



**Intake of fermented soy products was negatively associated with risk of hypertension in postmenopausal women and men aged 50 years or older: Korea National Health and Nutrition Examination Survey, 2013-2018**

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**Background:** Sodium intake is positively associated with risk of hypertension, but it is not clear whether there is an association between fermented soy products, a major source of salt and blood pressure (BP). The present study aimed to investigate the hypothesis that risk of hypertension and BP were negatively associated with intake of fermented soy products, but not associated with sodium from fermented soy products.

**Methods:** This cross-sectional study was performed using data from Korea National Health and Nutrition Examination Survey, 2013-2018.

**Results:** Intakes of fermented soy products were negatively associated with risk of hypertension (odds ratio: 0.81, 95% confidence interval: 0.66-0.98; P-trend = 0.023), and systolic blood pressure (SBP; P-trend = 0.043) in postmenopausal women. The mediation analysis showed that fermented soy products had total and direct effects on SBP, but no indirect effect since nutrients of soy such as protein, fiber, calcium, and potassium had no significant effects on SBP. Among men, fermented soy products were not associated with risk of hypertension and BP. In addition, intakes of sodium from fermented soy products were not significantly associated with risk of hypertension and BP in both postmenopausal women and men.

**Conclusion:** The present study suggested that risk of hypertension and BP was not associated with sodium from fermented soy products, and further inversely associated with intake of fermented soy products in postmenopausal women.

**Table 1. Baseline characteristics of men and postmenopausal women  $\geq 50$  years old**

	Women		<i>p</i> -Value	Men		<i>p</i> -Value
	Normotensive (n=3438)	Hypertensive (n=3058)		Normotensive (n=2655)	Hypertensive (n=2415)	
Age (years)	60.07±0.16	65.93±0.19	<0.001	59.72±0.18	63.26±0.23	<0.001
BMI (kg/m <sup>2</sup> )			<0.001			<0.001
<18.5	97 (2.9)	34 (1.2)		71 (2.4)	43 (1.6)	
18.5-<23.0	1504 (45.2)	808 (27.6)		1039 (37.6)	663 (26.1)	
23.0-<25.0	871 (25.0)	793 (24.7)		775 (29.7)	630 (26.5)	
$\geq 25.0$	966 (27.0)	1423 (46.4)		770 (30.3)	1079 (45.8)	
Family history of hypertension, n (%)	964 (29.6)	1166 (40.9)	<0.001	588 (25.8)	815 (37.2)	<0.001
Regular exercise, n (%) <sup>1</sup>	1594 (48.1)	1140 (39.5)	<0.001	1262 (48.4)	1078 (46.0)	0.149
Alcohol drinking, n (%) <sup>2</sup>	50 (1.5)	68 (2.6)	0.007	262 (11.2)	364 (18.0)	<0.001
Smoking, n (%)			0.781			0.020
Never	3263 (94.8)	2897 (94.7)		521 (19.1)	455 (19.2)	
Past	80 (2.3)	81 (2.6)		1343 (48.4)	1343 (52.5)	
Current	95 (3.0)	80 (2.8)		791 (32.5)	617 (28.4)	
Education, n (%)			<0.001			<0.001
$\leq$ Elementary	1191 (30.2)	1823 (55.2)		617 (18.7)	686 (25.2)	
Middle	658 (19.4)	467 (16.3)		425 (14.6)	447 (17.0)	
High	1040 (33.3)	540 (20.1)		820 (32.7)	752 (32.4)	
$\geq$ College	549 (17.2)	228 (8.4)		793 (34.0)	530 (25.4)	
Household income, n (%)			<0.001			<0.001
Low	753 (19.1)	1200 (36.1)		514 (15.0)	663 (22.9)	
Middle-low	917 (25.2)	808 (25.2)		697 (23.6)	644 (24.9)	
Middle-high	806 (25.0)	590 (21.3)		654 (27.1)	542 (24.3)	
High	962 (30.7)	460 (17.5)		790 (34.3)	566 (27.9)	
LDL-C (mmol/L)	3.29±0.02	2.98±0.02	<0.001	3.06±0.02	2.73±0.02	<0.001
HDL-C (mmol/L)	1.39±0.01	1.31±0.01	<0.001	1.21±0.01	1.19±0.01	0.057
TG (mmol/L)	1.38±0.02	1.56±0.02	<0.001	1.75±0.04	1.88±0.04	0.011
FPG (mmol/L)	5.48±0.02	5.95±0.03	<0.001	5.81±0.03	6.13±0.04	<0.001
SBP (mmHg)	114.84±0.24	134.88±0.39	<0.001	116.21±0.26	132.42±0.40	<0.001
DBP (mmHg)	72.78±0.15	78.11±0.26	<0.001	75.38±0.18	80.52±0.31	<0.001
Energy (kcal/day)	1681.51±12.61	1569.34±12.33	<0.001	2191.55±16.82	2105.22±17.56	<0.001
Total sodium (mg/day)	3011.98±42.35	2712.88±39.60	<0.001	4094.88±53.76	3934.62±60.97	0.043
Sodium from fermented soy products (mg/day)	707.51±16.59	669.33±15.24	0.074	939.14±22.03	875.38±21.55	0.032
Fermented soy products intake (g/day)	17.47±0.42	16.02±0.38	0.008	23.60±0.59	22.32±0.60	0.117

BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; LDL, low density lipoprotein cholesterol; HDL, high density lipoprotein cholesterol; TG, triglyceride; FPG, fasting plasma glucose. Continuous variables were presented as mean  $\pm$  and standard errors of the mean, while categorical variable as subject number (percentage distribution); <sup>1</sup>Regular exercise was defined as vigorous activity for >20 minutes for >3 times a week or walking for 20minutes for >5 days a week; <sup>2</sup>Alcohol drinking was defined as drinking at least 7 servings for men and 5 servings for women 2 or more times a week.

**Table 2. Associations between risk of hypertension and intake of sodium and fermented soy products in postmenopausal women  $\geq 50$  years old**

	Quintiles of intake					P-Trend <sup>1</sup>
	Q1 (n=1299)	Q2 (n=1299)	Q3 (n=1300)	Q4 (n=1299)	Q5 (n=1299)	
<b>Total sodium (mg/day)</b>	<1437.25	1437.25-<2085.23	2085.23-<2846.36	2846.36-<3936.08	$\geq 3936.08$	
Crude OR (95% CI)	1	0.80 (0.67-0.96)	0.71 (0.59-0.84)	0.63 (0.53-0.76)	0.62 (0.52-0.74)	<b>&lt;0.001</b>
Adjusted OR (95% CI) <sup>2</sup>	1	0.88 (0.71-1.08)	0.83 (0.67-1.02)	0.82 (0.66-1.02)	0.82 (0.64-1.05)	0.183
<b>Sodium from fermented soy products (mg/day)</b>	<130.57	130.57-<354.53	354.53-<627.84	627.84-<1076.44	$\geq 1076.44$	
Crude OR (95% CI)	1	0.85 (0.72-1.02)	0.82 (0.68-0.98)	0.90 (0.76-1.07)	0.76 (0.64-0.90)	<b>0.011</b>
Adjusted OR (95% CI) <sup>2</sup>	1	0.93 (0.76-1.14)	0.92 (0.76-1.13)	1.02 (0.83-1.25)	0.83 (0.68-1.01)	0.124
<b>Fermented soy products (g/day)</b>	<2.85	2.85-<7.89	7.89-<14.60	14.60-<26.39	$\geq 26.39$	
Crude OR (95% CI)	1	0.91 (0.76-1.08)	0.85 (0.71-1.02)	0.88 (0.74-1.05)	0.72 (0.61-0.86)	<b>&lt;0.001</b>
Adjusted OR (95% CI) <sup>2</sup>	1	0.97 (0.80-1.19)	1.00 (0.82-1.23)	1.00 (0.82-1.23)	0.81 (0.66-0.98)	<b>0.023</b>

BMI, body mass index; LDL, low density lipoprotein cholesterol; TG, triglyceride; FPG, fasting plasma glucose. Data were presented as odds ratio (OR) and 95% confidence intervals (95%CI); <sup>1</sup>Estimated P-trend for a linear trend was based on linear scores derived from the medians of the quintiles of each sodium and fermented soy products intake among women; <sup>2</sup>Adjusted for age, TG, LDL-C, energy, FPG, BMI, education, alcohol drinking, household income, and family history of hypertension.

**Table 3.** Associations between risk of hypertension and intake of sodium and fermented soy products in men  $\geq 50$  years old

	Quintiles of intake					<i>P</i> -Trend <sup>1</sup>
	Q1 (n=1014)	Q2 (n=1014)	Q3 (n=1014)	Q4 (n=1014)	Q5 (n=1014)	
<b>Total sodium (mg/day)</b>	<2165.32	2165.32-<3068.22	3068.22-<4013.82	4013.82-<5365.74	$\geq 5365.74$	
Crude OR (95% CI)	1	0.74 (0.61-0.91)	0.67 (0.55-0.83)	0.78 (0.64-0.94)	0.67 (0.54-0.82)	<b>&lt;0.001</b>
Adjusted OR (95% CI) <sup>2</sup>	1	0.80 (0.64-1.02)	0.78 (0.62-0.98)	0.94 (0.74-1.19)	0.77 (0.60-1.00)	0.209
<b>Sodium from fermented soy products (mg/day)</b>	<206.93	206.93-<493.55	493.55-<859.18	859.18-<1469.45	$\geq 1469.45$	
Crude OR (95% CI)	1	0.96 (0.79-1.18)	0.84 (0.69-1.03)	0.88 (0.72-1.09)	0.79 (0.65-0.97)	<b>0.020</b>
Adjusted OR (95% CI) <sup>2</sup>	1	1.03 (0.83-1.28)	0.90 (0.73-1.11)	1.01 (0.80-1.27)	0.85 (0.68-1.07)	0.150
<b>Fermented soy products (g/day)</b>	<4.66	4.66-<11.57	11.57-<20.62	20.62-<36.34	$\geq 36.34$	
Crude OR (95% CI)	1	0.88 (0.72-1.07)	0.88 (0.72-1.08)	0.74 (0.60-0.92)	0.81 (0.66-1.00)	<b>0.043</b>
Adjusted OR (95% CI) <sup>2</sup>	1	0.94 (0.76-1.17)	0.94 (0.75-1.17)	0.84 (0.66-1.05)	0.89 (0.70-1.12)	0.281

BMI, body mass index; LDL, low density lipoprotein cholesterol; FPG, fasting plasma glucose. Data were presented as odds ratio (OR) and 95% confidence intervals (95%CI); <sup>1</sup>Estimated *P*-trend for a linear trend was based on linear scores derived from the medians of the quintiles of intake of sodium and fermented soy products among men; <sup>2</sup>Adjusted for age, LDL-C, energy, FPG, BMI, education, alcohol drinking, regular exercise, and family history of hypertension.

**Table 4.** Associations between blood pressure and intake of sodium and fermented soy products in postmenopausal women  $\geq 50$  years old

	Quintiles of intake					<i>P</i> -Trend <sup>1</sup>
	Q1 (n=1299)	Q2 (n=1299)	Q3 (n=1300)	Q4 (n=1299)	Q5 (n=1299)	
<b>Total sodium (mg/day)</b>	<1437.25	1437.25-<2085.23	2085.23-<2846.36	2846.36-<3936.08	$\geq 3936.08$	
SBP (mmHg)	125.44 $\pm$ 0.61	124.47 $\pm$ 0.57	123.23 $\pm$ 0.59	122.74 $\pm$ 0.58	122.20 $\pm$ 0.57	0.612
DBP (mmHg)	75.16 $\pm$ 0.33	74.79 $\pm$ 0.31	75.15 $\pm$ 0.33	74.96 $\pm$ 0.31	75.50 $\pm$ 0.31	0.838
<b>Sodium from fermented soy products (mg/day)</b>	<130.57	130.57-<354.53	354.53-<627.84	627.84-<1076.44	$\geq 1076.44$	
SBP (mmHg)	124.51 $\pm$ 0.61	123.48 $\pm$ 0.55	123.91 $\pm$ 0.64	123.93 $\pm$ 0.56	122.25 $\pm$ 0.57	0.087
DBP (mmHg)	75.40 $\pm$ 0.32	75.16 $\pm$ 0.31	75.03 $\pm$ 0.33	75.24 $\pm$ 0.31	74.74 $\pm$ 0.29	0.148
<b>Fermented soy products (g/day)</b>	<2.85	2.85-<7.89	7.89-<14.60	14.60-<26.39	$\geq 26.39$	
SBP (mmHg)	124.51 $\pm$ 0.60	124.05 $\pm$ 0.56	123.56 $\pm$ 0.61	123.88 $\pm$ 0.55	122.05 $\pm$ 0.58	<b>0.043</b>
DBP (mmHg)	75.36 $\pm$ 0.33	75.21 $\pm$ 0.31	75.05 $\pm$ 0.32	75.29 $\pm$ 0.31	74.65 $\pm$ 0.30	0.067

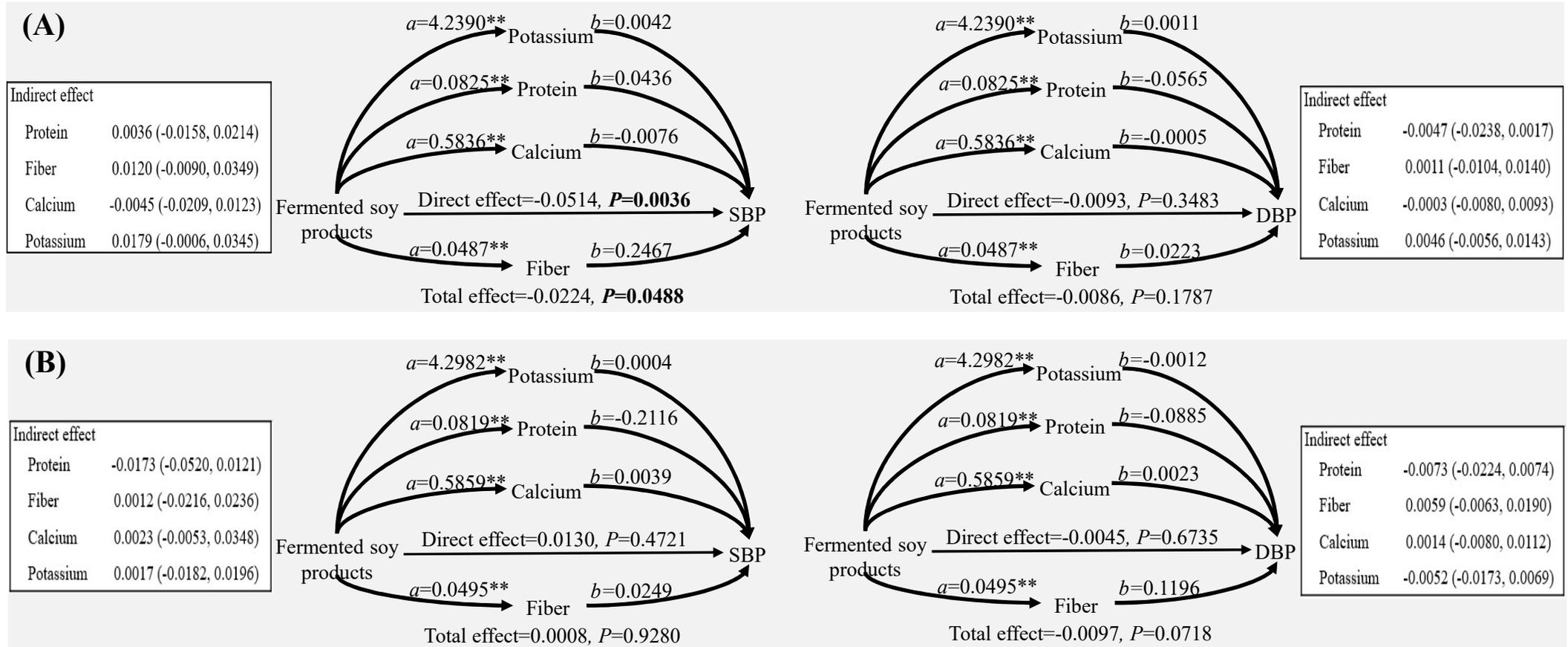
BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; LDL, low density lipoprotein cholesterol; TG, triglyceride; FPG, fasting plasma glucose. All values were presented as mean  $\pm$  standard errors of the mean; <sup>1</sup>*P*-trend for differences in SBP and DBP according to quintiles of intake of sodium and fermented soy products after adjustment for confounders, and adjusted for age, TG, LDL-C, energy, FPG, BMI, education, alcohol drinking, household income, and family history of hypertension.

**Table 5. Associations between blood pressure and intake of sodium and fermented soy products in men  $\geq 50$  years old**

	Quintiles of intake					<i>P</i> -Trend <sup>1</sup>
	Q1 (n=1014)	Q2 (n=1014)	Q3 (n=1014)	Q4 (n=1014)	Q5 (n=1014)	
<b>Total sodium (mg/day)</b>	<2165.32	2165.32-<3068.22	3068.22-<4013.82	4013.82-<5365.74	$\geq 5365.74$	
SBP (mmHg)	125.51 $\pm$ 0.57	123.50 $\pm$ 0.60	122.23 $\pm$ 0.54	123.41 $\pm$ 0.58	122.83 $\pm$ 0.58	0.180
DBP (mmHg)	77.70 $\pm$ 0.41	77.49 $\pm$ 0.39	77.01 $\pm$ 0.36	78.59 $\pm$ 0.37	78.43 $\pm$ 0.39	0.195
<b>Sodium from fermented soy products (mg/day)</b>	<206.93	206.93-<493.55	493.55-<859.18	859.18-<1469.45	$\geq 1469.45$	
SBP (mmHg)	123.90 $\pm$ 0.56	123.93 $\pm$ 0.58	122.66 $\pm$ 0.60	122.85 $\pm$ 0.57	123.96 $\pm$ 0.63	0.614
DBP (mmHg)	77.63 $\pm$ 0.40	78.16 $\pm$ 0.36	77.24 $\pm$ 0.39	77.26 $\pm$ 0.38	78.10 $\pm$ 0.38	0.304
<b>Fermented soy products (g/day)</b>	<4.66	4.66-<11.57	11.57-<20.62	20.62-<36.34	$\geq 36.34$	
SBP (mmHg)	124.07 $\pm$ 0.57	123.43 $\pm$ 0.58	123.34 $\pm$ 0.57	122.24 $\pm$ 0.54	124.22 $\pm$ 0.61	0.450
DBP (mmHg)	77.74 $\pm$ 0.39	77.70 $\pm$ 0.37	77.45 $\pm$ 0.36	77.43 $\pm$ 0.39	78.07 $\pm$ 0.38	0.239

BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; LDL, low density lipoprotein cholesterol; TG, triglyceride; FPG, fasting plasma glucose. All values were presented as mean  $\pm$  standard errors of the mean; <sup>1</sup>*P*-trend for differences in SBP and DBP according to quintiles of intake of sodium and fermented soy products after adjustment for confounders, and adjusted for for age, LDL-C, energy, FPG, BMI, education, alcohol drinking, regular exercise, and family history of hypertension.

**Figure 1. Mediation effects of nutrients on the association between fermented soy products intake and blood pressure in postmenopausal women (A) and men (B)**



Confounding factors were age, TG, LDL-C, energy, FPG, BMI, education, alcohol drinking, household income, and family history of hypertension in women; age, LDL-C, energy, FPG, BMI, education, alcohol drinking, regular exercise, and family history of hypertension in men. Unstandardized coefficients were shown along with their estimated p values using bootstrapping method. \* p < 0.05; \*\* p < 0.001.

- **Intakes of fermented soy products were negatively associated with risk of hypertension and systolic blood pressure in postmenopausal women, but not in men.**
- **Intakes of sodium from fermented soy products were not significantly associated with risk of hypertension and BP in both postmenopausal women and men.**
- **The present study suggested that sodium from fermented soy products did not increase the risk of hypertension and BP. Further inversely associated with intake of fermented soy products in postmenopausal women.**

## *Disclosure of Conflict of Interest*



The authors declare that no conflict of interest.

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