370	1014
Orange	1.6	39	150	3659
Broccoli	7	333	400	19048

The values are expressed as mg/100 g and as mg/1000 kcal. The unprocessed food items are emphasised by bold italics. Data derived from Rastas M, Seppänen R, Knuts L-R, Karvetti R-L, Varo, P (eds). *Nutrient Composition of Foods*. Publications of the Social Insurance Institution: Finland, Helsinki, 1993.

Table 2 Calcium (Ca) and magnesium (Mg) content of various food items

Food item	*Ca per 100 g*	*Ca per 1000 kcal*	*Mg per 100 g*	*Mg per 1000 kcal*
Tomato	9	500	11	611
Tomato ketchup	28	311	18	200
Sunflower seeds	116	191	355	586
Vegetable margarine	21	38	18	33
Milk	120	1765	11	162
Butter	24	33	2,6	4
Unprocessed meat	6.7	28	22	93
Processed meat (ham)	5.7	44	15	115
Whole wheat flour	26	88	130	441
Doughnut	24	52	16	35
Wheat flake cakes	35	96	120	329
Orange	54	1317	13	317
Broccoli	48	2286	24	1143

The values are expressed as mg/100 g and as mg/1000 kcal. The unprocessed food items are emphasised by bold italics.

use the other measures, which have proved to be effective and may be more acceptable both for consumers and the industry. The best scientifically based and technically suitable possibility, which has already been shown to be useful, is offered by the known beneficial effects of increased intakes of potassium, calcium, and magnesium.

In theory, there are several possibilities to change the intakes of the important mineral nutrients towards the genetically programmed levels, which are effective and safe in the control of elevated blood pressure.

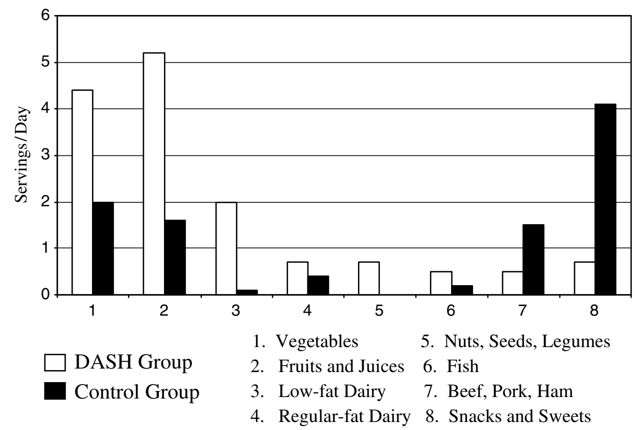

Figure 4 Consumption of different food items in the control group and the DASH group.

1. Replacement of the use of processed food items with the use of unprocessed natural foods would have dramatic effects on the intake of the mineral nutrients (Tables 1 and 2). Complete replacement of the processed foods would result in intakes that are equal with those derived from the Natural Diet (Figure 1). However, one has to realise that the use of processed food items is not decreasing. A continuously increasing proportion of the daily diet in industrialised countries consists of processed foods. It is hardly possible to change this trend in the present-day world.

2. The use of the DASH diet instead of the usual diet is currently recommended by the high blood pressure guidelines.

This approach has proved to be effective in carefully designed research settings. However, one should realise that the changes, which the population ought to do from the usual diet to the DASH diet, are remarkable, as illustrated by Figure 4.

Implementation of even much smaller changes in the dietary habits of the population has proved to be very difficult and slow. The DASH diet warrants recommendation, but the impact of the recommendation remains to be seen.

3. 'Functional food' ('food-ceutical'/'nutraceutical') approach

By far the easiest way, in principle, would be to change the composition of the processed food items that the population most likes and is used to eating. In Finland and some other populations, the enrichment of foods with iodine has been used with excellent success to combat the endemic goitre problem. In USA and some other countries, the enrichment of milk with vitamin D has been a successful measure to prevent vitamin D deficiency. The high effectiveness of this kind of method is due to the fact that it does not require any efforts from the population, and still practically all individuals receive the beneficial 'treatment'.

Enrichment of processed food items with appropriate potassium, calcium, and magnesium compounds would bring the levels of these mineral nutrients towards those found in natural, unprocessed foods. Such enrichment in several widely used foods would be able to improve the total intake of these nutrients to such an extent that they are able to produce remarkable beneficial effects on blood pressure. To avoid excessive increases in the intakes of potassium, calcium, and magnesium, it is not advisable to enrich all industrially processed foods with these mineral nutrients. The food items that are most suitable for such enrichments may be different in various communities with different food traditions.

Even a modest decrease in sodium would further improve the health effects of this enrichment-based approach.

Even partial application of this principle has proved successful in the control of hypertension. Replacement of common salt with potassium- and magnesium-enriched and sodium-reduced salts lowers blood pressure[23,39] and produces even other beneficial effects, such as improvement of glucose tolerance.[23]

Proposed actions

(1) Various health education and other means, which promote the replacement of high-sodium and low-potassium, low-calcium, and low-magnesium food items in the diet, should be effectively used.

The Reduced Sodium DASH- diet, which comprises high-potassium, high-calcium, and high-magnesium food items, which have a low content of sodium (salt), has proved to be highly beneficial. Therefore, this type of diet should be promoted.

Since a comprehensive change in the dietary habits of a community has proved to be a very slow process, other approaches are also needed.

(2) The so-called 'functional food/nutraceutical/food-ceutical' approach, which corrects the composition of extensively used processed foods, is likely to be particularly effective in producing immediate beneficial effects.

For the food industry this is a big challenge, but at the same time a major opportunity for innovative companies to improve the competitiveness of their products. Many processed foods could be enriched with appropriate potassium, calcium, and magnesium compounds to compensate for the losses of these important nutrients during processing. Whenever possible, the sodium levels should be decreased in the products, which have added salt or other added sodium compounds.

To further increase the competitiveness, such foods could be made even more health promoting by concomitant enrichment with other healthy compounds, such as plant sterols. Such composition changes result in foods that affect beneficially both blood pressure and serum cholesterol, the two major causative factors in heart diseases and stroke.[24,25]

It has proved to be easy to enrich products that contain added salt, with potassium and magnesium compounds by using potassium- and magnesium-enriched salt[23,39] Enrichment of different food items with potassium, calcium, magnesium, and plant sterols has also proved to be possible without adverse effects on taste or other important properties.[40] Recently, several calcium-enriched foods, such as milk products and juices, have become available.

(3) In USA, the Food and Drug Administration (FDA) encourages the production and use of foods that have a high content of calcium or potassium and a low content of sodium by allowing for such products health claims, which help in health education and are tempting for the consumers. The European Union and national governments should promote healthier food choices by allowing, on good scientific basis, various nutrition and health claims, which help the consumers to choose healthier alternatives.

(4) Tax reduction and other methods should also be used to promote the availability and use of healthier food compositions.

Conclusions

1. The present average sodium (salt) intake of approximately 3000–4500 mg per day in various industrialised populations is remarkably higher than the recommended intake and even exceeds the level of 2500 mg, which has been recently given as the maximum level of daily intake that is likely to pose no risk of adverse effects on blood pressure or otherwise.
2. The present average potassium, calcium, and magnesium intakes are remarkably lower than the recommended intake levels.
3. Decreased intake of sodium alone, and increased intakes of potassium, calcium, and magnesium each alone decrease elevated blood pressure. The most pronounced effects are brought about by a combination of several of these dietary factors.
4. The most recent US recommendations emphasise decrease in sodium, and increase in potassium, calcium, and magnesium intakes, which are characteristic of the so-called DASH (Dietary Approaches to Stop Hypertension) diets. Such changes bring the levels towards the levels that are encountered in the Natural Diet, and have an excellent blood pressure lowering effect.
5. For the prevention and basic treatment of elevated blood pressure (arterial hypertension), various methods to decrease the intake of sodium and to increase the intakes of potassium, calcium, and magnesium should be comprehensively applied in the communities.

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