

Feasibility and Effect on Blood Pressure of 6-Week Trial of Low Sodium Soy Sauce and Miso (Fermented Soybean Paste)

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A double-blind, randomized placebo-controlled study was conducted to evaluate the feasibility of the long-term use of low-sodium soy sauce and miso in the general Japanese population and its effect on blood pressure (BP). Forty men and 24 women were randomly allocated to a low-sodium group (n=32) or a control group (n=32). Low-sodium soy sauce and miso, which were approximately 25% and 20% lower in salt content than common soy sauce and miso, were used in the study. The change in BP after a 6-week intervention was evaluated. There were no significant differences in age, sex, body mass index, BP or hypertension between the 2 groups before intervention. After the 6-week intervention, no significant change in BP was observed in the entire cohort. However, in those aged 40 years and older, 6.4 mmHg net reduction in diastolic BP with no significant change in systolic BP was noted in the low-sodium group. Taste evaluation for the low-sodium seasoning was considerably good. Replacing soy sauce and miso of the common type with the low-sodium alternative is feasible in the general population and could be the basis for a salt reduction strategy in the Japanese diet. (*Circ J* 2003; 67: 530–534)

Key Words: Hypertension; Primary prevention; Randomized controlled trial; Sodium-restricted diet

A recent overview showed a steep continuous association between diastolic blood pressure (BP) and the risk of stroke with no apparent threshold of BP values in Eastern Asian populations!¹ Also, many recent clinical trials have clearly revealed that a sodium-restricted diet is effective in lowering BP^{2–13}. Dietary salt intake in Japan had decreased from 20–30 g/day to 13 g/day during the mid 20th century,⁴ but it has been largely unchanged since 1980¹⁵ despite efforts in health education by public health and medical staff to reduce dietary salt intake. It is very difficult for Japanese people to eat a traditional diet and reduce their dietary salt intake, but a practical and easy way to reduce dietary salt intake would contribute to the prevention of cardiovascular disease.

Salt-containing seasonings such as soy sauce and miso (fermented soybean paste) are used in traditional Japanese dishes to improve taste and the National Nutrition Survey in Japan showed that almost 50% of the dietary salt intake comes from these salty seasonings.¹⁶ Therefore, the source of the dietary salt in the Japanese diet, which is very different from that in Western countries, could be the target for a salt reduction strategy. Low-sodium soy sauce and miso are generally considered to have less taste and thus are ineffective in reducing dietary salt intake because people will simply consume more of the low-salt varieties to improve the taste. However, our previous double-blind randomized

controlled study revealed that a 1-week trial of low-sodium soy sauce and miso did reduce dietary salt intake, as evaluated by 24-h urinary salt excretion!¹⁷ On the basis of the previous study, we decided to use a double-blind, randomized placebo-controlled study to evaluate the feasibility of relatively long-term use of low-sodium soy sauce and miso in the general population and assess its effect on BP.

Methods

Subjects were recruited in 3 populations: town A, company B and company C. The eligibility criteria were: (1) people aged 20 years or older, (2) not using low-sodium soy sauce and miso in their daily diet and (3) eating home-made food at least twice a day. Participants were restricted to 1 per family. People receiving anti-hypertensive treatment were included in the study. Participants were asked to inform researchers about their medical treatment status in case there was any change either by their own decision or by their physician's decision. The subjects were given written information about the study and informed consent

Table 1 Types of Soy Sauce and Miso Used During the 6-Week Trial

Seasoning	Salt content* ¹	Salt content per 100 g
<i>Soy sauce</i>		
Low sodium	1.8 g/15 ml	10.4 g* ²
Control	2.4 g/15 ml	13.6 g* ²
Koikuchi		14.5 g* ³
<i>Miso</i>		
Low sodium	1.6 g/17 g	9.4 g
Control	1.9 g/16 g	11.9 g
Light yellow type		12.4 g* ³

*¹ Measured by the producer and shown on the product.

*² Calculated with salt content and weight volume ratio.

*³ Described in the Standard Tables of Food Composition in Japan, 5th revised edition!⁹

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Table 2 Characteristics of the Study Subjects

	Low-sodium group (n=32)	%	Controls (n=32)	%	p value
Age (Mean (SD ^{*3}), years)	44.9 (13.1)		48.2 (10.7)		0.27 ^{*4}
Sex					
Men		56.3		68.8	0.30 ^{*5}
Women		43.8		31.3	
Affiliation					
Town A		31.3		34.4	0.95 ^{*5}
Company B		37.5		37.5	
Company C		31.3		28.1	
Height (Mean (SD ^{*3}), cm)	162.6 (8.7)		162.7 (9.4)		0.96 ^{*4}
Body weight (Mean (SD ^{*3}), kg)	61.4 (10.5)		62.5 (11.1)		0.69 ^{*4}
Body mass index (Mean (SD ^{*3}), kg·m ⁻²)	23.2 (3.3)		23.5 (3.0)		0.71 ^{*4}
Systolic blood pressure (Mean (SD ^{*3}), mmHg)	126.4 (18.2)		126.5 (18.1)		0.98 ^{*4}
Diastolic blood pressure (Mean (SD ^{*3}), mmHg)	77.5 (10.8)		79.3 (14.2)		0.58 ^{*4}
Receiving anti-hypertensive treatment		21.9		25.0	0.77 ^{*5}
High blood pressure ^{*1}		25.0		40.6	0.18 ^{*5}
Hypertension ^{*2}		31.3		50.0	0.13 ^{*5}

^{*1} 140 mmHg or more in systolic blood pressure and/or 90 mmHg or more in diastolic blood pressure before the intervention.

^{*2} High blood pressure and/or receiving anti-hypertensive treatment.

^{*3} Standard deviation.

^{*4} t-test.

^{*5} Chi-square test.

was obtained from all participants.

The study was conducted between November and December 2001 in town A, between January and February 2002 in company B, and between February and March 2002 in company C. Low-sodium soy sauce and miso, which are commercially available at a reasonable price, were used for the 6-week intervention. The low-sodium soy sauce and miso were approximately 25% and 20% lower in salt, respectively, compared with common soy sauce and miso used by the controls in the study (Table 1), but the common soy sauce and miso were somewhat lower in salt than the products described in the Standard Tables of Food Composition in Japan (5th revised edition).¹⁹ The low-sodium products did not appear visually different to the common soy sauce and miso used by the controls. The potassium content of the seasoning was not obtained. More detailed information about interventions in food seasoning has been reported elsewhere.¹⁷ Participants were randomly allocated to the low-sodium group or to the control group stratified by 3 populations (ie, town A, company B or C) using a random number table. Allocation was strictly blinded to both participants and examiners during the entire study period. Participants were asked not to change their usual lifestyle other than using the food seasoning provided for the study.

Subjective assessment of sodium type (low sodium, common sodium or unknown) and taste evaluation (very good, good or fair) of the provided seasoning was obtained by interview after the 6-week intervention. Blood pressure after at least 5 min rest was measured by 3 medical doctors and 2 public health nurses using a mercury sphygmomanometer before and after the intervention. It was measured twice in the right arm and the mean value was obtained; however, if the difference between the 1st and 2nd measurements was greater than 5 mmHg, a third measurement was done and the mean value of the 2nd and 3rd measurements was obtained in order to exclude outliers. Urinary salt excretion during 24h with a proportional sampling method¹⁸ were evaluated only in the participants from town A, because no consent to 24-h urine collection was obtained from the 2 companies. For subgroup analyses, participants were divided by their age (<40 years and ≥40 years) and by

their BP status (ie, hypertension: people who were receiving anti-hypertensive treatment and/or people whose systolic BP was ≥140 mmHg and/or people whose diastolic BP was ≥90 mmHg before intervention; and others). Changes in BP after the 6-week intervention were evaluated.

The statistical analyses were carried out using the SPSS 11.0J for Windows and statistical significance was evaluated using the chi-square test or the t-test for 2 groups. All p-values were two-sided and the p<0.05 level was used for statistical significance.

Results

We randomly allocated 41 men and 24 women to the low-sodium group (n=33) and the control group (n=32). One man in the low-sodium group was excluded because he could not participate in the BP measurements after the intervention for occupational reasons. There were no significant differences in age, sex, body mass index, BP or the proportion of hypertensive subjects between the low-sodium group (n=32) and the controls (n=32), although the proportion of hypertensive subjects was somewhat higher in the controls than in the low-sodium group (Table 2).

One man in the low-sodium group informed us that he stopped taking anti-hypertensive drugs by his own decision (ie, without any medical advice) during the intervention, and he was included in the analyses. Table 3 shows the changes in BP after the 6-week dietary intervention. Systolic BP did not change either in the low-sodium group or in the controls in the entire cohort. Diastolic BP decreased by 2.3 mmHg in the low-sodium group, and increased by 0.8 mmHg in the controls, and the net reduction in the low-sodium group was 3.1 mmHg, which was statistically insignificant (t-test, p=0.18). In the people aged 40 years and older, the net reduction in the low-sodium group was very small for systolic BP (-0.3 mmHg); however, the difference was statistically significant for diastolic BP (-6.4 mmHg, p=0.02). In patients with hypertension, the net reduction in the low-sodium group was 5.8 mmHg for systolic BP and 1.3 mmHg for diastolic BP, although neither was statistically significant. In the people without hypertension, the net reduction for diastolic BP was

Table 3 Changes in Blood Pressure (BP) After the 6-Week Dietary Intervention

Group	Low sodium group		Controls		p value*2
	mean	SE*1 (mmHg)	mean	SE*1 (mmHg)	
All	(n=32)		(n=32)		
Systolic BP	-0.5	1.7	-0.5	1.6	0.99
Diastolic BP	-2.3	1.5	0.8	1.6	0.18
Subgroup 1					
<40 years	(n=10)		(n=8)		
Systolic BP	1.0	1.8	0.9	1.8	0.96
Diastolic BP	2.7	2.0	-2.6	3.8	0.21
≥40 years	(n=22)		(n=24)		
Systolic BP	-1.2	2.4	-0.9	2.1	0.93
Diastolic BP	-4.5	1.8	1.9	1.8	0.02
Subgroup 2					
Hypertension	(n=10)		(n=16)		
Systolic BP	-7.3	3.9	-1.5	3.0	0.24
Diastolic BP	-3.7	2.6	-2.4	2.1	0.71
Others	(n=22)		(n=16)		
Systolic BP	2.6	1.5	0.6	1.3	0.33
Diastolic BP	-1.6	1.9	3.9	2.3	0.07

*1 Standard error.

*2 t-test.

Table 4 Subjective Assessment of the Seasonings

Intervention seasoning	Assessment	Low-sodium group		Controls		p value*2
		n	%	n	%	
Soy sauce	Low sodium	16*1	50.0*1	11	34.4	0.42
	Common sodium	9	28.1	13*1	40.6*1	
	Unknown	7	21.9	8	25.0	
Miso	Low sodium	17*1	53.1*1	15	46.9	0.80
	Common sodium	10	31.3	10*1	31.3*1	
	Unknown	5	15.6	7	21.9	

*1 Number or proportion of participants who correctly answered the sodium type of the intervention seasoning.

*2 Chi-square test.

Table 5 Taste Evaluation of the Seasonings

Intervention seasoning	Evaluation	Low-sodium group		Controls		p value*
		n	%	n	%	
Soy sauce	Very good	5	15.6	8	25.0	0.64
	Good	24	75.0	21	65.6	
	Fair	3	9.4	3	9.4	
Miso	Very good	11	34.4	10	31.3	0.84
	Good	18	56.3	20	62.5	
	Fair	3	9.4	2	6.3	

* Chi-square test.

5.5 mmHg (p=0.07). Among the participants in town A, only 11 people (4 in the intervention group and 7 in the controls) completed the 24-h urine collection. Salt excretion decreased 0.7 g/day in the intervention group and increased 0.7 g/day in the controls and the net difference was 1.4 g/day. Potassium excretion increased 0.4 g/day in the intervention group and decreased 0.1 g/day in the controls. No apparent change was found in calcium and magnesium excretion (intervention group: -0.009 g/day, 0.001 g/day, controls: -0.002 g/day, 0.002 g/day, respectively).

The subjective assessment of the intervention seasonings is shown in Table 4. The number of people who correctly answered the sodium type was 50% for the low-sodium soy sauce, 41% for the common sodium soy sauce, 53% for the low-sodium miso and 31% for the common sodium miso. Regarding the taste evaluation (Table 5), no significant

difference was found between the low-sodium group and the controls, either for soy sauce or for miso. One-third of the people who consumed the low-sodium miso as well as those who consumed the common sodium miso reported that the miso tasted very good.

Discussion

This double-blind, randomized placebo-controlled trial shows that low-sodium soy sauce and miso had a reasonable taste evaluation and that the using the low-sodium seasonings significantly lowered diastolic BP in the people aged 40 and older. The BP lowering effect might be greater for those with hypertension, but it did not reach statistical significance in the present study.

Many recent clinical trials regarding the effect of salt

reduction on BP have been conducted mainly in Western countries²⁻¹³ One trial using comprehensive nutritional-hygienic counseling achieved a net reduction in urinary salt of 1.8 g/day and showed a lower incidence of hypertension in the intervention group.⁵ The Hypertension Prevention Trial revealed that dietary counseling treatment resulted in fewer hypertensive events during a 3-year follow-up;⁶ however, they observed the completion rate of follow-up visits for data collection in the sodium treatment group was the worst of the 4 dietary treatment groups (ie, reduced sodium, reduced calories, reduced sodium and calories or reduced sodium and increased potassium). The Trials of Hypertension Prevention-1 demonstrated that group educational sessions and individual counseling on sodium reduction lowered urinary sodium excretion by 2.6 g/day (baseline: 9.0 g/day), systolic BP by 1.7 mmHg, and diastolic BP by 0.9 mmHg over 18 months in people with high-normal diastolic BP.⁷ Dietary counseling was especially effective in the short term,⁷ and also contributed to a reduction in hypertension incidence during the 3- to 4-year study period.⁸ Moreover, reducing salt intake through dietary counseling was effective enough that older people receiving antihypertensive medication were able to cease taking the medication.⁹

In some trials, special foods or tablets were used for the intervention instead of providing dietary counseling.¹⁰⁻¹³ Cappuccio et al used sodium tablets to adjust sodium intake and observed a reduction in BP of 7.3/3.2 mmHg associated with a reduction in urinary salt of 4.9 g/day in older people.¹⁰ A diet that was rich in fruits, vegetables and low-fat dairy products and contained smaller amounts of red meat, sweets and sugar-containing beverages with high, intermediate or low sodium concentrations was used in the Dietary Approaches to Stop Hypertension (DASH) trial.¹¹ It clearly showed that a 30-day intake of the DASH diet with low salt (approximately 3.8 g/day) achieved a reduction in BP of 3.0/1.6 mmHg compared with the diet with high salt (approximately 8.3 g/day). Several studies used a low-sodium, high potassium, high magnesium mineral salt to reduce dietary sodium intake.^{12,13} Geleijnse et al observed that a 24-week use of mineral salt (sodium: potassium: magnesium 8:6:1) lowered BP by 7.6/3.3 mmHg in elderly people with mild hypertension.¹² In Japan, we could find only one randomized controlled trial for lowering BP using dietary intervention. Kawasaki et al reported that consuming mineral salt and mineral salt replaced-soy sauce and -miso for 5 weeks lowered BP in elderly people.¹³ Mineral salt is beneficial for dietary intervention study to lower BP because it can simultaneously achieve an increase in potassium intake and a decrease in sodium intake, and will be more effective than intervening in the sodium intake alone. However, the use of mineral salt is not common in Japan despite some evidence, partly because some people dislike its bitter taste and partly because mineral salt replaced-soy sauce and -miso are not widely available. Low-sodium soy sauce and miso such as used in this study are more widely available at a reasonable price in Japan.

In the present study, a 6-week trial of low-sodium soy sauce and miso resulted in a reduction in urinary salt of 0.7 g/day in the intervention group, and the net difference of urinary salt excretion between the intervention group and the controls was 1.4 g/day, which is broadly consistent with an estimated value using the results from the National Nutrition Survey of Japan. The National Nutrition Survey shows that in the Japanese diet one-fourth of dietary salt

intake comes from soy sauce and approximately one-eighth of salt comes from miso.¹⁶ Therefore, we can estimate that changing from the common salt type of seasonings to the low-sodium type, which are approximately 25% and 20% lower in salt content than the common soy sauce and miso, will reduce dietary salt intake by approximately 10% without any special effort. For example, when one consumes 13 g dietary salt daily, the estimated salt intake from soy sauce will change from 3.3 g to 2.4 g, and that from miso will change from 1.6 g to 1.3 g just by replacing the seasoning with the low-sodium type, and thus one can achieve 1.2 g reduction of daily dietary salt intake. The present results showed that an approximately 10% reduction of dietary salt intake affected diastolic BP in middle-aged or older people, and possibly had beneficial effects on BP in those with hypertension. The unexpected increase of urinary potassium excretion observed in the intervention group might also be related to the change in BP.

The major limitation of this study was the relatively small number of participants, especially in the subgroup analysis. There are several possible reasons why we could not recruit enough participants. One reason derives from the study design. In this study, low-sodium seasoning was used for all dishes prepared in the home of the study participants, so if a person intended joining this study, consent from all family members had to be obtained. Another possible reason is that many people eat out or eat prepared foods and eat home-made dishes less often. One of the eligibility criteria was that subjects eat home-made dishes at least twice a day. Another limitation of the study was lack of measurement of lifestyle factors such as alcohol intake and exercise; however, if lifestyle modification had occurred, it would have been non-differential between the intervention group and controls. In this study, the reason why systolic BP did not reduce in the older age group is not clear and a further comprehensive study may provide more robust evidence. Also, diet-drug interaction should be further studied because a sodium-restricted diet is thought to influence the antihypertensive activity of many antihypertensive drugs.^{20,21}

In conclusion, the feasibility of using low-sodium soy sauce and miso in the general population was found to be good and their use produced an approximately 10% reduction in dietary salt intake and could be the basis for a salt-reduction strategy in Japan.

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